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A Knowledge-Base of Prevalent Diseases in Sunyani Municipality, Ghana Using Ontological Engineering

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Abstract

Several works in healthcare diseases support systems in recent time are being inspired by a lot of semantic web technology. Specifically, there has been a rise in the number of knowledgebase system that has been developed using ontological engineering. For two decades, Sunyani Municipality records a lump number of diseases with a few such as Typhoid Fever, Malaria, Diarrhoea Diseases, Pneumonia, Anaemia, and so on being prevalent. Healthcare systems in the Municipal do not have a centralised knowledge base for these prevalent diseases, hence the need for a centralised knowledge-based system. This study proposes a knowledge-based system using ontological engineering to assist the formulation of a strong foundation for establishing a meaningful decision-making support system for the proper diagnosis and management of these diseases in the Municipality. We analysis 3,377,403 number of cases from 2013-2017 and thereafter categorised the case into different classes of diseases. Using a threshold ratio of +1% between several cases for a particular disease (Pdc) and total number cases in its category (Cr), we characterised about thirty-five (35) diseases as prevalent. Consequently, we designed a robust knowledge-based for the identified prevalent diseases by adopting the Cyc method, which includes three processes in connection with ontological engineering technique. The system was well rated of about 77% after staff from two primary health facilities in the municipality.

Keywords: Ontological engineering; Knowledgebase; Ontology; Prevalent diseases

Introduction

Prevalent diseases are diseases, which are widespread in a particular area at a particular period. According to Russell in 2004, the outbreak of prevalent diseases imposes a high economic burden on patients, their families and the society as well as the loss of workforce and its accompanying emotional stress [1,2]. Hence, it is significant to set up adequate awareness creation, preventive strategies, response management and curable care to manage the prevalent diseases. The climate condition of the Sunyani Municipality has been reported to be a significant contributing parameter which triggers the prevalence of diseases such as malaria, meningococcal meningitis, yellow fever and measles by Financing. The capacity of health centres in the municipality is often over-stretched when such cases arise. Health centres in the municipality, however, do not have a central knowledge base of these diseases. In this paper, we provided a detailed and sound description of prevalent diseases and their relations/interactions relative to the eliminating factors in Sunyani Municipality. Specifically, we surveyed to identify the prevalent diseases in the municipality. Consequently, we designed an ontological knowledge base of prevalent diseases in Sunyani Municipality. Succinctly, it is hoped that the study will aid health care professionals and decision-makers to effectively design to develop and deploy their strategic plans in managing the outbreak of these diseases.

Literature Review

There have been intense research efforts on different ontological methods to design and implement shareable and interoperable knowledge bases for public health care system to facilitate effective health care systems. However, the significant challenges are semantic and syntactic heterogeneity in health data Sunitha and Golla in 2014 [3]. Due to the heterogeneity nature of health data, Schulz and Martínez-costa in 2013 stated that Semantic in- teroperability of clinical information remains a largely unresolved issue [4]. A research conducted by Kuziemsky and Lau in 2010 illustrated four stages of ontology-based health information system. The states were presented as specification and conceptualisation, formalisation, implementation and evaluation, and maintenance [5]. Research conducted by Sunitha and Golla in 2014 in some countries revealed that medical and health care ontologies are widely used to; improve the accuracy of diagnoses by providing real-time correlations of symptoms, test results and individual medical histories, help build more robust and different healthcare information systems, assist the need of process healthcare patient data in transmission and reuse, and draws meaning from healthcare data [3]. Zeshan and Mohamad in 2012 developed a medical ontology for handling road accident injuries by providing immediate and quick knowledge supply. Ontology enhances sharing and reusing of knowledge supported by reasoning tools for the extraction of new knowledge are realised [6]. Ontology knowledge base, as described by Jasper and Uschold in 1999, and Lambrix and Tan, offers communication between human, among software, and interoperability [7,8]. Ontology knowledge has an essential impact on the healthcare domain, as stated by Raghupahia and Tan in 2012 in the United States spent 21.6 billion Dollars in healthcare-related technologies [9].

Knowledgebase Formulation

A complete knowledge base of prevalent diseases helps the policymakers and health professionals to derive conclusions and take right decisions. The knowledge base becomes beneficial decision-making source. Ontology-based semantic techniques provide excellent

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support to build a sufficient knowledge base of prevalent diseases by Sunitha and Golla in 2014 [3]. Adequate knowledge ensures; provision of a detailed and sound description of the relation among, a disease about the place and the environment, that obtain an intervention plan referenced to the health-care requirements are obtained automatically which helps physicians in the processes of disease prevention and detection and easily and accurately identifying the relationship between diseases and their geographical areas. This Ontology knowledge base helps the policymakers in evolving national guidelines through the results obtained through the inter-relationships. The knowledge base formulation is a two-stage process-Interoperability of ontologies domain into a single platform finding association between disease, place, and environment as indicated by Munir and Anjum in 2017 [10].

Materials and Methods

This research study aims to build an efficient knowledge base of prevalent diseases in Sunyani Municipality using ontological engineering. The methods, procedures and techniques adopted are organised into the following sections.

Study area

Data for the current study was obtained from health records and documents on diseases collected from the Sunyani Municipal Health Directorate. This data comprises health data from the all the towns and villages in the Municipality from 2013-2017, which include Abesim, Adantia, Ahyiayem, Asuakwaa, Kotokrom, Atronie, Chiraa, Dumasua, Fiapre, Kobedi, Kwatire, New Dormaa, Nsuatre, Nwawasua, Odamase, Liberation Barracks, Tanom and Yahwimakrom.

Dataset

Data were obtained from these mentioned areas in excel format. The Excel records were made up of 40 columns and 127 rows per year for each of the health centres combined from 2013-2017. The diseases were categorised into eight main components. The categorisation is presented in Table 1. Some of the attributes of the data were; Data Element, Gender (Male, Female), and a total number of records.

Data analysis processes

For each category of diseases (CI, CNI, NC, MHC, SC, OGC, RT, and IO), if the ratio of a particular disease (Pdc) to total cases recorded (Cr) in that diseases category is greater or equal to 0.01 (1%). Then the diseases are classified as prevalent.

Ie. $Pdc/Cr \geq 0.01$ (1)

Table 1: Categorisation of diseases.

Category of the disease	Total diseases	Total Cases Recorded (Cr)
Communicable immunizable (CI)	9	22
Communicable non-immunizable (CNI)	26	393615
Non-Communicable (NC)	18	34829
Mental Health Conditions (MHC)	14	694
Specialized Conditions (SC)	15	52354
Obstetrics and Gynaecological Conditions (OGC)	3	4213
Reproductive Tract (RT)	6	5101
Injuries and Others (IO)	14	82745

Results and Analysis

Microsoft Excel was used for analysing the data. During the analysis, the conditional formatting module was used to extract and classify the prevalent diseases from the health records. To extract all prevalent diseases, equation (1) was applied to the data using conditional format module in MS excel. This module was used because:

1. The data given by health directorate was in excel format.

2. After applying the Formula 1 on the data, it easy for excel application to convert the diseases that meet the condition to another sheet which is machine-readable in order words it can be converted by the protégé using the Cyc method. Details of the prevalent diseases in identified using eqn. (1) is presented in Table 2.

Cyc method

Several works have been on Ontology Engineering according to Perez (2004), Simperl and Vrande (2008), and Al-Arfaj and Al-Salman (2015) stated that, Ontology Engineering is the complete set of actions that concern the ontology development method, the ontology life cycle, and the procedures, tools and languages for constructing ontologies [11-13]. We adopted the Cyc ontological method for the design and development of the ontology used in this work. The cycle (CycL language) is a hybrid language that combines Frames with Predicate calculus. The cycle inference engine allows multiple inheritances, automatic classification, maintenance of inverse links, the firing of daemons, constraint checking, agenda-based best-first search, etc.; it also has a truth maintenance system, contradiction detection and a resolution module. The Cyc ontological method that was used has three processes, which is discussed in Figure 1.

System architecture: Figure 2 represents the conceptual framework of the proposed system; it illustrates clearly the process followed in arriving at our knowledge base. Each stage is uniquely and purposely designed to reduce the risk of errors and inaccuracy. The knowledgebase provides specific facts and rule about the subject domain. The inference engine provides the ability that enables the system to form precise conclusions. The system also provides additional tools in the form of user interface and explanation facilities. The user interface, as with any application, it enables people to form queries, provides information and otherwise interacts with the system by Adekoya, Akinwale and Oke in 2008 [14]. Knowledge Acquisition is a component which was used to build the knowledge base (Figure 3).

Ontology construction

The prevalent diseases which were identified using in Table 2 were fed into the protégé to develop the ontology as illustrated in Figure 4. Figure 3 is Intellij Idea a java platform; Jena Apache Libraries was set-up on this platform in other to read the .owl file (ontology) which is in .rdf format (Figure 3).

Classes and class hierarchy

Each prevalent diseases is categorised into age, gender and number cases recorded. A disease, which was identified as prevalent, was represented as a class in the protégé, as shown in Figure 5.

Object properties of the prevalent diseases show the detailed description of each disease object as shown in Figure 6.

Visualisation view using OntoGraf in Protégé

Here, we add important concepts or classes and add important

Disease Category	Prevalent Diseases	Total cases recorded as prevalent	Particular Disease Cases Recorded *(Pdc)*	Total cases Recorded *(Cr)*
CI	Measles	1	16	22
CNI	Uncomplicated Malaria Suspected Tested	11	124742	393615
	Uncomplicated Malaria Tested Positive		118322	
	Uncomplicated Malaria not tested but treated as malaria		54858	
	Uncomplicated Malaria in Pregnancy tested positive		5433	
	Chicken Pox		1450	
	Diarrhoea		17847	
	Intestinal Worms		6218	
	Pneumonia		3744	
	Septicaemia		4577	
	Typhoid Fever		2139	
	Upper Respiratory Tract Infections		48836	
NC	Anaemia	5	7750	34829
	Asthma		1042	
	Hypertension		2793	
	Diabetes Mellitus		953	
	Rheumatism and Other Joint Pains		21116	
MHC	Acute Psychotic Disorder	6	72	694
	Depression		81	
	Epilepsy		167	
	Generalised Anxiety		83	
	Neurosis		74	
	Other Oral Condition		115	
SC	Acute Eye Infection	6	10298	52354
	Acute Urinary Tract Infection		14815	
	Other Acute Ear Infection		3299	
	Otitis Media		3022	
	Skin Diseases		12647	
	Ulcer		5818	
OGC	Gynecological conditions	2	3240	4213
	Pregnancy-Related Complications		940	
RT	Vaginal Discharge	2	2354	5101
	Other Diseases of the Female Reproductive System		2146	
IO	Transport injuries (Road Traffic Accidents)	3	2354	82745
	Home Injuries (Home Accidents and Injuries)		1610	
	All other Diseases		80146	

Table 2. Identified prevalent diseases.

subclasses of our ontology shows in the visualisation view using OntoGraf. Here, we display some visualisation results of diseases ontology. Asserted view display classes graph, which we define in the ontology and after reasoned protégé tool give its result according to our relationship (inferred view). Below we displayed asserted view and inferred view of concepts in Figure 7.

Query retrieval process

SPARQL Query searches for any information about our prevalent diseases. Enter the class or an object property or data property name. Confirm that "reasoned" has started or not by Horridge, Knublauch, Steven and Wroe in 2014 [15].

Firstly, start it and for checking if your "reasoned" start or not. Check inferred class in the class tab option if in the inferred class did not display any class it means that your "reasoned" has not started after checking such task you can type class or any property name correctly and then it will display related information about particular class or property.

Proposed system

The system was implemented using Java, Jena API, JavaScript programming. The home page of the knowledge based system is as shown in Figure 8.

System testing and evaluating

A total of 61 (representing 87%) responses were received out 70 questionnaires administered from staff from Sunyani Municipal Hospital and University of Energy and Natural Resources (UENR) Clinic after interacted with the system. The staff response to positive (PR) statements 1, 3, 5, 7 and nine were 54 (representing 77%) above the midpoint which means that staff found the Knowledge-based

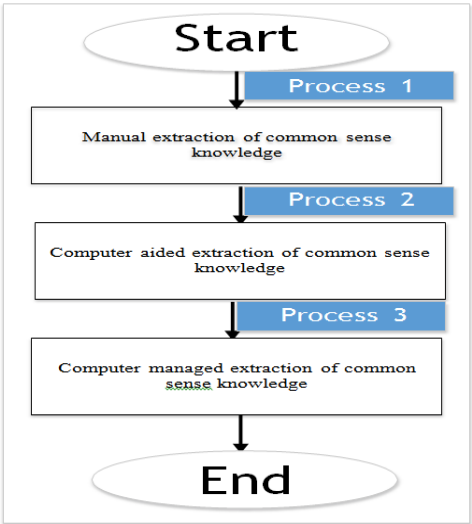

Figure 1: Data analysis process.

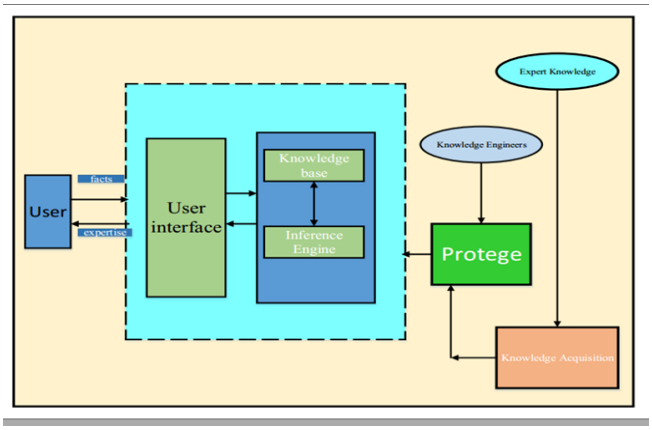

Figure 2: System Architecture.

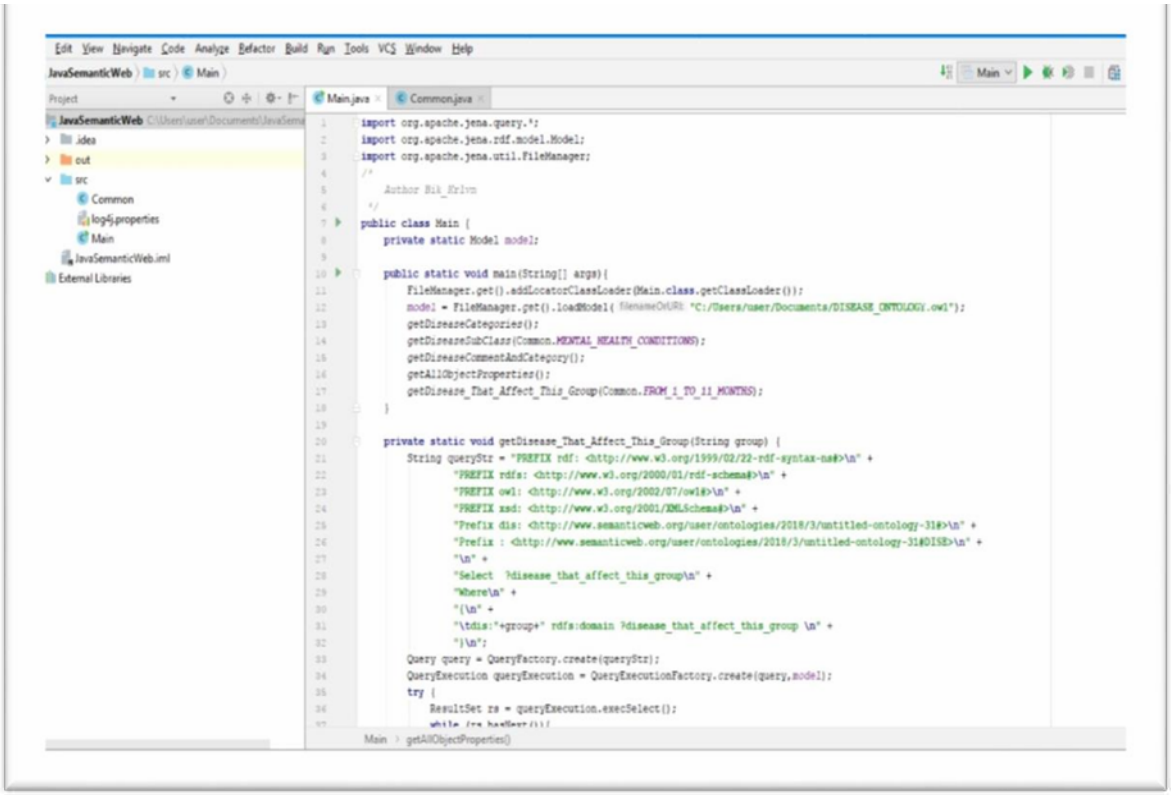

Figure 3: Intellij idea platform.

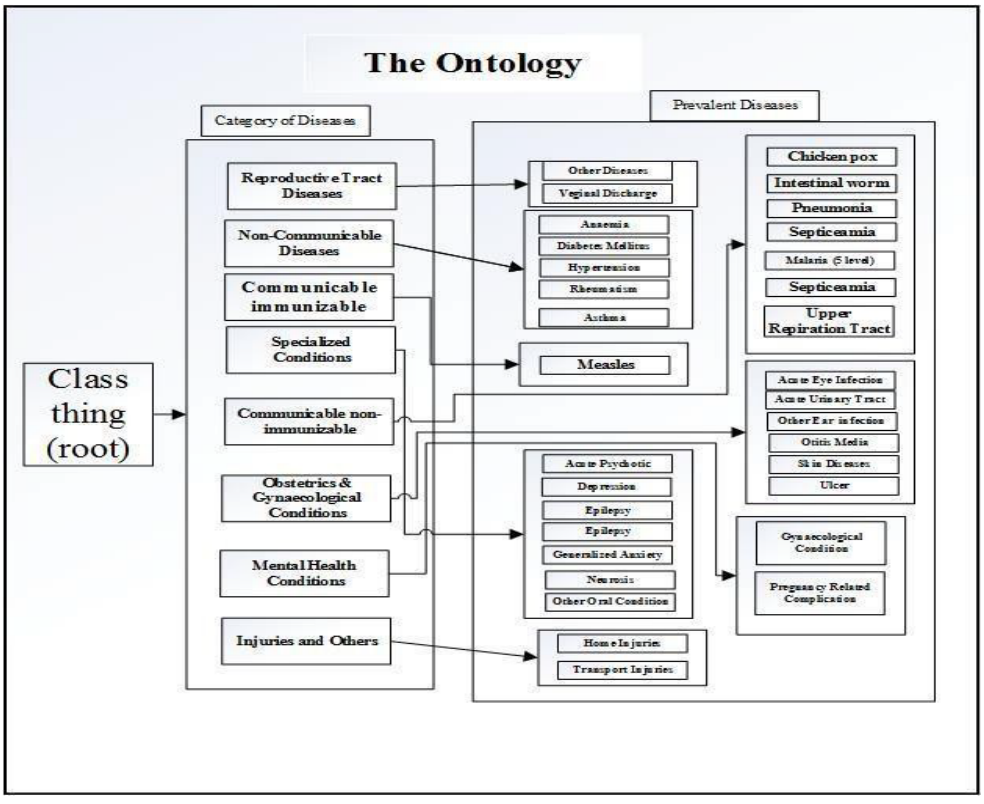

Figure 4: Ontology knowledgebase design of the prevalent diseases.

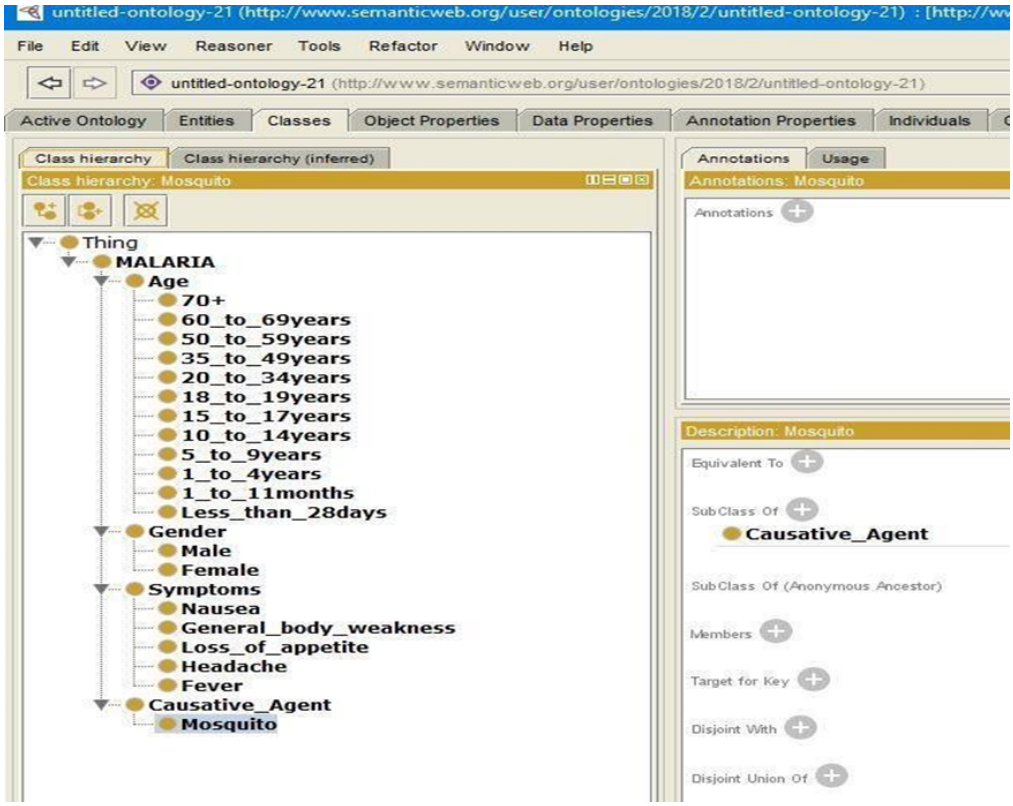

Figure 5: Ontology classes.

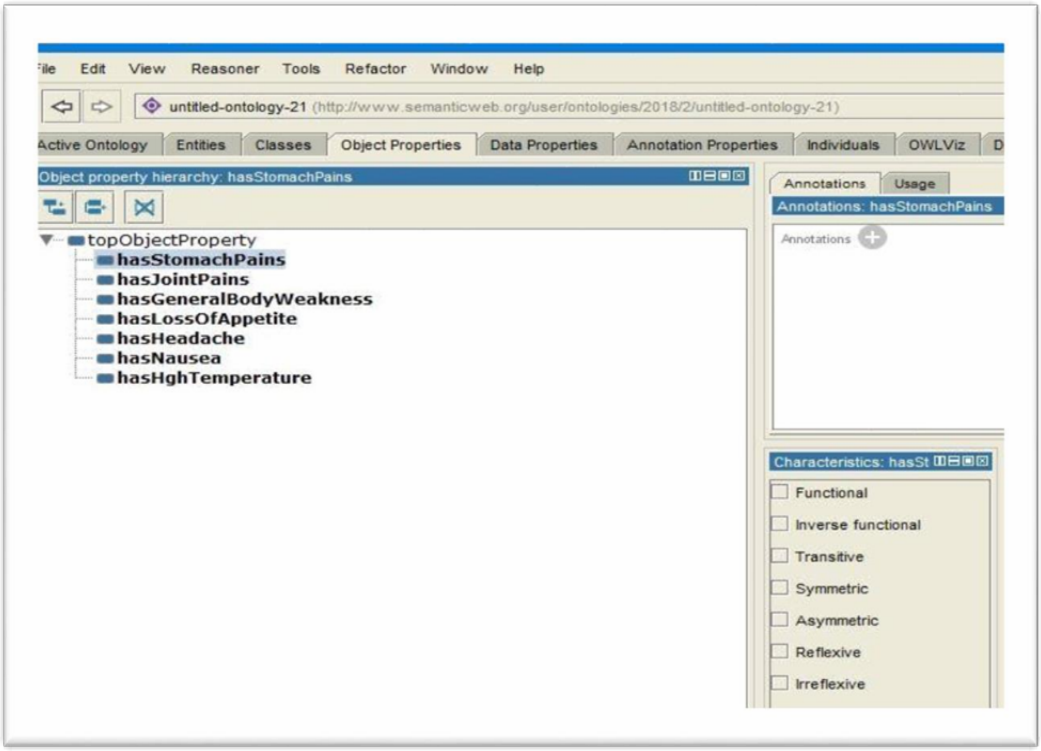

Figure 6: Object property hierarchy.

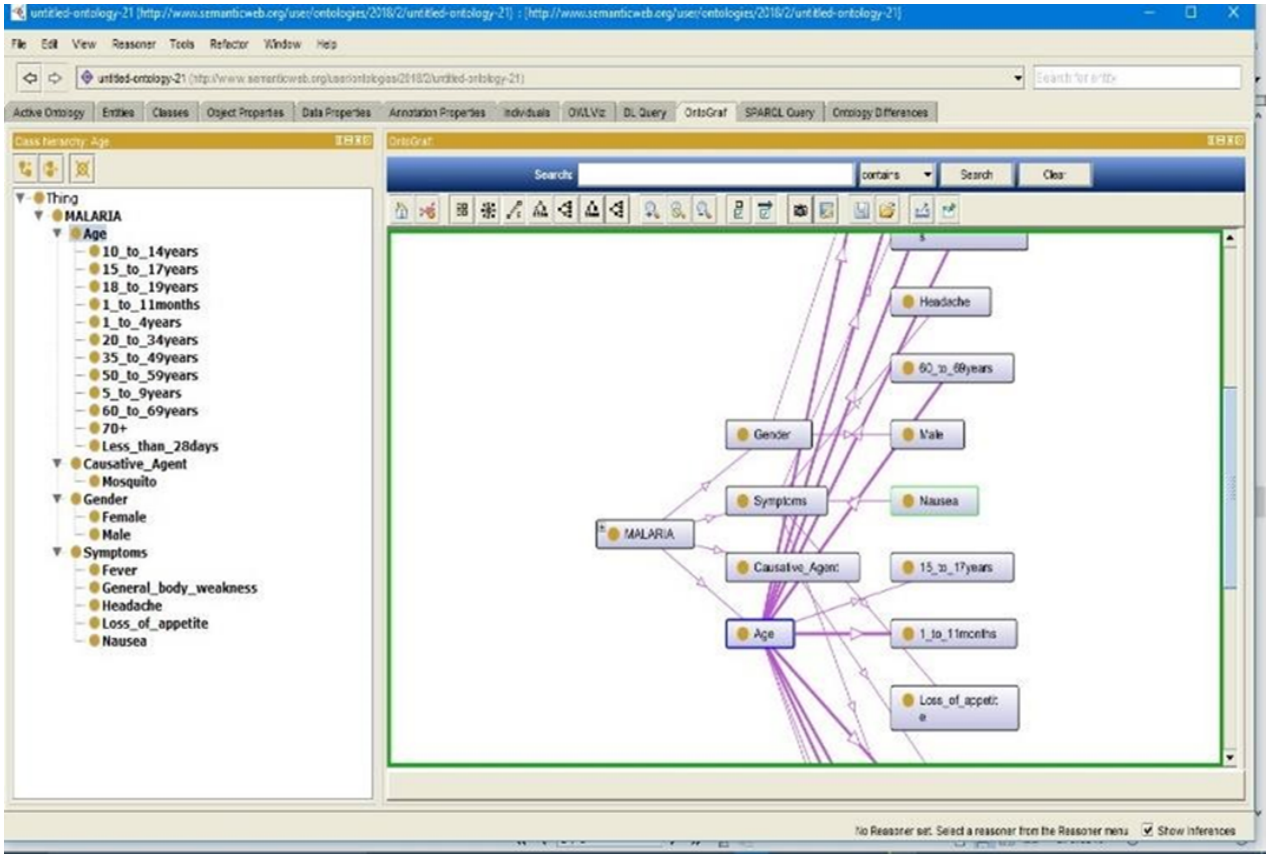

Figure 7: Visualisation view of ontology.

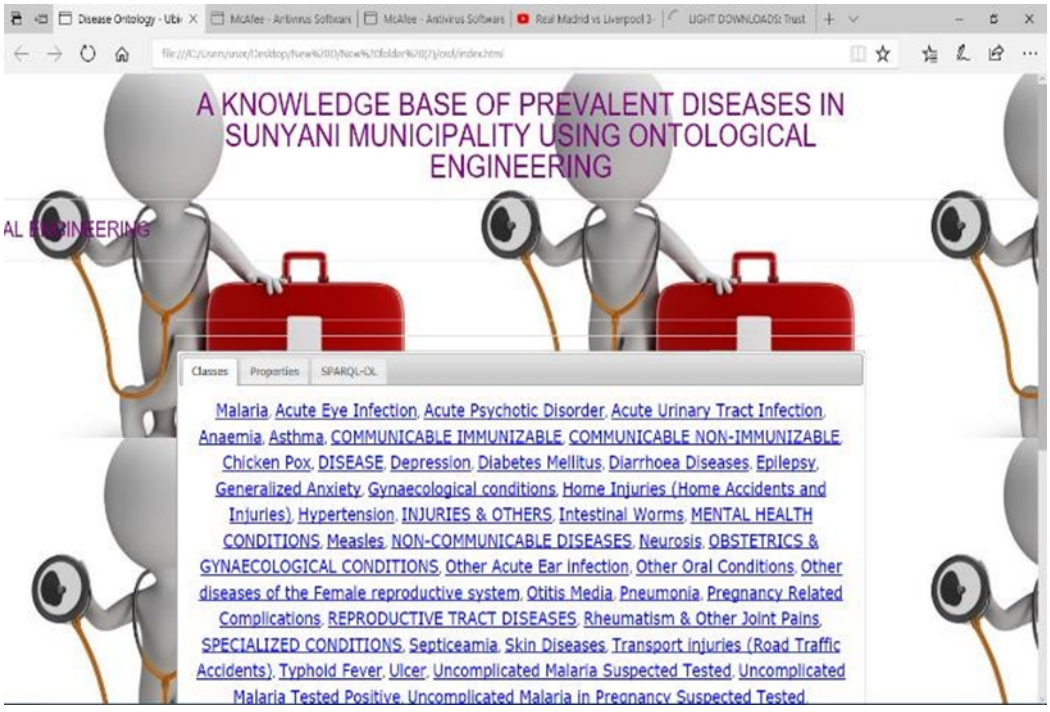

Figure 8: Homepage of the proposed system.

easy to use and its functionalities were appropriately designed and well-integrated. On the other the hand, the response to negative (NR) statements 2,3,4,6, and eight were 7 (representing 10%) discovered that even though the Knowledge-based was user friendly and easy to use, it still has some inconsistency, complexity and irregular action in it functionalities. Moreover, nine staff (representing 13%) did not get a response to the questionnaire at all.

Conclusion

In this work, we presented semantic knowledge base for the healthcare system in Sunyani Municipal, which is an effective and efficient means of presenting and organising knowledge in the medical domain and assisting Sunyani Municipality and policymakers.

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