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An Ontology-Based Approach for Diagnosing and Recommending Treatments for Myasthenia Gravis Disease

طريقة تعتمد على الأنطولوجيا لتشخيص واقتراح علاج لمرض وهن العضلات الوبيل

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أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

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بناءً على موافقة شئون البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ **محمد سليمان موسى السطري** لنيل درجة الماجستير في **كلية *تكنولوجيا المعلومات*** برنامج تكنولوجيا المعلومات وموضوعها:

طريقة تعتمد على الأنطولوجيا لتشخيص وإقتراح علاج لمرض وهن العضلات الوبيل

An Ontology-Based Approach for Diagnosing and Recommending Treatments for Myasthenia Gravis Disease

وبعد المناقشة التي تمت اليوم الأحد 24 ربيع الثاني 1438هـ، الموافق 2017/01/22م الساعة العاشرة صباحاً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق،،،

نائب الرئيس لشئون البحث العلمي والدراسات العليا

أ.د. عبدالرؤوف علي المناعمة

Abstract

Various diseases have emerged in recent time, which were not known to our ancestors, or they have limited deployment. The diversity of these diseases led doctors to face difficulties in diagnosing these diseases, especially when they are rare and chronic such as Myasthenia Gravis (MG) disease. Additionally, patients suffer a lot before being diagnosed correctly.

The purpose of this thesis is to develop an ontology-based approach that would help doctors to diagnose the Myasthenia Gravis disease and to recommend treatments and practices that may decrease the Myasthenia Gravis impact.

We reviewed several approaches and ontologies that deal with diseases such as diagnoses, patient-records, clinical decision support systems and healthcare systems. We tried to reuse that ontologies, but most of it is general ontologies for several diseases and does not focusing on specific one. Because of that we find ourselves having to develop a specific ontology for the Myasthenia Gravis disease to achieve our goals because the Myasthenia Gravis is totally different from most of the diseases.

The proposed approach consists of a knowledge base (ontology and instances) and several modules such as querying, reasoning, diagnosing, and recommending treatments. A system prototype is developed with web application. It receives users' inputs such as symptoms, then returns the results in the form of query results, diagnosis results or recommended treatments and practices.

The user of the system (which is a doctors), can select patient's symptoms or query about the MG disease. The system would help these doctors to decide if this patient suffers from MG disease or not, then can provide a recommended treatment for this patient through the enriched knowledge base (ontology and various instances).

We made a preliminary evaluation to evaluate the diagnosing accuracy by entering information about a number of persons infected with MG disease and evaluate the results. Also, we evaluate the recommending treatments according to a human expert in Brian and Neurology by comparing his recommended treatments of a patient with a doctor's prescription who treated that patient, then with the approach recommendations to that patient. Additionally, we evaluate the efficiency of the approach by comparing the processes speed with average delay of diagnosing patients.

The approach achieved a rate of accuracy in the results of diagnosing the MG disease of 86.11%, a rate of accuracy in the results of the recommending treatments of 72%. These are a better result compared to those of doctors' accuracy that treat patients' cases which is 50%. The average efficiency in the diagnosing process is 0.17 seconds and in the recommending process was 40 seconds. This time does not compare at all if we knew that the average delay in the diagnosis of patients' cases was 2.46 years.

Keywords: Myasthenia Gravis, MG, diagnose, disease, treatment, recommendation systems, ontology and semantic web.

الملخــص

يواجه العالم اليوم أنواعاً جديدة من الأمراض لم تكن معروفة في أسلافنا؛ منها النادر ومنها ما هو واسع الانتشار. ومع وجود هذه الأمراض النادرة؛ يواجه كلا من المرضى والأطباء مشكلات عديدة في تشخيصها وعلاجها لندرتها تارة؛ ولضعف الخبرة لدى الأطباء في مواجهة هذه الأمراض تارة أخرى، وقد يعاني المريض – نتيجة لذلك – لسنوات عديدة قبل أن يتم تشخيصه تشخيصاً صحيحاً.

من الأمثلة على ما ذكرنا من أمراض؛ المرض العصبي المزمن والنادر "وهن العضلات الوبيل" (Myasthenia Gravis)، والذي واجه الأطباء – ولا زالوا يواجهون – صعوبات بالغة في تشخيصه وعلاجه، لأن أعراضه تتأرجح بين الظهور والاختفاء بين الفينة والأخرى، وقد يتشابه بعضها مع أمراض أخرى، ونتيجة لذلك قد يعاني المريض كثيرا قبل تشخيصه؛ وذلك بسبب التشخيص الخاطئ للمرض من قبل الأطباء وتناوله للعديد من الأدوية الخاطئة؛ والذي قد يؤثر بالسلب على حالة المريض الصحية والنفسية، وقد تسوء أحواله وتتفاقم؛ إلى أن تصل إلى شلل الأطراف.

في هذا البحث، نقترح طريقة تعتمد على الأنطولوجيا، وتهدف إلى تطوير نظام لديه القدرة على تشخيص مرض "وهن العضلات الوبيل"، واقتراح العلاج المناسب لكل مريض على حدة، وبعض الممارسات التي قد تزيد أو تخفف من حدة المرض. تتكون هذه الطريقة المقترحة من ثلاثة مكونات مترابطة وهي: قاعدة المعرفة (knowledge base)، والمكون الثاني عبارة عن واجهة للتفاعل كوسيط بين واجهة المستخدم والأنطولوجي، والمكون الثالثة هو تطبيق ويب والذي سيعمل كواجهة للنظام. تم إنشاء قاعدة المعرفة باستخدام لغة الأنطولوجيا (OWL) والتي تحتوي على بيانات عدد من المرضى، أما المكون الثاني فيحتوي على عدة وحدات هي: وحدة الاستعلام، وحدة المنطق (reasoning)، وحدة التشخيص، وحدة العلاج المقترح، وسيعمل تطبيق الويب كواجهة للنظام؛ وسيكون دوره الرئيس استقبال مدخلات المستخدم كالأعراض، وإرسالها لواجهة التفاعل، ومن ثم استقبال النتائج وعرضها للمستخدم.

قمنا بتقييم نتائج الطريقة المقترحة من خلال ثلاثة طرق؛ الأولى تقييم دقة التشخيص من خلال تشخيص النظام لعدد من المرضى، والثانية تقييم توصيات العلاج وفقاً لخبير في أمراض المخ والأعصاب والذي قارن نتائج النظام ونتائج الأطباء المعالجين للمرضى، أما الثالثة فتم تقييم سرعة النظام من خلال مقارنته بمدة تأخر تشخيص المرضى.

أظهر النظام المقترح دقة ممتازة في تشخيص المرض بنسبة 86.11%، كما أظهر دقة جيدة في توصية العلاج المناسب بنسبة 72% وتعد هذه النتيجة – وفقاً للخبير – أفضل من الأطباء المعالجين حيث كانت دقتهم 50%، كذلك أظهر النظام سرعة جيدة في كلا العمليتين السابقتين، حيث استغرق معدل 0.17 ثانية في التشخيص، و40 ثانية في توصية العلاج المناسب، وتعد هذه النتيجة أفضل بكثير لو علمنا أن معدل تأخر تشخيص المرضى هو 2.46 سنة.

كلمات مفتاحية: مرض وهن العضلات الوبيل، Myasthenia Gravis، MG، تشخيص، علاج، توصية، الأنطولوجيا ontology، الويب الدلالي.

"Myasthenia Gravis is a thief. It steals your pride, your time, your life, and leave you with little. MG is greedy. It takes what it wants, and leaves behind a shadow of what once was"

MG Patient.

Dedication

To my parents.

The reasons of what I become today.

Thanks for your great support and continuous care.

To my wonderful wife and sons whose unyielding love, support, and encouragement have enriched my soul and inspired me to pursue and complete this thesis.

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I should thank Dr. Iyad Hussein the consultant of Brain and Neurology who evaluated the results of our system despite the shortness of his time.

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List of Abbreviations

CADx	Computer-Aided Diagnosis
CDSS	Clinical Decision Support System
CER	Clinical Evolution Record
CHD	Coronary Heart Disease
CPG	Clinical Practice Guideline
DNA	Deoxyribonucleic Acid
DO	Diseases Ontology
EMRs	Electronic Medical Records
EOMs	Extrinsic Ocular Muscles
EPR	Electronic Patient Record
gMG	Generalized Myasthenia Gravis Disease
IGS	Institute For Genome Sciences
MG	Myasthenia Gravis Disease
NKI	National Knowledge Infrastructure
oMG	Ocular Myasthenia Gravis Disease
SPARQL	SPARQL Protocol And RDF Query Language
SWRL	Semantic Web Rule Language
SYMP	Symptoms Ontology
VnHIES	Vietnamese Health Care Information Extraction System

Chapter 1
Introduction

1.1 Background and Context

The enormous scientific and technological progress – that mankind is living today – keep pace with the emergence of many lethal and deadly diseases, which may be not known by our ancestors, or it has limited deployment.

Every year a new disease appears at an unprecedented rate, due to several reasons of radical changes in the way of people's lives these days, ease of travel and movement between cities and countries, and pollution of the environment in many ways.

The spread of the diseases is accompanied by numerous risks, which negatively affect the correct way to live for human, as well as that of some of these diseases may end patient's life, and with the great diversity of these diseases we certainly different or similar symptoms and diversity of diagnosis and methods of treatment.

That makes doctors face serious difficulties in the diagnosis of some diseases, especially if they are rare and chronic, as well as patients are facing the same difficulties or more and the patients suffer a lot before they are being diagnosed correctly. They can be to diagnosed several times incorrectly, then they are given wrong treatment or several wrong drugs. All of that certainly negatively affect the patient, especially on the patient's psychological status, because the uncontrolled of disease can increase the problem and can reach him to the paralysis or the death, so that one of them delayed diagnose for twelve years of misery.

The mortality because of the non-communicable diseases were responsible for 68% of all deaths globally in 2012, up from 60% in 2000, that mean the patients who have died because of the disease is reached to 38.08 million in 2012 only (World Health Organization, 2014).

One of these diseases which maybe deadly in some cases is the Acquired Myasthenia Gravis disease (MG), its symptoms are caused by a characteristic Muscle weakness when exertion that worsens after use of affected muscles. In about two-thirds of patients, the extrinsic ocular muscles (EOMs) present the initial symptoms. The symptoms usually progress to the other bulbar muscles and limb muscles, resulting in generalized MG (gMG). In about 10% of MG patients, symptoms remain limited to

the EOM, and this condition is termed ocular MG (oMG) (Conti-Fine, Milani, & Kaminski, 2006).

Early, Myasthenia Gravis disease has incidence about 2-4 per million (Schon, Drayson, & Thompson, 1996), but nowadays it is probably more than previously expected. The spreading of the Myasthenia Gravis disease ranges between 0.015-0.04%, this means that the number of Myasthenia Gravis diagnosed people in the world's is 150 patients per million (Conti-Fine et al., 2006; Jayam Trouth, Dabi, Solieman, Kurukumbi, & Kalyanam, 2012).

When we talk about the mortality of Myasthenia Gravis disease, early it has a big rate such as the diagnosis was epidemiologically defined cohort was followed until probably limited to the more severely affected patients 1985. Since these patients were in part survivors of a with mortality rates of 30-40% (Oosterhuis, 1989).

The digital revolution has affected to the human life, which cannot be overlooked, even sometimes difficult to keep up. It has been controlled in the social, economic and cultural life style, also the economic development has become closely associated to the ability of countries to keep pace with this rapid development.

In the addition of this great development, the role of technology in the life began expanding little by little, and no longer the 'technology' word strange to the general public, it has entered into the education, the economy and the industry. Then stepped in multiple areas such as medicine, engineering, earth sciences and space, until it has become an essential part in armament and wars.

From the above, we can realize the value of information technology, and no wonder of that because it was the secret behind the success of countries, and also the development of these technologies has helped in the detection of a lot of facts and opened the human eye on the hidden facts which was absent for years especially in the field of medicine.

The semantic web technologies can be used in medicine field to solve some problems such as representing and taking into account all inputs about one patient to provide the best possible solutions about his disease, especially when these data be

huge such as our case of Myasthenia Gravis disease. Also, the semantic web can contribute of decision making such as diagnosing diseases, unlike traditional technologies such as the Web.

The basic component of the Semantic Web, collections of information called ontologies (Shadbolt, Hall, & Berners-Lee, 2006). An ontology has been defined as a specification of a conceptualization consisting of a collection of concepts, properties and interrelationships between concepts that can exist for an agent or a community of agents. From our point of view an ontology is a set of terms of interest in a particular information domain and the relationships among them. They can characterize knowledge in an application or domain-specific manner (domain ontologies) or in a domain-independent manner (upper ontologies). This set of terms and interrelationships between them can exist and have been represented in a wide variety of information artifacts such as thesauri, database schemas and UML models to name a few (Vipul, Christoph, & Matthew, 2008).

This insight can help to build more powerful and more interoperable information systems in healthcare and support the need of the healthcare process to transmit, reuse and share patient's data. Additionally, the reasoners considered a significant role in the creating knowledge base, it can provide means to deduce new facts from existing facts and axioms. Finally, users need means to pose questions to knowledge bases and retrieve answers to those queries. Ideally, query processing over ontologies take the meaning – as formally specified via logical axioms – into account when deriving answers to a query (Suárez-Figueroa, Gómez-Pérez, Motta, & Gangemi, 2012).

So, the ontologies in medicine field are useful and effective approach of representing enrich medical knowledge base and diagnosis recommendation systems. Ontologies can help in Myasthenia Gravis disease through representing of patient information and find a new relations between this information which can be useful to diagnose the disease, proof a new symptoms and provide recommended treatment.

Most of the related work focused on building some general ontologies for several diseases and not focusing on a specific diseases expect some type of common diseases such as cancer and coronary artery diseases as a general too. There is no one – to our

knowledge – used semantic web to serve a particular disease such as the Myasthenia Gravis.

Patients suffer from a lack of interest from doctors and pharmaceutical companies. Therefore, they suffer a lot before they are diagnosed correctly, that certainly negatively affect to the psychological status of the patients, because the uncontrolled of Myasthenia Gravis disease can increase the problem and can reach the patients to the paralysis or the death.

The purpose of this research is to develop an ontology-based approach would help doctors and patients to diagnose the Myasthenia Gravis disease, in addition to provide a recommended treatments and recommended practices that may increase or decrease the Myasthenia Gravis disease impact.

We firstly, reviewed the current related works that related to our research in the same domain and the same problem, then we collected patient data to use it as individuals in our own ontology of Myasthenia Gravis disease.

Subsequently we developed a prototype of the proposed approach that would consist of several modules such as query module, reasoning module, diagnosing module, and finally recommending treatments module.

These modules are connected and are dependable on the knowledge base (ontology and instances of Myasthenia Gravis patients), the user of the proposed system which is the doctors, can select patient's symptoms or query about the Myasthenia Gravis disease. The system would help these doctors to decide if this patient has a Myasthenia Gravis disease or not, then can provide a recommended treatment for this patient through the enriched knowledge base that consists of the ontology and various instances.

1.2 Statement of the Problem

Myasthenia Gravis patients suffer from the lack of interest from doctors and pharmaceutical companies before they are diagnosed correctly because of the rarity of the disease, where doctors find it very difficult to diagnose this disease because its symptoms intersect and overlap with other diseases.

So, there is a need to build an approach that employs semantic techniques to help doctors to diagnose Myasthenia Gravis disease and to recommend appropriate treatments.

1.3 Objectives

1.3.1 Main Objective

The main objective of this thesis is to develop an ontology-based approach to diagnose the Myasthenia Gravis disease and to provide appropriate treatments that is likely to be accurate, fast, and effective.

1.3.2 Specific Objectives

The specific objectives of the research are:

- To study some of the current disease diagnosing systems and how they work and to determine their suitability as a basis for diagnosing the Myasthenia Gravis disease.
- To collect data about the domain of patients, symptoms and diagnosis of the Myasthenia Gravis disease.
- To build a domain-specific ontology related to diagnosing the Myasthenia Gravis disease enriched with semantic relations between patients, symptoms and treatments.
- To build a rich knowledge base about the Myasthenia Gravis disease and patients based on the ontology.

- To build a prototype of an ontology-based approach that uses the knowledge base to diagnose the Myasthenia Gravis disease and recommend appropriate treatments.

- To evaluate the ontology and the approach for accuracy and speed of diagnosis and the effectiveness of the recommended treatment.

1.4 Research Significance

With the great spread of the known diseases all over the world, and the appearance of a new types of disease every day, all of these diseases differ and vary from each other on types, symptoms, diagnosis, treatment methods and drugs. However, some of these diseases are similar in their symptoms making doctors face a lot of difficulties in the diagnosis of these diseases especially these who are newly practicing the medical profession or these who did not treat many patients infected with the Myasthenia Gravis disease before.

Patients often suffer from illness before they are diagnosed correctly with the Myasthenia Gravis disease, which may sometimes lead to paralysis or death.

Therefore, the importance of this research stand out by contributing to saving patients' lives, and contribute effectively to mitigate and treat them the right treatment at the right time. Also, helping doctors to diagnose these difficult diseases such as the Myasthenia Gravis disease. Additionally, it will reduce the time required to diagnose and the amount of unnecessary laboratory tests and unnecessary drugs needed for treatments.

Furthermore, the cost for using our approach is very low. it only needs Internet connection which is available everywhere now. It is also costless for patients compared with patients frequently going to several doctors and pay for each one of them, let alone the wrong treatment costs and the wrong drugs prescriptions, where the patient has to pay an additional cost to treat himself again from new disease such as stomach diseases, that may be caused by the wrong drugs.

Moreover, the approach is likely to help in discovering an effective treatment methods to the Myasthenia Gravis disease, and ends the suffering of patients of the Myasthenia Gravis disease.

Additionally, ontologies play a critical role in representing knowledge through representing objects and relations between them in a given domain. Therefore, employing ontology in the medical domain is a significant topic. It is considered a very useful and helpful for diagnosis recommendation systems. Ontologies can help in the Myasthenia Gravis disease through representing patient information and finding new relations between this information which can be useful to diagnose the disease and provide recommended treatment.

1.5 Scope and Limitations

This research aims to develop an approach that helps doctors to diagnose only the chronic, rare and neuromuscular disease called Myasthenia Gravis disease by developing an ontology that will be specialized only on the Myasthenia Gravis disease and it will not cover any other diseases.

The proposed ontology consists of symptoms, diagnostic methods, drugs or surgical treatment and finally information about the patient such as geographic area, country, weather, career, eating, mood, disease duration, practice sport and other diseases and medical history of his family. Then we enrich the ontology with several instances through patient information to be collected, leading to creating a knowledge base for diagnosing and treatment recommending of the Myasthenia Gravis disease.

The approach will be realized through a prototype not a full system. The prototype provides a proof of concept for the proposed approach and the expected results based on the ontology are expected to improve the diagnosis and treatment of the Myasthenia Gravis disease but as it is well known that final treatment of the diseases usually need several experiments and time, and the final decision of the recommended treatment will be for doctors only and we are not responsible for any risks to the patient resulting from the use of our approach without consulting the Myasthenia Gravis doctors.

The research also evaluates a preliminary evaluation, firstly, evaluate the accuracy of the diagnostic process of the approach by entering information about a number of persons who are infected with the Myasthenia Gravis disease and evaluate the results. Secondly, we evaluate the accuracy of the recommendation treatments process according to a human expert in Brian and Neurology by comparing his recommended treatments of a Myasthenia Gravis patient case with the recommended treatments of doctor who treated this case, then with the recommendations of the approach which is recommended to treat the same patient case. Finally, we evaluate the efficiency of the approach by comparing the speed of the processes with the average delay in the diagnosis of patients using the conventional way.

1.6 Methodology

In this section, we will talk about the methodology of this research we will use to achieve research goal by followed the next steps:

1.6.1 Literature Review

This step contains a reviewing of current related works that related our research in the same domain and the same problem, especially in the field of human disease diagnosis. Then we will discuss any proposed approach or ontology to indicate the shortcoming in that researches.

1.6.2 Collecting of Information About Patients

We made a questionnaire and distributed it to a lot of local and international Myasthenia Gravis patients, to collect information about patients themselves and disease symptoms, disease diagnose and effective treatment. All of this will enable us to build a rich knowledge base (ontology and instances) that can make us able to rely on in building the proposed approach.

1.6.3 Building the Ontology

Building and developing the proposed ontology with the help of a guide through following the identified steps by Ontology Development A Guide (Noy & McGuinness, 2001) and using the Protégé (Stanford Center for Biomedical Informatics Research (BMIR), 2016) in building the ontology.

1.6.4 Creating Semantic Rules

A set of rules is defined to obtain specific information from the knowledge base (ontology and instances) for diagnosing patients for the Myasthenia Gravis disease, and obtaining recommendations for appropriate treatments.

1.6.5 Reasoning

Applying a reasoner to obtain new relations from existing ones. The reasoner is able to identify the different types of ontological relations such as transitive, symmetric, inverse and functional properties and use them to add new facts. Additionally, applying the predefined rules in the previous step to obtain the desired results, which is diagnosing the Myasthenia Gravis disease and providing an appropriate recommended treatments for patients.

1.6.6 Developing A Prototype of the Proposed Approach

We developed an ontology-base prototype that can diagnosing the Myasthenia Gravis disease and providing a recommended treatments to achieve the goals of this approach.

1.6.7 Evaluating Proposed Approach

We evaluate the implemented prototype of the approach, to evaluate the accuracy of diagnosing and recommending treatments of the of Myasthenia Gravis disease according to a human expert in Brain and Neurology.

1.7 Thesis Organization

The thesis consists of seven chapters: Introduction, Theoretical and Technical Foundation, Literature Review, Myasthenia Gravis Ontology Development, Diagnosing and Recommending Treatment for Myasthenia Gravis Disease, Results and Discussion and finally the Conclusion and Future Work.

- ***Chapter 1 (Introduction):*** introduction to the research area, the Myasthenia Gravis disease, research overview; including the problem, the objectives, the scope and limitation of the research.

- ***Chapter 2 (Theoretical and Technical Foundation):*** describes the theoretical and technical foundation underlying the research including the Myasthenia Gravis disease, disease pathophysiology, signs and symptoms, diagnostic methods, semantic web, ontology concepts, ontology development and ontology tools.

- ***Chapter 3 (Literature Review):*** reviews several approaches and related works that deal with diseases such as diagnosis, patient-records, meaningful search, clinical decision support systems and healthcare systems.

- ***Chapter 4 (Myasthenia Gravis Ontology Development):*** presents the steps to develop the Myasthenia Gravis disease domain ontology, then it presents the evaluation of the Myasthenia Gravis ontology.

- ***Chapter 5 (Diagnosing and Recommending Treatment for Myasthenia Gravis Disease):*** presents and describes of the steps of analysing, designing and developing the prototype of the approach. It presents the structure of the proposed approach, collecting patients' data, creating semantic rules, developing the parts of the prototype and finally system functions.

- ***Chapter 6 (Results and Discussion):*** presents the experiments performed, the results, the evaluation and discussion of the proposed ontology and the results.

- ***Chapter 7 (Conclusion and Future Work):*** presents the conclusions and the possible future works.

Chapter 2

Theoretical and Technical Foundation

In this chapter, we present the theoretical as well as the technical foundation of the proposed approach, we talk firstly about the Myasthenia Gravis disease, then we define the Semantic Web, including ontology and finally we enumerate the tools that we used to develop the proposed approach.

2.1 The Myasthenia Gravis Disease

Myasthenia Gravis (pronounced /maɪ.əsˌθiː.ni.ə ˈgrɑː.vɪs/ (Walter, 2008)) is a chronic autoimmune neuromuscular disease characterized by varying fluctuations of weakness of the skeletal (voluntary) muscle groups of the body (National Institute of Neurological Disorders and Stroke (NINDS), 2016).

The name of the disease comes from the Greek and Latin words meaning "grave muscular weakness" (Myasthenia Gravis Foundation of America, 2016) and the first time it is called with this name was by Thomas Willis in 1672 (Drachman, 1981).

The hallmark of the Myasthenia Gravis is weakness of the muscles that increases during periods of activity and improves after periods of rest. The most muscles vulnerable to this disease are the muscles that control eye and eyelid movements, facial expression, chewing, talking, and swallowing are often (National Institute of Neurological Disorders and Stroke (NINDS), 2016), but is not a condition all of these symptoms to suffer from one patient.

Figure (2.1): Myasthenia Gravis disease affects the eyelid muscles (Puklin, Sacks, & Boshes, 1976).

In about two-thirds of patients, the extrinsic ocular muscles (EOMs) present the initial symptoms as shown in Figure (2.1). The symptoms usually progress to the other bulbar muscles and limb muscles, resulting in generalized MG (gMG). In about 10% of MG patients, symptoms remain limited to the EOM, and this condition is termed ocular MG (oMG) (Conti-Fine et al., 2006) as shown in Figure (2.1).

Early, Myasthenia Gravis disease has incidence about 2-4 per million (Schon et al., 1996), but nowadays it is probably more than previously expected. The spreading of the Myasthenia Gravis disease ranges between 0.015-0.04%, this means that the number of Myasthenia Gravis diagnosed people in the United States of America is 100 per million (Myasthenia Gravis Foundation of America, 2016), and in the world is about 150 patients per million (Conti-Fine et al., 2006; Jayam Trouth et al., 2012).

2.2 Disease Pathophysiology

Myasthenia Gravis disease affects humans in case of a disorder that causes weakness of the skeletal muscles and occurs in the immune system. The disorder of the immune system generates antibodies that attack, by mistake, the body's tissues. Those antibodies in the Myasthenia Gravis disease attack a normal human protein, targeting a protein called acetylcholine receptor or a related protein called muscle-specific kinase (National Institutes of Health, 2015) as shown in Figure (2.2).

One of the components of the body's immune system is the Thymus gland cells as shown in Figure (2.3). This Thymus gland in the Myasthenia Gravis disease has large size and abnormal behaviour. It is thought that the Thymus gland is responsible for the disorder of the immune system and may give wrong instructions to immune cells which cause muscles weakness (National Institute of Neurological Disorders and Stroke (NINDS), 2016; National Institutes of Health, 2015; Sathasivam, 2014).

2.3 Signs and Symptoms of the Myasthenia Gravis Disease

The symptoms that commonly appear on Myasthenia Gravis patients are commonly intermittent and fluctuating in their impact. They may appear singularly or two or more combined together in a fast sequence (Herrmann Jr, 1970).

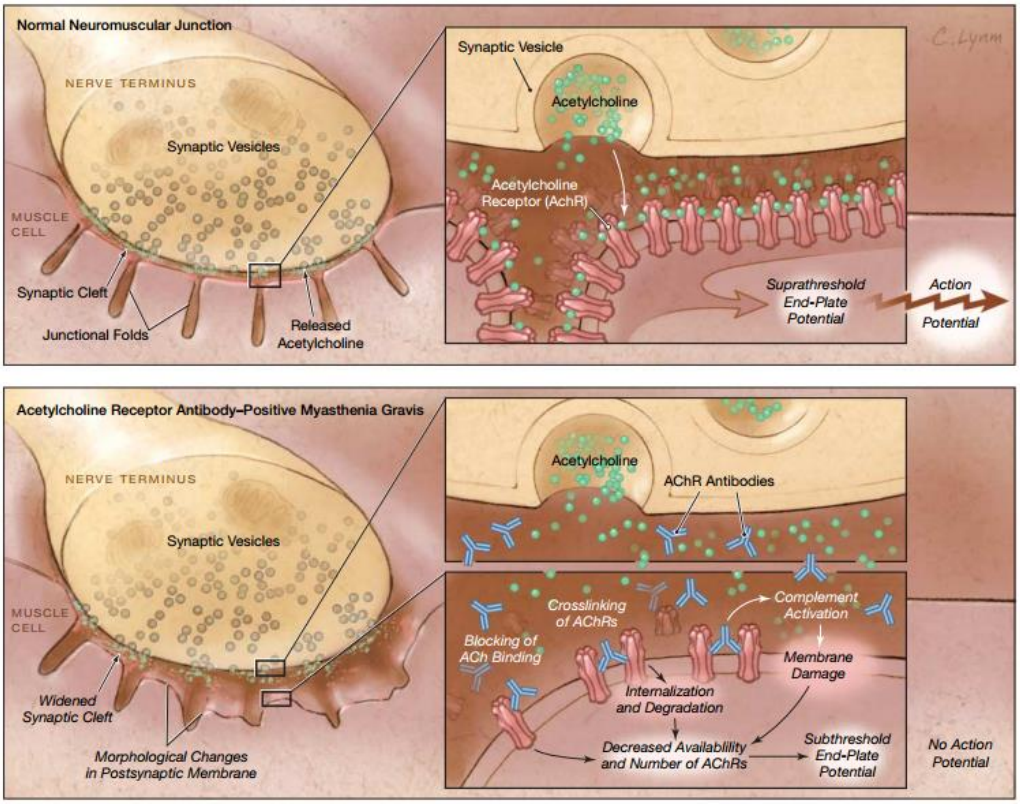

Figure (2.2): How the Myasthenia Gravis disease affects the muscles (Scherer, Bedlack, & Simel, 2005).

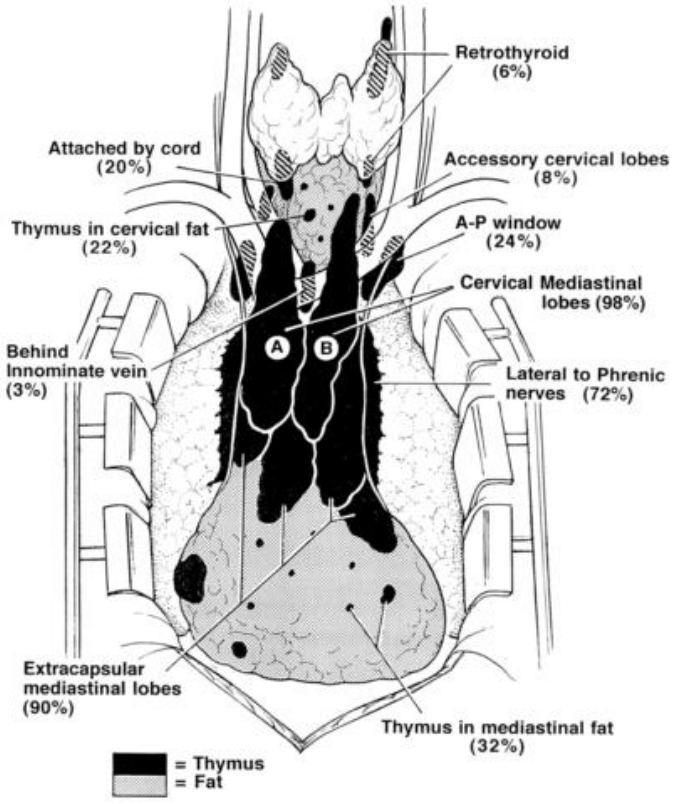

Figure (2.3): The anatomy of the Thymus (Jaretzki et al., 2000).

The general symptom of the Myasthenia Gravis disease is weakness of the muscles that increases during periods of activity and improves after periods of rest.

The most common symptom affect the muscles around the eye that may lead droop the eyelid which is called ptosis (Herrmann Jr, 1970; Jayam Trouth et al., 2012; Puklin et al., 1976) as shown in Figure (2.4). This symptom may make the patient to appear sleepy.

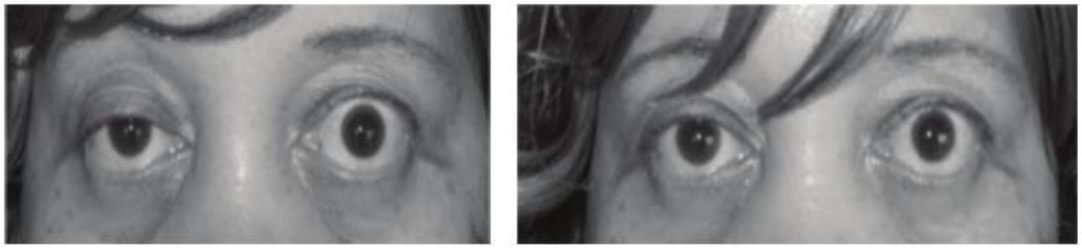

Figure (2.4): The effect of the Myasthenia Gravis disease on the eyelid before and after treatment (Jayam Trouth et al., 2012).

Also the patient suffers from double vision (Danchaivijitr & Kennard, 2004; Herrmann Jr, 1970; Khreisat, 2011), this symptom leads to get worse when watching television, reading or driving, particularly in bright conditions as shown in Figure (2.5).

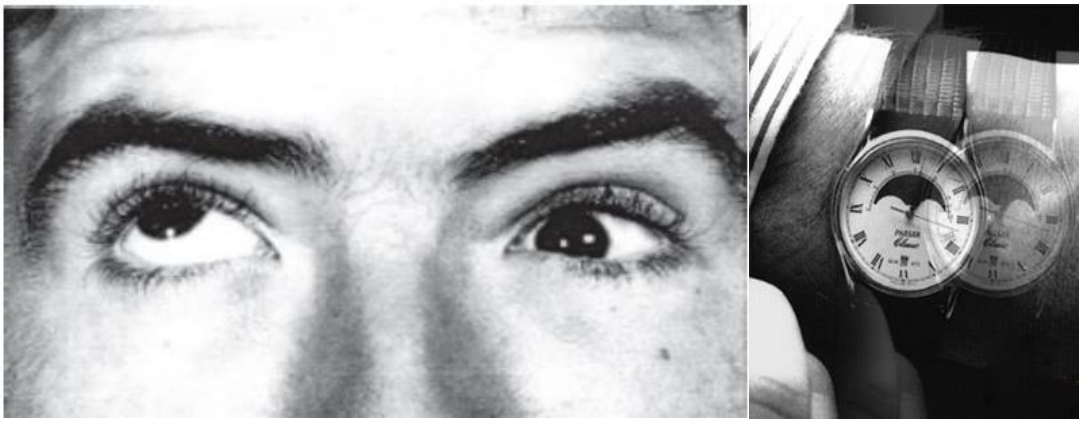

Figure (2.5): Vertical diplopia on the left eye cause double vision (Khreisat, 2011).

The Myasthenia Gravis disease may cause weakness of the muscles involved in swallowing leading to swallowing difficulty (dysphagia). Typically, this means that some foods and liquids may be left in the mouth after the swallowing process,

additionally those foods and liquids may regurgitate from the patient nose (velopharyngeal insufficiency) (Danchaivijitr & Kennard, 2004; Herrmann Jr, 1970).

Furthermore, the Myasthenia Gravis disease may cause weakness to the muscles that move the jaw which cause difficulty chewing and speaking, in this case speech may be slow and slurred, or have a nasal quality (Herrmann Jr, 1970; Nair, Patil-Chhablani, Venkatramani, & Gandhi, 2014).

Also, the weakness of the muscles can reach the facial expression, that may be affect the ability to close the mouth and causes snarling appearance when attempting to smile. This symptom may make the patient appear sad (Herrmann Jr, 1970).

There are a lot of symptoms of the Myasthenia Gravis disease such as Paralysis, but we preferred to enumerate the most common symptoms.

2.4 Diagnostic Methods of the Myasthenia Gravis Disease

The first diagnostic method is physical examination; a doctor may ask the potentially affected patient to look at a fixed point for 30 seconds and to relax the muscles of his forehead. This test makes the patient involuntarily use his muscles of forehead and instead of focusing on the muscles of his eyelids. The doctor may ask the patient to do some quick and hard movements with his hand, leg or all body to check the stand of the muscles (Sathasivam, 2014).

The second diagnostic method is the Antibody testing (Anti-MuSK) which is a test of the patient blood, but about 15% of the Myasthenia Gravis patients have tested negative for the acetylcholine antibody.

The next method is office tests which is lying the patient and making a test with an ice pack and Edrophonium tests, these tests lead to an improvement in strength for the muscles.

The last one is Electromyography (EMG) which make a repetitive simulation for the nerves and muscles to study the patterns of their response and behaviour (Herrmann Jr, 1970; Myasthenia Gravis Foundation of America, 2016).

Occasionally, all of these previous tests maybe negative or doubtful in someone whose medical tests still seem to point to a diagnosis of the Myasthenia Gravis. So, the diagnosing process needs a clinician who skilled enough to recognize the Myasthenia Gravis disease and distinguish it from other diseases.

2.5 Semantic Web

One of the modern information technology techniques is known as “Semantic Web”. The term was coined by Tim Berners-Lee for a web of data that can be processed by machines (Shadbolt et al., 2006).

The first part of Berners-Lee vision for the Semantic Web was the turn the Web into a truly collaborative medium, to help people share information and services and make it easier to aggregate data from different sources and different formats.

The second part of his vision was to create a Web that would be understandable and processable by machines. While humans can read and comprehend current Web pages, Berners-Lee envisioned new forms of Web pages that could be understood, combined, and analyzed by computers, with the ultimate goal of enabling humans and computer to cooperate in the same manner as humans do among each other (Sugumaran & Gulla, 2011).

The current web is a web of text and pictures. Such media are very useful for people, but computers play a very limited role on the current web: they index keywords, and they ship information from servers to clients. All the intelligent work (selecting, combining, aggregating, etc.) has to be done by the human reader (Antoniou & Van Harmelen, 2008).

Berners-Lee did not think of the Semantic Web as a replacement of the current Web. It was intended as an extension for adding semantic descriptions of information and services. Central to the Semantic Web vision is the shift from applications to data. The key to machine procceable data is to make the data smarter (Sugumaran & Gulla, 2011).

The Semantic Web would facilitate many things that are impossible on the current web: Search would be no longer limited to simply looking for keywords, but could become more semantic, which would include looking for synonyms, being aware of homonyms, and taking into account context and purpose of the search query (Antoniou & Van Harmelen, 2008).

The development of the Semantic Web proceeds in steps, each step building a layer on top of another as shown in Figure (2.6). In building one layer of the Semantic Web on top of another, two principles should be followed downward compatibility or upward partial understanding (Antoniou & Van Harmelen, 2008).

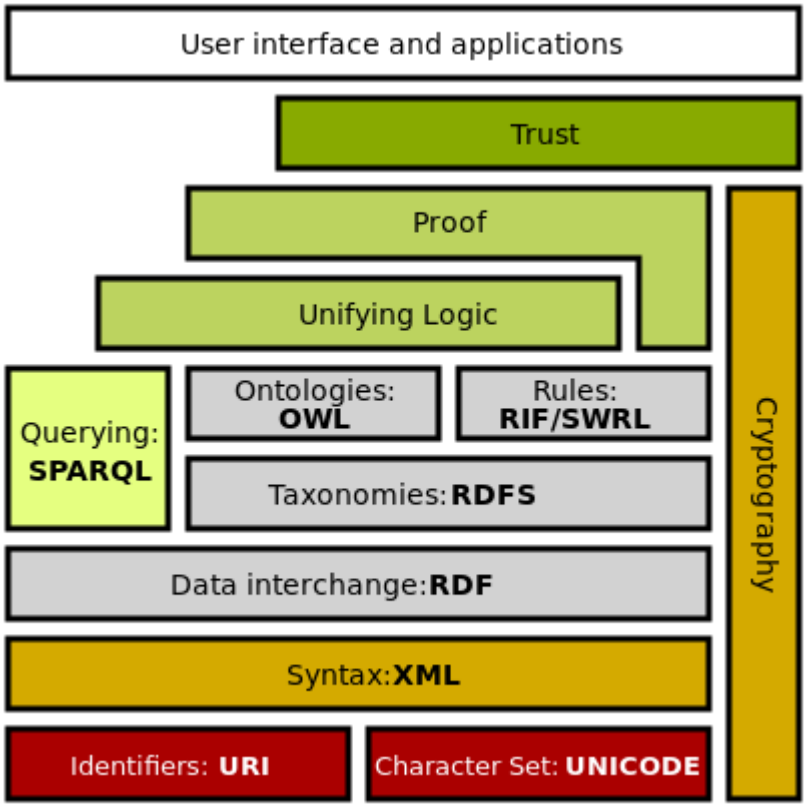

Figure (2.6): The semantic web layer (Antoniou & Van Harmelen, 2008; World Wide Web Consortium (W3C), 2016).

The semantic web technologies can be used in medicine field to solve some problems such as representing and taking into account all inputs about one patient to provide the best possible solutions about his disease, especially when these data are huge such as our case of the Myasthenia Gravis disease. Also, the semantic web can contribute to decision making such as diagnosing diseases.

2.6 Ontology

The basic component of the Semantic Web are collections of information called ontologies (Shadbolt et al., 2006) that play a prime role in the process of information exchange in various areas (Fensel, 2001a). Ontologies are developed in Artificial Intelligence to facilitate knowledge sharing and reuse. More recently, the ontology became widespread in several fields such as intelligent information integration, cooperative information systems, information retrieval, electronic commerce, and knowledge management (Fensel, Horrocks, Van Harmelen, McGuinness, & Patel-Schneider, 2001). The main reason that make ontologies popular is being a shared understanding of a domain that can be communicated between application systems and humans (Fensel, 2001b).

So, ontologies in medicine are useful and effective approach for representing enrich medical knowledge base and for diagnosis and recommendation systems. Ontologies can help in the Myasthenia Gravis disease through representing patient information and find new relations between this information which can be useful to diagnose the disease and to provide recommended treatment and recommended habits and practices that may increase or decrease the impact of the Myasthenia Gravis disease.

2.7 Ontology Development

In this section, we present the methodology to be followed in building and developing our proposed ontology. There exist various methodologies to guide the development process such as the United Process for ONtologies (UPON) (De Nicola, Missikoff, & Navigli, 2009), On-To-Knowledge (OTK) (Sure, Tempich, & Vrandecic, 2006), METHONTOLOGY (Fernández-López, Gómez-Pérez, & Juristo, 1997) and much more.

There is no one “correct” methodology for developing ontologies, we chose the Ontology Development 101: A Guide to Creating Your First Ontology (Noy & McGuinness, 2001) as a methodology to build our proposed ontology because it

describes an iterative approach to ontology development, starts with a rough first pass at the ontology, then it revises and refines the evolving ontology and fill in the details.

The Ontology Development 101consists of the following steps:

1. Determine the domain and scope of the ontology.
2. Consider reusing existing ontologies.
3. Enumerate the important terms in the ontology.
4. Define the classes and the class hierarchy.
5. Define the properties of classes - slots.
6. Define the facets of the slots.
7. Create instances.
8. Ontology evaluation.

2.7.1 Determine the Domain and Scope of The Ontology:

In this step, we starting the development of our proposed ontology by defining our domain and scope. That is, answer a lot of basic questions such as what is the domain that the ontology will cover? For what we are going to use the ontology? For what types of questions, the information in the ontology should provide answers? will use and maintain the ontology? (Musen, 1998).

2.7.2 Consider Reusing Existing Ontologies:

A lot of ontologies are already available in electronic form and can be imported into an ontology-development environment that you are using form a several libraries of reusable ontologies on the Web and in the literature, such as the Ontolingua ontology library and the DAML ontology library. So in this step we will decide if we can reuse an existing ontology to interact with in our proposed approach or not (Simperl, 2009).

2.7.3 Enumerate the Important Terms in the Ontology:

In this step, we will write a list of all terms we would talk about in the proposed ontology, list of all properties of those terms without worrying about overlap between properties among the terms.

2.7.4 Define the Classes and the Class Hierarchy:

This step and the next one is the most important steps in the ontology design process, where we will develop the hierarchy of the class and defining to be ready to define the properties in the next step.

There are a three ways to design the class hierarchy, the top-down development process which starts with the definition of the most general concepts in the domain and subsequent specialization of the concepts. The second way is the bottom-up development process which starts with the definition of the most specific classes, with subsequent grouping of these classes into more general concepts. The last one is combination development process which is a combination of the previous two approaches, top-down and bottom-up (Baraka & Dalloul, 2014; Roussey, Pinet, Kang, & Corcho, 2011).

2.7.5 Define the Properties of Classes - Slots:

The classes alone will not provide enough information to answer the questions we defined in Section 2.7.1. So, we have to define a list of the properties of these classes. Additionally, we must determine the domain and the range of each property in that list.

2.7.6 Define the Facets of the Slots:

The slots that we defined in the previous step can have different facets to describe its value type, allowed values, the number of the values, and other features of the values that slot can take.

2.7.7 Create Instances:

The last step in developing the ontology is creating individual instances of all classes in the hierarchy. This step could be applied by choosing a class, creating an individual instance of that class, and finally filling in the slot values.

2.7.8 Ontology Evaluation:

There are a several approaches to the evaluation of the ontologies which depending on what kind of ontologies are being evaluated and for what purpose. The most approaches for evaluating the ontologies are categorized by the following categories:

- Comparing the ontology to a "golden standard" which may itself be an ontology.
- Using the ontology in an application and evaluating the results.
- Comparing the ontology with a source of data about the domain such as a collection of documents to be covered by the ontology.
- Evaluating by a human who try to evaluate how well the ontology meets a set of predefined criteria, standards, requirements, etc. (Brank, Grobelnik, & Mladenic, 2005).

An overview of approaches to ontology evaluation are shown in Table (2.1).

Table (2.1): An overview of approaches to ontology evaluation (Brank et al., 2005).

	Approach to evaluation			
Level	Golden Standard	Application -based	Data-driven	Assessment by humans
Lexical, vocabulary, concepts, data	X	X	X	X
Hierarchy, taxonomy	X	X	X	X
Other semantic relation	X	X	X	X
Context, application		X		X
Syntactic	X			X
Structure, architecture, design				X

The Golden standard evaluation could be in fact another ontology, or it could be taken statistically from a corpus of documents or prepared by domain experts. The lexical content of an ontology can also be evaluated using the concepts of precision and recall which the precision is the percentage of the ontology lexical entries that also appear in the golden standard, relative to the total number of ontology words. Recall is the percentage of the golden standard lexical entries that also appear as concept identifiers in the ontology, relative to the total number of golden standard lexical entries (Brank et al., 2005; Kao & Poteet, 2007).

The evaluation by an application which using the ontology in an application or a task. The outputs of the application, or its performance on the given task, might be better or worse depending on the ontology used in it. We can apply this evaluating method may applied simply by plugging them into an application and evaluating the results of the application (Brank et al., 2005).

The Data-driven evaluation where evaluating the ontology by comparing it to existing data such as a collection of textual documents about the problem domain to which the ontology refers (Brank et al., 2005).

The Assessment by human's evaluation can done by humans who try to assess how well the ontology meets a set of predefined criteria, standards، requirements (Poli, Healy, & Kameas, 2010).

2.8 Ontology Tools

2.8.1 Web Ontology Language

The Web Ontology Language OWL is a language for defining and instantiating ontologies on the Web. An OWL Ontology describes a domain in terms of classes, properties and individuals and may include rich descriptions of the characteristics of those objects. OWL ontologies can be used to describe the properties of Web resources (Bechhofer, 2009).

Web ontologies that designed for use by applications that need to process the content of information instead of just presenting information to humans. OWL

facilitates greater machine interpretability of Web content than that supported by XML, RDF, and RDF Schema (RDF-S) by providing additional vocabulary along with a formal semantics (McGuinness & Van Harmelen, 2004).

2.8.2 Protégé Tool (version 5.0.0)

An open-source and free editor for ontologies documents and framework for building intelligent systems. It is supported by a strong community of academic "Stanford University" (Stanford Center for Biomedical Informatics Research (BMIR), 2016). We decided to use Protégé to build our knowledge based for the Myasthenia Gravis disease.

We chose the Protégé tool among the various tools available for developing ontologies to design and build the previous proposed ontology, then we run a reasoner to obtain a new knowledge such as new symptoms or effective treatment, and finally must use an ontology query language such as SPARQL.

2.8.3 SPARQL Query Language

The SPARQL Protocol and RDF Query Language (SPARQL) is a query language and protocol for RDF that convey SPARQL queries from query clients to query processors and returning the query results to the entity that requested them (Prud'Hommeaux & Seaborne, 2008).

We used the SPARQL to returning the results of a queries and show it to the end user.

2.8.4 Apache JENA Semantic Framework

An open source Semantic Web framework for Java programming language, used for building an application of Semantic Web additionally it provides an API to extract and write data from and to OWL files. The OWL files are represented as an abstract "model". A model can be sourced with data from files, databases, URLs or a combination of these. A model can also be queried through (Apache JENA, 2015).

We used JENA framework (Apache JENA, 2015) as inference engine that interact with the proposed ontology by running a lot of queries and rules, then getting various results to answer users' inquiries that come from the web page (JSP).

2.8.5 JENA Reasoner

The reasoner is a part of software can infer logical consequences from a set of assured facts or axioms. The concept of a semantic reasoner generalizes that of an inference engine, by providing a richer set of mechanisms to work with. The first-order predicate logic used by a lot of reasoners to carry out reasoning (Apache JENA, 2016).

We used the JENA reasoner (Apache JENA, 2016) to applying a lot of web semantic rules and obtain a new facts that will help to achieve the goals of our research which is diagnosing the Myasthenia Gravis disease and providing a recommended treatments, recommended habits and practices that help to improve the Myasthenia Gravis disease and finally recommended habits and practices that may increase the impact of the Myasthenia Gravis disease to avoid it by the patients.

2.8.6 Java Server Pages

Java Server Pages is a technology that helps software developers to create dynamically generated web pages, or other document types. Released in 1999 by Sun Microsystems, JSP is similar to PHP and ASP, but it uses the Java programming language (Oracle, 2015) to write the code of the web pages.

JSP technology enables us to mix regular, static HTML with dynamically generated content from servlets (Hall, 2001). To deploy and run Java Server Pages, a compatible web server with a servlet container, such as Apache Tomcat or Jetty, is required.

We used JSP to design a web pages that interact with the JENA interface (Apache JENA, 2015) which in turn interact with the proposed ontology.

Chapter 3

Literature Review

In this chapter, we review several approaches that deal with diseases such as diagnoses, patient-records, meaningful search, clinical decision support systems and healthcare systems. We classify related works into several sections according to the above topics. After the presentation of every research we write a discussion about it to show its relation to our research.

3.1 Ontologies Developed for Managing Patient Information

We know that this section is not on the care of the domain of our research, but we include it to learn about representing patient information in the ontology.

Bayegan, Nytrø and Grimsmo (2002) presents a practical approach for improving an existing patient-record architecture. They extend an existing patient-record data model with a level of knowledge; knowledge that enables the patient-record system to explain cases in the care process and provide appropriate means for ranking information according to its relevance in these care cases.

They extend the current data model with means to explain cases, knowledge about clinicians work and needed information, and the means to rank information according to its relevance in these care cases.

They define fundamental concepts, properties, and interrelationships by using the ontologies in a specific domain. They present an ontology that provide a three necessary features for a future helpful patient-record system: a family-care workflow process, a problem-oriented patient record, and identify related information to the care process and medical problems.

They propose knowledge level through a two-layer framework for a problem-oriented patient record, a fact layer and a knowledge layer as shown in Figure (3.1).

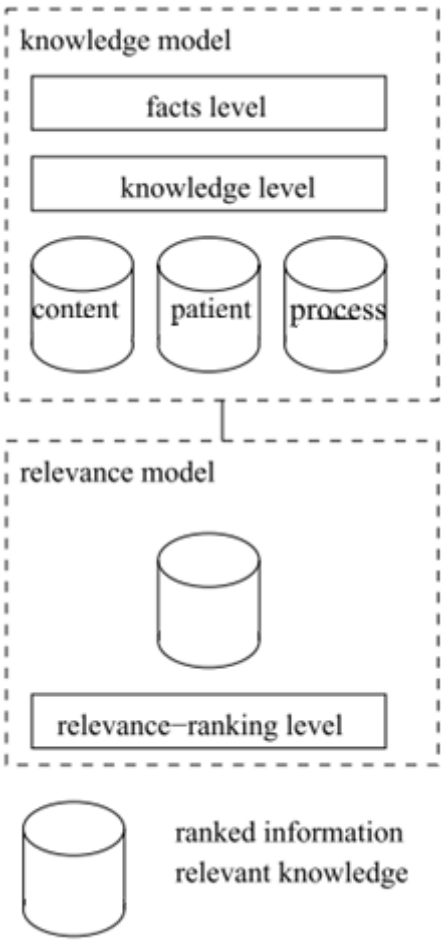

Figure (3.1): Relationship between the knowledge model and the relevance model (Bayegan et al., 2002).

They develop three independent ontologies: *Process Ontology*, *Content Ontology* and *Information Ontology* or *Patient Record Ontology*. The first one defines the family-care workflow process, activities, and any interaction with the patient-record system. The second one is a bridge between the *Process Ontology* and the *Information Ontology* which joins concepts in the *Process Ontology* with concepts in the *Patient Record Ontology* through its set of care act types. The last one defines the underlying information model of the patient-record system. It represents patient data and supports a problem-oriented view of it.

These proposed ontologies deal with various diseases not a specific one such as the Myasthenia Gravis disease, which means it takes a general trend not a specific one.

Dung and Kameyama (2007) presents an ontology-based health care information extraction system called *VnHIES* (implemented in Vietnamese language). They develop two algorithms; *semantic elements extracting algorithm* and *new semantic elements learning algorithm* for extracting semantic words. The first algorithm extracts concepts, descriptions of concepts, pairs of concepts and description and names of diseases in health care information domain from Web pages. Those extracted semantic elements are used by the second algorithm to provide suggestions which might contain new semantic elements to use it later by domain users to enrich the ontology.

After the extraction process for semantic elements, they apply a *document weighting algorithm* to get document summary information according to all extracted semantic words. Then store this information in a knowledge base which contains ontology and database in order to be used later in other applications. VnHIES can be uses in many health care information management systems such as medical document classification, health care information retrieval system.

This research attempts to extract a lot of information from the web pages and adds it to the ontology to enrich it and to use it when needed. It has nothing to do with diagnosing the diseases.

Miyoshi, Ferreira and Felipe (2009) develops of an Electronic Patient Record (EPR) with is a computerized repository of all patient health care information by designing and implementing an ontology. It uses the UMLS Semantic Network as an upper-level ontology based on a clinical data structure.

The EPR contain a section that stores the whole history of the patient's clinical conditions, that section is called Clinical Evolution Record (CER). This research focuses on some problems about the complexity and the heterogeneous of information stored in CER, and in most health institutions it is written by hand and stored in paper format.

They propose a structure of CER to organize the information and reduce its complexity by identifying filling patterns through the analysis of medical records and

interviews with physicians, but this reduction of complexity is not enough to achieve semantic interoperability. Because of that they propose an ontology to make that information machine interpretable and then use it as a semantic connection and exchanging information between two different health systems.

Also, this research does not focus on a specific disease and all its focus on semantic communication between systems, and does not come out with results related to medicine or beneficial to diagnosing diseases, but it facilitates the task of doctors and managers to manage medical centres.

Iqbal, Shepherd and Abidi (2011) develops an ontology to represent knowledge for Electronic Medical Records (EMRs) and achieve semantic interoperability between systems of healthcare information and to make decision support systems better.

They propose an ontology-based EMR for Chronic Disease Management by customizing the W3C Computer-based Patient Record ontology (Ogbuji, 2011) with concepts and attributes from Western Health Info structure Canada chronic disease management model (Western Health Information Collaborative (WHIC), 2005). They find that ontology is able to represent knowledge about chronic diseases.

This research is customized an existing ontology based on the standards of Canada. We try to use their ontology with the Myasthenia Gravis disease but it does not fit because the Myasthenia Gravis disease has unknown causes, the treatment varies from patient to patient, and symptoms vary from one patient to another.

3.2 Ontologies Developed for Various Diseases

Hadzic, Chang, Wongthongtham and Meersman (2004) describes an enhancement for searching meaningfully and quick information sharing by implementing Disease Ontology based on Grid Middleware which works as an intelligent *search engine* through receiving customers' requests and finding services or service providers for them. They propose exchanging information by Grid Middleware to get accessible information beyond web content, then giving users the correct information. They obtain knowledge from ontologies of medical issues, health matters,

disease factors, DNA, etc. Additionally, they record who is doing research on the medical field, work done and up-to-dated research, needed web database and its content, distinguishing what is the valuable and invaluable content and how it fits into specific disease knowledge and how it can be accessed and finding relation between works.

Grid Middleware is used to enhance searching processes. They obtain information about diseases from various ontologies then let the users search on that information and extract the desired information for a specific disease, but it does not support diagnosis of diseases.

Schriml et al. (2012) proposes Disease Ontology (DO) database which later become the well-known ontology for diseases available at (http://disease-ontology.org). It is considered a universal knowledge base of 8043 inherited, developmental and acquired human diseases. DO is based on a graph database. It allows users to query using full-text contextual search for name, synonym, definition, etc.

The system has a rich knowledge for with considerable number of diseases, it purposes provides a lot of information for diseases but does not diagnose them.

Mendonça, Rosa, Oliveira and Teixeira (2012) develops an ontology as a workflow to enhance search and advanced queries, because the health related information is distributed across different locations, that makes gathering, structuring and managing information very difficult.

The developed ontology makes information available through search by the health professionals, students and researchers.

It allows to gather annotations during the document processing, after that it stores its semantic index using the published information on the Web. That means it has to use a Web crawler to retrieve and create a list of selected documents that will be used to build semantic collection.

They develop a platform for the searching process that is able to present most relevant documents as a result for advanced user's queries as shown in Figure (3.2). Then they take the neurologic diseases as a case study.

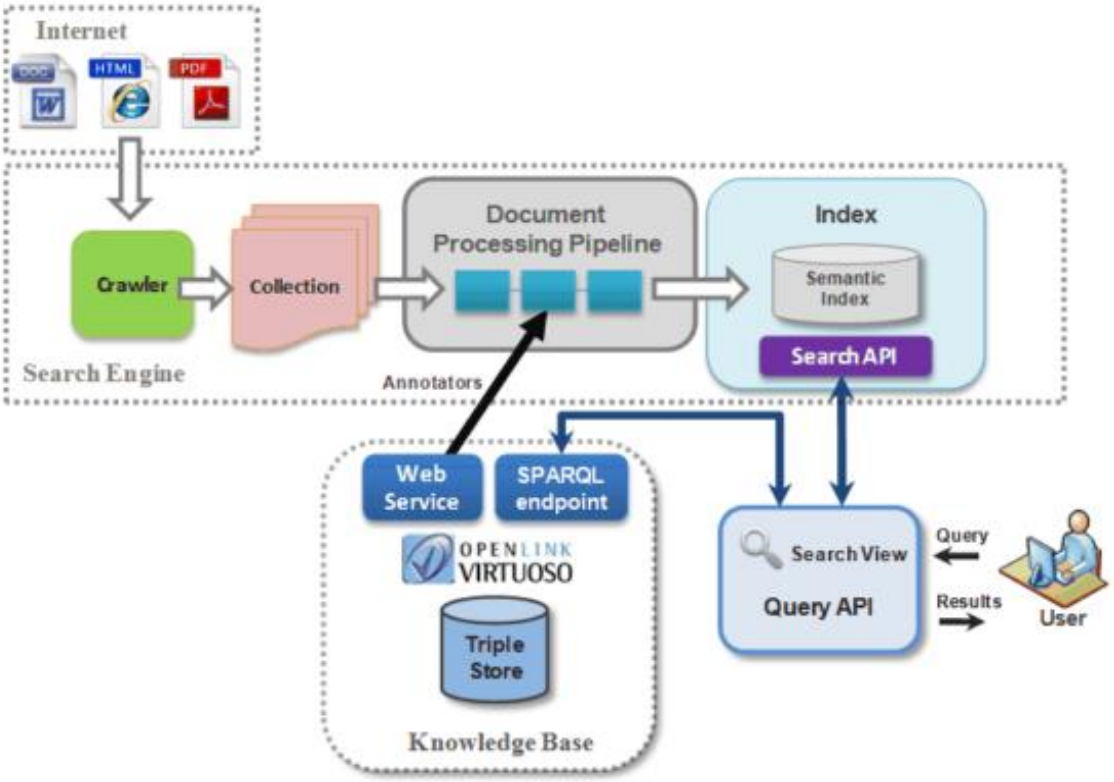

Figure (3.2): Search platform architecture (Mendonça et al., 2012).

They use the ontologies to facilitate the semantic search and query processes. It extracts data, but does not come out with results for a new specific diseases. It facilitates the task of doctors when they need information about any disease.

3.3 Diagnosis Systems Without Using Ontologies

We have selected a one system as a sample of systems that are represented the patient's information and diagnosed diseases without using ontologies to highlight the benefits from using ontologies in the medical field.

Luculescu and Lache (2008) presents a new diagnoses system concerning the diagnosis of visual diseases. The system combines aspects from Biosystems (human

visual system), image acquisition and processing (medical imaging), artificial intelligence techniques (neural networks) and information management (databases).

Their system is called Computer-Aided Diagnosis (CADx) system, which identifies eyes macular diseases accurately. They use databases to store the images with patient personal information, treatments and diagnosis information. The software includes image processing modules, databases and artificial neural networks for recognizing images of new diseases.

Computer-Aided Diagnosis reduces the doubt level of the doctor in some diseases, improves the accuracy of initial diagnosis of diseases, allows monitoring the health status of the patient during new treatment methods, and finally diagnoses database store digital images to be used later in research, medical practice and specialized teaching.

The system does not use ontology but instead uses artificial neural networks. Ontologies in medicine are useful and effective for representing rich medical knowledge base and diagnosis recommendation systems. Ontologies can help in the Myasthenia Gravis disease through representing patient information and find a new relations between these information.

3.4 Ontologies Developed in Medicine for Specific Diseases

Binfeng, Xiaogang, Chenglin and Qian (2007) proposes an ontology that provides a primary framework of semantic web and artificial intelligence. Their approach presents a method for medical knowledge base.

Their approach proposes an ontological structures including ontology of Chinese traditional medical and ontology of Western medicine. They combine the current medical knowledge by applying National Knowledge Infrastructure (NKI) frame language to the proposed system, and build the category of Coronary Heart Disease (CHD) and other relevant categories.

The system improves the feasibility, expansibility and reusability by combining several ontologies to enhance the medical services. But it does not deal with a specific disease.

Alfonse, Aref and Salem (2014) discusses the technical parts of some of ontology-based medical systems for cancer diseases. Additionally, they develop an ontology-based system for cancer diseases knowledge management. Patients, students and doctors can use the proposed system to know about the type of the cancer, the stage of the cancer and the treatment. They claim that the accuracy of the proposed system with cancer diseases classification is 92%.

The proposed ontology-based system deals with several types of cancer diseases but it is only a cancer diseases classification system not a diagnoses system. In our case, we propose an ontology-based approach to help doctors to diagnose the Myasthenia Gravis disease and provide a recommended treatment for each patient.

Abidi (2007) develops a semantic web clinical decision support system (CDSS) to support family doctors to provide follow-up care for the breast cancer disease. The approach includes a breast cancer follow-up Clinical Practice Guideline (CPG) which is disease-specific recommendations to help doctors to make a decision in accordance with symptoms. The clinical practice guideline lead to creating a breast cancer ontology. Which models the knowledge inherent within the breast cancer follow-up clinical practice guideline. This ontology is considered as the knowledge source to determine specific recommendations of patient.

Since this approach deals with the breast cancer disease with different objectives than ours. But it can help doctors in making a decision for each patient individually, their ontology is considered as a knowledge source to determine patient-specific recommendations. But in our case, we propose an ontology-based approach to help doctors for diagnosing the Myasthenia Gravis disease and recommending treatments for the patients.

3.5 Ontologies Developed for Diagnosing Diseases

Mohammed, Benlamri and Fong (2012) suggests that medical ontologies are valuable and effective methods of representing medical knowledge and much stronger than biomedical vocabularies. Every disease has a lot of symptoms, but there are no ontologies that combine diseases and symptoms except for some simple proposed

models. However, well establish ontologies for diseases and for symptoms were already developed independently.

They propose an alignment algorithm to combine the diseases ontology (DOID) with the symptoms ontology (SYMP) to create a diseases symptoms ontology that can be suitable to any number of diseases and symptoms. The DOID ontology started in 2003 as part of the NUgene project (http://disease-ontology.org/). It is currently a standard ontology for categorizing disease only. The SYMP ontology developed in 2005 by the Institute for Genome Sciences (IGS) at (https://bioportal.bioontology.org/ontologies/SYMP/). It includes more than 900 symptoms.

The previous two ontologies are empty and can be used as a container of any disease, that means it can help people who are not doctors, and yet dealing with the disease, to help them in the classification of disease and symptom.

The proposed ontology is very huge, and cannot be use in one specific disease such as the Myasthenia Gravis disease.

Rawte and Roy (2015) develops an ontology based expert system to diagnose thyroid diseases. This ontology make it easy to perform knowledge representation by any domain experts and non-experts. They develop an ontology for thyroid diseases, symptoms and diagnosis using expert system.

The study is beneficed for us, but it talks about a different disease. We try to use their ontology with the Myasthenia Gravis disease but it does not fit because the Myasthenia Gravis disease has unknown causes, the treatment varies from patient to patient, and symptoms vary from one patient to another.

Hadzic and Chang (2005) discusses an ontology-based system and approach that provides interoperability support for research in and diagnosis of human disease. The proposed approach combine a prototype for a Generic Human Disease Ontology including common general information for human diseases. This proposed approach represents the information in four ‘dimensions’: disease types, symptoms, disease causes and finally providing the treatments for the disease.

The goal of the proposed ontology is studying complex disorders caused by many different factors at the same time. They explain how this generic human disease ontology helps to produce specific human disease ontologies to help doctors and medical researchers.

This research is similar to our research, but according to their claim, it can be used for all diseases, we try to use their ontology with Myasthenia Gravis disease but it does not fit because the Myasthenia Gravis disease has unknown causes. The treatments vary from patient to patient, and symptoms vary from one patient to another.

Al-Hamadani (2014) presents an expert system named CardioOWL, that is able to diagnose any type of coronary artery diseases and suggests a suitable treatment such as drugs and/or other needed surgery for patients.

CardioOWL depends on ontology knowledge about the symptoms that are apparent on the patient to build the knowledge base and then be able to use Semantic Web Rule Language (SWRL) to conclude the necessary treatment, whether drugs or surgery.

The research talks about a specific disease differs in causes, symptoms and treatments methods from the Myasthenia Gravis disease. we try to use their ontology with Myasthenia Gravis disease but it does not fit because the Myasthenia Gravis disease has unknown causes. The treatment varies from patient to patient, and symptoms vary from one patient to another.

3.6 Summary

Most of the related work focuses on building some general ontologies for several diseases and does not focusing on some specific disease except for some type of common disease such as cancer and coronary artery diseases in a general sense. There is no research – to our knowledge – uses ontologies to serve a particular disease such as Myasthenia Gravis, which it is totally different from all the diseases in symptoms, diagnosing and the treatments methods that non-constant which varies from person to person and treatment that varies from one patient to another.

We try to use previous ontologies and customize it to suit the Myasthenia Gravis disease, but they do not fit because the Myasthenia Gravis disease has unknown causes, the treatment varies from patient to patient and symptoms vary from one patient to another.

Because of that we find ourselves having to develop a specific ontology for the Myasthenia Gravis disease to help doctors and patients to diagnose the Myasthenia Gravis disease and provide recommend treatment.

Chapter 4

Myasthenia Gravis Ontology Development

In this chapter, we present the steps to develop the Myasthenia Gravis disease domain ontology to be used as a basis to diagnose the Myasthenia Gravis disease and provide recommended treatments. Additionally, we present the evaluation of the Myasthenia Gravis ontology.

4.1 Introduction

Building the ontology is very significant in our approach to diagnose the Myasthenia Gravis disease and provide recommended treatments; the ontology content is relevant to medical domain and is collected from a number of patients from a questionnaire sent to a lot of local and international Myasthenia Gravis patients with supervision of a domain expert.

We chose the Protégé (Stanford Center for Biomedical Informatics Research (BMIR), 2016) tool from the various tools available for developing ontologies to design and build the Myasthenia Gravis ontology with the help of a guide through following the identified steps by Ontology Development Guide (Noy & McGuinness, 2001):

1. Determine the domain and scope of the ontology.
2. Consider reusing existing ontologies.
3. Overview of the ontology.
4. Enumerate the important terms in the ontology.
5. Define the classes and the class hierarchy.
6. Define the properties of classes - slots.
7. Define the facets of the slots.
8. Create instances.
9. Evaluating (testing) the ontology.

4.2 Determine the Domain and Scope of the Ontology

The first step to start the development of the ontology must be defining its domain and scope. This can be done by answering several questions:

1. **What is the domain that the ontology will cover?**

   The domain of the ontology is diagnosing the Myasthenia Gravis disease and providing appropriate treatments.

2. **What is the use of the ontology?**

   The ontology is to provide a knowledge base consisting of symptoms, diagnostic methods, drugs or surgical treatments, drug names and information about patients such as geography of area, country, weather, career, eating, mood, disease duration, playing sports, other diseases and medical history of his family. Additionally, consist several instances through collected patient information.

   It will be used in a system to make diagnoses of the Myasthenia Gravis diseases and to provide a recommended treatments and recommended practices that may increase or decrease the impact of the Myasthenia Gravis disease.

3. **What types of questions the information in the ontology should provide answers?**

   The ontology would provide valuable answers for questions that are related to Myasthenia Gravis disease, such as:

   1. What are the symptoms of the Myasthenia Gravis disease?
   2. How can we diagnose the Myasthenia Gravis disease (diagnostic methods)?
   3. What are the treatment methods of the Myasthenia Gravis disease?
   4. What are the drugs to a void by the patients of the Myasthenia Gravis disease?

5. What are the drugs that can reduce the impact of the Myasthenia Gravis disease?
6. What are the recommended treatments of a particular patient?
7. Is a particular patient having the Myasthenia Gravis disease?

4. Who will use and maintain the ontology?

The ontology will be available on the web to provide a new approach to helps doctors to diagnose the Myasthenia Gravis disease and provide appropriate treatments for the patients. Additionally, the patient can use and benefit from the approach through query for the symptom, drugs to avoid, treatment methods and diagnosis methods. But as it is well known that final treatments to diseases usually need several experiments and time, the final decision of the recommended treatment will be decided by doctors. Therefore, we are not responsible for any risks to the patient resulting from the use of our approach without consulting the Myasthenia Gravis doctors.

4.3 Reusing Existing Ontologies

With the widespread of the semantic web, there are a lot of available applications that use and depend on ontologies. However, unfortunately we did not find any of them that can serve a particular disease such as the Myasthenia Gravis disease, which is very different from all the diseases in symptoms, diagnose and treatments which are non-constant and varies from patient to patient.

We have tried to use the standard existing ontologies such as the Disease Ontology (DOID) (Schriml et al., 2012) and the Symptoms Ontology (SYMP) and customize it to suit the Myasthenia Gravis disease but they did not fit because, as mentioned, the Myasthenia Gravis disease has unknown causes, the treatments varies from patient to patient, and symptoms vary from one patient to another.

Because of that, we need to develop a specific ontology for the Myasthenia Gravis disease to help doctors and patients to diagnose the Myasthenia Gravis disease and provide recommended treatment.

4.4 Overview of the Ontology

We developed a specific ontology for the Myasthenia Gravis disease that consist of symptoms class divided into body parts such as head, upper limbs, lower limbs, abdominal, back and general symptoms. Then the diagnostic methods class, the treatment class divided into surgical, drugs, physiotherapist, psychiatric and alternatively medicine. Then the patients class that consists of information about the patients such as geography of area, country, weather, career, eating, mood, disease duration, practice Sport, other diseases and medical history of his family and other information. The final class is the drugs to avoid by the patient of the Myasthenia Gravis disease. The ontology metrics are shown in Table (4.1) and the main classes in the ontology are shown in Figure (4.1).

Table (4.1): Ontology metrics.

Domain and scope of the ontology	The rare and chronic Myasthenia Gravis disease
Axiom	3243
Logical axiom count	2670
Declaration axioms count	532
Class count	78
Object property count	55
Data property count	19
Individual count	368

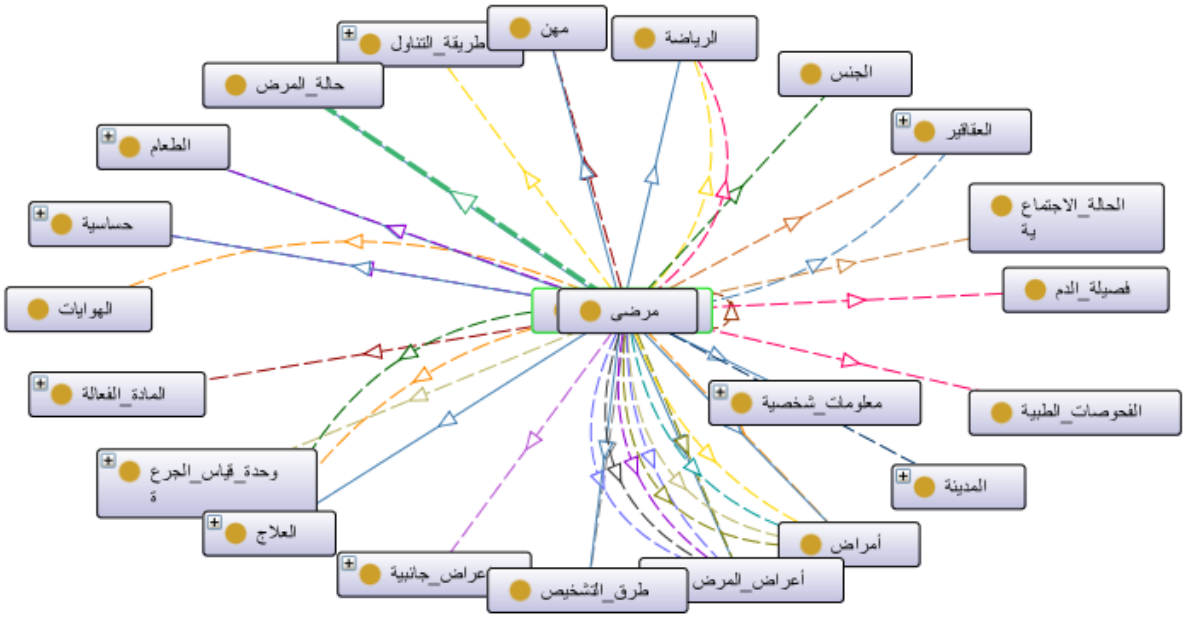

Figure (4.1): Main classes in the Myasthenia Gravis ontology.

4.5 Enumerate the Important Terms in the Ontology

In this step, we add terms and properties for these terms by studying the Myasthenia Gravis disease and its diagnosis, and through analyzing the structure of the disease and symptoms. The enumeration of these important terms to use it in the creating of the classes in our proposed ontology. The following questions guides our brain storming activity to determine the terms:

1. *What are the main terms that we want to talk about?*

The main terms we talk about are the Myasthenia Gravis disease, patients, personal information about patients, symptoms, country, weather, diagnostic methods of the disease, treatments, drugs, jobs, foods, sports and medical history of the patient family.

2. *What are the properties of these terms? What is needed to be said about those terms?*

The ontology terms and its properties in Arabic and English languages are shown in Table (4.2).

Table (4.2): The Myasthenia Gravis ontology terms and its properties.

No.	Term in English	Term in Arabic	Term Property in English	Term Property in Arabic
1.	Patients	مرضى	Sex	الجنس
			Marital Status	الحالة الاجتماعية
			Blood Type	فصيلة الدم
			Has Hobbies	لديه هواية
			Live In	يسكن في مدينة
			Job	يعمل في
			Practice Sport	يمارس رياضة
			Same Patient	يشبه
			Diagnosed By	تم تشخيصه
			Diagnosed Through	تم تشخيصه من خلال
			Has Allergy for	لديه حساسية تجاه
2.	Medical Tests	الفحوصات الطبية	Made Medical Tests	عمل فحوصات طبية

No.	Term in English	Term in Arabic	Term Property in English	Term Property in Arabic
3.	Stabilize the situation	استقرار الحالة	Disease Status	حالة المرض
			Decrease MG	يشعر بتحسن مع
			Increase MG	يشعر بسوء مع
4.	Symptoms	الاعراض	Has Symptoms After Diagnosed	بعد التشخيص
			Has Symptoms before Diagnosed	قبل التشخيص
			Has Continuous Symptoms	عرض مستمر
			Has Rare Symptoms	عرض نادر
5.	Drugs	العقاقير	Has Side Effects	أعراض جانبية
			Has Effective Material	المادة الفعالة
			Drugs to Avoid	دواء محظور
			Has Taking Way	طريقة التناول
			Has Unit Dosimetry	وحدة قياس الجرعة
6.	Treatments	العلاج	Used treatments	استخدم علاج
			Proposed Treatments	علاج مقترح
			Drugs decrease the MG	يشعر بتحسن عند زيادة جرعات
			Drugs increase the MG	يشعر بسوء عند زيادة جرعات
			Using treatments	يستخدم علاج
7.	Address	العنوان	Has Weather	حالة الطقس
			Consist of Cities	دولة تحتوي على
			Belong to Country	مدن تتبع دولة
			Has Natural Region	طبيعة المنطقة الجغرافية
8.	Disease Information	معلومات عن المرض	Synchronized with Disease	تزامن المرض مع ظهور مرض آخر
			Disease Causes another Disease	سبب المرض وهن آخر
			Family Disease	مرض في العائلة
			Disease Increase the MG	مرض يؤثر على الوهن

4.6 Define the Classes and the Class Hierarchy

We developed a specific ontology for Myasthenia Gravis disease that consists of the classes shown in Table (4.3).

Table (4.3): The classes and subclasses in the Myasthenia Gravis ontology.

No.	Class Name	Arabic Class Name	Sub Class Of	Description
1.	Diseases	أمراض	Thing	Represents the diseases
2.	Immune system disease	مرض جهاز المناعة	Diseases	Represents the disease of the Immune System
3.	Patients	مرضى	Thing	Represents the patients
4.	Symptoms	أعراض المرض	Thing	Represents the symptom of the Myasthenia Gravis disease
5.	Limbs	الأطراف	Symptoms	Represents the symptoms that appear on the limbs
6.	Lower Limbs	الأطراف السفلية	Limbs	Represents the symptoms that appear on the lower limbs
7.	Upper Limbs	الأطراف العلوية	Limbs	Represents the symptoms that appear on the upper limbs
8.	Lower Part	الجزء السفلي	Symptoms	Represents the symptoms that appear on the lower part of the human body
9.	Upper Part	الجزء العلوي	Symptoms	Represents the symptoms that appear on the upper part of the human body
10.	Back	الظهر	Upper Part	Represents the symptoms that appear on the human back
11.	Head	الرأس	Symptoms	Represents the symptoms that appear on the human head
12.	Eye	العين	Head	Represents the symptoms that appear on the human eye
13.	Tongue	الفم	Head	Represents the symptoms that appear on the human tongue
14.	General Symptom	عام	Symptoms	Represents general symptom of the human body
15.	Diagnostic methods	طرق التشخيص	Thing	Represents the diagnostic methods of the

No.	Class Name	Arabic Class Name	Sub Class Of	Description
				Myasthenia Gravis Disease
16.	Medical tests	الفحوصات الطبية	Diagnostic methods	Represents the medical test that the MG disease did
17.	Jobs	مهن	Thing	Represents jobs that can the patients work
18.	Sport	الرياضة	Thing	Represents the sports that can be practiced by the patient
19.	Food	الطعام	Thing	Represents the foods that can be eaten by the patient
20.	Dairy	الألبان	Food	Represents the dairy as part of the foods
21.	Proteins	البروتينات	Food	Represents the proteins as part of the foods
22.	Fats and sweets	الدهون والحلويات	Food	Represents the fats and sweets as part of the foods
23.	Vegetables	الخضروات	Food	Represents the vegetables as part of the foods
24.	Fruits	الفواكه	Food	Represents the fruits as part of the foods
25.	Starches	النشويات	Food	Represents the starches as part of the foods
26.	Treatment	العلاج	Thing	Represents the treatment of the MG disease
27.	Herbs	أعشاب	Treatment	Represents the treatment of the MG disease by herbs
28.	Drugs	العقاقير	Treatment	Represents the treatment of the MG disease by drugs
29.	Nerves drugs	أعصاب	Drugs	Represents the drugs that used to treat the neurological diseases
30.	Mestinon	Mestinon	Nerves drugs	Represents the drugs that belong to Mestinon drugs.
31.	Pyridostigmine	Pyridostigmine	Nerves drugs	Represents the drugs that belong to Pyridostigmine drugs.
32.	Heart drugs	القلب	Drugs	Represents the drugs that used to treat the heart diseases
33.	Metalyse	Metalyse	Heart drugs	Represents the drugs that belong to Metalyse drugs.

No.	Class Name	Arabic Class Name	Sub Class Of	Description
34.	Vaccinations	تطعيمات	Drugs	Represents the vaccinations list as part of the drugs
35.	Reduced immunity drugs	مخفض مناعة	Drugs	Represents the drugs that used to reduced immunity diseases
36.	Cellcept	Cellcept	Reduced immunity drugs	Represents the drugs that belong to Cellcept drugs.
37.	Imuran	Imuran	Reduced immunity drugs	Represents the drugs that belong to Imuran drugs.
38.	NSAIDs	مضادات الالتهابات	Drugs	Represents the drugs that used to treat the infections.
39.	Cortisone	Cortisone	NSAIDs	Represents the drugs that belong to Cortisone drugs.
40.	Prednisolone	Prednisolone	NSAIDs	Represents the drugs that belong to Prednisolone drugs.
41.	Food Supplements	مكملات غذائية	Drugs	Represents the food supplements list as part of the drugs
42.	Potassium	بوتاسيوم	Food Supplements	Represents the potassium as part of the food supplements
43.	Iron	حديد	Food Supplements	Represents the iron as part of the food supplements
44.	Zinc	زنك	Food Supplements	Represents the zinc as part of the food supplements
45.	Vitamin	فيتامين	Food Supplements	Represents the vitamin list as part of the food supplements
46.	Vitamin A	A	Food Supplements	Represents the vitamin A as part of the food supplements
47.	Vitamin B	B	Food Supplements	Represents the vitamin B as part of the food supplements
48.	Vitamin C	C	Food Supplements	Represents the vitamin C as part of the food supplements
49.	Vitamin D	D	Food Supplements	Represents the vitamin D as part of the food supplements

No.	Class Name	Arabic Class Name	Sub Class Of	Description
50.	Vitamin E	E	Food Supplements	Represents the vitamin E as part of the food supplements
51.	Calcium	كالسيوم	Food Supplements	Represents the calcium as part of the food supplements
52.	Magnesium	ماغنيسيوم	Food Supplements	Represents the magnesium as part of the food supplements
53.	Psychiatric treatment	نفسي	Treatment	Represents the Psychiatric treatment.
54.	Surgical	جراحي	Treatment	Represents the treatment of the MG disease by surgical operations
55.	Physiotherapist	علاج طبيعي	Treatment	Represents the treatment of the MG disease by Physiotherapist
56.	Preventive treatment	وقائي	Treatment	Represents the treatment of the MG disease by prevention treatment
57.	Drugs information	معلومات عن العقاقير	Drugs	Represents all information about the drugs
58.	Side Effects	أعراض جانبية	Drugs information	Represents the side effects of the drugs
59.	Effective Material	المادة الفعالة	Drugs information	Represents the effective material of the drugs
60.	Drugs Taking Way	طريقة التناول	Drugs information	Represents the taking way of the drugs
61.	Drugs unit dosimetry	وحدة قياس الجرعة	Drugs information	Represents the unit dosimetry of the drugs
62.	Disease status	حالة المرض	Thing	Represents the disease status
63.	Allergy	حساسية	Thing	Represents the allergy list
64.	Drugs Allergy	أدوية	Allergy	Represents the allergy from the drugs
65.	Animal Allergy	حيوانات	Allergy	Represents the allergy from the animal
66.	Food Allergy	طعام	Allergy	Represents the allergy from the foods
67.	Personal Information	معلومات شخصية	Thing	Represents the personal information of the patient
68.	Gender	الجنس	Personal Information	Represents the gender of the patient
69.	Marital status	الحالة الاجتماعية	Personal Information	Represents the marital status of the patients

No.	Class Name	Arabic Class Name	Sub Class Of	Description
70.	Address	العنوان	Personal Information	Represents the address of the patients
71.	Country	الدولة	Address	Represents the country list
72.	Weather	الطقس	Address	Represents the state of the weather at the city where the patient lives
73.	City	المدينة	Address	Represents the cities list as part of the country
74.	Natural region	طبيعة المنطقة الجغرافية	Address	Represents the natural region of the city
75.	Hobbies	الهوايات	Personal Information	Represents hobbies list
76.	Blood Type	فصيلة الدم	Personal Information	Represents blood types list

After the class identification process resulted in Table (4.3), we must design the class hierarchy of the ontology (as shown in Figure (4.2)) – by the three known ways to develop the class hierarchy. We chose and apply the Top-Down approach.

The Top-Down approach starts from the most generic concept and build a structure by specialization. The ontology is built by determining first the top concepts and by specializing them. The top concepts can be chosen in a foundational ontology (Roussey et al., 2011).

4.7 Define the Properties of Classes - Slots

The previous step built the classes of the ontology. But those classes alone will not provide enough information to answer the competency questions from Step 1 such as diagnosing the Myasthenia Gravis disease. So, we have to define a lot of the relations between those classes which is the properties of the classes to achieve our goals of this approach. Object properties are shown in Table (4.4) and the data properties are shown in Table (4.5).

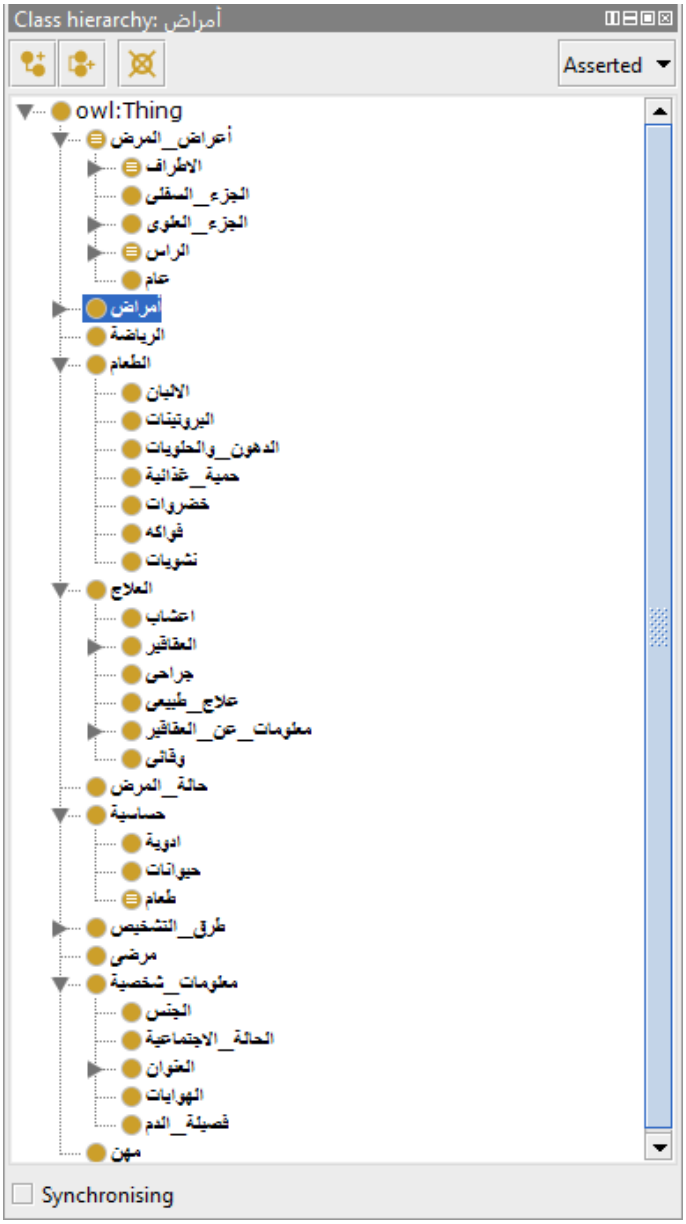

Figure (4.2): The class hierarchy of the Myasthenia Gravis ontology.

Table (4.4): The object properties of the ontology classes.

#	Object properties	In Arabic	Domain	Range
1.	Stabilize the situation	استقرار الحالة	Patients	Thing
2.	Disease status	حالة المرض	Patients	Disease status
3.	Decrease MG (Known)	يحسن الحالة (شيء معروف)	Patients	Thing
4.	Increase MG (Known)	يسيء الحالة (شيء معروف)	Patients	Thing
5.	Decrease MG	يشعر بتحسن مع	Patients	Thing

#	Object properties	In Arabic	Domain	Range
6.	Increase MG	يشعر بسوء مع	Patients	Thing
7.	Symptoms	الاعراض	Disease	Symptoms
8.	Known Symptoms	اعراض معروفة للمرض	Disease	Symptoms
9.	Has Symptoms	يعاني من أعراض	Patients	Symptoms
10.	Has Symptoms After Diagnosed	بعد التشخيص	Patients	Symptoms
11.	Has Symptoms before Diagnosed	قبل التشخيص	Patients	Symptoms
12.	Has Continuous Symptoms	عرض مستمر	Patients	Symptoms
13.	Has Rare Symptoms	عرض نادر	Patients	Symptoms
14.	Drugs	العقاقير	Patients	Drugs
15.	Has Side Effects	أعراض جانبية	Drugs	Side effects
16.	Has Effective Material	المادة الفعالة	Drugs	Effective Material
17.	Drugs to Avoid	دواء محظور	Disease	Drugs
18.	Has Taking Way	طريقة التناول	Drugs	Drugs taking way
19.	Has Unit Dosimetry	وحدة قياس الجرعة	Drugs	Drugs unit dosimetry
20.	Treatments	العلاج	Patients	Treatment
21.	Used treatments	استخدم علاج	Patients	Treatment
22.	Proposed Treatments	علاج مقترح	Patients	Treatment
23.	Drugs decrease the MG	يشعر بتحسن عند زيادة جرعات	Patients	Drugs
24.	Drugs increase the MG	يشعر بسوء عند زيادة جرعات	Patients	Drugs
25.	Using treatments	يستخدم علاج	Patients	Treatment
26.	Address	العنوان		
27.	Has Weather	حالة الطقس	City	Weather
28.	Consist of Cities	دولة تحتوي على	Country	City
29.	Belong to Country	مدن تتبع دولة	City	Country
30.	Has Natural Region	طبيعة المنطقة الجغرافية	City	Natural region
31.	Enter Hospital because	دخول المستشفى	Patients	Disease
32.	Medical Tests	الفحوصات الطبية		
33.	Made Medical Tests	عمل فحوصات طبية	Patients	Medical tests
34.	Has Allergy for	لديه حساسية تجاه	Patients	Allergy

#	Object properties	In Arabic	Domain	Range
35.	Personal Information of Patient	معلومات المريض الشخصية	Patients	
36.	Sex	الجنس	Patients	Gender
37.	Marital Status	الحالة الاجتماعية	Patients	Marital status
38.	Blood Type	فصيلة الدم	Patients	Blood Type
39.	Follow Diet	لديه حمية غذائية	Patients	Foods
40.	Has Hobbies	لديه هواية	Patients	Hobbies
41.	Live In	يسكن في مدينة	Patients	City
42.	Job	يعمل في	Patients	Jobs
43.	Practice Sport Before MG	يمارس رياضة قبل المرض	Patients	Sport
44.	Practice Sport After MG	يمارس رياضة بعد المرض	Patients	Sport
45.	Disease Information	معلومات عن المرض	Patients	
46.	Synchronized with Disease	تزامن المرض مع ظهور مرض آخر	Patients	Disease
47.	Diagnosed By	تم تشخيصه	Patients	Disease
48.	Diagnosed Through	تم تشخيصه من خلال	Patients	Diagnostic methods
49.	Disease Causes another Disease	سبب المرض وهن آخر	Patients	Disease
50.	Family Disease	مرض في العائلة	Patients	Disease
51.	Disease Increase the MG	مرض يؤثر على الوهن	Patients	Disease
52.	Disease Status	حالة المرض	Patients	Disease status
53.	Same Patient	يشبه	Patients	Patients

Table (4.5): The data properties of the ontology classes.

No.	Data properties	In Arabic	Domain	Range
1.	Personal Information of Patient	معلومات المريض الشخصية	Patients	Literal
2.	Patient Name	الاسم	Patients	String
3.	Patient First Name	الاسم الأول	Patients	String
4.	Patient Last Name	الاسم الأخير	Patients	String
5.	Patient Length	الطول	Patients	Integer
6.	Patient Age	العمر	Patients	Integer
7.	Patient Job	المهنة		
8.	Work Hours	عدد ساعات العمل	Patients	Integer
9.	Patient weight	الوزن	Patients	Integer

No.	Data properties	In Arabic	Domain	Range
10.	Patient email	بريد الكتروني	Patients	String
11.	Drink Alcohol	شارب للكحول	Patients	Boolean
12.	Smoking	مدخن	Patients	Boolean
13.	Patient Phone	هاتف	Patients	String
14.	Drug Addict	يتعاطى مخدرات	Patients	Boolean
15.	Disease Information	معلومات عن المرض	Patients	Literal
16.	Diagnosed for	تاريخ تشخيص المرض	Patients	Integer
17.	Sick for	عمر المرض	Patients	Integer

Example of ontology properties is the properties of the Myasthenia Gravis ontology which is shown in Figure (4.3), and the properties of patient (individual) P001 shown in Figure (4.4).

4.8 Define the Facets of the Slots

Many of the facets was adopted during the development of the ontology, that adds a lot of restrictions on values we can enter to the ontology. These restrictions include the allowed values, the cardinality (the number of values) and other features.

In our research, all of slots' values are string using UTF-8 (Arabic Language), for example:

1. *Value type*: describes what types of values can be filled in the slot such as:
    a. **String**: we used this for the *classes*, the *object properties*, the *data properties* and the *individuals* such as the class "patient" (in Arabic "مرضى") the object property "made_medical_tests" (in Arabic "عمل_فحوصات_طبية") the data property "patient_first_name" (in Arabic "الاسم_الاول") and finally the symptoms individual "eyelid_drooping_symptom" (in Arabic "عرض_ارتخاء_الجفون").

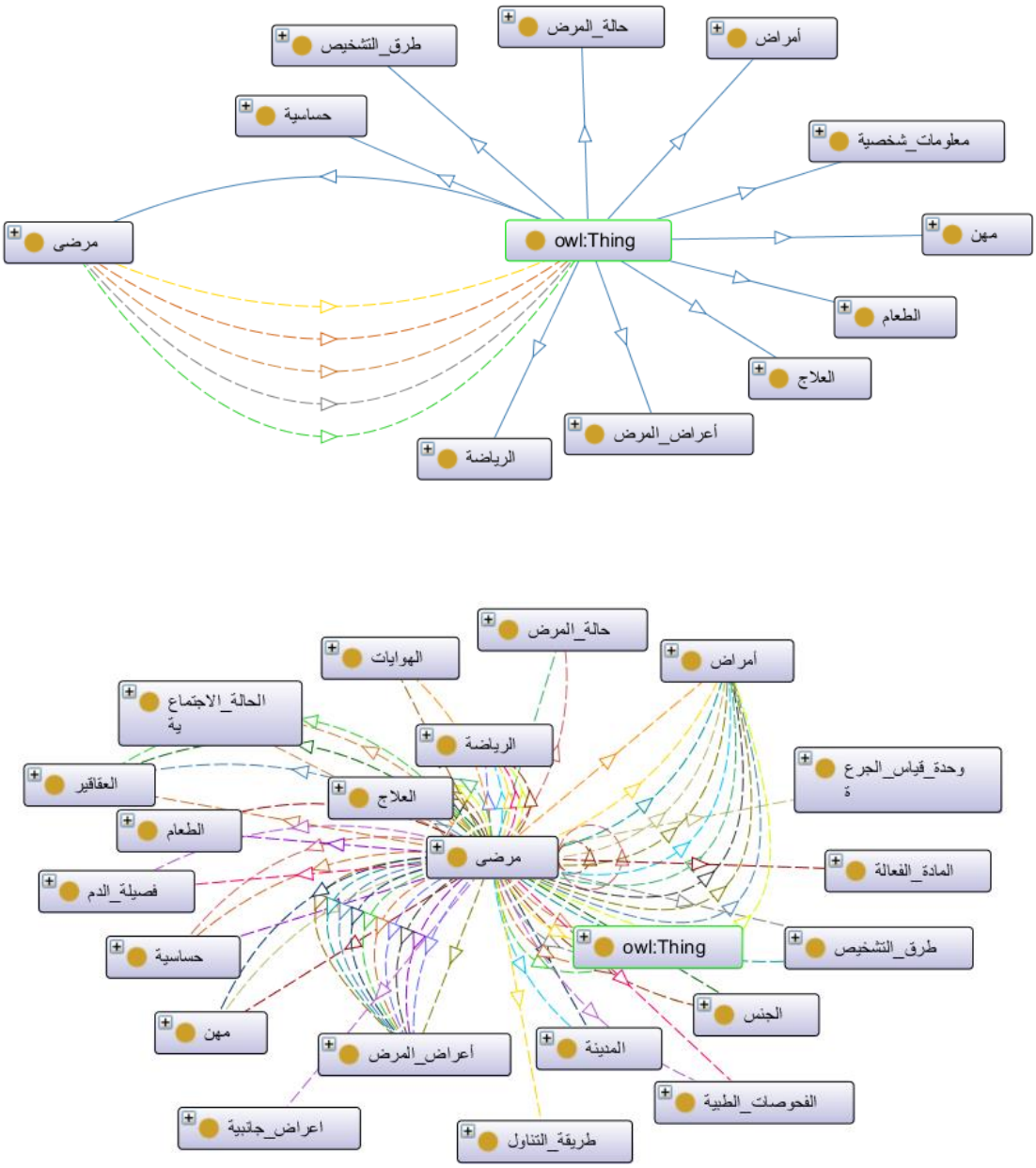

Figure (4.3): The properties of the classes of the Myasthenia Gravis Ontology.

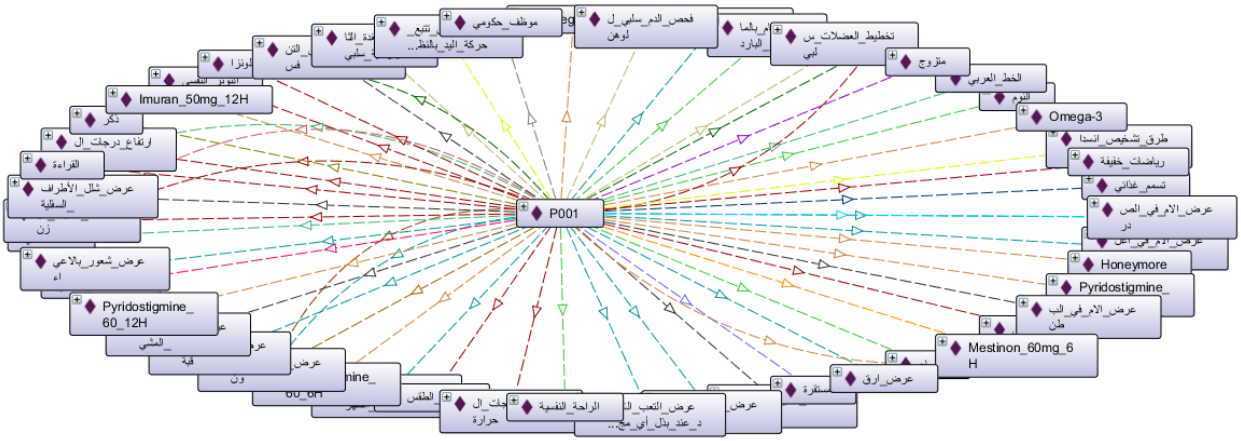

Figure (4.4): The properties of the patient P001.

Figure (4.5) shows how object properties look like in the Protégé tool and Figure (4.6) shows how data properties look like in the Protégé tool.

Figure (4.5): Object properties as shown in the Protégé tool.

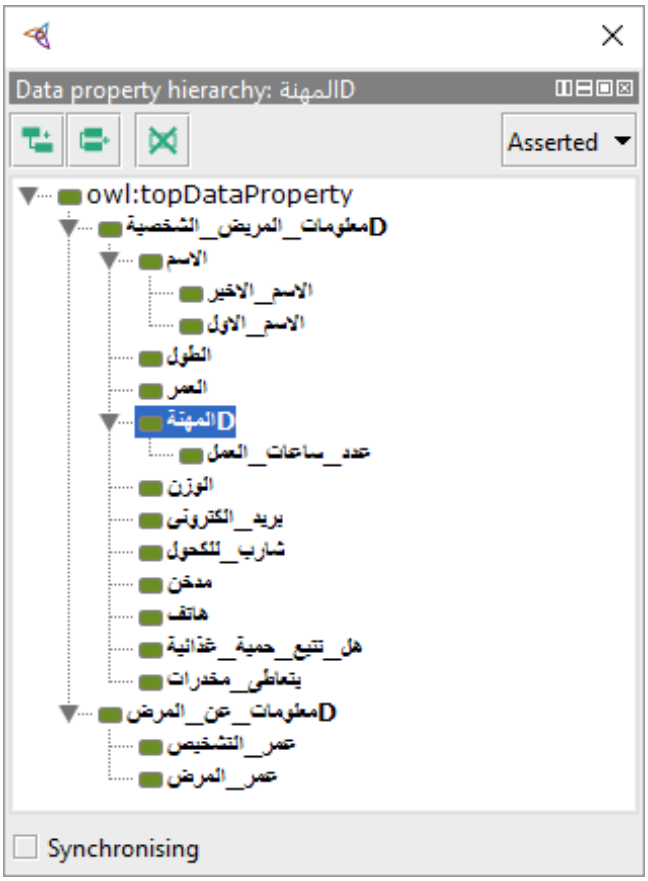

Figure (4.6): The data properties as shown in the Protégé tool.

b. **Number**: we used this for some data properties with a numeric values such as "weight" (in Arabic "الوزن") and "age" (in Arabic "العمر") as integer data type as shown in Figure (4.7).

c. **Boolean**: we used this for yes–no flags. For example, "smoking" (in Arabic "مدخن"), "drink_Alcohol" (in Arabic "شارب_للكحول") and "drugs_addict" (in Arabic "يتعاطى_مخدرات") as shown in Figure (4.7).

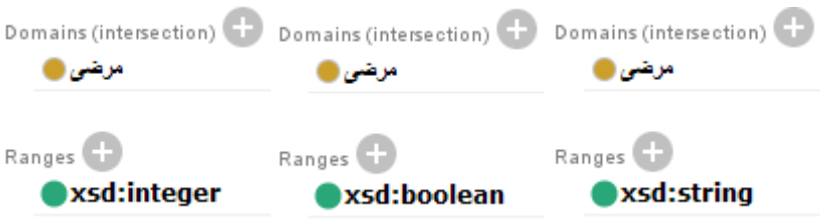

Figure (4.7): Examples of varius data types of the literal.

2. *Allowed values*: This represents values allowed for different properties. Such as the property "has_hobbies" (in Arabic "لديه_هواية") has allowed values form the "hobbies" (in Arabic "الهوايات") and "sports" (in Arabic "الرياضة") classes.
3. *Cardinality*: A property can have single value or multiple values. Cardinality defines how many values a property can have. Such as the property "sex" (in Arabic "الجنس") has exactly one object form "male" (in Arabic "ذكر") and "female" (in Arabic "انثى") as show in Figure (4.8).

4.9 Create Instances

In this step, we created the individual instances of all classes in the hierarchy of the ontology to enrich it. The created individuals in our ontology represent the chosen sample of the Myasthenia Gravis patients which is used to diagnose patients and give a recommended treatment for each patient. We used it for the ontology evaluation. For example, we created individuals in the "sports" (in Arabic "الرياضة") class such as "swimming" (in Arabic "السباحة"), "run" (in Arabic "الجري") and "football" (in Arabic "كرة_القدم").

Figure (4.8): Examples of cardinality.

In our ontology, we defined around 368 individuals that are representing all ontology concepts including 60 patients and a lot of their personal patient information, 16 diseases, 37 symptoms, 10 sports, 17 types of foods, 67 treatments, 41 individuals

to represent information about the treatments, 20 diagnostic methods and other individuals. An example of patients' instances is shown in Figure (4.9).

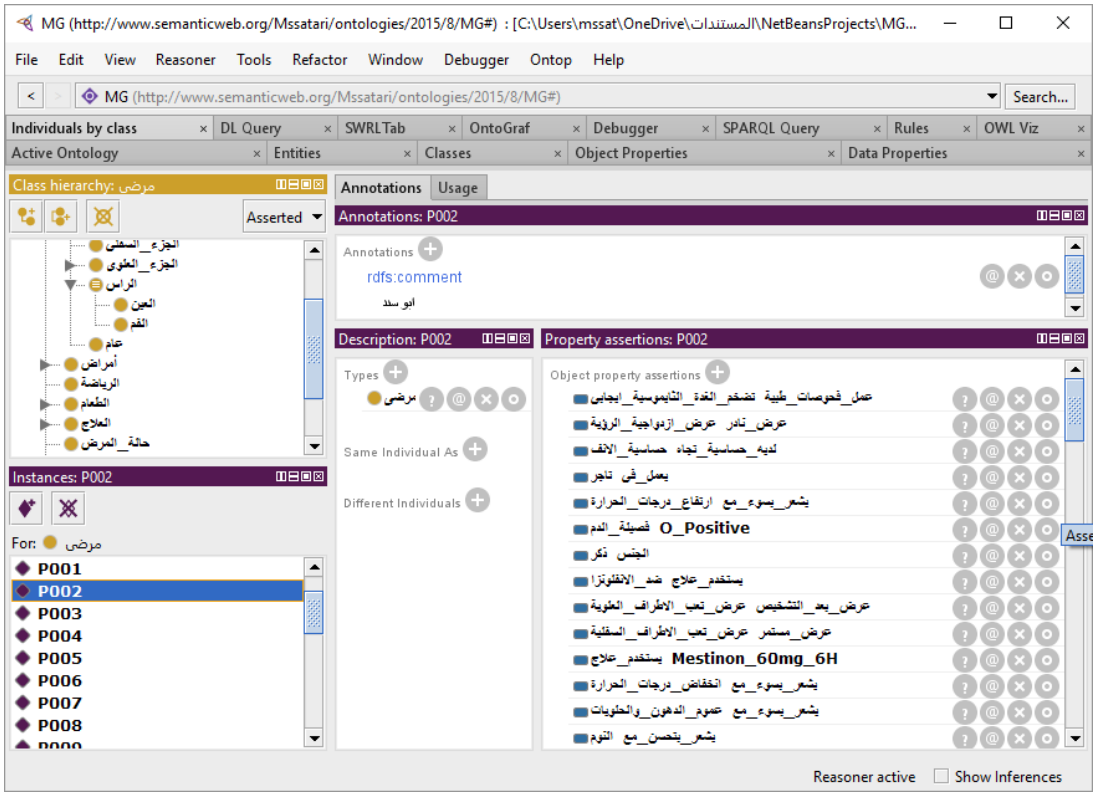

Figure (4.9): Example of ontology instances.

We used Google documents to publish a questionnaire for collecting huge information about the patients and their Myasthenia Gravis disease. An example of a patient information is shown in Table (4.6).

Table (4.6): An instance of Myasthenia Gravis patient.

Patient Instance: P001			
Data Properties			
Domain		**Values**	
Patient First Name	الاسم الأول	Samer	سامر
Patient Length	الطول	175	175
Patient Age	العمر	31	31
Work Hours	عدد ساعات العمل	10	10
Patient weight	الوزن	91	91
Drink Alcohol	شارب للكحول	False	False
Smoking	مدخن	False	False

Drug addict	يتعاطى مخدرات	False	False
Diagnosed for (in years)	تاريخ تشخيص المرض (بالسنوات)	3	3
Sick for (in years)	عمر المرض (بالسنوات)	14	14
Object Properties			
Domain		**Values**	
Disease status	حالة المرض	Stable	مستقرة
Decrease MG	يشعر بتحسن مع	Massage Sleeping Psychological comfort Weather changes Bathing with cold water	المساج النوم الراحة_النفسية تقلبات_الطقس الاستحمام_بالماء_البارد
Increase MG	يشعر بسوء مع	Weight loss herbs Flue Diarrhea Psychological tension Swimming Lite Sports High temperatures Walking Reading	أعشاب_تخفيف_الوزن الانفلونزا الاسهال التوتر_النفسي السباحة رياضات_خفيفة ارتفاع_درجات_الحرارة رياضة_المشي القراءة
Has Symptoms After Being Diagnosed	عرض بعد التشخيص	Eyelid dropping Shoulders pain Nick pain Poor memory Upper back pain Feeling sick Middle back pain Muscle weakness when exertion Insomnia	ارتخاء_الجفون الام_في_الاكتاف الام_في_الرقبة ضعف_الذاكرة الام_في_اعلى_الظهر شعور_بالاعياء الام_في_وسط_الظهر التعب_الشديد_عند_بذل_مجهود ارق

Has Symptoms before Being Diagnosed	عرض قبل التشخيص	Eyelid dropping Shoulders pain Nick pain Poor memory Upper back pain Feeling sick Middle back pain Chest pain Muscle weakness when exertion Insomnia	ارتخاء_الجفون الام_في_الاكتاف الام_في_الرقبة ضعف_الذاكرة الام_في_اعلى_الظهر شعور_بالاعياء الام_في_وسط_الظهر الام_في_الصدر التعب_الشديد_عند_بذل_مجهود ارق
Has Continuous Symptoms	عرض مستمر	Eyelid dropping	ارتخاء_الجفون
Has Rare Symptoms	عرض نادر	Paralysis of the lower limbs Unstable walking Shortness of breath Belly pain Lower back pain	شلل_الاطراف_السفلية عدم_استقرار_المشي عرض_ضيق_في_التنفس عرض_الام_في_البطن عرض_الام_في_اسفل_الظهر
Using treatments	يستخدم علاج	Mestinon_60mg_6H	Mestinon_60mg_6H
Used treatments	استخدم علاج	Imuran_50mg_12H Pyridostigmine_60_8H Pyridostigmine_60_6H Pyridostigmine_60_12H Omega-3 Honeymore Omega-3-6-9	Imuran_50mg_12H Pyridostigmine_60_8H Pyridostigmine_60_6H Pyridostigmine_60_12H Omega-3 Honeymore Omega-3-6-9
Made Medical Tests	عمل فحوصات طبية	EMG Negative Blood test Negative Thymus tumor Negative	تخطيط_العضلات_سلبي فحص_الدم_سلبي_للوهن تضخم_الغدة_الثايموسية_سلبي
Sex	الجنس	Male	ذكر
Marital Status	الحالة الاجتماعية	Married	متزوج
Blood Type	فصيلة الدم	O_Positive	O_Positive
Has Hobbies	لديه هواية	Reading Swimming Arabic Calligraphy	القراءة السباحة الخط العربي
Lives In	يسكن في مدينة	Gaza	غزة

Job	يعمل في	Employee	موظف
Practice Sport	يمارس رياضة قبل المرض	Swimming Kung Fu Nunchaku	السباحة الكونج_فو النشاكو
Diagnosed Through	تم تشخيصه من خلال	Eyelid dropping Locking at movement hand	انسدال_الجفن تتبع_حركة_اليد_بالنظر
Disease Increase the MG	مرض يؤثر على الوهن	Flue Diarrhea	الانفلونزا الاسهال

4.10 Evaluating (Testing) the Ontology

In this section, we use the Description Logic Query (DL-Query) and the SPARQL Protocol and RDF Query Language (SPARQL) to evaluate the ontology as stated in Section (2.7).

We present several examples to answer some questions that are asked in the development process in Section (4.2).

Example 1:

- The question: Who are the patients (instances) diagnosed for the Myasthenia Gravis disease?
- Reasoner: HermiT 1.3.8.413.
- Query type: DL-Query.
- The query: مرضى **and** تشخيصه_تم **value** العضلات_وهن
- The result of the query is shown in Figure (4.10) which returned all the patients who are diagnosed for the Myasthenia Gravis disease.

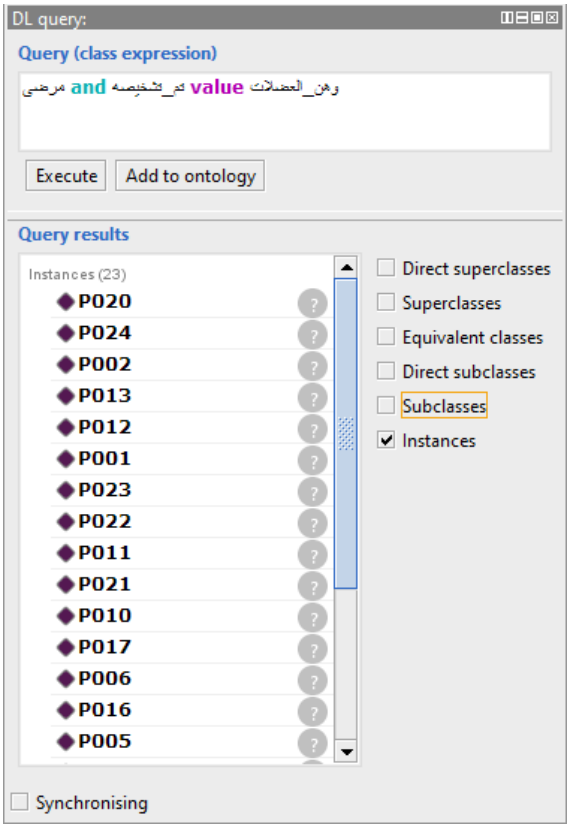

Figure (4.10): Query for all patients diagnosed for the Myasthenia Gravis disease.

Example 2:

- The question: Is the patient with name "محمد" diagnosed for the Myasthenia Gravis disease?
- Reasoner: HermiT 1.3.8.413.
- Query type: DL-Query.
- The query: مرضى **and** الاسم_الاول **value** "محمد" **and** تم_تشخيصه **value** وهن_العضلات
- The result of the query is shown in Figure (4.11) which returned the diagnosing of the patient with name "محمد".

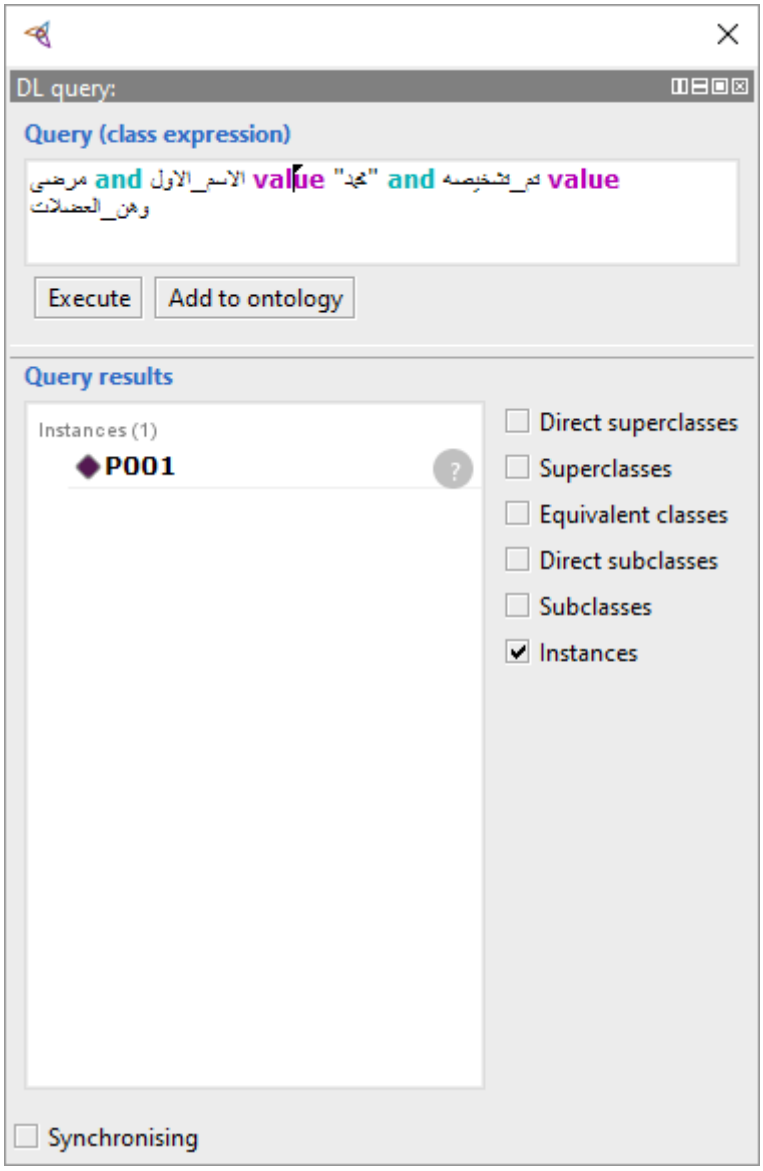

Figure (4.11): Query for diagnosing the patient with name "محمد".

Example 3:

- The question: Who are the patients with blood type O+?
- Query type: DL-Query.
- The query: مرضى **and** فصيلة_الدم **value** O_Positive
- The result of the query is shown in Figure (4.12) which returned all patients with blood type O+.

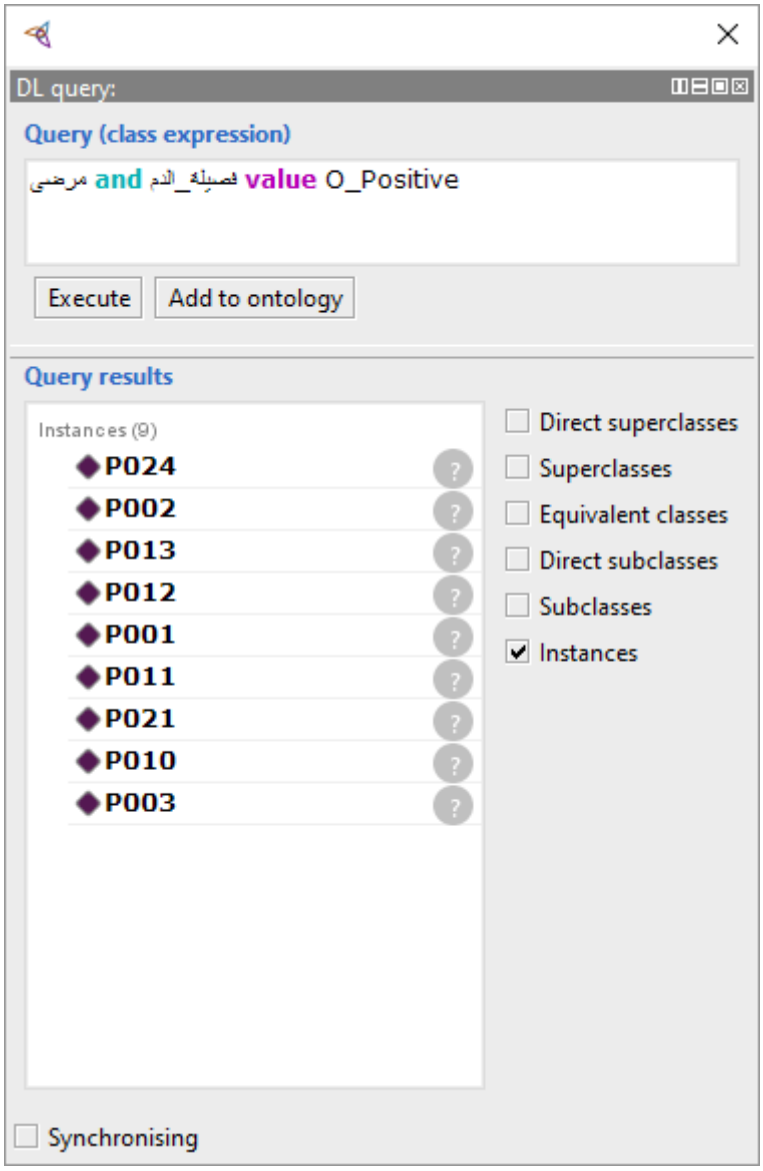

Figure (4.12): Query for all patients with blood type O+.

Example 4:

- The question: What is the symptoms of the Myasthenia Gravis disease?
- Query type: SPQRQL.
- The query:

```
PREFIX abc: <http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#>
SELECT ?symptom
    { WHERE
        ? abc:وهن_العضلات abc:اعراض_معروفة_للمرض ?symptom }
```

- The result of the query is shown in Figure (4.13) which returned the symptoms of the Myasthenia Gravis disease.

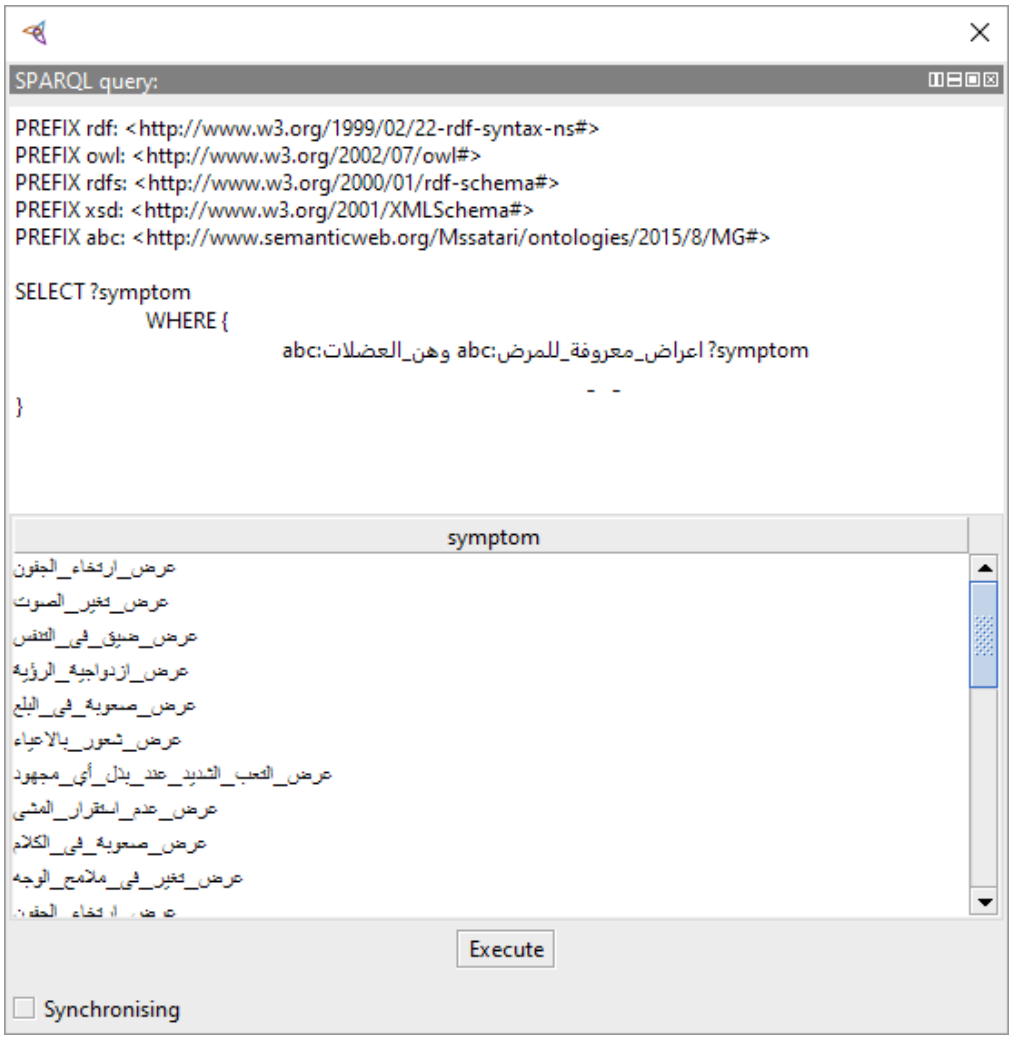

Figure (4.13): Query for the symptoms of the Myasthenia Gravis disease.

Example 5:

- The question: What are the symptoms that the patient "P001" suffered from before and after being diagnosed for the Myasthenia Gravis disease?
- Query type: SPQRQL.

- The query:

```
PREFIX abc: <http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#>
SELECT Distinct ?symptom
{ WHERE
        abc:P001 abc؟ عرض_قبل_التشخيص:symptom.
        abc:P001 abc:عرض_بعد_التشخيص ?symptom .}
```

- The result of the query is shown in Figure (4.14) which returned the symptom patient P001 suffered from before and after being diagnosed for the Myasthenia Gravis disease.

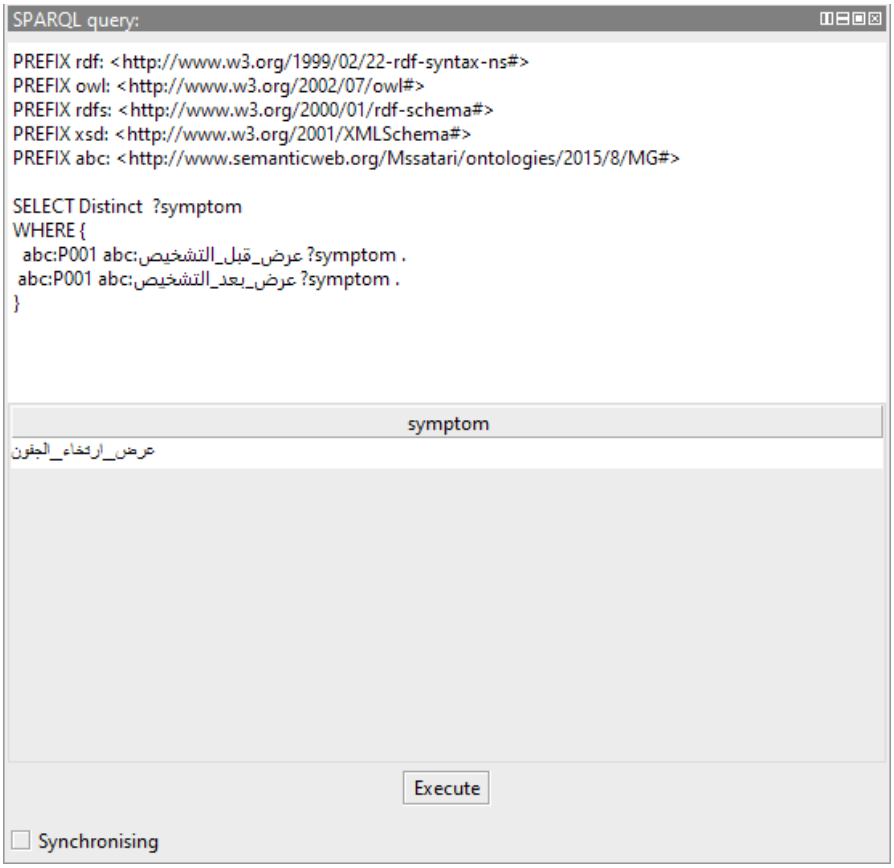

Figure (4.14): Query for the symptoms patient P001 suffered from before and after being diagnosed for the Myasthenia Gravis disease.

Example 6:

- The question: What are the age averages of the patients?
- Query type: SPQRQL.
- The query:

```
PREFIX abc: <http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#>
SELECT  (AVG(?age) AS ?avg)
WHERE   {
      ؟patient abc؟ العمر:age. }
```

- The result of the query is shown in Figure (4.15) which returned the age averages of the patients.

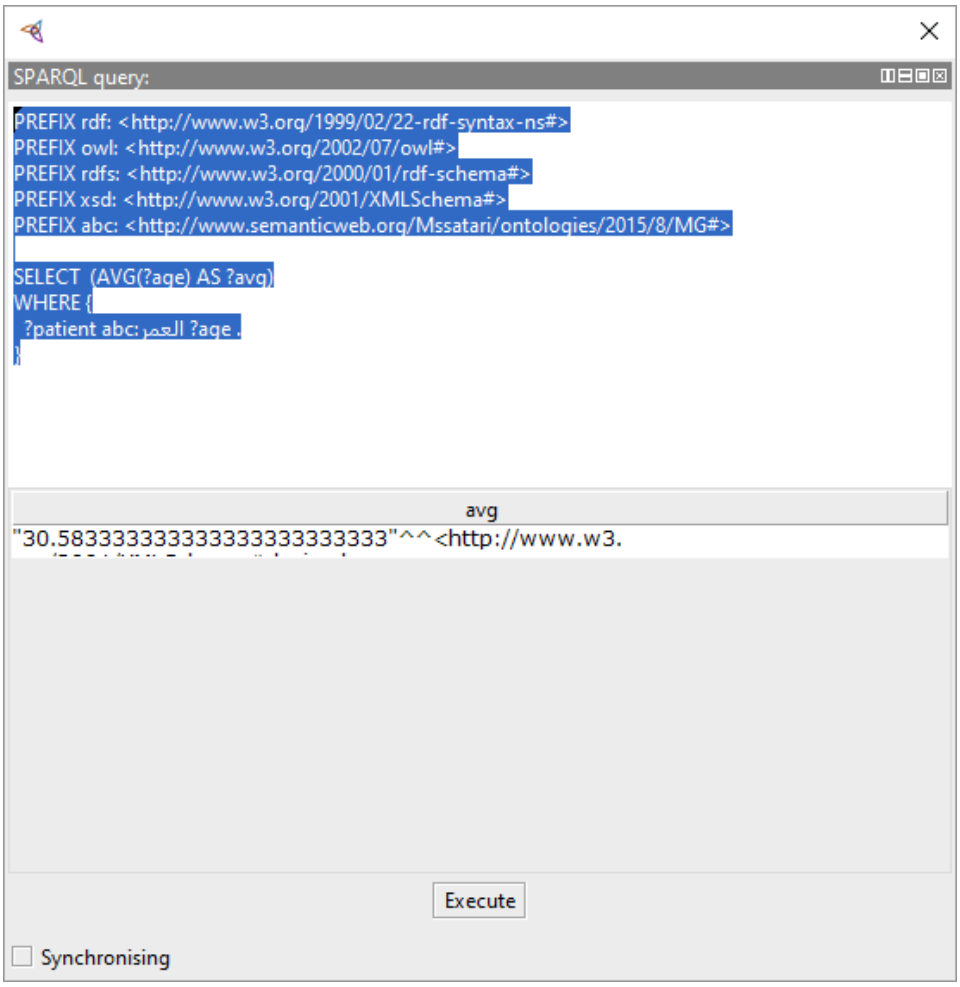

Figure (4.15): Query for the age averages of the patients.

4.11 Summary

In this chapter, we have stated the development and evaluation process of the Myasthenia Gravis disease ontology. We have explained all steps followed to build the ontology. Firstly, we identified the domain and the scope of the ontology, then we defined the terms and their properties. We have used the ontology development protégé tool to implement the ontology, then we have added instances to the ontology to create a reliable knowledge base, therefore explained some of the factors that are related to the values of some properties. Finally, we have presented an evaluation of the Myasthenia Gravis disease ontology and proved that the ontology has answered all questions and returned the correct results.

Chapter 5
Diagnosing and Recommending Treatments for Myasthenia Gravis Disease

5.1 Introduction

In this chapter, we present and discuss the steps of analysing, designing and developing the ontology-based approach for diagnosing Myasthenia Gravis disease and providing recommended treatments include the ontology development to be used as a knowledge base for the proposed approach.

We first talk about the description of the overall system structure, then secondly, we explain the development process and enumerate its various steps which are followed to achieve the goals of the proposed approach, we describe these steps in details in separated sections:

1. Collecting data: We design a questionnaire to collect information about the Myasthenia Gravis disease and the Myasthenia Gravis patients to enrich the ontology and therefore creating a knowledge base.

2. Building the ontology: we described how we build the ontology with the help of a guide through following the identified steps of (Noy & McGuinness, 2001):
    a. Determine the domain and scope of the ontology.
    b. Consider reusing existing ontologies.
    c. Enumerate the important terms in the ontology.
    d. Define the classes and the class hierarchy.
    e. Define the properties of classes - slots.
    f. Define the facets of the slots.
    g. Create instances.
    h. Evaluating (testing) the ontology.

    Full details about the development process of the Myasthenia Gravis ontology are found in Chapter 4.

3. Creating semantic rules: we define a set of rules for diagnosing the Myasthenia Gravis disease, checking the similarity between patients on the Myasthenia Gravis ontology and recommending appropriate treatments for the patients. They help us to achieve the goals of our approach which is diagnosing the Myasthenia Gravis disease and providing recommended

treatments for the patients, then to help us for correcting the approach results to obtain acceptable rate.

4. Reasoning: we apply an ontology reasoner we have chosen from the various reasoners such as HermiT, Pellet or FaCT++ reasoners on the ontology to get new facts that help to obtain the desired results from the knowledge base.
5. Developing a prototype for the proposed approach: we develop a system to achieve the goals of the proposed approach which consists of three parts as follows:
    a. *Knowledge base Interface*: we use JENA framework (Apache JENA, 2015) to develop this interface which will interact with the proposed ontology by running several SPARQL queries and extract results from that ontology.
    b. *User Interface*: the role of this interface is to send the various users' requests of information about the Myasthenia Gravis disease to the knowledge base, then receives the results and displays them on a web page to be used by the end user.

5.2 The Structure of the Proposed Approach

The structure of proposed system consists of the following modules as shown in Figure (5.1).

1. **The Myasthenia Gravis Disease Knowledge Base:** the core of our proposed approach is the ontology which consists of two parts. The first part is the proposed ontology; the second one is represented by the instances that are inserted into the ontology to make it as enriched knowledge base of the Myasthenia Gravis symptoms, habits and practices that may increase or decrease the impact of the Myasthenia Gravis disease, diagnostic methods, treatments methods, recommended treatments and several patients' information.

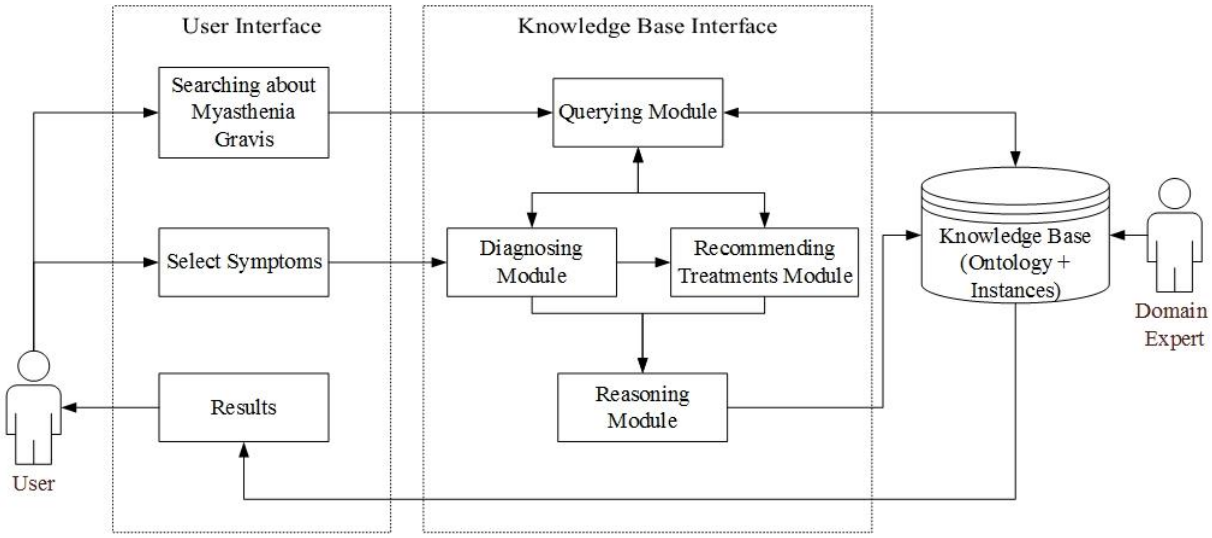

Figure (5.1): Proposed system architecture.

2. **Querying Module**: using this module, we can answer very specific questions about the Myasthenia Gravis disease that would be difficult to answer by looking at ontology directly. We can use SPARQL queries to extract, filter, calculate and summarize knowledge from the proposed ontology.

4. **Reasoning Module**: this module receives several rules from the Diagnosing module and the Recommending Treatments module, then it applies these rules to the ontology, finally run the JENA reasoner (Apache JENA, 2016) on the ontology to get new facts and relations. These facts can be queried through the Diagnosing module and the Recommending Treatments module by interacting with the querying module.

5. **Diagnosing Module**: this module receives selected symptoms from the user through the user interface then decides if the patient is infected with the Myasthenia Gravis disease or not by sending some specific diagnosing rules to the Reasoning module to apply and run them on the ontology, then using the Querying module to get the results from the ontology, finally it sends these results to the end user by displaying it on the web page.

6. **Recommending Treatments Module**: this module provides the recommended treatments through the knowledge base for each patient gradually starting from the body rest, drugs, surgery and other treatment methods. This means the treatment recommendations are determined based on how bad the condition of the patient and being compared to similar cases.

7. **User Interface**: the role of the user interface is to send the users' inputs such as symptoms to the knowledge base interface, and then receive the results that output from the knowledge base interface such as a query results or diagnosing the disease, then arranges, coordinates and displays it appropriately on a web page to be ready to use by the user.

The inputs of the proposed approach are symptoms and queries about information of the Myasthenia Gravis disease. The output is diagnosing status, recommending treatments if the patient is infected by Myasthenia Gravis disease and finally the results of the requested queries that are sent before by the user.

We can see how the proposed approach works from the flow chart diagram shown in Figure (5.2).

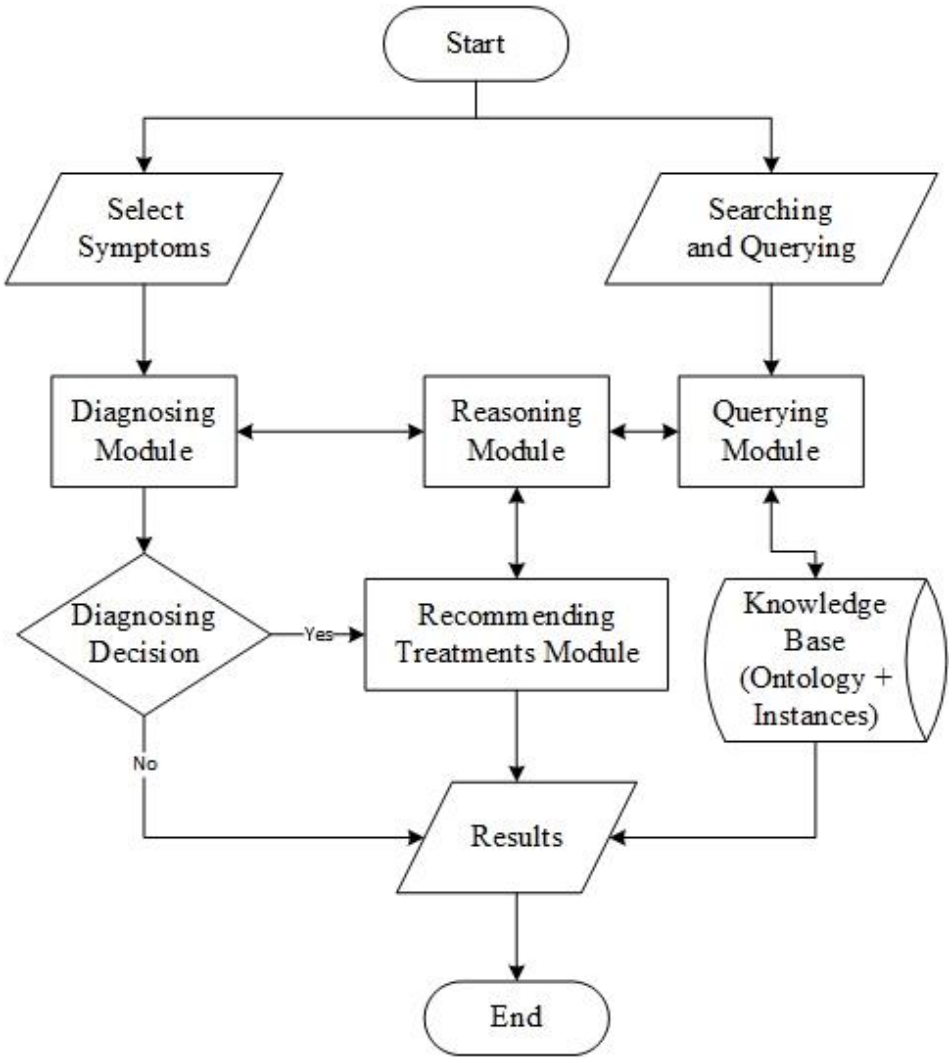

Figure (5.2): System flowchart.

Based on the flowchart, the user can:

- Select symptoms as input to the system which transfers these inputs to the Diagnosing module which decides if the patient who suffers from the selected symptoms is infected with the Myasthenia Gravis disease or not by applying specific diagnosing rules to the ontology, then using the Querying module to interact with the ontology and get results.
- If the patient is not infected by the Myasthenia Gravis disease, the result will appear immediately. But if he is infected, the Diagnosing module transfers all patient information to the Recommending Treatments module which provides the recommended treatments based on the ontology

through the knowledge base for this particular patient through comparing his case to a similar stable known cases in the knowledge base, then the results will appear.

- Also, the user can search and query about the disease such as reviewing the Myasthenia Gravis symptoms, diagnostic methods, treatment methods and other information. The system transfers the requested queries to the Querying module which queries the ontology using SPARQL queries and retrieves the results.

5.3 Collecting Patient Data (Making the Knowledge Base)

We made a questionnaire and distributed it to a number of local and international Myasthenia Gravis patients, to collect information about patients, disease symptoms, disease diagnoses and effective treatments. This enables us to build a rich ontology and knowledge base as a basis for building the proposed approach.

We used Google Forms (Google Inc., 2016) to design this questionnaire. It was difficult to find and reach the Myasthenia Gravis patients around the world because of the rarity of the Myasthenia Gravis disease. We contacted these patients to guide them to fill the questionnaire.

We have divided the questionnaire into several parts to facilitate the filling process for the patients, it consists of the following sections:

- A front page and introduction.
- The personal information of the patient.
- The disease history of the patient, diagnostic process and the symptoms.
- The treatments and drugs taken for the Myasthenia Gravis disease.
- Eaten foods and the Myasthenia Gravis disease.
- Played sport and the Myasthenia Gravis disease.
- The thymus gland and the adenectomy surgical of it.
- Other treatments as herbs and the Prophet Muhammad medicine.

After collecting patients' data, we arrange and prepare the data to be entered to our proposed ontology to become ready for use as a knowledge base.

Figure (5.3) shows the front page of the questionnaire; all parts of the questionnaire can be found in the Appendix.

Figure (5.3): The front page of the questionnaire.

5.4 Building the Ontology

Building and developing the proposed ontology is done based on Ontology Development 101: A Guide to Creating Your First Ontology (Noy & McGuinness, 2001) and using the Protégé tool (Stanford Center for Biomedical Informatics Research (BMIR), 2016) among various tools available for developing ontologies. The details of the ontology building process are found in Chapter 4.

5.5 Creating Semantic Rules

A set of rules is defined to obtain specific information from the knowledge base for diagnosing patients for the Myasthenia Gravis disease, and obtaining recommendations for appropriate treatments for each new patient by comparing his case with other stable cases in the knowledge base which have been diagnosed previously for the Myasthenia Gravis disease and suffer from the same symptoms and live a stable life.

We have chosen the JENA rule language among the various sematic rule languages such as SWRL to create the desired rules that we used in our approach. For example, one rule from the rules for diagnosing the Myasthenia Gravis disease is:

```
1.  [(?patient   التشخيص_قبل_عرض   الجفون_ارتخاء_عرض),
2.  (?patient    التشخيص_قبل_عرض   بالاعياء_شعور_عرض),
3.  (?patient    التشخيص_قبل_عرض   مجهود_أي_بذل_عند_الشديد_التعب_عرض)
4.  ->
5.  (?patient    تشخيصه_تم         العضلات_وهن)]
```

The rule states that: all patient individuals with the symptoms individuals "eyelid dropping" (in Arabic "ارتخاء الجفون"), "feeling sick" (in Arabic "الشعور بالإعياء") and "Muscle weakness when exertion" (in Arabic "التعب الشديد عند بذل أي مجهود") are diagnosed for the Myasthenia Gravis disease.

The set of rules to check the similarity between patients having the same symptoms are:

```
1.  [(?patient1 التشخيص_قبل_عرض ?symptom1),
2.  (?patient2 التشخيص_قبل_عرض ?symptom1),
3.  (?patient1 التشخيص_قبل_عرض ?symptom2),
4.  (?patient2 التشخيص_قبل_عرض ?symptom2),
5.  (?patient1 التشخيص_قبل_عرض ?symptom3),
6.  (?patient2 التشخيص_قبل_عرض ?symptom3),
7.  (?patient1 التشخيص_قبل_عرض ?symptom4),
8.  (?patient2 التشخيص_قبل_عرض ?symptom4),
9.  (?patient1 التشخيص_قبل_عرض ?symptom5),
10. (?patient2 التشخيص_قبل_عرض ?symptom5),
11. (?patient2 حالة_المرض مستقرة),
12. notEqual(?patient1,? patient2),
13. notEqual(?symptom1,?symptom2),
14. notEqual(?symptom1,?symptom3),
15. notEqual(?symptom1,?symptom4),
16. notEqual(?symptom1,?symptom5),
17. notEqual(?symptom2,?symptom3),
18. notEqual(?symptom2,?symptom4),
19. notEqual(?symptom2,?symptom5),
20. notEqual(?symptom3,?symptom4),
21. notEqual(?symptom3,?symptom5),
22. notEqual(?symptom4,?symptom5),
23. ->
24. (?patient2 يشبه ?patients1)],
```

These rules state that: if patient1 has the same five symptoms of patient2 and all five symptoms differ from each and the case status of patient2 is "stable" (in Arabic "مستقرة"), then the case of patient2 is similar to that of patient1.

The set of rules that provides the recommendation of appropriate treatments are:

```
1.  [(?patient1 type مرضى),
2.  (?patient2 type مرضى),
3.  notEqual(?patient1,? patient2),
4.  (?patient1 يشبه ?patient2),
5.  (?patient1 علاج_يستخدم ?treatment),
6.  (?patient1 مع_يتحسن_يشعر ?treatment),
7.  (?patient1 علاج_يستخدم ?treatment2),
8.  (?patient1 مع_يتحسن_يشعر ?treatment2),
9.  (?treatment3 type العقاقير),
10. (?patient1 علاج_يستخدم ?treatment3),
11. (?patient1 مع_يتحسن_يشعر ?treatment3),
12. (?treatment4 type العقاقير),
13. (?patient1 علاج_يستخدم ?treatment4),
14. (?patient1 مع_يتحسن_يشعر ?treatment4),
15. (?patient1 حالة_المرض مستقرة),
```

```
16. (?treatment3 type       ?class3),
17. (?treatment4 type       ?class4),
18. notEqual(?treatment,?treatment2),
19. notEqual(?treatment3,?treatment4),
20. notEqual(?class3,?class4),
21. ->
22. (?patient2 مقترح_علاج ?treatment2),
23. (?patient2 مقترح_علاج ?treatment3),
24. (?patient2 مقترح_علاج ?treatment4),
25. (?patient2 مقترح_علاج ?treatment)]
```

These rules state that: if two different patient individuals are members of the ontology class "Patients" (in Arabic "مرضى") and one of them takes different treatments for the Myasthenia Gravis disease and feels better with these treatments, and the case status of patient2 is "stable" (in Arabic "مستقرة"), then these different treatments are proposed the other patient.

We add these rules to the ontology using the Protégé tool as shown in Figure (5.4).

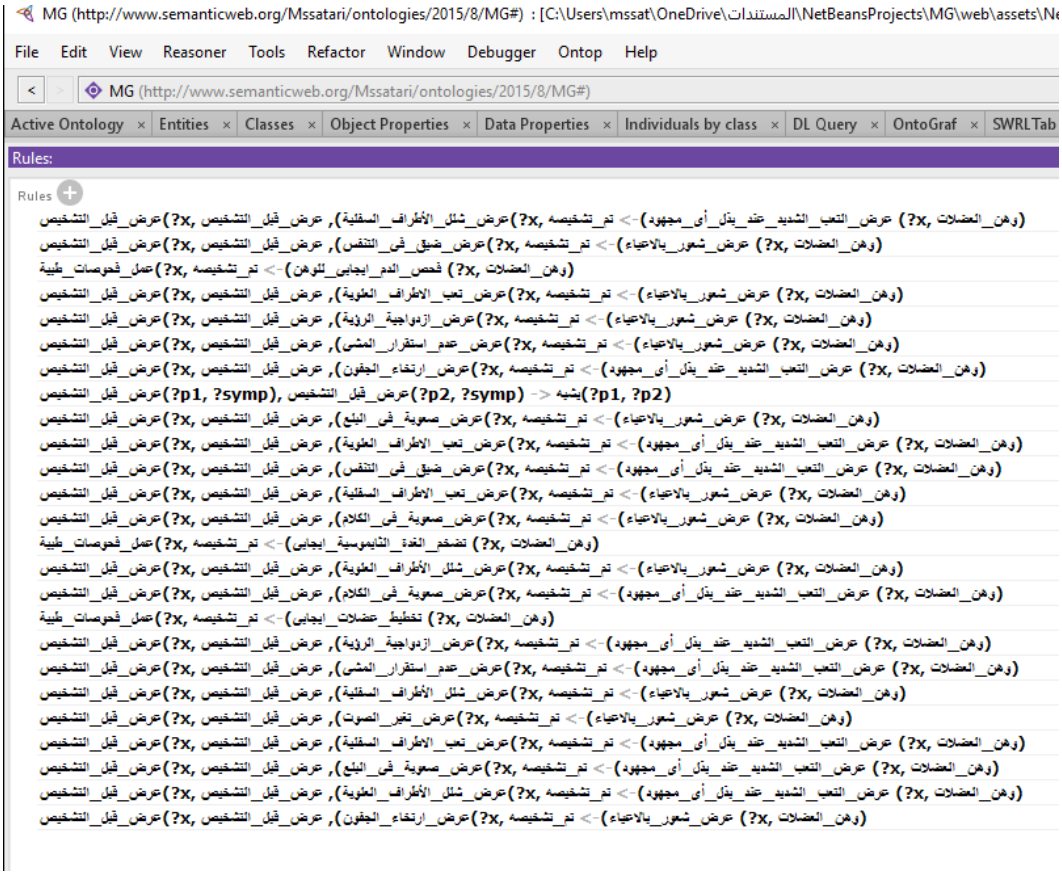

Figure (5.4): The defined rules shown in Protégé.

5.6 Reasoning

Reasoning is important to obtain new relations from existing ones. The reasoner is able to identify the different types of ontological relations such as transitive, symmetric, inverse and functional properties and use them to add new facts such as the "similar to" (in Arabic "يشبه"). In addition to reasoning, applying the predefined rules is performed to obtain new results of diagnosing the Myasthenia Gravis disease and also providing appropriate recommended treatments for patients.

An example of the reasoning applied to the ontology is the reasoning result of the "similar to" (in Arabic "يشبه") object property that is shown in Figure (5.5).

Figure (5.5): Reasoning result of the "similar to" (in Arabic "يشبه") object property.

The Figure (5.5) shows the result of applying reasoning on the ontology to get the similar patients of the patient "Mohammed Hasan" (in Arabic "محمد حسن") we found 4 patients whose cases are similar patient Mohammed Hasan are (P013, P018, P023 and P024).

5.7 Querying

The semantic querying allows to perform query statements which are written in SPARQL Query or DL Query. This semantic queries enable us to retrieve both explicitly and implicitly derived information. We can answer very specific questions about the Myasthenia Gravis disease that would be difficult to answer by looking at the ontology directly.

We use querying in all parts of the system to retrieve the desired information as needed such as Myasthenia Gravis symptoms (in Arabic "أعراض مرض وهن العضلات") and recommended practices that may increase or decrease the Myasthenia Gravis disease impact (in Arabic "ما يحسن الوهن" and "ما يزيد الوهن") as shown in Figure (5.6).

Figure (5.6): A recommended practices that may increase or decrease the Myasthenia Gravis disease impact.

5.8 Diagnosing

Diagnosing and recommending treatments are the core of the approach as we explain in Section (5.2). The knowledge base plays an important role in the system where it stores the knowledge about disease, symptoms, patients and treatments.

Based on the step of creating rules and the step of reasoning, we can diagnose new patients of Myasthenia Gravis disease. An example of one semantic rule that responsible for diagnosing a patient for the Myasthenia Gravis disease was presented as first example in Section (5.5).

The steps followed to diagnose a patient for the Myasthenia Gravis disease on the system are:

Step 1: Starting the diagnosis of disease process.

Step 2: The system shows a form including information about the patient such as his name, email, phone, blood type, sex, marital status and a list of symptoms, this form must be filled to continue the diagnosis process as shown in Figure (5.7).

Figure (5.7): The patient information form.

Step 3: After the user fills the form, he clicks to the "diagnose" button (in Arabic "تشخيص المرض").

Step 4: When the user clicks to the "diagnose" button (in Arabic " تشخيص المرض") the system inserts this patient into the ontology.

Step 5: The system creates the semantic rule for the diagnosis process as explained in Section (5.5).

Step 6: The system applies the previous semantic rules to the ontology by running the reasoner.

Step 7: The system executes a SPARQL query statement to obtain the diagnosis result. The query that is used to retrieve the check if the patient is diagnosed for the Myasthenia Gravis disease or not is:

```
1.  PREFIX abc: <http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#>
2.  SELECT ?subject ?object
3.      WHERE {
4.              ?subject abc:تشخيصه_تم ?object
5.              FILTER (?object = abc:العضلات_وهن).
6.              FILTER (?subject = abc:patientName).
7.      } order by ?subject
```

Step 8: the system displays the results of the diagnosis process on the user interface as shown in Figure (5.8)

5.9 Recommending Treatments

Based on creating rules and reasoning, we can recommend treatments for specific patients who are diagnosed for the Myasthenia Gravis disease. An example of one semantic rule that responsible for recommending appropriate treatments for a patient of the Myasthenia Gravis disease was presented as third example in Section (5.5)

Figure (5.8): The result of the diagnosis process.

The steps followed to recommend appropriate treatments are:

Step 1: After all of the diagnosis process steps, the system searches about similar patients to the given patient.

Step 2: The system creates the semantic rules for finding out similar patients of the given patient.

Step 3: The system applies the previous semantic rules to the knowledge base by running the reasoner.

Step 4: The system executes a SPARQL query statement to obtain the result of similarity of patients. The query that is used to retrieve the similar patients of the given patient is:

```
1.  PREFIX abc: <http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#>
2.  SELECT ?subject ?object
3.      WHERE {
4.              ?subject abc:يشبه ?object
5.              FILTER (?subject = abc:patientName).
6.      } order by ?subject
```

Step 5: The system displays the similar patients on the user interface as shown in Figure (5.8)

Step 6: The system creates the semantic rules for recommending appropriate treatments for the given patient.

Step 7: The system applies the previous semantic rules to the ontology by running the reasoner.

Step 8: The system executes a SPARQL query statement to obtain the result of recommending appropriate treatments. The query that is used to retrieve the recommended appropriate treatments of the given patient is:

```
1. PREFIX abc: <http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#>
2. SELECT ?subject ?object
3.       WHERE {
4.                ?subject abc:علاج_مقترح ?object
5.                FILTER (?subject = abc:patientName).
6.       } order by ?subject
```

Step 9: The system executes a SPARQL query statement to retrieve practices that may decrease the Myasthenia Gravis disease impact which is:

```
1. PREFIX abc: <http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#>
2. SELECT ?patient ?similar  ?decreaseMG
3.       WHERE {
4.                ?patient abc:يشبه ?similar.
5.                ?similar abc:يشعر_بتحسن_مع ?decreaseMG.
6.                FILTER (?patient = abc:patientName)
7. }
```

Step 10: The system executes a SPARQL query statement to retrieve practices that may increase the Myasthenia Gravis disease impact which is:

```
1. PREFIX abc: <http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#>
2. SELECT ?patient ?similar  ?decreaseMG
3.       WHERE {
4.                ?patient abc:يشبه ?similar.
5.                ?similar abc:يشعر_بسوء_مع ?decreaseMG.
6.                FILTER (?patient = abc:patientName)
7. }
```

Step 11: The system displays the appropriate recommended treatments and the previous practices on the user interface as shown in Figure (5.9)

Figure (5.9): The recommended treatments and practices that may decrease or increase the impact of the Myasthenia Gravis disease.

5.10 Developing a Prototype of the Proposed Approach

After building the knowledge base, we developed an ontology-based prototype that can be used to diagnose the Myasthenia Gravis disease and provide recommended treatments to achieve the goals of the approach. Next, we elaborate in this prototype.

5.10.1 Requirements

- The system allows the doctor to enter symptoms to diagnose a patient for the Myasthenia Gravis disease.
- The system returns a recommended treatments and recommended practices that may increase and decrease the Myasthenia Gravis disease to each patient separately from the other stabled patients.
- The system allows doctors and patients to query for the diagnostic methods of the Myasthenia Gravis disease.
- The system allows doctors and patients to query for drugs to avoid that may increase the impact of the Myasthenia Gravis disease.
- The system allows doctors and patients to query for drugs that may be used to treat for the Myasthenia Gravis disease.
- The system allows doctors and patients to query for treatment methods of the Myasthenia Gravis disease.
- The system allows doctors and patients to find out what habits and practices can increase the impact of the Myasthenia Gravis disease for all patients.
- The system allows doctors and patients to query for the unknown symptoms of the Myasthenia Gravis disease.
- The system allows doctors and patients to query for the known symptoms of the Myasthenia Gravis disease

5.10.2 System Functions

We employ use cases to describe each functional requirement. We describe various of use cases that define the interactions between a role (actor) and the system. That actor can be a human or other external system.

The use cases that are used to describe the functionality of the whole system are shown in Table (5.1).

Table (5.1): Use cases table.

Use Case No.	Use Case	Actor
1.	Diagnosing a patient for the Myasthenia Gravis disease or not	Doctor
2.	Getting the recommended treatments and recommended practices from the system that may be increase or decrease the impact of the Myasthenia Gravis disease.	Doctor
3.	Query for the diagnosing methods of the Myasthenia Gravis disease	Doctor or patient
4.	Query for the drugs to avoid that may increase the impact of the Myasthenia Gravis disease	Doctor or patient
5.	Query for the drugs that are used to treat the Myasthenia Gravis disease	Doctor or patient
6.	Query for the treatment methods of the Myasthenia Gravis disease	Doctor or patient
7.	Find out what habits and practices might increase the impact of the Myasthenia Gravis disease for all patients.	Doctor or patient
8.	Find out what habits and practices might decrease the impact of the Myasthenia Gravis disease for all patients.	Doctor or patient
9.	Query for the unknown symptoms of the Myasthenia Gravis disease	Doctor or patient
10.	Query for the known symptoms of the Myasthenia Gravis disease	Doctor or patient

Use case 1: Diagnosing a patient for the Myasthenia Gravis disease or not.

Primary Actor	Doctor
Main Scenario	1. A patient suffers from symptoms similar to the Myasthenia Gravis symptoms. 2. The doctor enters to the user interface of the Myasthenia Gravis system to diagnose patient. 3. He presses to the "diagnosing the MG" button. 4. The user interface shows a web page contain fields must be filled about the personal information and the symptoms of the patients. 5. The system decides if the patient is infected with the Myasthenia Gravis disease or not. 6. The user interface displays the results.

Use case 2: Getting the recommended treatments and recommended practices from the system that may increase or decrease the impact of the Myasthenia Gravis disease.

Primary Actor	Doctor
Main Scenario	1. The doctor enters to the user interface of the Myasthenia Gravis system to get a recommended treatments for a patients. 2. He presses "diagnosing the MG" button. 3. User interface shows a web page which contain fields that must be filled about the personal information and the symptoms of the patient. 4. The user interface displays the treatments recommendations for this patient.

Use case 3: Query for the diagnostic methods of the Myasthenia Gravis disease**.**

Primary Actor	Doctor or patient
Main Scenario	1. A user of the web enters on the user interface of the Myasthenia Gravis system. 2. He presses "diagnostic methods" button. 3. The user interface requests the diagnosing methods list of the Myasthenia Gravis disease by sending a SPARQL query to the MG ontology. 4. The ontology executes the SPARQL query. 5. The ontology gets a result from the SPARQL query. 6. The ontology sends the result to the user interface. 7. The user interface displays the results of the query to the user in a table.

Use case 4: Query for the drugs to avoid that may increase the impact of the Myasthenia Gravis disease**.**

Primary Actor	Doctor or patient
Main Scenario	1. A user of the web enters on the user interface of the Myasthenia Gravis system. 2. He presses "drugs to avoid with MG" button. 3. The user interface requests the drugs to avoid list of the Myasthenia Gravis disease by sending a SPARQL query to the MG ontology. 4. The ontology executes the SPARQL query. 5. The ontology gets a result from the SPARQL query. 6. The ontology sends the result to the user interface.

Primary Actor	Doctor or patient
	7. The user interface displays the results of the query to the user in a table.

Use case 5: Query for the drugs that are used to treat the Myasthenia Gravis disease**.**

Primary Actor	Doctor or patient
Main Scenario	1. A user of the web enters on the user interface of the Myasthenia Gravis system. 2. He presses "MG drugs" button. 3. The user interface requests the drugs list of the Myasthenia Gravis disease by sending a SPARQL query to the MG ontology. 4. The ontology executes the SPARQL query. 5. The ontology gets a result from the SPARQL query. 6. The ontology sends the result to the user interface. 7. The user interface displays the results of the query to the user in a table.

Use case 6: Query for the treatment methods of the Myasthenia Gravis disease**.**

Primary Actor	Doctor or patient
Main Scenario	1. A user of the web enters on the user interface of the Myasthenia Gravis system. 2. He presses "MG treatment" button. 3. The user interface requests the treatment methods of the Myasthenia Gravis disease by sending a SPARQL query to the MG ontology. 4. The ontology executes the SPARQL query. 5. The ontology gets a result from the SPARQL query. 6. The ontology sends the result to the user interface. 7. The user interface displays the results of the query to the user in a table.

Use case 7: Find out what habits and practices might increase the impact of the Myasthenia Gravis disease for all patients**.**

Primary Actor	Doctor or patient
Main Scenario	1. Hasan is a scientist in medicine and he enters on the user interface of the Myasthenia Gravis system. 2. Hasan presses "be careful with MG" button. 3. The user interface request what habits and practices can increase the impact of the Myasthenia Gravis disease by sending a SPARQL query to the MG ontology.

Primary Actor	Doctor or patient
	4. The ontology executes the SPARQL query. 5. The ontology gets a result from the SPARQL query. 6. The ontology sends the result to the user interface. 7. The user interface displays the results of the query to the user in a table.

Use case 8: Find out what habits and practices might decrease the impact of the Myasthenia Gravis disease for all patients**.**

Primary Actor	Doctor or patient
Main Scenario	1. Ali is a Myasthenia Gravis patient and he enters on the user interface of the Myasthenia Gravis system. 2. Ali presses "improving the MG" button. 3. The user interface request what habits and practices can improves the Myasthenia Gravis disease by sending a SPARQL query to the MG ontology. 4. The ontology executes the SPARQL query. 5. The ontology gets a result from the SPARQL query. 6. The ontology sends the result to the user interface. 7. The user interface displays the results of the query to the user in a table.

Use case 9: Query for the unknown symptoms of the Myasthenia Gravis disease**.**

Primary Actor	Doctor or patient
Main Scenario	1. Ahmed is a Myasthenia Gravis patient and he enters on the user interface of the Myasthenia Gravis system. 2. Ahmed presses "unknown symptoms" button. 3. The user interface requests the MG unknown symptoms by sending a SPARQL query to the MG ontology. 4. The ontology executes the SPARQL query. 5. The ontology gets a result from the SPARQL query. 6. The ontology sends the result to the user interface. 7. The user interface displays the results of the query to the user in a table.

Use case 10: Query for the known symptoms of the Myasthenia Gravis disease**.**

Primary Actor	Doctor or patient
Main Scenario	1. Dr. Mohammed enter to the user interface of the Myasthenia Gravis system. 2. Dr. Mohammed presses "known symptoms" button. 3. The user interface requests the MG known symptoms by sending a SPARQL query to the MG ontology. 4. The ontology executes the SPARQL query. 5. The ontology gets a result from the SPARQL query. 6. The ontology sends the result to the user interface. 7. The user interface displays the results of the query to the user in a table.

5.10.3 Knowledge Base Interface Development

We develop a JENA (Apache JENA, 2015) modules interface whose major role is to interact with the Myasthenia Gravis knowledge base by running several SPARQL queries and extracting results from the knowledge base. It receives the user input such as symptoms and queries, then it executes some SPARQL queries as it is required from the user, getting the desired results and finally return these results to the user.

The knowledge base interface consists of a set of modules such as querying module, diagnosing module, recommending treatments module. Full details about these modules are covered in Section (5.2).

5.10.4 Applying an Ontology Reasoner

After creating semantic rules, we invoke the ontology reasoner called JENA reasoner (Apache JENA, 2016) to get new facts from the ontology and its instances (knowledge base) that help to obtain the desired results of diagnosing for the Myasthenia Gravis disease and providing an appropriate recommended treatments for patients.

An example of applying a rule from the rules that recommend the appropriate treatments on the knowledge base:

```
1.  public List<String> treatmentReommendations(String patientName) {
2.  List<String> list = new ArrayList<String>();
3.  OntModel model = ModelFactory.createOntologyModel();
4.  FileManager.get().readModel(model, "http://localhost:8080/MG/assets/NewMG.owl");
5.
6.  String rdf = "http://www.w3.org/1999/02/22-rdf-syntax-ns#";
7.  String rdfs = "http://www.w3.org/2000/01/rdf-schema#";
8.  String prefix = "http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#";
9.  String owl = "http://www.w3.org/2002/07/owl#";
10. String rule = "";
11. rule += "[(?p1 " + rdf + "type " + prefix + "مرضى),"
12.       + "(?p2 " + rdf + "type " + prefix + "مرضى),"
13.       + "notEqual(?p1,?p2),"
14.       + "(?p1 " + prefix + "يشبه ?p2),"
15.       + "(?p1 " + prefix + "علاج_يستخدم ?treatment),"
16.       + "(?p1 " + prefix + "مع_يتحسن_يشعر ?treatment),"
17.       + "(?p1 " + prefix + "علاج_يستخدم ?treatment2),"
18.       + "(?p1 " + prefix + "مع_يتحسن_يشعر ?treatment2),"
19.       + "notEqual(?treatment,?treatment2),"
20.       + "(?p1 " + prefix + "علاج_يستخدم ?treatment3),"
21.       + "(?p1 " + prefix + "مع_يتحسن_يشعر ?treatment3),"
22.       + "(?p1 " + prefix + "علاج_يستخدم ?treatment4),"
23.       + "(?p1 " + prefix + "مع_يتحسن_يشعر ?treatment4),"
24.       + "(?treatment3 " + rdf + "type " + prefix + "العقاقير)"
25.       + "(?treatment4 " + rdf + "type " + prefix + "العقاقير)"
26.       + "(?treatment3 " + rdf + "type ?class3)"
27.       + "(?treatment4 " + rdf + "type ?class4)"
28.       + "notEqual(?treatment3,?treatment4),"
29.       + "notEqual(?class3,?class4),"
30.       + "-> "
31.       + "(?p2 " + prefix + "مقترح_علاج ?treatment2),"
32.       + "(?p2 " + prefix + "مقترح_علاج ?treatment3),"
33.       + "(?p2 " + prefix + "مقترح_علاج ?treatment4),"
34.       + "(?p2 " + prefix + "مقترح_علاج ?treatment)]";
35.
36. Reasoner reasoner = new GenericRuleReasoner(Rule.parseRules(rule));
37.
38. infModelRecommendations = ModelFactory.createInfModel(reasoner, infModelSimilar);
39. Query query = QueryFactory.create(
40.         "PREFIX abc: <http://www.semanticweb.org/Mssatari/ontologies/2015/8/MG#>\n"
41.       + "SELECT ?subject ?object\n"
42.       + "       WHERE { \n"
43.       + "       ?subject abc:مقترح_علاج ?object\n"
44.       + "    FILTER (?subject = abc:" + patientName + ")."
45.       + "       } order by ?subject"
46. );
47.
48. QueryExecution qe = QueryExecutionFactory.create(query, infModelRecommendations);
49. ResultSet rs = qe.execSelect();
50.
```

```
51.  while (rs.hasNext()) {
52.        QuerySolution qs = rs.nextSolution();
53.        RDFNode d1 = qs.get("object");
54.        String[] pp = d1.toString().split("#");
55.        list.add(pp[1].toString());
56.  }
57.
58.  return list;
59.  }
```

As shown in the previous code we can find the code that is responsible for opening and loading the ontology on line number 4, the prefixes definition that is used the ontology processes are found on lines 6 to 9, the definition of the semantic rules that are used to proposed appropriate recommended treatments is found on lines 10 to 34, the code that is responsible for reasoning and getting a new facts from the ontology is shown on lines 36 to 38, and finally executing a query to get new facts and return them as array list is found on lines 39 to the end of the code.

5.11 User Interface

The major role of the user interface is to send to the knowledge base interface various user's requests of information about the Myasthenia Gravis disease, to receive the results from the knowledge interface, arrange and display these results to the user.

The user interface is implemented using HTML, Java Server Pages (JSP) and Servlet.

An example of using the user interface by entering the patient symptoms is shown in Figure (5.10).

The patient's symptoms interface consists of information about the patient such as the contact information included name, email, and phone number, and the patient health information included blood type, sex, marital status and symptoms list.

Another example of diagnosing and recommending treatments and practices are shown in Figure (5.11) and Figure (5.12).

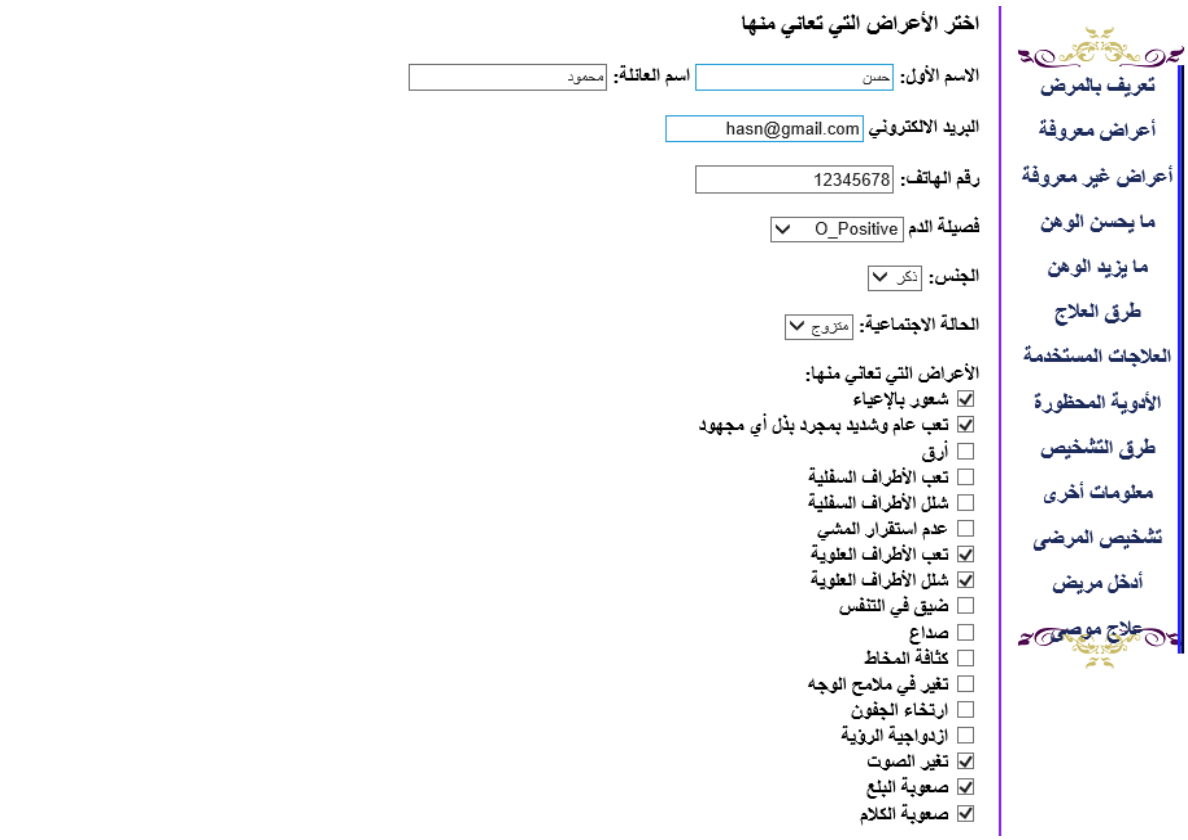

Figure (5.10): Entering the patient symptoms.

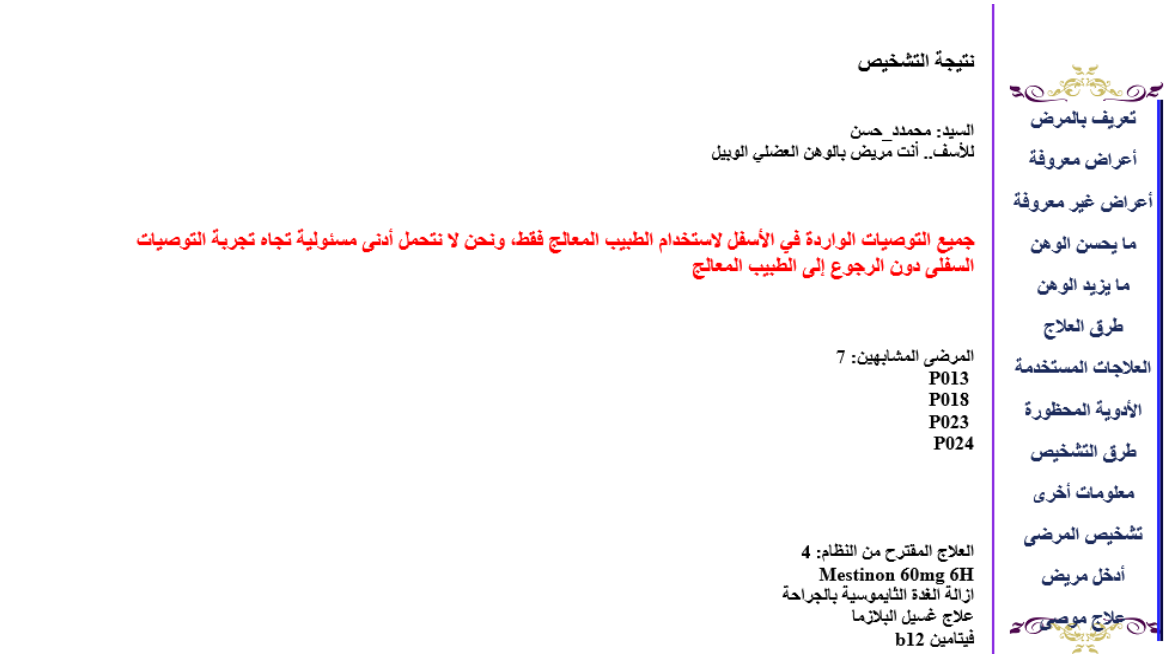

Figure (5.11): The diagnosing process of a patient and the recommended treatments that the system provided.

We design the results page, shown in Figure (5.11), to consist of the results of diagnosing the patient for the Myasthenia Gravis disease. In the case that is shown in Figure (5.11), the entered symptoms of a patient show that this patient suffers from the Myasthenia Gravis disease.

Figure (5.12): The recommended practices that may decrease or increase the impact of the Myasthenia Gravis disease.

The next part in the results page, shown in Figure (5.12), shows the recommended treatments for the given patient, a recommended practices that may decrease the Myasthenia Gravis disease impact and a recommended practices that may increase the Myasthenia Gravis disease impact.

In the case shown in Figure (5.12), the system recommended four treatments for the given patient consisting of the drug Mestinon 60mg every 6 hours, the removal of thymus gland (in Arabic "إزالة الغدة الثايموسية"), Plasmapheresis and IVI (in Arabic "غسيل البلازما") and vitamins and supplements drug B12 (in Arabic "فيتامين B12"). The other

two parts show a number of recommended practices that may decrease or increase the Myasthenia Gravis disease impact included, as examples, decreasing the impact of the disease such as sleeping (in Arabic "النوم"), bathing with cold water (in Arabic "الاستحمام بالماء البارد") and another example of increasing the impact of the disease such as cortisone drug, staying up late (in Arabic "السهر") and weather changes (in Arabic "تقلبات الطقس").

5.12 Summary

In this chapter, we explain the Myasthenia Gravis system architecture and system processes through system flowchart. Then we have presented the phases of building the Myasthenia Gravis system which are collection patients data, building the knowledge base (ontology and instances), creating the semantic rules, reasoning, implemented the knowledge base interface and the user interface. We have described the system functionality through various use cases.

Chapter 6

Results and Discussion

In this chapter, we present the experiments performed for the preliminary evaluation process of the proposed ontology and system. We evaluate firstly the diagnostic process accuracy of the approach by entering information about a number of persons who are infected with the Myasthenia Gravis disease and evaluate the results. Secondly, we evaluate the recommendation treatments process according to a human expert in Brian and Neurology by comparing his recommended treatments of a case of a patient with the recommended treatments of the doctor who treated this case, then with the recommendations of the approach which recommended to treat the same patient, finally we evaluate the efficiency of the approach by comparing the speed of the processes with the average delay in traditional diagnosing of a patient.

6.1 Evaluation Tools

For the evaluation process and carrying out the experiments to obtain the results, we used the following tools:

6.1.1 SPARQL Query Language

We used the SPARQL Protocol and RDF Query Language (SPARQL) (Prud'Hommeaux & Seaborne, 2008) to perform the evaluation results of queries.

6.1.2 Apache JENA

We used the JENA (Apache JENA, 2015) as interface to interact with the ontology (OWL files) to send the test cases, running a lot of queries and getting the results.

6.1.3 JENA Reasoner

We used the JENA reasoner (Apache JENA, 2016) to evaluate the diagnosing process by applying a lot of web semantic rules to the test cases and get the test results.

6.1.4 JavaServer Pages

We used the Java Server Pages (Oracle, 2016) to implement user interface and interact with the JENA interface (Apache JENA, 2015) and display the results of the evaluation process.

6.2 Preliminary Evaluation of the System

In this section, we describe how we carried out the experimental test to evaluate the accuracy and efficiency of the system according to three parts as follows:

6.2.1 The Accuracy of Diagnosing MG by the System

This is the first part of the preliminary evaluation process. We calculate how many patients the system can diagnose correctly for the Myasthenia Gravis disease; this part of the preliminary evaluation includes 36 real patients who are diagnosed for the Myasthenia Gravis disease. We enter the symptoms of each of these patients to the Diagnosing module in the system, get the diagnosing results and calculate the accuracy of diagnosing the Myasthenia Gravis disease.

The test cases with their symptoms that are used in this part of the preliminary evaluation and entered to the Diagnosing module are shown in Table (6.1).

Table (6.1): Test cases with their symptoms that are entered to the Diagnosing module.

Case No.	Symptoms (English and Arabic)
1	Muscle weakness when exertion, weakness of upper limbs, shortness of breath, change in facial features, eyelid dropping, change in voice, difficulties with swallow, difficulties with speech and chest pain.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف العلوية، ضيق في التنفس، تغير في ملامح الوجه، ارتخاء الجفون، تغير الصوت، صعوبة البلع، صعوبة الكلام، آلام في الصدر.
2	Muscle weakness when exertion, insomnia, weakness of lower limbs, paralysis of the lower limbs, unstable walking, weakness of upper limbs, paralysis of the upper limbs, eyelid dropping, change in voice, difficulties with swallow, difficulties with speech.
	تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، شلل الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، شلل الأطراف العلوية، ارتخاء الجفون، تغير الصوت، صعوبة البلع، صعوبة الكلام.

Case No.	Symptoms (English and Arabic)
3	Eyelid dropping, double vision, chest pain.
	ارتخاء الجفون، ازدواجية الرؤية، آلام في الصدر.
4	Feeling sick, muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, changes in facial features, double vision, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، تغير في ملامح الوجه، ازدواجية الرؤية، صعوبة الكلام.
5	Eyelid dropping, double vision.
	ارتخاء الجفون، ازدواجية الرؤية.
6	Muscle weakness when exertion, insomnia, weakness of lower limbs, unstable walking, shortness of breath, double vision, eyelid dropping, changes in facial features, change in voice, difficulties with speech.
	تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، عدم استقرار المشي، ضيق في التنفس، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة الكلام.
7	Feeling sick, weakness of lower limbs, unstable walking, changes in facial features, eyelid dropping, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب الأطراف السفلية، عدم استقرار المشي، تغير في ملامح الوجه، ارتخاء الجفون، صعوبة البلع، صعوبة الكلام.
8	Muscle weakness when exertion, weakness of lower limbs, shortness of breath, eyelid dropping, double vision, change in voice, difficulties with swallow, difficulties with speech, chest pain.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، ضيق في التنفس، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام، آلام في الصدر.
9	Insomnia, eyelid dropping, double vision, change in voice, difficulties with swallow.
	أرق، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع.
10	Feeling sick, muscle weakness when exertion, insomnia, change in voice, difficulties with swallow, difficulties with speech.

Case No.	Symptoms (English and Arabic)
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، أرق، تغير الصوت، صعوبة البلع، صعوبة الكلام.
11	Feeling sick, muscle weakness when exertion, insomnia, weakness of lower limbs, unstable walking, weakness of upper limbs, shortness of breath, changes in facial features, eyelid dropping, double vision, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ضيق في التنفس، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
12	Eyelid dropping, muscle weakness when exertion, insomnia, chest pain.
	ارتخاء الجفون، ازدواجية الرؤية تعب عام وشديد بمجرد بذل أي مجهود، أرق، آلام في الصدر.
13	Insomnia, double vision, eyelid dropping, double vision, feeling sick, heavy mucus.
	أرق، كثافة المخاط، ارتخاء الجفون، ازدواجية الرؤية، شعور بالإعياء.
14	Muscle weakness when exertion, weakness of lower limbs, weakness of upper limbs, paralysis of the upper limbs, shortness of breath, heavy mucus, changes in facial features, change in voice, difficulties with swallow, difficulties with speech.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، تعب الأطراف العلوية، شلل الأطراف العلوية، ضيق في التنفس، كثافة المخاط، تغير في ملامح الوجه، تغير الصوت، صعوبة البلع، صعوبة الكلام.
15	Muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, shortness of breath, changes in facial features, eyelid dropping, double vision, change in voice, difficulties with swallow, difficulties with speech, heavy mucus.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ضيق في التنفس، كثافة المخاط، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.

Case No.	Symptoms (English and Arabic)
16	Feeling sick, muscle weakness when exertion, unstable walking, shortness of breath, heavy mucus, changes in facial features, eyelid dropping, double vision.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، عدم استقرار المشي، ضيق في التنفس، كثافة المخاط، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية.
17	Feeling sick, muscle weakness when exertion, unstable walking, shortness of breath, changes in facial features, eyelid dropping, double vision, heavy mucus.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، عدم استقرار المشي، ضيق في التنفس، كثافة المخاط، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية.
18	Feeling sick, muscle weakness when exertion, chest pain, shortness of breath, eyelid dropping, double vision.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، آلام في الصدر، ضيق في التنفس، ارتخاء الجفون، ازدواجية الرؤية.
19	Feeling sick, muscle weakness when exertion, eyelid dropping, double vision.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، ارتخاء الجفون، ازدواجية الرؤية.
20	Muscle weakness when exertion, weakness of upper limbs, eyelid dropping, chest pain.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف العلوية، ارتخاء الجفون، آلام في الصدر.
21	Muscle weakness when exertion, insomnia, weakness of lower limbs, unstable walking, weakness of upper limbs, eyelid dropping, double vision.
	تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ارتخاء الجفون، ازدواجية الرؤية.
22	Feeling sick, muscle weakness when exertion, weakness of upper limbs, shortness of breath, headache, heavy mucus, changes in facial features, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف العلوية، ضيق في التنفس، صداع، كثافة المخاط، تغير في ملامح الوجه، تغير الصوت، صعوبة البلع، صعوبة الكلام.

Case No.	Symptoms (English and Arabic)
23	Feeling sick, muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, changes in facial features, eyelid dropping, double vision, change in voice, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة الكلام.
24	Feeling sick, muscle weakness when exertion, weakness of lower limbs, weakness of upper limbs, change in voice, headache, change in voice, difficulties with swallow.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، تعب الأطراف العلوية، صداع، تغير الصوت، صعوبة البلع.
25	Muscle weakness when exertion, paralysis of the lower limbs, changes in facial features, eyelid dropping, difficulties with speech, chest pain.
	تعب عام وشديد بمجرد بذل أي مجهود، شلل الأطراف السفلية، تغير في ملامح الوجه، ارتخاء الجفون، صعوبة الكلام، آلام في الصدر.
26	Muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, shortness of breath, heavy mucus, headache, changes in facial features, eyelid dropping, double vision, change in voice, difficulties with swallow, difficulties with speech.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ضيق في التنفس، صداع، كثافة المخاط، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
27	Feeling sick, changes in facial features, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تغير في ملامح الوجه، تغير الصوت، صعوبة البلع، صعوبة الكلام.
28	Feeling sick, muscle weakness when exertion, insomnia, weakness of lower limbs, unstable walking, weakness of upper limbs, shortness of breath, changes in facial features, eyelid dropping, double vision, change in voice, difficulties with swallow, difficulties with speech.

Case No.	Symptoms (English and Arabic)
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ضيق في التنفس، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
29	Feeling sick, weakness of lower limbs, weakness of upper limbs, difficulties with speech, changes in facial features.
	شعور بالإعياء، تعب الأطراف السفلية، تعب الأطراف العلوية، تغير في ملامح الوجه، صعوبة الكلام.
30	Feeling sick, muscle weakness when exertion, insomnia, weakness of lower limbs, paralysis of the lower limbs, unstable walking, weakness of upper limbs, paralysis of the upper limbs, heavy mucus, headache, shortness of breath, double vision, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، شلل الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، شلل الأطراف العلوية، ضيق في التنفس، صداع، كثافة المخاط، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
31	Muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, changes in facial features, change in voice, difficulties with swallow, difficulties with speech, chest pain.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، تغير في ملامح الوجه، تغير الصوت، صعوبة البلع، صعوبة الكلام، آلام في الصدر.
32	Muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, changes in facial features, eyelid dropping, double vision, change in voice, difficulties with swallow, difficulties with speech.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
33	Feeling sick, muscle weakness when exertion, weakness of lower limbs, paralysis of the lower limbs, unstable walking, weakness of upper limbs, paralysis of the upper limbs, changes in facial features, eyelid dropping,

Case No.	Symptoms (English and Arabic)
	double vision, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، شلل الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، شلل الأطراف العلوية، صداع، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
34	Muscle weakness when exertion, shortness of breath.
	تعب عام وشديد بمجرد بذل أي مجهود، ضيق في التنفس.
35	Feeling sick, muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, eyelid dropping, double vision.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ارتخاء الجفون، ازدواجية الرؤية.
36	Weakness of lower limbs, unstable walking, weakness of upper limbs, change in voice, chest pain.
	تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، تغير الصوت، آلام في الصدر.

The results of evaluating the diagnosing process are shown in Table (6.2).

Table (6.2): Results of test cases that are entered to the Diagnosing module.

Case No.	System Result
1	Diagnosed to have Myasthenia Gravis disease.
2	Diagnosed to have Myasthenia Gravis disease.
3	**Diagnosed not to have Myasthenia Gravis disease.**
4	Diagnosed to have Myasthenia Gravis disease.
5	**Diagnosed not to have Myasthenia Gravis disease.**
6	Diagnosed to have Myasthenia Gravis disease.
7	Diagnosed to have Myasthenia Gravis disease.
8	Diagnosed to have Myasthenia Gravis disease.
9	**Diagnosed not to have Myasthenia Gravis disease.**
10	Diagnosed to have Myasthenia Gravis disease.
11	Diagnosed to have Myasthenia Gravis disease.
12	Diagnosed to have Myasthenia Gravis disease.

Case No.	System Result
13	Diagnosed to have Myasthenia Gravis disease.
14	Diagnosed to have Myasthenia Gravis disease.
15	Diagnosed to have Myasthenia Gravis disease.
16	Diagnosed to have Myasthenia Gravis disease.
17	Diagnosed to have Myasthenia Gravis disease.
18	Diagnosed to have Myasthenia Gravis disease.
19	Diagnosed to have Myasthenia Gravis disease.
20	Diagnosed to have Myasthenia Gravis disease.
21	Diagnosed to have Myasthenia Gravis disease.
22	Diagnosed to have Myasthenia Gravis disease.
23	Diagnosed to have Myasthenia Gravis disease.
24	Diagnosed to have Myasthenia Gravis disease.
25	Diagnosed to have Myasthenia Gravis disease.
26	Diagnosed to have Myasthenia Gravis disease.
27	**Diagnosed not to have Myasthenia Gravis disease.**
28	Diagnosed to have Myasthenia Gravis disease.
29	Diagnosed to have Myasthenia Gravis disease.
30	Diagnosed to have Myasthenia Gravis disease.
31	Diagnosed to have Myasthenia Gravis disease.
32	Diagnosed to have Myasthenia Gravis disease.
33	Diagnosed to have Myasthenia Gravis disease.
34	**Diagnosed not to have Myasthenia Gravis disease.**
35	Diagnosed to have Myasthenia Gravis disease.
36	Diagnosed to have Myasthenia Gravis disease.

Based on these results, it is clear that the system was able to diagnose 31 patients correctly out of 36 patients, and failed to diagnose 5 patients (the cases 3, 5, 9, 27 and 34).

Therefore, the system achieved a rate of accuracy in diagnosing the Myasthenia Gravis disease of 86.11%.

6.2.2 The accuracy of the Recommendation Treatments by the System

This is the second part of the preliminary evaluation process, we reviewed the recommended treatments by an expert in Brian and Neurology through comparing his recommended treatments of patient with the recommended treatments of the doctor who treated this patient and with the recommended treatments of the system.

The first step of the method of calculating the degree of accuracy by the expert is as follows: every recommendation which the expert recommends exists in the system's recommendations take full accuracy ratio from the total of recommendations, and vice versa, if it does not exist in the system's recommendations takes zero accuracy from the total of recommendations. For example, if the expert recommends 4 a treatment recommendations, every recommendation takes 25% of the total ratio. That means, if the system recommends 3 a treatment recommendations from the previous 4, it will achieve accuracy of 75%.

The second step, every wrong recommendation of the system that may be harmful to the patient will decrease the total accuracy ratio of the recommendations. For example, if the system recommends 5 treatment recommendations, 4 of them are correct and the fifth one may be harmful to the patients, the accuracy of the treatment recommendations is 75%. The same method applies to the prescriptions too.

This part of the preliminary evaluation includes a 24 real patients who are diagnosed for the Myasthenia Gravis disease and taking drugs and treatments according to their doctors' prescriptions. The test cases and their symptoms in this part of the preliminary evaluation which are given to the human expert shown in Table (6.3).

Table (6.3): Test cases with their symptoms that are reviewed by the human expert.

Case No	Symptoms in English	Symptoms in Arabic
P001	Eyelid dropping Weakness of lower limbs Weakness of upper limbs Muscle weakness when exertion Feeling sick	ارتخاء الجفون تعب الأطراف السفلية تعب الأطراف العلوية تعب عام وشديد بمجرد بذل أي مجهود شعور بالإعياء
P002	Difficulties with swallow Insomnia Shortness of breath Muscle weakness when exertion Weakness of lower limbs	صعوبة في البلع أرق ضيق في التنفس تعب عام وشديد بمجرد بذل أي مجهود تعب الأطراف السفلية
P004	Changes in facial features Difficulties with speech Muscle weakness when exertion Weakness of upper limbs Shortness of breath Change in voice Difficulties with swallow Eyelid dropping	تغير ملامح الوجه صعوبة في الكلام تعب عام وشديد بمجرد بذل أي مجهود تعب الأطراف العلوية ضيق في التنفس تغير الصوت صعوبة في البلع ارتخاء الجفون
P005	Eyelid dropping Muscle weakness when exertion Difficulties with swallow Difficulties with speech Paralysis of the lower limbs Unstable walking Change in voice Insomnia Weakness of lower limbs Paralysis of the upper limbs Weakness of upper limbs	ارتخاء الجفون تعب عام وشديد بمجرد بذل أي مجهود صعوبة في البلع صعوبة في الكلام شلل الأطراف السفلية عدم استقرار المشي تغير في الصوت أرق تعب الأطراف السفلية شلل الأطراف العلوية تعب الأطراف العلوية
P006	Muscle weakness when exertion Weakness of upper limbs Unstable walking Difficulties with speech Weakness of lower limbs Changes in facial features Feeling sick Double vision	تعب عام وشديد بمجرد بذل أي مجهود تعب الأطراف العلوية عدم استقرار المشي تعب الأطراف السفلية صعوبة في الكلام تغير في ملامح الوجه شعور بالإعياء ازدواجية الرؤية
P008	Difficulties with swallow Insomnia Shortness of breath	صعوبة في البلع أرق ضيق في التنفس

Case No	Symptoms in English	Symptoms in Arabic
	Muscle weakness when exertion Weakness of lower limbs	تعب عام وشديد عند بذل أي مجهود تعب الأطراف السفلية
P009	Weakness of lower limbs Changes in facial features Eyelid dropping Difficulties with swallow Feeling sick Unstable walking Difficulties with speech	تعب الأطراف السفلية تغير في ملامح الوجه ارتخاء الجفون صعوبة في البلع شعور بالإعياء عدم استقرار المشي صعوبة في الكلام
P010	Shortness of breath Change in voice Weakness of lower limbs Eyelid dropping Muscle weakness when exertion Difficulties with swallow Difficulties with speech Double vision	ضيق في التنفس تغير في الصوت تعب الأطراف السفلية ارتخاء الجفون تعب عام وشديد عند بذل أي مجهود صعوبة في البلع صعوبة في الكلام ازدواجية الرؤية
P011	Eyelid dropping Change in voice Double vision Difficulties with swallow Insomnia Feeling sick	ارتخاء الجفون تغير الصوت ازدواجية الرؤية صعوبة في البلع أرق شعور بالإعياء
P012	Feeling sick Insomnia Changes in facial features Difficulties with swallow Muscle weakness when exertion Difficulties with speech	شعور بالإعياء أرق تغير ملامح الوجه صعوبة في الكلام تعب عام وشديد عند بذل أي مجهود صعوبة في البلع
P013	Double vision Insomnia Shortness of breath Change in voice Weakness of lower limbs Weakness of upper limbs Changes in facial features Muscle weakness when exertion Difficulties with swallow Feeling sick Eyelid dropping Unstable walking Difficulties with speech	ازدواجية الرؤية أرق ضيق في التنفس تغير في الصوت تعب الأطراف السفلية تعب الأطراف العلوية تغير ملامح الوجه صعوبة البلع تعب عام وشديد عند بذل أي مجهود شعور بالإعياء صعوبة في الكلام عدم استقرار المشي ارتخاء الجفون

Case No	Symptoms in English	Symptoms in Arabic
P016	Insomnia Eyelid dropping Heavy mucus Double vision Feeling sick	أرق ارتخاء الجفون كثافة المخاط ازدواجية الرؤية شعور بالإعياء
P017	Heavy mucus Change in voice Shortness of breath Muscle weakness when exertion Difficulties with swallow Weakness of lower limbs Paralysis of the upper limbs Changes in facial features Difficulties with speech Weakness of upper limbs	كثافة المخاط تغير الصوت ضيق في التنفس تعب عام وشديد عند بذل أي مجهود صعوبة في البلع تعب الأطراف السفلية شلل الأطراف العلوية تغير ملامح الوجه صعوبة في الكلام تعب الأطراف العلوية
P018	Muscle weakness when exertion Unstable walking Difficulties with speech Weakness of lower limbs Weakness of upper limbs Heavy mucus Eyelid dropping Changes in facial features Shortness of breath Double vision Difficulties with swallow Change in voice	تعب عام وشديد عند بذل أي مجهود عدم استقرار المشي صعوبة في الكلام تعب الأطراف السفلية تعب الأطراف العلوية كثافة المخاط ارتخاء الجفون تغير ملامح الوجه ضيق في التنفس ازدواجية الرؤية صعوبة البلع تغير في الصوت
P019	Changes in facial features Double vision Unstable walking Eyelid dropping Heavy mucus Muscle weakness when exertion Shortness of breath Feeling sick	تغير ملامح الوجه ازدواجية الرؤية عدم استقرار المشي ارتخاء الجفون كثافة المخاط تعب عام وشديد عند بذي أي مجهود ضيق في التنفس شعور بالإعياء
P20	Double vision Eyelid dropping Muscle weakness when exertion Shortness of breath Feeling sick	ازدواجية الرؤية ارتخاء الجفون تعب عام وشديد عند بذي أي مجهود ضيق في التنفس شعور بالإعياء
P21	Feeling sick	ازدواجية الرؤية شعور بالإعياء

Case No	Symptoms in English	Symptoms in Arabic
	Muscle weakness when exertion Changes in facial features	تعب عام وشديد عند بذل أي مجهود تغير في ملامح الوجه
P22	Eyelid dropping Muscle weakness when exertion Weakness of lower limbs Insomnia Weakness of upper limbs Double vision Unstable walking	ارتخاء الجفون تعب عام وشديد عند بذل أي مجهود تعب الأطراف السفلية أرق تعب الأطراف العلوية ازدواجية الرؤية عدم استقرار المشي
P023	Difficulties with speech Weakness of upper limbs Headache Heavy mucus Changes in facial features Change in voice Shortness of breath Difficulties with swallow Muscle weakness when exertion Feeling sick	صعوبة في الكلام تعب الأطراف العلوية صداع كثافة المخاط تغير ملامح الوجه تغير الصوت ضيق في التنفس صعوبة في البلع تعب عام وشديد عند بذل أي مجهود شعور بالإعياء
P024	Changes in facial features Feeling sick Difficulties with speech Weakness of upper limbs Double vision Unstable walking Muscle weakness when exertion Eyelid dropping Weakness of lower limbs Change in voice	تغير في ملامح الوجه شعور بالإعياء صعوبة في الكلام تعب الأطراف العلوية ازدواجية الرؤية عدم استقرار المشي تعب عام وشديد عند بذل أي مجهود ارتخاء الجفون تعب الأطراف السفلية تغير الصوت
P25	Difficulties with swallow Change in voice Muscle weakness when exertion Feeling sick Difficulties with speech Weakness of lower limbs Weakness of upper limbs Headache	صعوبة في البلع تغير الصوت تعب عام وشديد عند بذل أي مجهود شعور بالإعياء صعوبة في الكلام تعب الأطراف السفلية تعب الأطراف العلوية صداع
P026	Muscle weakness when exertion Eyelid dropping Changes in facial features	تعب عام وشديد عند بذل أي مجهود ارتخاء الجفون تغير ملامح الوجه صعوبة في الكلام

Case No	Symptoms in English	Symptoms in Arabic
	Difficulties with speech Paralysis of the lower limbs	شلل الأطراف السفلية
P028	Difficulties with swallow Double vision Muscle weakness when exertion Unstable walking Difficulties with speech Weakness of lower limbs Eyelid dropping Heavy mucus Shortness of breath Changes in facial features Headache Change in voice	صعوبة في البلع ازدواجية الرؤية تعب عام وشديد عند بذل أي مجهود عدم استقرار المشي صعوبة في الكلام تعب الأطراف السفلية ارتخاء الجفون كثافة المخاط تغير في ملامح الوجه ضيق في التنفس صداع تغير في الصوت
P029	Change in voice Difficulties with swallow Changes in facial features Difficulties with speech	تغير في الصوت صعوبة في البلع تغير ملامح الوجه صعوبة في الكلام

The patients' prescriptions, human expert evaluation of the patients' prescriptions, system treatment recommendations and human expert evaluation of these recommendation are shown in Table (6.4).

Table (6.4): The expert evaluation of the prescriptions and system recommendations.

Case No	Prescription	Accuracy Prescription Evaluation	System Treatments Recommendation	Accuracy System Evaluation
P001	• Mestinon 60mg 6H • Imuran 50mg 12H • Prednisolone 10mg 8H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	80%	• Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	80%

Case No	Prescription	Accuracy Prescription Evaluation	System Treatments Recommendation	Accuracy System Evaluation
P002	• Mestinon 60mg 12H • Imuran 50mg 12H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	60%	• Imuran 100mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Prednisolone 10mg 24H • Solupred 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	80%
P004	• Imuran 50mg 12H • Mestinon 60mg 8H • Cortisone 25mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية")	25%	• Imuran 50mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	100%
P005	• Mestinon 60mg 8H	0%	• Imuran 50mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Solupred 20mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	75%

Case No	Prescription	Accuracy Prescription Evaluation	System Treatments Recommendation	Accuracy System Evaluation
P006	• Imuran 50mg 12H • Mestinon 60mg 3H • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	33%	• Imuran 50mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	33%
P008	• Imuran 50mg 12H • Mestinon 60mg 12H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	75%	• Imuran 50mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	75%
P009	• Mestinon 60mg 3H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية")	25%	• Imuran 50mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	75%

Case No	Prescription	Accuracy Prescription Evaluation	System Treatments Recommendation	Accuracy System Evaluation
P010	• Mestinon 60mg 12H • Prednisolone 5mg 12H • Imuran 50mg 12H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	60%	• Imuran 50mg 12H • Mestinon 60mg 12H • Solupred 20mg 24H • Cellcept 1000mg 12h • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	100%
P011	• Solupred 20mg 24H • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية")	25%	• Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	75%
P012	• Mestinon 60mg 4H • Solupred 5mg 12H • Imuran 50mg 8H	33%	• Imuran 50mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Prednisolone 20mg 24H • Solupred 20mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	33%

Case No	Prescription	Accuracy Prescription Evaluation	System Treatments Recommendation	Accuracy System Evaluation
P013	• Vitamins and supplements (in Arabic " فيتامينات ومكملات") • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Mestinon 60mg 6H	75%	• Imuran 50mg 12H • Mestinon 60mg 6H • Solupred 20mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")	75%
P016	• Prednisolone 10mg 24H • Mestinon 60mg 12H • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Imuran 50mg 12H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية")	80%	• Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Solupred 20mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	80%
P017	• Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Mestinon 60mg 12H • Imuran 100mg 12H • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Prednisolone 10mg 24H	60%	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	100%
P018	• Imuran 100mg 12H • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية")	60%	• Imuran 50mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Prednisolone 20mg 24H • Solupred 20mg 24H • Cellcept 1000mg 12h	100%

Case No	Prescription	Accuracy Prescription Evaluation	System Treatments Recommendation	Accuracy System Evaluation
	• Solupred 20mg 24H		• Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	
P019	• Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Mestinon 300mg 5H • Imuran 100mg 12H	25%	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 20mg 24H • Pyridostigmine 60mg 6H • Solupred 20mg 24H • cellcept 1000mg 12h • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")	75%
P20	• Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Solupred 20mg 24H • cellcept 1000mg 12h • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية")	80%	• Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	60%
P21	• Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Mestinon 180mg 8H • Imuran 200mg 12H • Plasmapheresis and IVI (in Arabic "غسيل البلازما")	50%	• Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")	75%

Case No	Prescription	Accuracy Prescription Evaluation	System Treatments Recommendation	Accuracy System Evaluation
			• Vitamins and supplements (in Arabic " فيتامينات ومكملات")	
P023	• Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Mestinon 60mg 8H	40%	• Imuran 50mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	100%
P024	• Prednisolone 15mg 24H • Imuran 100mg 12H • Mestinon 60mg 6H	67%	Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 20mg 24H • Solupred 20mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	33%
P25	• Imuran 50mg 12H • Prednisolone 10mg 24H • Mestinon 60mg 8H	67%	• Imuran 50mg 12H • Mestinon 60mg 6H • Pyridostigmine 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")	33%

Case No	Prescription	Accuracy Prescription Evaluation	System Treatments Recommendation	Accuracy System Evaluation
			• Vitamins and supplements (in Arabic " فيتامينات ومكملات")	
P028	• Mestinon 60mg 6H	33%	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	33%
P029	• Imuran 50mg 8H • Cortisone 25mg 24H • Plasmapheresis and IVI (in Arabic "غسيل البلازما")	40%	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")	100%

The treatment recommendations of the human expert of each case that are shown in Table (6.4) are shown in Table (6.5).

Table (6.5): The treatments recommendations of the human expert.

Case No	Expert Treatment Recommendation
P001	• Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Imuran 50mg 12H • Vitamins and supplements (in Arabic " فيتامينات ومكملات")
P002	• Imuran 50mg 12H • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما") • Vitamins and supplements (in Arabic " فيتامينات ومكملات")
P004	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P005	• Imuran 50mg 12H • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P006	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone • 10mg 24H
P008	• Imuran 50mg 12H • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P009	• Imuran 50mg 12H • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")

Case No	Expert Treatment Recommendation
P010	• Imuran 50mg 12H • Mestinon 60mg 12H • Solupred 20mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P011	• Imuran 50mg 12H • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P012	• Imuran 50mg 12H • Mestinon 60mg 6H • Solupred 20mg 24H
P013	• Imuran 50mg 12H • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P016	• Imuran 50mg 12H • Mestinon 60mg 6H • Solupred 20mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P017	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P018	• Imuran 50mg 12H • Mestinon 60mg 6H • Solupred 20mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P019	• Imuran 50mg 12H • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية")

Case No	Expert Treatment Recommendation
	• Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P20	• Imuran 50mg 12H • Mestinon 60mg 6H • Solupred 20mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P21	• Imuran 50mg 12H • Mestinon 60mg 6H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P023	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")
P024	• Imuran 50mg 12H • Mestinon 60mg 6H • Solupred 20mg 24H
P25	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 10mg 24H
P028	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 10mg 24H
P029	• Imuran 50mg 12H • Mestinon 60mg 6H • Prednisolone 10mg 24H • Removal of thymus gland (in Arabic " ازالة الغدة الثايموسية") • Plasmapheresis and IVI (in Arabic "غسيل البلازما")

Based on these results, it is clear that the rate of accuracy in the results of the recommending treatments by the proposed approach is 72% which is better than the accuracy of the doctors' treatment which is 50%.

6.2.3 The Efficiency of the Diagnosing and Recommending Processes

This is the third part of the preliminary evaluation process. We evaluate the efficiency of the approach by calculating the speed of the diagnosing process and the recommending process, then comparing these speeds with the average delay in the diagnosis of the Myasthenia Gravis patients.

This part of the preliminary evaluation includes a 30 real patients who are diagnosed for the Myasthenia Gravis disease. We entered the symptoms and calculated the duration of time that the system took in the diagnosis and recommendation processes to each patient.

The test cases and their symptoms for this part of the preliminary evaluation that are entered to the system to calculate the duration of time of the diagnosing and recommending process are shown in Table (6.6).

Table (6.6): Test cases and their symptoms that are used in calculating the duration of time of the diagnosing and recommending process.

Case No.	Symptoms (English and Arabic)
1	Muscle weakness when exertion, weakness of lower limbs, weakness of upper limbs, paralysis of the upper limbs, shortness of breath, heavy mucus, changes in facial features, change in voice, difficulties with swallow, difficulties with speech.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، تعب الأطراف العلوية، شلل الأطراف العلوية، ضيق في التنفس، كثافة المخاط، تغير في ملامح الوجه، تغير الصوت، صعوبة البلع، صعوبة الكلام.
2	Muscle weakness when exertion, insomnia, weakness of lower limbs, unstable walking, weakness of upper limbs, paralysis of the lower limbs, eyelid dropping, change in voice, difficulties with swallow, difficulties with speech.

Case No.	Symptoms (English and Arabic)
	تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، شلل الأطراف السفلية، ارتخاء الجفون، تغير الصوت، صعوبة البلع، صعوبة الكلام.
3	Feeling sick, weakness of lower limbs, unstable walking, changes in facial features, eyelid dropping, difficulties with swallow, difficulties with speech, change in voice.
	شعور بالإعياء، تعب الأطراف السفلية، عدم استقرار المشي، تغير في ملامح الوجه، ارتخاء الجفون، صعوبة البلع، صعوبة الكلام، تغير في الصوت.
4	Feeling sick, muscle weakness when exertion, unstable walking, weakness of upper limbs, changes in facial features, double vision, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، عدم استقرار المشي، تعب الأطراف العلوية، تغير في ملامح الوجه، ازدواجية الرؤية، صعوبة الكلام.
5	Muscle weakness when exertion, eyelid dropping, double vision.
	تعب عام وشديد بمجرد بذل أي مجهود، ارتخاء الجفون، ازدواجية الرؤية.
6	Muscle weakness when exertion, insomnia, weakness of lower limbs, unstable walking, shortness of breath, changes in facial features, eyelid dropping, double vision, change in voice, chest pain, difficulties with swallow.
	تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، عدم استقرار المشي، ضيق في التنفس، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، ارتخاء الجفون، ازدواجية الرؤية، آلام في الصدر، صعوبة الكلام.
7	Muscle weakness when exertion, weakness of lower limbs, change in voice, eyelid dropping, double vision, difficulties with swallow, insomnia, chest pain, feeling sick.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، تغير الصوت، ارتخاء الجفون، ازدواجية الرؤية، صعوبة البلع، أرق، آلام في الصدر، شعور بالإعياء.
8	Eyelid dropping, double vision, Muscle weakness when exertion, difficulties with swallow, chest pain.

Case No.	Symptoms (English and Arabic)
	ارتخاء الجفون، ازدواجية الرؤية، تعب عام وشديد بمجرد بذل أي مجهود، صعوبة في الكلام، آلام في الصدر.
9	Feeling sick, insomnia, eyelid dropping, double vision, change in voice, difficulties with swallow.
	شعور بالإعياء، أرق، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع.
10	Feeling sick, muscle weakness when exertion, insomnia, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، أرق، تغير الصوت، صعوبة البلع، صعوبة الكلام.
11	Feeling sick, muscle weakness when exertion, insomnia, weakness of lower limbs, unstable walking, weakness of upper limbs, shortness of breath, changes in facial features, eyelid dropping, double vision, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ضيق في التنفس، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
12	Muscle weakness when exertion, weakness of lower limbs, shortness of breath, eyelid dropping, double vision, change in voice, difficulties with swallow, chest pain.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، ضيق في التنفس، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، أرق، آلام في الصدر.
13	Insomnia, heavy mucus, eyelid dropping, double vision, feeling sick.
	أرق، كثافة المخاط، ارتخاء الجفون، ازدواجية الرؤية، شعور بالإعياء.
14	Feeling sick, muscle weakness when exertion, unstable walking, shortness of breath, heavy mucus, changes in facial features, eyelid dropping, double vision.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، عدم استقرار المشي، ضيق في التنفس، كثافة المخاط، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية.
15	Muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, shortness of breath, heavy mucus,

Case No.	Symptoms (English and Arabic)
	changes in facial features, eyelid dropping, double vision, change in voice, difficulties with swallow, difficulties with speech.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ضيق في التنفس، كثافة المخاط، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
16	Muscle weakness when exertion, weakness of upper limbs, shortness of breath, changes in facial features, eyelid dropping, change in voice, difficulties with swallow, difficulties with speech, chest pain.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف العلوية، ضيق في التنفس، تغير في ملامح الوجه، ارتخاء الجفون، تغير الصوت، صعوبة البلع، صعوبة الكلام، آلام في الصدر.
17	Feeling sick, muscle weakness when exertion, unstable walking, shortness of breath, heavy mucus, changes in facial features, eyelid dropping, double vision, chest pain.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، عدم استقرار المشي، ضيق في التنفس، كثافة المخاط، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، آلام في الصدر.
18	Feeling sick, muscle weakness when exertion, eyelid dropping, double vision.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي، ارتخاء الجفون، ازدواجية الرؤية.
19	Feeling sick, muscle weakness when exertion, eyelid dropping, double vision, weakness of upper limbs.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، ارتخاء الجفون، ازدواجية الرؤية، تعب الأطراف العلوية.
20	Muscle weakness when exertion, eyelid dropping, chest pain.
	تعب عام وشديد بمجرد بذل أي مجهود، ارتخاء الجفون، آلام في الصدر.
21	Muscle weakness when exertion, insomnia, weakness of lower limbs, unstable walking, weakness of upper limbs, eyelid dropping, double vision.
	تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ارتخاء الجفون، ازدواجية الرؤية.

Case No.	Symptoms (English and Arabic)
22	Feeling sick, muscle weakness when exertion, weakness of upper limbs, shortness of breath, headache, heavy mucus, changes in facial features, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف العلوية، ضيق في التنفس، صداع، كثافة المخاط، تغير في ملامح الوجه، تغير الصوت، صعوبة البلع، صعوبة الكلام.
23	Feeling sick, muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, changes in facial features, eyelid dropping, double vision, change in voice, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة الكلام.
24	Feeling sick, muscle weakness when exertion, weakness of lower limbs, weakness of upper limbs, headache, change in voice, difficulties with swallow.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، تعب الأطراف العلوية، صداع، تغير الصوت، صعوبة البلع.
25	Muscle weakness when exertion, paralysis of the lower limbs, changes in facial features, eyelid dropping, difficulties with speech, chest pain, headache, heavy mucus.
	تعب عام وشديد بمجرد بذل أي مجهود، شلل الأطراف السفلية، تغير في ملامح الوجه، ارتخاء الجفون، صعوبة الكلام، آلام في الصدر، صداع، كثافة المخاط.
26	Muscle weakness when exertion, weakness of lower limbs, unstable walking, weakness of upper limbs, shortness of breath, changes in facial features, eyelid dropping, double vision, change in voice, difficulties with swallow, difficulties with speech.
	تعب عام وشديد بمجرد بذل أي مجهود، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ضيق في التنفس، تغير في ملامح الوجه، ارتخاء الجفون، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
27	Feeling sick, changes in facial features, change in voice, difficulties with swallow, difficulties with speech, eyelid dropping.

Case No.	Symptoms (English and Arabic)
	شعور بالإعياء، تغير في ملامح الوجه، تغير الصوت، صعوبة البلع، صعوبة الكلام، ارتخاء الجفون.
28	Feeling sick, muscle weakness when exertion, insomnia, weakness of lower limbs, unstable walking, weakness of lo limbs, shortness of breath, changes in facial features, double vision, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ضيق في التنفس، تغير في ملامح الوجه، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.
29	Feeling sick, weakness of lower limbs, weakness of upper limbs, changes in facial features, difficulties with speech, paralysis of the upper limbs.
	شعور بالإعياء، تعب الأطراف السفلية، تعب الأطراف العلوية، تغير في ملامح الوجه، صعوبة الكلام، شلل الأطراف العلوية.
30	Feeling sick, muscle weakness when exertion, insomnia, weakness of lower limbs, paralysis of lower limbs, unstable walking, weakness of upper limbs, shortness of breath, headache, heavy mucus, double vision, change in voice, difficulties with swallow, difficulties with speech.
	شعور بالإعياء، تعب عام وشديد بمجرد بذل أي مجهود، أرق، تعب الأطراف السفلية، شلل الأطراف السفلية، عدم استقرار المشي، تعب الأطراف العلوية، ضيق في التنفس، صداع، كثافة المخاط، ازدواجية الرؤية، تغير الصوت، صعوبة البلع، صعوبة الكلام.

The time that each process took to get the results is shown in Table (6.7).

Table (6.7): The time that each process took to get results.

Case No.	Duration of time to diagnose patient (in seconds)	Duration of time to recommend treatments (in seconds)
1	0.124827	38.9429
2	0.144264	35.22699
3	0.18531	33.81236
4	0.142659	40.26894
5	0.113682	34.10538
6	0.147086	44.65827

Case No.	Duration of time to diagnose patient (in seconds)	Duration of time to recommend treatments (in seconds)
7	0.189906	35.86233
8	0.133464	41.36676
9	0.184659	34.1236
10	0.17549	44.39864
11	0.118726	40.86548
12	0.206102	31.13203
13	0.133219	46.68985
14	0.377146	44.95534
15	0.194943	35.25639
16	0.164264	48.13699
17	0.227561	41.35865
18	0.129403	34.12569
19	0.120499	39.04493
20	0.14347	35.25639
21	0.166107	44.01447
22	0.120066	41.67813
23	0.169831	44.12999
24	0.138521	49.45863
25	0.157389	48.06189
26	0.2249	50.35769
27	0.166221	33.11246
28	0.221173	38.76235
29	0.153766	39.02302
30	0.134903	32.41233
Average	**0.166985**	**40.01996**

Based on the above results, it is clear that the overall time average of diagnosing the Myasthenia Gravis disease is 0.17 seconds, and the overall time average of recommending treatments is 40 seconds.

We calculate the average time needed in the traditional diagnosis of these patient cases by subtracting the year diagnosing of patients for the Myasthenia Gravis disease from the year of patient infection with the Myasthenia Gravis disease. Based on this process we get 2.46 years as average time needed in the traditional diagnosing of patients.

The time that the doctor takes to diagnose a patient and provide a recommended treatments using the proposed approach is not comparable with the average of time needed in the traditional diagnosis of patients.

6.3 Discussion

According to the previous preliminary evaluations, the significant and effectiveness of the proposed approach in diagnosing the Myasthenia Gravis disease and providing a recommended treatments are clear. The proposed approach has achieved an acceptable accuracy and speed compared to traditional diagnosing and traditional prescriptions, that means, the proposed approach provides to the doctors a significant contribution in the field of treatments of the Myasthenia Gravis disease.

The accuracy achieved using the system in diagnosing the Myasthenia Gravis disease is attributed to the small number of the Myasthenia Gravis patients we were able to reach and ask them to fill the Myasthenia Gravis questionnaire. There a possibility that this accuracy may decreased if a number of patients is entered to the system. But increasing the number of patients is likely to increase the accuracy of the treatments recommendations by the system, because this number will enrich the knowledge base.

6.4 Summary

We firstly evaluate the accuracy of diagnosing process of the approach by entering information about a number of patient infected with the Myasthenia Gravis disease and evaluate the accuracy. Secondly, we evaluate the treatment recommendations process according to an expert in Brian and Neurology by comparing his recommended treatments of patient to the recommended treatments of the doctor who treated this case then with the recommendations of the approach which recommended to treat the same patient. Finally, we evaluate the efficiency of the approach by comparing the speed of the processes with the average delay in the traditional diagnosis of patients.

The approach achieved a rate of accuracy of 86.11% in the results of diagnosing the Myasthenia Gravis disease. The accuracy in the results of the recommending

treatments was 72% which is good results compared to the accuracy of the doctors that treat patients' cases which was 50%. The efficiency of the approach in the diagnosing process is 0.17 seconds and in the recommending process is 40 in seconds. This time is not comparable to average of delay in the diagnosis of patients' cases which is around 2.46 years.

We found the results of our approach better than those of the doctors that treat the patients and achieved more accuracy and efficiency.

Chapter 7

Conclusions and Future Work

In this thesis, we developed an ontology based approach for diagnosing the Myasthenia Gravis disease and providing treatment recommendations.

Firstly, we presented an overview of the current ontology based approaches that used to manage patients' information in medicine field for various diseases or specific diseases and diagnosing systems with and without ontologies. We found that most of the related works focus on building some general ontologies for several diseases and not on some specific diseases except on some type of common disease such as cancer and coronary artery diseases in a general sense. We tried to use the current ontologies and customize them to suit the Myasthenia Gravis disease but they did not fit because the Myasthenia Gravis disease has unknown causes. The treatment varies from patient to patient, and symptoms vary from one patient to another.

Because of that we developed a specific ontological knowledge base for the Myasthenia Gravis disease to help doctors and patients to diagnose the Myasthenia Gravis disease and provide recommended treatments. Then we collected information about the Myasthenia Gravis disease and Myasthenia Gravis patients to enrich the ontology through a questionnaire.

After that we defined a set of semantic rules to achieve the goals of our approach, then we developed a prototype that consists several modules such as Querying module, Reasoning module, Diagnosing module and Recommending Treatments module.

The proposed approach was evaluated firstly for the accuracy of the diagnosing process through entering information about a number of persons who infected with the Myasthenia Gravis disease and evaluate the results. Secondly it was evaluated for the treatment recommendations process according to a human expert in Brian and Neurology. Finally, the approach was evaluated for the time efficiency by computing the speed of the processes.

The approach achieved an accuracy of 86.11% in diagnosing the Myasthenia Gravis disease. It achieved an accuracy of 72% in the results of the recommending treatments which was a good results compared to the rate of accuracy of the doctors who treat patients which was 50%. The average of the efficiency of the approach in

diagnosing process was 0.17 seconds and in the recommending process was 40 seconds. This time is not comparable at all to the average delay in the diagnosis of patients which is 2.46 years.

The main contribution of this thesis is the ontology and the related knowledge base which can support the process of diagnosing the Myasthenia Gravis disease, providing a recommended treatments and providing a recommended habits and practices that may decrease or increase the impact of the disease, with higher rate of accuracy and efficiency.

Since only a prototype of the proposed approach was implemented, we recommend to implement a complete system. Success of our proposed prototype encourages us to look for ways to increase the scope of this approach to provide a new effective services for the Myasthenia Gravis patients. In addition, the ontology can be extended to cover other diseases.

Furthermore, we look forward to increase the accuracy of our proposed approach, and apply the quality assurance theories to the complete system, then we look forward to spread our proposed approach and make it available to all doctors and hospitals in all over the world to decrease the suffering of the Myasthenia Gravis patients.

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Appendices

Appendix 1: Myasthenia Gravis Questionnaire

استبانة لمرضى الوهن العضلي

استبانة لمرضى الوهن العضلي... سنبحث في نتائج هذه الاستبانة للوصول إلى معلومات أكثر عن المرض والعلاج الأنجع له وما يؤثر عليه بالسلب والإيجاب

ننوه لكم أيها الزائر الكريم أن كل ما تقدمه من بيانات في مأمن؛ ولن نستخدم البيانات في أي أغراض غير هدف الدراسة كما ونوصيك بأن تدلي ببيانات صحيحة للخروج بنتائج دقيقة

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استبانة لمرضى الوهن العضلي

* Required

معلومات شخصية

الاسم (اختياري)

Your answer

البريد الالكتروني (اختياري)

Your answer

هاتف/ محمول (اختياري)

Your answer

العمر *

Your answer

الجنس *

- ذكر
- أنثى

الطول بالسنتيمتر *

Your answer

الوزن (كجم) *

Your answer

فصيلة الدم *

- A+
- A-
- AB+
- AB-
- B+
- B-
- O+

الحالة الاجتماعية *

- أعزب
- متزوج
- أرمل
- مطلق

الدولة *

أدخل اسم الدولة التي تسكن فيها الآن

Your answer

المدينة *

أدخل اسم المدينة التي تسكن فيها الآن

Your answer

طبيعة المنطقة التي تسكنها *

- [ ] ساحلية
- [ ] سهلية
- [ ] جبلية
- [ ] تلال
- [ ] أغوار
- [ ] وديان

مناخ المدينة *

- ○ استوائي
- ○ جبلي
- ○ صحراوي
- ○ قاري (ندرة المطر، صيف حار جدا، شتاء بارد جدا)
- ○ قطبي
- ○ معتدل
- ○ مداري (صيف حار، شتاء دافئ)

المهنة *

Your answer

عدد ساعات العمل يوميا *

Your answer

هل تشرب الكحول *

نعم

لا

هل تدخن *

نعم

لا

هل تتعاطى مخدرات *

نعم

لا

الهوايات *

Your answer

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اكتشاف المرض وتاريخه

عمر المرض بالسنوات *

Your answer

منذ كم سنة تم تشخيصك بالوهن العضلي *

Your answer

كيف تم تشخيص مرضك؟ *

- [ ] المشي
- [ ] تتبع حركة اليد بالعين
- [ ] حقنة مستنون
- [ ] حركات رياضية
- [ ] فحص الجفن بالثلج
- [ ] فحص الغدة الثايموسية
- [ ] تخطيط العضلات
- [ ] فحص الدم - الأجسام المضادة

نتيجة فحص للغدة الثاميوسية (إن أجريت الفحص)

- إيجابي
- سلبي

نتيجة تخطيط العضلات (إن أجريت الفحص)

- إيجابي
- سلبي

نتيجة فحص الدم - الأجسام المضادة الذي أثبت الوهن (إن أجريت الفحص)

- إيجابي
- سلبي

إذا أجريت فحوص أخرى أذكرها مع النتيجة

Your answer

إذا أجريت فحوص أخرى أذكرها مع النتيجة

Your answer

إذا أجريت فحوص أخرى أذكرها مع النتيجة

Your answer

هل تزامن مرضك بالوهن العضلي مع ظهور مرض آخر *

- نعم
- لا

إذا كانت إجابة السؤال السابق بـ (نعم) اكتب اسم المرض الآخر

Your answer

هل سبب لك الوهن مرض آخر *

- نعم
- لا

إذا كانت إجابة السؤال السابق بـ (نعم) اكتب اسم المرض الآخر

Your answer

هل توجد أمراض في عائلتك خاصة المناعية *

- نعم
- لا

إذا كانت إجابة السؤال السابق بـ (نعم) اكتب اسم المرض

Your answer

هل تزامن ظهور المرض مع صدمة عاطفية أو نفسية *

- نعم
- لا

ما هي الأعراض التي عانيت منها عند اكتشاف المرض *

- [ ] شعور بالإعياء
- [ ] تعب عام وشديد بمجرد بذل أي مجهود
- [ ] أرق
- [ ] تعب الأطراف السفلية

- [ ] شلل الأطراف السفلية
- [ ] عدم استقرار المشي
- [ ] تعب الأطراف العلوية
- [ ] شلل الأطراف العلوية
- [ ] ضيق في التنفس
- [ ] صداع
- [ ] كثافة المخاط
- [ ] تغير في ملامح الوجه
- [ ] ارتخاء الجفون
- [ ] ازدواجية الرؤية
- [ ] تغير الصوت
- [ ] صعوبة الكلام

إذا كانت لديك - مع بداية المرض - أعراض أخرى أذكرها

كضعف الذاكرة مثلاً أو أي أعراض أخرى

Your answer

ما هي الأعراض التي استمرت أو ظهرت بعد اكتشاف المرض بفترة زمنية *

- [ ] شعور بالإعياء
- [ ] تعب عام وشديد بمجرد بذل أي مجهود
- [ ] أرق
- [ ] تعب الأطراف السفلية
- [ ] شلل الأطراف السفلية
- [ ] عدم استقرار المشي

- [ ] عدم استقرار المشي
- [ ] تعب الأطراف العلوية
- [ ] شلل الأطراف العلوية
- [ ] ضيق في التنفس
- [ ] صداع
- [ ] تغير في ملامح الوجه
- [ ] ارتخاء الجفون
- [ ] ازدواجية الرؤية
- [ ] تغير الصوت
- [ ] صعوبة البلع
- [ ] صعوبة الكلام

إذا كانت لديك - بعد اكتشاف المرض - أعراض أخرى أذكرها

كضعف الذاكرة مثلاً أو أي أعراض أخرى

Your answer

ما هي الأعراض التي تعاني منها بشكل دائم *

أعراض تصاحبك فترات كبيرة في حياتك المرضية

- [ ] شعور بالإعياء
- [ ] تعب عام وشديد بمجرد بذل أي مجهود
- [ ] أرق
- [ ] تعب الأطراف السفلية
- [ ] شلل الأطراف السفلية

- [ ] تعب الأطراف العلوية
- [ ] شلل الأطراف العلوية
- [ ] ضيق في التنفس
- [ ] صداع
- [ ] كتافة المخاط
- [ ] تغير في ملامح الوجه
- [ ] ارتخاء الجفون
- [ ] ازدواجية الرؤية
- [ ] تغير الصوت
- [ ] صعوبة البلع
- [ ] صعوبة الكلام

ما هي الأعراض التي تعاني منها بشكل نادر *

أعراض تظهر فترة قصيرة ثم تختفي

- [ ] شعور بالإعياء
- [ ] تعب عام وشديد بمجرد بذل أي مجهود
- [ ] أرق
- [ ] شلل الأطراف السفلية
- [ ] عدم استقرار المشي
- [ ] تعب الأطراف العلوية
- [ ] شلل الأطراف العلوية
- [ ] ضيق في التنفس

- [ ] صداع
- [ ] كثافة المخاط
- [ ] تغير في ملامح الوجه
- [ ] ارتخاء الجفون
- [ ] ازدواجية الرؤية
- [ ] تغير الصوت
- [ ] صعوبة البلع
- [ ] صعوبة الكلام

هل تعاني من آلام معينة في جسدك عند اكتشاف المرض

- [ ] الرقبة
- [ ] الأكتاف
- [ ] أعلى الظهر
- [ ] وسط الظهر
- [ ] أسفل الظهر
- [ ] الصدر
- [ ] البطن
- [ ] منطقة الحوض
- [ ] الذراعين
- [ ] كف اليدين
- [ ] أصابع اليدين
- [ ] الفخذين

- [ ] الساقين
- [ ] كفي القدمين
- [ ] أصابع القدمين

هل تعاني من آلام معينة في جسدك استمرت أو ظهرت بعد اكتشاف المرض بفترة زمنية

- [ ] الرقبة
- [ ] الأكتاف
- [ ] أعلى الظهر
- [ ] وسط الظهر
- [ ] أسفل الظهر
- [ ] الصدر
- [ ] البطن
- [ ] منطقة الحوض
- [ ] الذراعين
- [ ] كف اليدين
- [ ] أصابع اليدين
- [ ] الفخذين
- [ ] الساقين
- [ ] كفي القدمين
- [ ] أصابع القدمين

هل تعاني من حساسية من أي شيء

مثل حساسية تجاه دواء معين، طعام معين، أو حيوان معين... إلخ

Your answer

هل هناك أمراض عندما تصاب بها تتدهور حالتك المرضية

الانفلونزا مثلا..

Your answer

إذا كنت أنثى، هل تجدين تأثير للدوره الشهرية

- تزيد من حدة الوهن
- تخفف من حدة الوهن
- لا علاقة لها بالوهن

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الأدوية والعلاجات

هل تتناول المستنون *

- نعم
- لا

مقدار الجرعة

Your answer

كم مرة تتناوله يوميا

Your answer

هل تتناول أي نوع من أنواع الكورتيزون *

- نعم
- لا

اسم العلاج

Your answer

مقدار الجرعة

Your answer

كم مرة تتناوله يوميا

Your answer

هل تتناول أي نوع من أنواع الميتاليز *

- نعم
- لا

اسم العلاج

Your answer

مقدار الجرعة

Your answer

كم مرة تتناوله يوميا

Your answer

هل تتناول أي نوع من أنواع مثبطات المناعة *

- نعم
- لا

اسم العلاج

Your answer

مقدار الجرعة

Your answer

كم مرة تتناوله يوميا

Your answer

أدوية أخرى تناولتها خلال مشوارك مع المرض غير مذكورة في الأعلى
(اكتب اسم الدواء، مقدار الجرعة، كم مرة تتناوله في اليوم)

Your answer

أدوية أخرى تناولتها خلال مشوارك مع المرض غير مذكوره في الأعلى
(اكتب اسم الدواء، مقدار الجرعة، كم مرة تتناوله في اليوم)

Your answer

أدوية أخرى تناولتها خلال مشوارك مع المرض غير مذكوره في الأعلى
(اكتب اسم الدواء، مقدار الجرعة، كم مرة تتناوله في اليوم)

Your answer

هل قمت/ تقوم بعملية غسل البلازما من الدم *

- نعم
- لا

هل شعرت بتحسن مع غسيل البلازما

- نعم
- لا

هل تجد أن زيادة جرعة المستنون عن الحد *

- يزيد من حدة الوهن
- يخفف من حدة الوهن
- لم أزد الجرعات مطلقا

هل وصف لك طبيب الوهن دواءً مضاداً للاكتئاب *

- نعم
- لا

إذا كانت إجابة السؤال السابق بنعم فهل شعرت بتحسن

- نعم
- لا

إذا كانت إجابة السؤال قبل السابق بنعم اذكر الدواء

Your answer

هل تتناول أي تطعيمات *

مثل تطعيم الأنفلونزا

- نعم
- لا

هل أثرت هذه التطعيمات على الوهن

مثل تطعيم الأنفلونزا

- أدت إلى تحسين الوهن
- أدت إلى سوء الوهن
- ليس لها علاقة

إذا كانت إجابة السؤال السابق بنعم - أذكر اسم التطعيمات

مثل تطعيم الأنفلونزا

Your answer

هل تتناول أي مكملات غذائية *

- نعم
- لا

هل أثرت هذه المكملات على الوهن

- أدت إلى تحسين الوهن
- أدت إلى سوء الوهن
- ليس لها علاقة

إذا كانت إجابة السؤال السابق بنعم - أذكر اسم المكملات
مثل تطعيم الأنفلونزا

Your answer

هل جربت العلاج الطبيعي *

- نعم
- لا

هل أثر العلاج الطبيعي على الوهن

- أدى إلى تحسين الوهن
- أدى إلى سوء الوهن
- ليس له علاقة

هل جربت العلاج النفسي *

- نعم
- لا

هل أثر العلاج النفسي على الوهن

- أدى إلى تحسين الوهن
- أدى إلى سوء الوهن
- ليس له علاقة

كيف تقيم حالتك مع الوهن بعد استخدام العلاجات التي ذكرتها *

- مستقرة
- غير مستقرة
- ريميشن
- حرجة

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المأكولات

أذكر الأطعمة التي تتناولها من النشويات

الخبز، الحبوب، الأرز، المكرونة... إلخ... - إذا لا تتناول هذا الصنف مطلقا دعه فارغا

Your answer

أذكر الأطعمة التي تتناولها من الفواكه

Your answer

أذكر الأطعمة التي تتناولها من الخضروات

Your answer

أذكر الأطعمة التي تتناولها من الدهون والحلويات

الزيوت، الزبد، الكريمة، السمن، السكريات والحلويات... إلخ... - إذا كنت لا تتناول هذا الصنف مطلقا دعه فارغا

Your answer

أذكر الأطعمة التي تتناولها من البروتينات

اللحوم، الطيور، السمك، البقوليات، البيض... إلخ... - إذا كنت لا تتناول هذا الصنف مطلقا دعه فارغا

Your answer

أذكر الأطعمة التي تتناولها من الألبان

مثل الحليب، الجبن، اللبن... إلخ... - إذا كنت لا تتناول هذا الصنف مطلقا دعه فارغا

Your answer

هل أكل اللحوم والدهون *

- يزيد من حدة الوهن
- يخفف من حدة الوهن
- لا علاقة له بالوهن

هل تناول نوع معين من الفواكه أو الخضروات *

- مفيد للوهن
- ضار للوهن
- لا علاقة له بالوهن

إذا كانت إجابة السؤال السابق بـ (نعم) اكتب اسم الفاكهة أو الخضار

Your answer

هل شرب الماء بكثرة *

- يزيد من حدة الوهن
- يخفف من حدة الوهن
- لا علاقة له بالوهن

هل اتبعت فيما مضى أو تتبع الآن حمية غذائية معينة *

- نعم
- لا

إذا كانت إجابة السؤال السابق بـ (نعم)، فهل تشعر بتحسن

- نعم
- لا

إذا كانت إجابة السؤال السابق بـ (نعم) اكتب عن الحمية الغذائية

Your answer

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الرياضة

هل كنت تمارس رياضة قبل الإصابة بالوهن *

- نعم
- لا

إذا كانت إجابة السؤال السابق بـ (نعم) اذكر الرياضات

Your answer

هل تمارس الآن أي رياضة الآن بعد الإصابة بالوهن *

- نعم
- لا

إذا كانت إجابة السؤال السابق بـ (نعم) اذكر الرياضات

Your answer

بعد إصابتك بالوهن ممارسة رياضاتك القديمة

- تزيد من حدة الوهن
- تخفف من حدة الوهن
- لا علاقة له بالوهن

هل تعتقد أن ممارسة بعض الأنشطة الرياضية المعقولة كالمشي مثلا *

- تزيد من حدة الوهن
- تخفف من حدة الوهن
- لا علاقة له بالوهن

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الغدة الثايموسية

هل التصوير أظهر غدتك متضخمة؟ *

- نعم
- لا

هل أجريت عملية إزالة الغدة *

- نعم
- لا

إذا أجريت عملية إزالة الغدة، فهل كانت العملية

- جراحة
- منظار

إذا أجريت عملية إزالة الغدة، كيف شعرف بعدها

- تحسن في الحالة المرضية
- زيادة سوء في الحالة المرضية
- لم أشعر بأي تغيير

ما هو نتيجة تحليل الغدة بعد العملية؟

- ◯ متضخمة
- ◯ متورمة
- ◯ طبيعية

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علاجات أخرى

هل جربت العلاج بالرقية الشرعية *

- ◯ نعم
- ◯ لا

إذا كانت إجابة السؤال السابق بـ (نعم) هل شعرت بتحسن

- ◯ نعم
- ◯ لا

هل جربت العلاج بالأعشاب *

- ◯ نعم
- ◯ لا

إذا كانت إجابة السؤال السابق بـ (نعم) هل شعرت بتحسن

- نعم
- لا

إذا كانت إجابة السؤال قبل السابق بـ (نعم) أذكر الأعشاب

Your answer

هل جربت العلاج بالحجامة *

- نعم
- لا

إذا كانت إجابة السؤال السابق بـ (نعم) هل شعرت بتحسن

- نعم
- لا

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تغيرات الطقس

هل تقلبات الطقس *

- تزيد من حدة الوهن
- تخفف من حدة الوهن
- لا علاقة له بالوهن

هل ارتفاع درجات الحراره *

- تزيد من حدة الوهن
- تخفف من حدة الوهن
- لا علاقة له بالوهن

هل انخفاض درجات الحراره *

- تزيد من حدة الوهن
- تخفف من حدة الوهن
- لا علاقة له بالوهن

هل الاستحمام بالماء البارد *

- تزيد من حدة الوهن
- تخفف من حدة الوهن
- لا علاقة له بالوهن

هل الاستحمام بالماء الساخن *

- تزيد من حدة الوهن
- تخفف من حدة الوهن
- لا علاقة له بالوهن

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أمور أخرى

هل تعتقد أن التوتر النفسي *

- يزيد من حدة الوهن
- يخفف من حدة الوهن
- لا علاقة له بالوهن

أمور أخرى تحسن من حالة الوهن

Your answer

أمور أخرى تعمل على زيادة حدة الوهن

Your answer

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