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An Expert System to Implement Symptom Analysis in Healthcare

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Abstract
An expert model can highlight the clinical decision for patients that need accurate, timely, and up-to-date healthcare information, effectively. In this paper, the authors try to construct a use case that collects information from a variety of sources. It showcases objects, situations, in semantic use case domain. Unified Modeling Language (UML) emphasizes on software construction and OWL (web ontology language) formalizes knowledge representation about any system before development. The promotion of an expert model needs the digital competencies of a healthcare professional at a remote hospital. Recent reviews regarding healthcare show that in remote areas people are still dying because of the lack of timely health care facilities. The mortality rate is still high among infants and pregnant women. Because of lack of human expert in a remote area, paramedical workers run certain hospitals. They cannot predict symptoms of some disease because of lack of sufficient knowledge and proper training. An expert system assists the patient at the point of contact. The knowledge base for symptoms, collected from patient end, continues to be observed regularly. UML is a powerful technique to explore the syntactic behaviour of any decision logic framework. For a significant expert model design in healthcare, it needs integration of a colossal amount of heterogeneous data from multiple sources such as symptom data, image data, disease information. For a major health-care project, the semantic web delivers a recurrent infrastructure an expert system can segregate and rephrase which. Here in this paper, the authors make a good attempt by analyzing the UML use case model and ontology-based use case model for an expert system in healthcare.

***Keywords*:** Expert model, supervised learning, symptom-disease, knowledge base, decision logic

4.1 Introduction

The expert system provides an adequate treatment of information and attention without delay. We should not treat the patient as a specimen by a healthcare professional if adequate human expert is not available. The patient does not like delayed information because the delaying of information may deteriorate the health condition of the patient.

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Again, some issue lies with the patient side also as some patients face difficulty in communicating their health issues to the doctor properly. Some people dislike going to the hospital as they have certain allergic reactions to the smell of drugs [1–3]. So, an expert system based preliminary diagnosis can be a solution for the above-discussed scenario [4–6]. It is a discouraging sign for any developing nation like India if it does not check mortality rates because of minor ailments and lack of in-time treatment [10–12]. It only happens for the delay in information. For countries like India, one of the major issues is depicted as follows for predominant rural communities a few medical experts available because most of them like to serve the urban hospital [18]. There is a widening quality of service gap between urban and rural areas. So, an expert model described in this paper presents a novel medical diagnostic approach that can check on the mortality rate. Here, we have focused on a robust mechanism, i.e. CNN-Fuzzy inference mechanism. Expert systems (ES) arise from artificial intelligence (AI) which learn, understand, and solve problems based on decision logic & inference mechanism. An Expert system is an essential requirement for every organization as it provides sound and in-time advice to the patients, which is an essential requirement to set up a multidisciplinary and value-based healthcare infrastructure [13–15]. Ontology entails correct information dissemination by integrating controlled use case models and class models. Ontology use case analysis is a powerful technique to further analyze a decision support system in health care. In a health context, it will improve decision making in healthcare. UML Class profile ontology provides an actionable knowledge sequence. It can showcase medical inconsistencies after analyzing the semantic gap between Class and ontology use cases. Expert model analysis through ontology can diversify concepts as per the growth of information. Nowadays, an expert system is considered as one of the effective, accessible, and resilient techniques to bridge the communication gap between a patient and the doctor. It is tremendously improving healthcare sustainability and provides access to the patient in remote areas. It can avoid over diagnosis treatment by mining symptoms i.e. collected from the patient. The expert model is in utmost demand to build a sustainable healthcare ecosystem. As per some reports, 74% of doctors are in the urban area and they are only serving 28% of the population. So, the universal health coverage to all people of India by 2022 remains a bliss. The crucial variation in healthcare service still lies in remote areas. Considering all these issues, an expert system hopes to provide significant healthcare solutions in remote areas. The decision support service expert system makes it an autonomous agent [15]. The proposed expert model effectively coordinates the patient request [16–18]. It is a supervised adaptive form of learning that can manage symptom data from the patient to detect disease patterns. This research is studied upon UML (Unified Modelling Language) service model [19]. UML analysis is necessary for providing fast and efficient service implementation in real-world scenarios. It can capture the correct diagnosis path and immediate monitoring before it's implementation. UML is a corrective technique for any successful project implementation. Various approaches to UML are used to improve the healthcare expert model. This research paper projects upon class interaction technique, Flow chart, Use case analysis, Activity diagram [5]. An expert system provides correct and immediate responses that can serve the people in remote areas. Decision logic explained in this paper is used to classify symptoms based on disease, subsequently the CNN-Fuzzy inference mechanism is considered as an effective data mining tool for adaptive expert learning.

4.2 Related Work

In healthcare services, the expert system is used to manage autonomy in disease diagnosis and client request processing. The proposed expert agent model can detect disease pattern, and it provides an advance treatment plan to save lives. For real-time analysis, UML adaptive technique is used to diagnose its accuracy and efficiency. It implements UML for object-oriented ontological modelling. It formalizes knowledge interaction format in ontology. Further, it establishes linking knowledge base from class to class. UML defines ontological sets to class, activity and use case. Expert system is an autonomous control agent. It can solve complex problems. It focuses the core idea behind expert system learning on data acquisition, learning, perception, and communication. We consider an expert system a boon for society as it can find an expert solution technique where constraints lie for human expert i.e. unavailability of hospital, doctor, etc. We give the abstract expert model for health care in Figure 4.1. The control flow of this model was presented in ESDA-2019, International conference, Kolkata. We give the detail flow of this model in section-3. We give the detailed analytical processing of this model in section-4. In section–5, we focus upon real-time scenario analysis that delivers extensive analysis of UML behavioral diagram, class interaction diagram, etc. We invoke the fundamental aspect behind this expert model design to consult service remotely. Subsequently, semantic operation, control flow detection, of expert module design is given by UML static, and behavioral diagram. UML need and demand for expert model design before its implementation is adopted widely as it bridges the gap between client need and demand. Subsequently, it provides financial and technical protection to the research group. We consider UML as first arm strategy to provide value-based healthcare infrastructure can improve the quality and safety of the model by analyzing explicitly choice from the outside environment and client. It optimally chooses resources to illustrate the right health care program. This is a new paradigm for quality-based healthcare, though it finds a wonderful balance between individual patient needs and remotely assisted clinical services [21]. It enshrines the UML concept in the object-oriented analysis where each diagram contributes specific action of the expert module from cradle to grave. The concept of

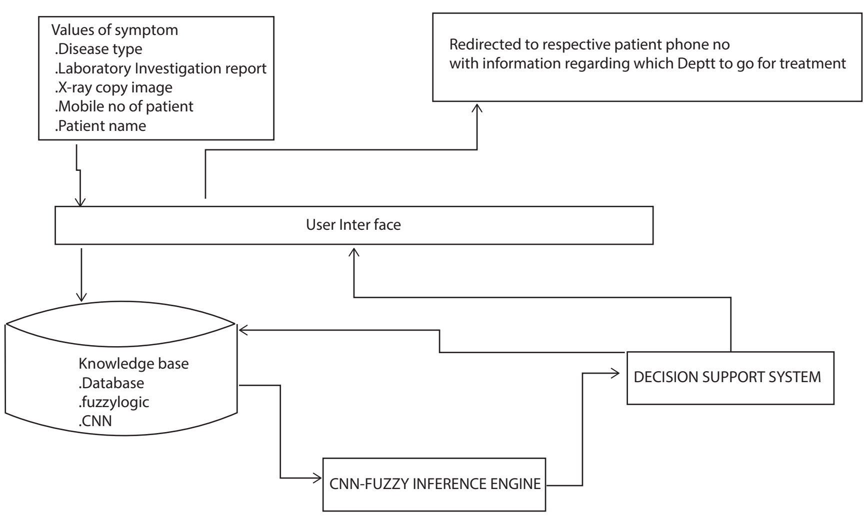

Figure 4.1 Expert model in the healthcare domain for capturing patient symptoms.

UML analysis in the healthcare expert model provides re-emergence of an adaptive supervised learning scheme. Seeking in-time healthcare service is the social right of every citizen. It should be the primary focus of every hospital to provide curative healthcare help to every citizen. The expert system can only ensure social health care cohesion within the nation [20].

4.3 Proposed Model Description and Flow Chart

4.3.1 Flowchart of the Model

The model described above has its benefits and future scope for smaller symptoms based on applications in the complex research-based domain in healthcare. Following are the components that make up this healthcare model:

4.3.1.1 Value of Symptoms

This phase collects the Disease type and its corresponding symptoms tabular. Patient name and their contact number, is collected using an interactive user interface terminal for further information dissemination. If the patient has an X-ray report or any such report, then they are kept in a separate database using a graphical end-user specific interface.

4.3.1.2 User Interaction Web Module

The user specific interactive page is a web-based application to collect information from the patient, and it acts as a sensor in this expert system-based model.

4.3.1.3 Knowledge-Base

The knowledge-base (KB) comprises symptoms database, convolution neural network and used for image analysis and prediction for a set of diseases like (blood cancer, bone cancer, flaws in the ligament, etc.). The fuzzy logic establishes a fuzzification of symptoms data and emerges with certain rules. If certain symptoms match with specific disease or disease set, then the output is moved forward to the decision support system [22]. We show this in Figure 4.4. The fundamental paradigm of KB emerges within this expert model as three synergistic approaches, like symptoms collection database from patient, CNN algorithm for analyzing, and predicting various set of disease, and fuzzy rule to analyze the set of symptoms and to generate one crisp set of disease for these symptoms that the expert system collects from the patient [23].

4.3.1.4 Convolution Neural Network

CNN provides the architectural idea for the detection of disease. It is a further enhancement of learning for feature extraction based on symptoms data. CNN, otherwise known as conv net. It is exhibiting a linear computation. It is nothing but a combination of multiplication with a set of weight and input parameter, same as a conventional neural network. It takes a two-dimensional feature pattern which is nothing but an array of linear input and weight based on RELU at inner layer and Softmax at the outer layer [27–29].

4.3.1.5 CNN-Fuzzy Inference Engine

It is a novel approach in which a fuzzy specific convolution neural network (F-CNN) method is suggested to foretell the disease from symptoms data more accurately. Here, a precise fuzzy method has been implemented to showcase symptoms of features when instigating unsure disease-based symptom details. They then feed it into the CNN at a specific interval of time. This is used to pull out the place of occurrence and time of initiation of characteristics to the symptoms database, CNN and fuzzy-based inference mechanism that can give the desired information to the patient that he is seeking for his treatment [24–26].

Decision support for a patient is a highly heterogeneous task because of the structural symptom complexity of the disease, so this paper introduces a new cooperative task tracking in the expert model as shown in the Figure 4.2. This paper focuses on the idiosyncrasy of CNN-FUZZY based event-driven model for a patient. A huge disparity in access to doctors and the distribution of healthcare experts in India makes this model patient-friendly.

Diagnosis of disease in Decision support systems logic (DSS) formally establish a precise framework of clinical knowledge management technologies through their capacity to support the clinical process and to extraction of knowledge, from prognosis and scrutiny through treatment and long-term care. The Fuzzy-CNN based conceptual model can serve the patient efficiently while handling and tracking their symptoms and give proper guidance to further service consultation where a human expert does not give precise information to the patient [30–32].

Finally, the model redirects the person for consultation, at which place of the hospital is given to a person either displaying the information on-screen of the user interface or through their sufficient contact number.

The flowchart, as shown in Figure 4.6, represents the initial stage of understanding. It discusses the integration logic of each module. Each subsystem schedules activity of information from patient login, symptom data analysis, and decision logic. The flow chart emphasizes the static and dynamic aspects of design. It captures the client in the initial phase of design. Along with the flowchart description, the authors give a wide scope of narration by using UML analysis.

The flow chart description is:

- First, users register themselves through the user interface.
- In this step, we collect all symptom data and store them in knowledgebase (KB).
- The CNN-FUZZY inference interacts with KB for classification of disease and it provides high-end decision logic for prediction [7].

Expert module interaction flowchart has a well-documented process. It can customize the module to show the steps of the process. The conceptual approach of the flowchart has contributed significantly in module design. It delivers a systematic service framework to enhance the performance of the model during the implementation phase. It proposes a feasibility set of actions by evaluating different constituents. New artifacts, from the flow chart visualization, are added and deleted to improve the service. It captures the operational perspective of the module by visual orientation.

4.4 UML Analysis of Expert Model

The use case diagram, UCD, is a tremendous application to a sustainable expert system. It is an innovative approach to save energy, resource, and infrastructure cost. It concentrates upon the standardization of expert module interaction. It also highlights the major points for expert module interaction. It highlights a certain point for expert module development. The use case-based utility checking of method interaction ensures the success rate of the expert system. We study the abstraction phase of an expert module through an incremental approach, which is an innovative scheme supported by use case analysis as it provides a visual modelling framework to the expert system. This paper concentrates upon building online service components of the expert system. The use case analysis is needed to automate and to enhance the performance of the expert system. It integrates services through the external environment. A vital goal of use case analysis is to schedule events integrate with external environment, knowledgebase (KB), user interface (UI). In Figure 4.2, the researchers provide tracking of interaction among patient and expert modules. It provides a detailed insight into effective action control mechanisms under the natural environment. It focuses on the monitoring of the event. Here, in this paper use case does the fundamental management of patient interaction with the expert module [33, 34].

In this context, the use case diagram given in Figure 4.3 provides a trace-ability tool that accomplishes connectivity, authentication, and presentation layout of an expert model. The Use Case Analysis (UCA) approach, in this subsection, provides a precise understanding of the communication pattern between the patient and expert module. This use case analysis leads to several advantages as it ensures a clear graphical representation of the vital components in the expert module. It assists the module specific requirement for a new software unit and its nascent stage of development. It is an effective technique to specify extern user behaviour. As said, the use case analysis maximizes the relationship between the patient, expert module, and a core communication. It can capture system validation by developing test cases.

It gives the UCA conventional notation:

- An actor replica is given by a stick man symbol.
- A use case is illustrated by an ellipse.
- Communication between actors with use cases are established by arrows.

In this paper, the patient and expert module are the actors as depicted in Figure 4.3. The granularity of use case tells how the information is organized to achieve the right level of specification.

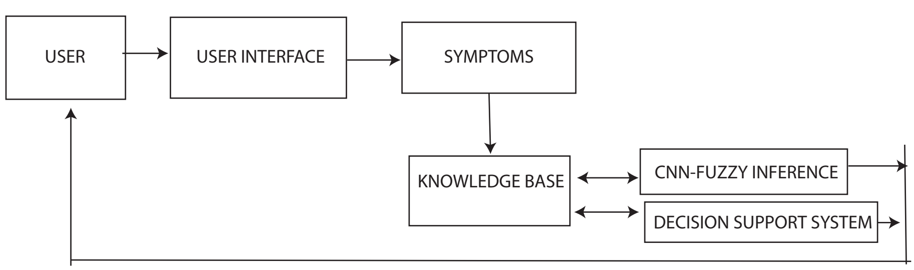

Figure 4.2 Expert module interaction process.

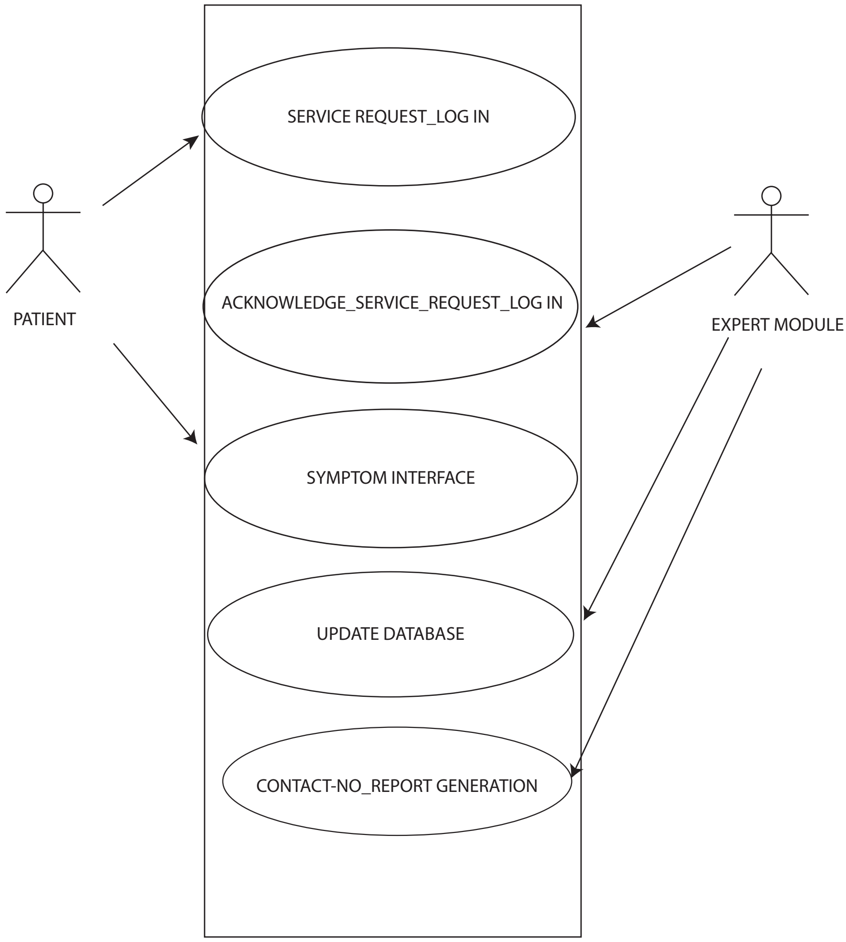

Figure 4.3 Use case diagram of patient and expert module.

4.4.1 Expert Module Activity Diagram

The expert module activity diagram is one of vital aspects of UML that narrates the dynamic behavior of the system. It is a flowchart like representation that shows the flow from one activity to another [5]. The operating system controls it. It is a visual representation of the preceding and succeeding task and hence, gives a pictorial view of model operation is given by authors in Figure 4.4.

The activity diagram exhibits sequential or concurrent message flow using a graphical representation. It conceptualizes the dynamic flow of the model and subsequently; it concentrates on forward and reverse mapping of the model. Figure 4.4 gives a clear understanding of the model. It captures the graphical modelling simulation to a model, though the high-level view of activity diagram investigates the operational requirement of the model in later development stage. In Figure 4.4, we give the conventional notation used for the activity diagram. The dark filled circle symbol represents the start and end of the activity. The rounded cornered rectangle symbol represents activity, the diamond symbol shows the decision condition, the arrow represents control flow from one activity

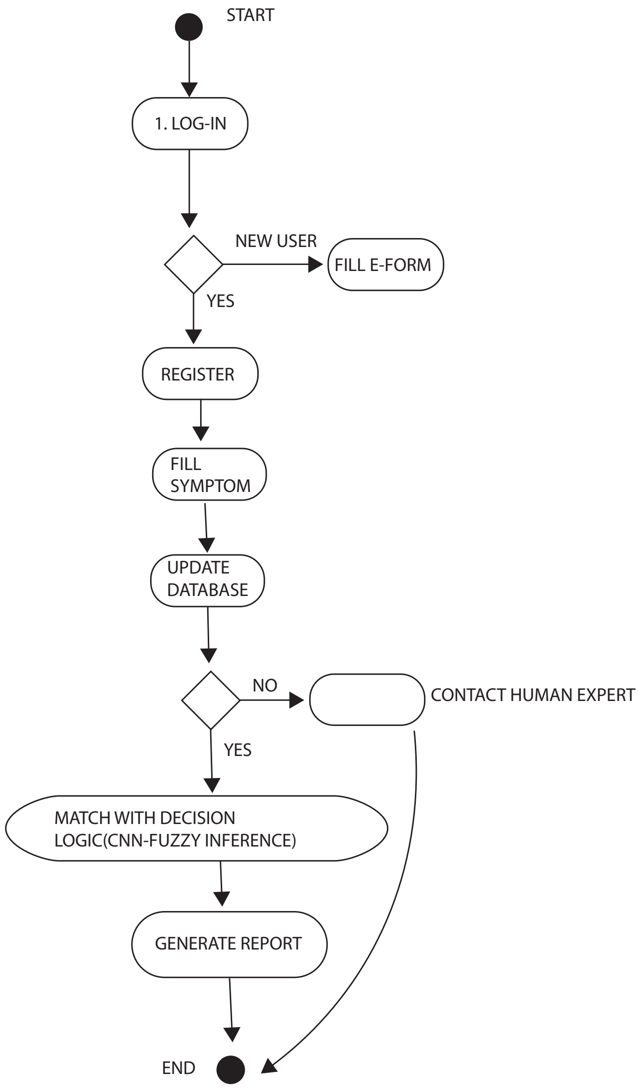

Figure 4.4 Expert module activity diagram for decision logic.

to another, and it maintains concurrent activity in the same layer. The high-level view of this model investigates the operational requirement in a later stage. In Figure 4.4 authors provide a high-level view of an activity diagram. As the knowledge layout of authors is sharpened by activity analysis, so we transform a good activity analysis into a suitable model [12]. This pictorial representation works as a software blueprint, as an activity diagram describes the real-time dynamic flow of a system. Each activity flow gives the developers a piece of precise information regarding the model. Each activity collaborates with the responsibility that will provide access and equity during the developmental stage of the model. The Figure 4.4 shows the validation of patient information, symptom collection, availability of the report, and exception handling for the external events. It provides a computer interpretative structure ontology from end-user login to the report generation by an expert module. This is a unified ontology plan to synchronize intuitive model flow and explore a workable diagnosis plan [35, 36].

4.4.2 Ontology Class Collaboration Diagram

The collaboration diagram, as shown in Figure 4.5, depicts the structural framework of a model. It is another flavour of the ontological linking of knowledge interaction diagram. The impetus of the collaboration diagram is to show the flow of messages between the classes. Classes are the building blocks of any model. In Figure 4.5, the authors have shown several classes that are involved in offering services. It shows the service request transfer, and service request send between the classes.

In this service class ontology model, request transfer and sending of service responses are added between sub-classes i.e. user interface, knowledgebase, login, decision support system, and external contact for remote patients. It can facilitate platform-specific ontology function establishment between nodal class and subclass. It is a prototype framework for ontology integration between clusters of specific classes.

- User Interface Class: It provides a graphical user interface for patients. The patients can fill their credentials as per the expert system data capture form.
- Knowledge base class: It acts as a repository for collecting patient information (patient data, symptom data, etc).
- Login class: This class checks and validates the patient credential by providing a user-id and password that the patients can use to access the expert module remotely.
- Decision Support Class: This class can efficiently interact with knowledge base class to classify disease patterns based on adaptive learning techniques. Here, in this expert module, the authors have focused on the CNN-FUZZY inference mechanism.

The message flow among classes depicts relevance, and authenticity of the model class relationship is given by arrow signs in Figure 4.5. It is the preparatory phase to establish an outline of the expert model. We will analyse the detail class attribute, method interaction, and external cloud connectivity module class as a future direction of this paper.

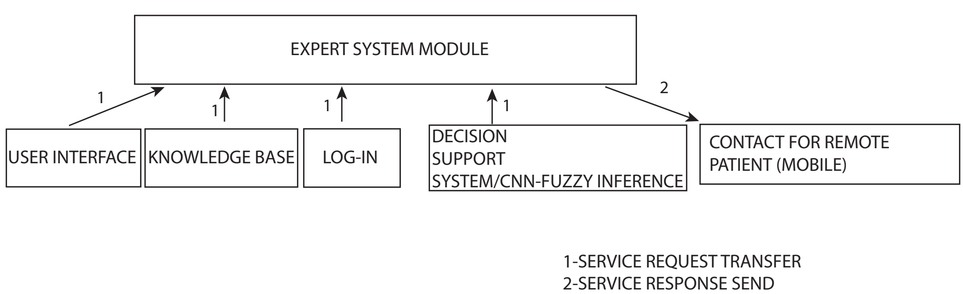

Figure 4.5 Class collaboration diagram.

4.5 Ontology Model of Expert Systems

The ontological use case model retrieves the extensive knowledge for real-life scenario analysis. It provides an easy conceptualization domain for IoT healthcare stakeholders. It automates the model for test case generation. Hence, in this section, the authors introduced the use case model analysis for an expert system that delivers action semantic information between the user and the expert system. The Figure 4.6 graphically shows an abstract level of standardization that UML provides.

The use case model makes an informal analysis of any model [36]. So, to automate the analysis of an expert system, the authors introduced ontology-based use case analysis in Figure 4.6 for the model shown in Figure 4.1. In this paper, ontology highlights the use case driven architecture and ontology-driven development. The rationale idea behind this paper is not only to overview their extensive relationship but also to compare their core features to the wholesale integration to a model. Many industries adopt both UML and OWL because of their rich infrastructure [18]. In this paper, the authors precisely embedded these two techniques that provide a meta-model facility to real-world applications. We consider UML

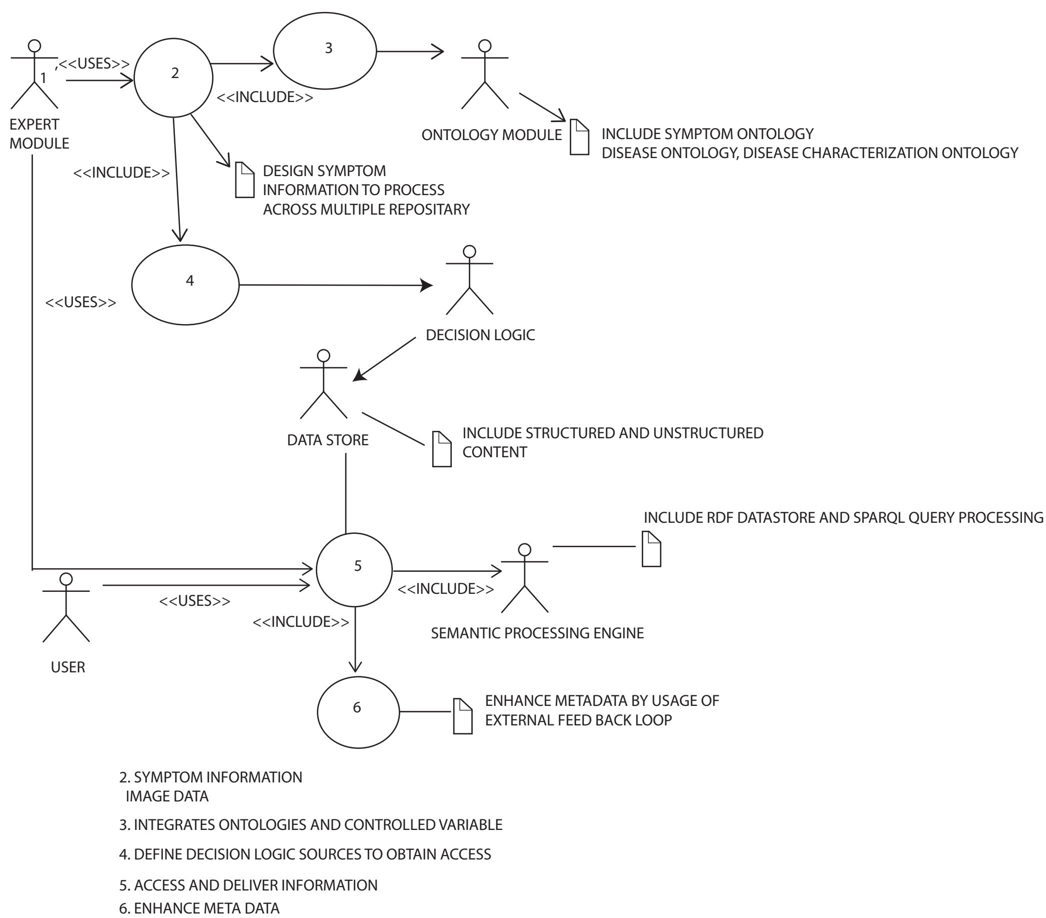

Figure 4.6 Ontological knowledge base diagram.

as an object constrained language but OWL provides a resource description framework to specialize in each activity of use case model. In this section, the authors clarify the aim of the expert model given in Figure 4.6, by semantic use case mapping. It gives the discrete semantic representation of an expert model in this section. The ontology module gives the semantic repository of disease symptoms and relevant precautionary measures. It collects information for the disease meta-data repository. The theoretic semantic model explicitly defines how to construct a semantic domain for the symptom. In this paper, the authors integrate the underlying goal of both UML and OWL for an expert model in healthcare. It represents an object centric intention to knowledge representation [20]. Object centric representation provides a logical cut insight to analyse object behaviour in a system and OWL analysis for any model differentiates the role of empirical knowledge and coherent knowledge. Ontology provides the terminological information about a system. In Figure 4.6, we depict these as symptom data, feedback for enhancement, and ontology module. Because of the limited scope of this paper, the authors have only given the behaviour analysis of the model in UML and Ontological use cases for model interpretation given in Figure 4.1. It centers both UML and OWL on the objects which are the backbone of extensional knowledge representation. The Ontology framework is best suited for a heterogeneous environment that enhances automatic inter-operability and deployment. It reduces the shift of complexity of operation. Here, in Figure 4.6, the ontological work flow analysis is an enhanced form of the UML use case model which has been elaborated in Section 4.4.

4.6 Conclusion and Future Scope

In this research finding, we conceptualized end user interactive patterns by taking the logic of the UML diagram. For documenting this healthcare based expert system authors focused upon several principles i.e. effectiveness, solidarity, and trustworthiness analysis shows the technical aspect of implementation modelling of the system gives a quick understanding as developers can map and change system requirements in a dynamic environment. UML infrastructure analysis can detect flaws in scenario analysis in use cases. AI-based expert system is still under research as it needs continuous UML based simulation before its implementation. UML captures intelligently the flow of algorithm that enhances the learning automation. The authors are taking it sincerely as a point to integrate expert module decision logic over cloud-connected architecture. The OWL supports distributed and interoperable properties. Therefore, it grants the existence of any model. The ontological aspect shows the class- and set-based operation between them. It offers flexibility and remote help to a patient for any unknown pattern of symptoms. The ontological processing and UML processing can provide autonomy to the expert system that can transform the entire healthcare pathway by linking expert module and patient that may include the not so digitally literate and old people who face difficulty in communication. Providing rational service is an essential feature of the expert system. Migrating symptom database to cloud is a challenging task that needs deliberate planning. Researchers must map the significant obstacle of cloud computing with the expert module. Cloud assisted decision making is the key feature to enhance trustworthiness in the expert system. Cloud migration for the expert system needs large data centers to store, process, and analyze symptoms information as they may include images, X-ray reports, data sheets, etc. CNN model needs a high-end GPU to analyze an image. We must develop a use case for cloud functionality module before its implementation. This scientific paper expands the logic of cloud activity, planning, messaging, and decision-logic in compliance with existing technologies. Last, the ontology facilitates system driven use case classification i.e. concentrated upon terminological information. The Ontology model further describes the service of decomposition for a conceptual model.

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