Smart Learning Systems in Healthcare Domain: Methodologies and Challenges

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Abstract—A challenging AI field that have achieved a great reputations in the last few year is the smart learning technologies. In the recent years artificial intelligence (AI) methods and theories has got a great attention recently. Therefore, a new generation of smart tutoring and learning system are developed by the reseachers based on different AI Concepts. The spread of the smart technologies based on the AI, web science, internet of things (IOT) lead to the creation of important improvements in the field of web-based smart learning systems. This improvements lead to a great enhacement in various fields, task, and domians. This paper discusses the AI methodologies and techniques for developing the smart learning systems(SLSs) in healthcare domain .Foure most popular techiques are discussed namely; case-based reasoning ,ontological engineering, data mining and intelligent agents. Also, the paper presents some of resent research regarding the application of machine leaning techniques and AI pardigms in the battle against the corona virus. In addition to this, this study investigates the current obstacles that are faced by various programmers and developers. It can also be considered that the knowledge engineers are enhncing their work in the process of developments and the deployment of different intelligent AI systems. Moreover, the manuscript illustrated some real cases of SLS implemented using various authors and their collegues at Artificial intelligence and Knowledge Engineering Research Labs, Ain Shams University, AIKE Labs-ASU , Cairo,Egypt.

Key words: Knowledge Engineering , Smart Learning Systems, Machine Learning, Corona virus Medical Informatics, Artifical Intelligence.

1. Introduction

Smart learning (SL) represents a collection of e-services that employ digital media and information and communication technologies for supporting educational processes. Smart Learning Systems (SLSs) are based on many disciplines such as: cognitive science, computational neuroscience, educational science, library sciences, artificial intelligence(AI) and knowledge engineering. So, SLS are considered enhanced system that simulate the human brain. The most common features of the current systems are the ability of inference, reasoning, perception, learning, and knowledge-based systems (figure 1). To a limited degree, AI permits SLS to accept knowledge from human input, then use that knowledge through simulated thought and reasoning processes to solve problems.Many types of SLSs are in existence today and are

applies to different domains and tasks, e.g., geology,busnies,biological sciences, medical sciences, health care, commerce, and education [1,12].

SL is interdisciplinary area, encompassing many aspects of the educational technologies that cover instruction, training, teaching, learning, pedagogy, communication and collaboration. On the other side, SmarrtLearning Systems (SLSs)represent a special kind of knowledge-based systems,not data-base systems[1,8,12].Such systems permits the knowledge and experience of one or more experts to be captured and stored in its knowledge base.

This paper is organized as follows; the second section introduces an overview ofthe knowledge representation and reasonong techniqies andmethodoloies for developing the SLSs. In the third section we present the Case-Based intelligent e-Learning systems. Sections four, five and six describe the ontological engineering , data mining and agent-based approaches and methodologies for developing SLSs respectively. The seventh section gives an overview of some applications of SLSs in healthcare domaindeveloped by the author and his colleagues at AIEK Labs-ASU.The eight section pesents some applications of AI in the detection of Corona virus.Section nine discusses the difficulties and challenges.The last section draws conclusion and perspectives.

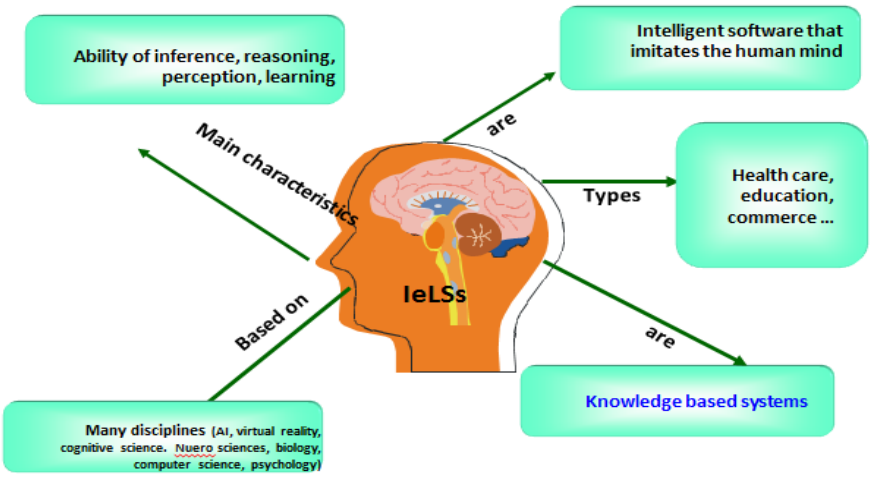

Fig. 1 Smart Learning Systems Characteristics

2. Smart Learning Systems(SLSs)

2.1 Techical Structure of SLS

Smart Learning system consists of three major components: a ***knowledge base***, an ***inferenceengine***, and a ***user interface***. The ***knowledge base*** contains all the facts, ideas, relationships, and interactions of a narrow domain. The ***inference engine***analyzes the knowledge and draws conclusions from it. This engine(software) uses search and pattern matching methodolgies applied on the inference engine to reveal the answer of the questions. Then, based on graphic user intereface the system will allow new knowledge to be added to the knowledge base. Then, a communication based on an implemention is done with the user. The main aim of this system not to eliminate the experts and their opinions, but to make their advice and information be available more widely. It can be seen that their exist a lot of problems to

solve, but a few number of experts are found. The system provides the experience of the experts widely. It also has the ability to solve problems, improve the decisions even if there is no existence for an expert.

2.2. Knowledge representation and management techniques for Smart Learning Systems

The main challenge in developing SLS is to build a "knowledge base" for any required task in any kind of domain. Information about the domain and knowledge can be organized, collected, implements, and finally arranged in a sequence or in an scientific order. The former process is considered one of the most important and expensive stage in the development of the SLS processes. In figure. 2 (a) a representation of some production rules and hierarchial methodologies in terms of trees, lists, production rules, scripts, onotology, frames, and semantic networks. In figure. 2 (b) a represention of some knowledge representation rules. To achieve an efficient system we must select the convienient techniques that best fit the domain knowedge and the selection of the methodolgy that is more appropriate for the problem being solved and recognized. All of this related to the experience of the developer and the knowledge engineer. Further details can be found in [8, 12].

Eventhough there exist different types of management and knowledge representation methodologies that are implemented and discovered over yearsm but these techniques and methods have common features and characteristics. These common features are that they can be be implemented with specific programming languages. In addition to this, these methods are designed so that the facts and knowledge are updated and controlled by an inference engine system. The inference system is considerd the major part of an SLS. Inference systems depends on different matching and seach methods on the knowledge base. The aim for this is to perform intelligent function and draw different obervations and conclusions.

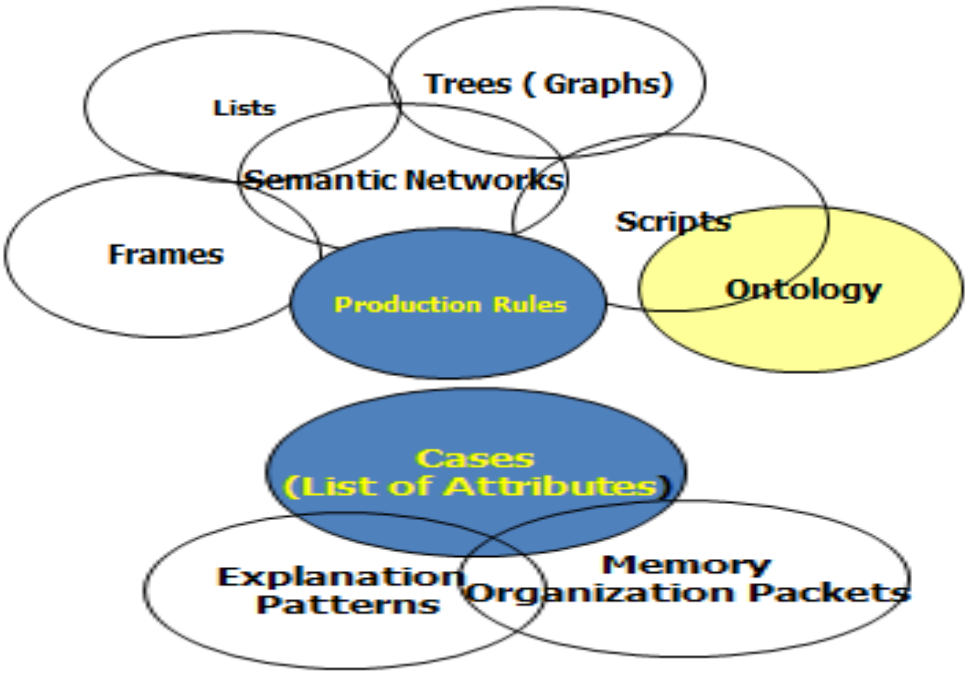

Fig. 2: Knowledge representation and management techniques

2.3 Reasoning Methodologies for Smart Learning Systems

In the domain of the reasoning techniques, the capability to apply anyone of them in the developed of SLSs is important. The reasoning methodologies vary and they can be used in various applications and they can solve different problems. The reasoning methods are divided into temporal, qualitative, spatial, probablistic, geormetic, casual, model-based, fuzzy, automated, common sense, fuzzy reasoning techniques [13, 17]. Figure. 3 represent the most common reasoning techniques based on the domain of knowledge and engineering computing. In fact these methodologies receive increasing attention within the development of a new generation of smart Learning systems.

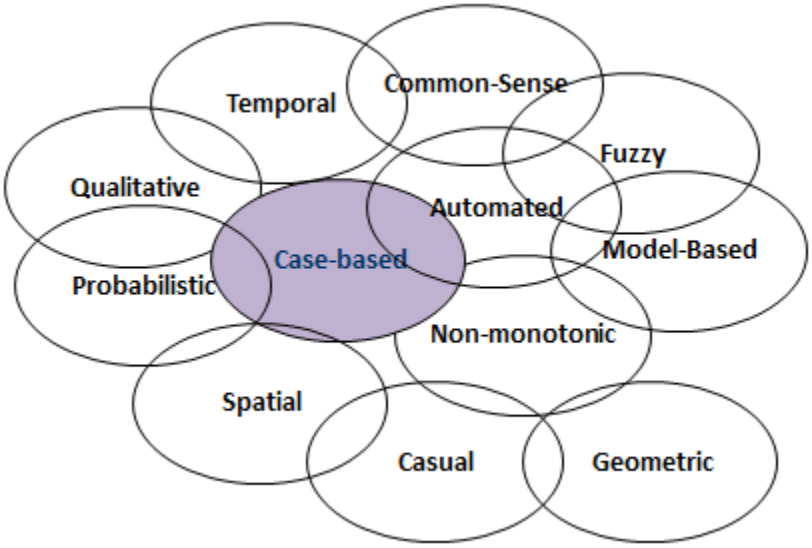

Fig.3 Reasoning methodologies within the knowledge engineering community

3. Case-Based Reasoning (CBR)Methodology for Developing SLSs

3.1 CBR Approach

CBR is considered an analogical reasoning methodology that aims to provide both the techniques for congitive model and problem sovling of individuals [15]. CBR has the ability to obtain reasoning from old cases or old experiences with an aim to solve various problems, discover solutions, and provide anomlous solutions. People also tend to be more confortable with old doctors because they have more knowledge and experience than others in terms of decision making. In some problems and situtations the solutions are clear and obvious, but in other sitations the solutions are not clear or sometimes are unknown. In terms of knowledge representation techniques concept the case can be viewed as a list of features that produce a specific outcome. Figure.4 shows an important case and an example in terms of “liver cancer case”. To determine the features of a specific case it is considered to be the most important knowledge engineering problems in terms of case-based AI software. The task of CBR include collecting and defining different representative cases for problem solving under the information gathered from the expert. The determination of the reasonable case features and attributes is considered the most important and salient task of the CBR-based methodology. The task depends on collecting and obtaining knowledge for problem solving from the experts. The cases can be represented in different forms in terms of frames, scribes, predicates. CBR can be seen as the number of methods and algorithms that can be helpful in solving different cases and problems.

Moreover, there exist various techniques that can be applied to update earlier cases so that they can match new and better cases. In addition to this, various techniques exist to handle new problems. CBR has already been applied in a number of different applications in many domains ,e.g. , medicine, industry, law, banking [10,11,15].

Patient: 65-years old female not working, with nausea and vomiting.

Medical History: cancer head of pancreas

Physical Exam: tender hepatomgaly liver, large amount of inflammatory about 3 liters, multiple liver pyogenic abscesses and large pancreatic head mass.

Fig. 4 Example of a " liver cancer case" description .

3.2 Case-Based Smart Learning Systems

The methodology of CBR is becoming popular in developing new generation of Smart Learning systems (CBR-SLSs) because it automates applications that are based on precedent or that contain incomplete causal models [15]. The methodologies based on CBR try to get around by analyzing the data of the problem. Afterwards, similar cases are retrieved from the case memory. Finally, the solution is displayed based on previous cases examinations.

The CBR-SLS uses an extensive case-based of exercises and examples to teach students. The CBReLSs solve new problems by adapting solutions that were used for previous and similar problems. The methodology of CBR-SLSs can be summarized in the following steps:

1. The system starts be searching its memory for available cases that are existed in their databases so that they can match the input case entered the system input.
2. It the system has matched case of problem in its database then we are lucky and based on the similar case the input problem is forwarded directly in the direction of the solution.
3. If the system did not find any matched case of the problem then based on the rules and information provided the system will not be able to find a complete solution to the problem.
4. The next step for the system is to find and update small portions of the retrieved case that does not connect with the specification of the input. This step is known by the adaptation of the case.
5. The results of the fourth step is a complete adaptation process. A full solution is provided and the new case and its solution are added in an automatic way to the system database for any further purposes.

3.3 Benefits of CBR Approach to Smart Learning systems

Based on this study it can be seen that the user know better when they are introduced to different examples or cases related to the knowledge problem solving and this knowledge are then applied to real and critical situations. The memory that hold the case based on examples and different excerises obtain the situations of problem solving and forward them to various or different learners in different simulations.

It can be seen that the student learners can perform better based on CBR method. It can also be seen that this way provide a huge number of benefits. The advantages of the CBR for the student learners can be seen as follows:

1. If many cases are available, the students will benefit from CBR and it will be able to solve and identify more situations. If the solutions provided failure cases. The students will be able to benefit from this failure in other cases that can be defined.
2. The process of retrieving the cases will permit the students to define better what is critical and important in new and different situations. The cases that are meet by the experts will help and assist the students to look at the problem in different ways that may not provide the expertise without the system.
3. The student will have the ability to gain access to ambiguous cases and difficult cases because otherwise they will not have the ability to obtain this access to these cases. The ambiguous cases can assist with any cases discussed previously.
4. The training of the CBR period allows the students to model the way so that the decision can be made obviously. In other words, what work preserved to be available so that it can provide them with concrete and defined examples defined more with abstract knowledge.

4. Ontological Engineering (OE) Methodology for Developing SLSs

4.1 OE from the AI Perspective

Ontology is a field of metaphysics concerned with the nature of being that has been borrowed from philosophy. The primary goal of using ontologies is to transfer knowledge between computers, or between humans and computers. Computers can transfer and display data stored in various file formats, but they are not yet capable of interpreting them. All participants in the digital domain (computers and humans) must share a common vocabulary in order to allow communication and intelligent processing of information. Ontologies are the bedrock of both computer-to-computer interaction and human-to-human cooperation[23].

The majority of ontology applications in computer science are related to knowledge-based and intelligent systems. These ontologies include a small number of concepts and their major goal is to make reasoning easier. A core ontology, private ontologies, and a knowledge base, for example, are used to describe knowledge in a multi-agent system. The agents' own ontologies are derived from the core ontology. Although the identities of the concepts utilised in the agents' private ontologies are unknown, their definitions make use of terminology from the fundamental ontology. Ontologies have gotten a lot of attention in the last ten years [4,14]. At the moment, ontologies are used in commercial, industrial, medical, academic, and research settings [7,20].

4.2 Benefits of Ontologies to SLSs

The use of ontologies in educational systems can be viewed from a variety of perspectives, including as a common vocabulary for multi-agent systems, as a link between heterogeneous educational systems, ontologies for sharing pedagogical resources or data, and ontologies for mediating the search for learning materials on the internet[21].
A system's abstract specification is made up of functionally related pieces. An interface and a shared vocabulary are used to communicate between these parts. Artificial Intelligence tools can be used to successfully implement the online teaching procedure. The intelligence of the machine is provided by sophisticated software programmes with the following characteristics: adaptability and flexibility. Capacity for learning, reactivity, autonomy, collaboration, and comprehension. This method allows for the complexity and uncertainty of instructional systems to be resolved. A multi-agent intelligent learning system consists of a collection of intelligent agents that must communicate. They communicate via text messages. Agents for software can comprehend. Due to a shared ontology or the compatibility of private ontologies, and understand the messages.

5.Data Mining Methodology for Developing SLSs

5.1 Data Mining Approach

The goal of data mining is to extract usable information and uncover hidden patterns in massive databases that statistical approaches are unable to uncover. Machine learning, databases, statistics, expert systems, visualisation, high-performance computing, rough sets, fuzzy logic, neural networks, and knowledge representation are all part of this diverse field of research. Data mining approaches attempt to provide intelligent computational methods for amassing, modifying, and updating knowledge in intelligent systems, with a focus on learning mechanisms that can help us infer knowledge from data or information.

The knowledge discovery in databases (KDD) process entails the following steps: (a) using the database, including any necessary selection, preprocessing, subsampling, and transformations, (b) applying data mining methods (algorithms) to enumerate patterns from it, and (c) evaluating the data mining products to determine which subset of the enumerated patterns is deemed knowledge. The computational mechanisms by which patterns are extracted and enumerated from data are addressed by the data mining components of the KDD process. The review and probable interpretation of the mined patterns is part of the entire KDD process to identify whether patterns can be considered new information. A host supports data mining by capturing the nature of data in a variety of ways, including as clustring, classification, link analysis, sequence analysis, regression models, summarization, text mining, sequential pattern mining, and association rules mining. In addition, there are a variety of sophisticated ways for doing these tasks, such as neural networks and machine learning, support vector machines, decision trees, genetic algorithms, k-means and others. For more details we refer to the books [13,18].

5.2 **Benefits of data mining methods to smart learning (SL)**

This section presents the applications of some of the data mining paradigms and tasks in smart earning domain. Further details and another applications can be found in [2].

(a) Information Visualization in Smart Learning

Web-based learning/educational systems can employ information visualisation (IV) to graphically portray complicated, multidimensional student monitoring data. The IV can be used in e-learning for the following educational tasks: admitted questions, further assignments, exam results, and so on. Furthermore, visualisation tools (such as GISMO CourseVis) allow teachers to edit the graphical representations generated, allowing them to better comprehend their students and become aware of what is going on in remote classes.

(b) Clustering in Smart Learning

• Finding clusters of students with similar learning characteristics and promoting group-based collaborative learning, as well as providing incremental learner diagnostic.
• Identifying patterns that reflect user behaviours and using them to describe comparable behaviour groups in unstructured collaborative environments for collaboration management.
• Using learning objects to group students and create tailored itineraries for courses.
• Sorting pupils into groups to provide differentiated guidance based on their abilities and other criteria.
• Using the data in the score matrix, grouping tests and questions into related groups.
• Sorting people into groups based on the duration of their navigation sessions.

(c) Classification in Smart Learning

In SL, categorization has been used to accomplish the following goals: • Identifying possible student groups with comparable features and responses to a particular teaching technique.

- Predicting a student's final grade and performance.
- Detecting student misbehaviour or pupils having fun.
- Sorting pupils into groups based on whether they are clue-driven or failure-driven, and identifying common misconceptions among them.
- Identifying low-motivated students and devising remedial strategies to reduce dropout rates.
- Predicting the success of a course
- Sorting people into groups based on the duration of their navigation sessions.

6. Agent-Based Approaches for Smart Learning

Intelligent agents (IAs) are artificial beings exhibiting a number of intelligent characteristics, such as being autonomous, responding appropriately to changes in their environment, consistently pursuing goals, being flexible, robust, and social when interacting with other agents. Negotiation, collaboration, cooperation, and teamwork are examples of human interaction types that IA simulates. IAs are described as computer systems that operate in a given environment and achieve their goals by: I behaving autonomously, i.e. making their own decisions, and (ii) being social, i.e. communicating with other software agents. Agents are frequently viewed as embodiments of numerous AI techniques such as machine learning, reasoning, and data mining. Modeling, design, and development of advanced software systems that are appealing for a variety of computer applications are all issues of interest in agent systems research[19].

Agent technologies have been proposed to improve the efficiancy of smart learning systems in at least two ways namely; (i) agents as a modelling and design paradigm for better human-computer interaction, and (ii) agents for smart functional decomposition of complex systems.
To begin, agents have been defined as entities with a variety of intriguing qualities that make them ideal for modelling and designing complex user interfaces such as those seen in smart learning systems: teachers, tutors, and students.Second, generic agent types have been shown to be effective in e-learning system functional decomposition. The dynamic and interoperable properties of agents are ideal for supporting smart learning systems' maintainability and expansion.

7. Some Examples of Smart Learning Systems in Medical domain

Table (1) presents some of our SLSs developed at Medical Informatics and Knowledge Engineering Research Unit (MIKERU-Shams), Computer Science Department, Ain Shams University, Cairo, during 2001-2014. Further technical details of each system/tool can be found in the corresponding reference.

Table 1: Some of examples of SLSs developed by the author and his colleagues(2001-2014)

eLearning Tool	Type	Task/Purpose	AI Methodology/ Technology	
BreastON	Web-based Ontology	Designed to show the relationship between related terms/knowledge of breast cancer	OWL-DL & Protégé-OWL environment	[4]
LungON	Web-Based Ontology	Designed to show the relationship between related terms of Lung Cancer	OWL-DL & Protégé-OWL environment	[5]
LiverON	Web-Based Ontology	Designed to show the relationship between related terms of Liver Cancer	OWL-DL & Protégé-OWL environment	[6]
ViralHON	Web-Based Ontology	to show the classes of the Viral Hepatitis Diseases Classification Tree(A,B,C and D)	Ontology of Biomedical Reality (OBR) framework	[14]
BreastClass	Classification System	to classify the patient based on his/her electronic record whether he/she is benign or malignant. Breast cancer	Combination of CBR and ontological engineering	[11]
CancerRES	Expert System	Cancer diagnosis	Production Rules	[3]
CancerCES	Expert System	Cancer diagnosis	Case-Based Reasoning	[3]
HeartRES	Expert System	Diagnosis of heart diseases	Production Rules	[10]
HeartCES	Expert System	Diagnosis of heart diseases	Case-Based Reasoning	[10]
ThrombDM	Data Mining System	To determine the Thrombosis and helps young physicians to predict the thrombosis disease.	Rough Sets	[9]
BrainTClass	Classification System	Brain Tumor diagnosis (acoustic neuroma, astrocytomas, optic glioma)	Hybrid Neural Netwrks (PCA+MLP)	[16]
ECGI	ElectrocardiogramIdentification System	User(student/tutor) authentication / identification	Behavioral Biometrics	[21]
EEGI	Electroencephalography Identification System	User(student/tutor) authentication / identification	Behavioral Biometrics	[22]

8. The Potential Role of AI Techniques in Corona Detection

Artificial Intelligence (AI) has been shown to be an effective tools in diseases diagnosis ,particularly in emerging corona disease.***AI software can rapidly detect people who have a fever among in a crowd. Figure 5 shows Some examples of the production rules***

IF you eat the meat of the bats THEN you will be infected by Corona, CF .95
Prolog Code : infected (person, corona):- eats(person, bat_meat).

IF you eat one guava everyday THEN your immunity increases , CF .90
Increase (person, immunity):- eats(person, one_guava_everyday)

Fig. 5 some examples of the production rules

Artificial intelligent (AI) has the potential to be a tools in the fight against (COVID-19) disease and similar pandemics. However, AI systems are still at a preliminary stage to solve (COVID-19) problems . In this case of the use of AI within this research , a database must be provided ,which is a medical image for image analysis and disease diagnosis**.** Table 2 presents some effort of resent research regarding the application of machine leaning techniques in the battle against the corona virus.

Table 2 Applications of Artificial Intelligence in the battle against the corona virus

ML Technique	Task /Reference
Bayesian Reasoning	Study of Bayesian Reasoning and AI against COVID-19 [24]
Deep belief network	Detection of Corona Virus Disease COVID-19 [25]
Convolution neural network	Detect COVID-1identification of COVID-19 persons [26]
Computational intelligence	Identification of COVID-19 persons [27]
Fuzzy logic	Investigation of fuzzy sets In the battle against corona [28]

More technical details and computing aspects of each application can be found in the corresponding reference.

8.1 Application of deep belief network for Detection of Corona COVID-19 .

In this application, deep learning technique has been applied to analyze the medical images of respiratory diseases [25]. Two data set was used ; first dataset is normal lungs taken from Kaggle data repository. While abnormal lungs was taken from (https://github.com/muhammedtalo/COVID-19) . Figure 6 shows the Architecture of Deep belief network. The results show that the proposed system identifies the COVID-19 cases with an accuracy of 90%.

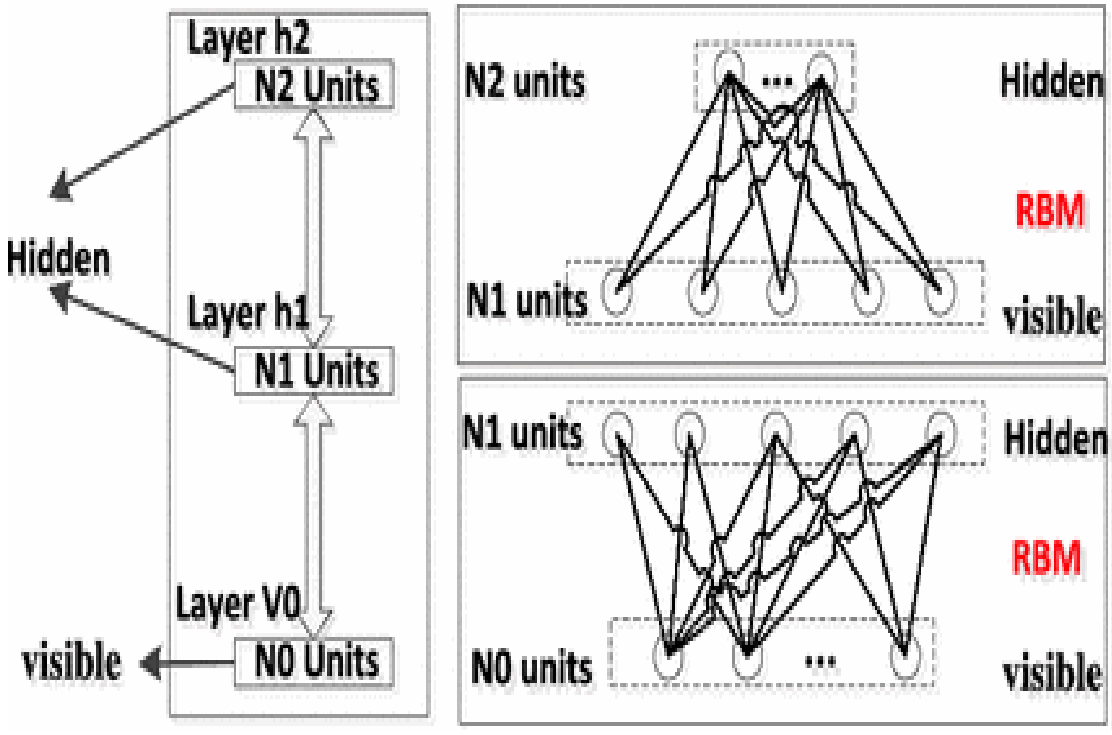

Fig 6. Architecture of Deep belief network

9. Challenges

The development of smart Learning systems is a very difficult and complex process that raises a lot of technological and research challenges that have to be addressed in an interdisciplinary way. From the technical point of view, SLSs face the following difficulties and challenges

1-The knowledge-acquisition difficulty: Knowledge is a valuable resource, and it is generally held by a small number of experts. It's critical to document that expertise so that others can benefit from it. Experts pass away, retire, become ill, change fields, or otherwise become unavailable. As a result, the knowledge is lost. Books can capture some knowledge, but they leave the reader to solve the problem of application. This challenge is addressed by the case-based reasoning methodology, which makes it easier to describe, investigate, and evaluate cases than rules.

2- Maintenance difficulties: SLSs are difficult to construct and maintain. Maintaining a case-based eLearning system is easier than maintaining a rule-based eLearning system since adding new knowledge is as simple as adding a new case, according to the CBR methodology.

3- Performance Experience: The efficiency of their knowledge representation strategies and reasoning procedures determines the productivity of SLS development. The selection of the proper technique and methodology that best suits the domain knowledge and the problem to be solved is critical to the success of such systems. This decision is based on the knowledge engineer's experience. A case-based SLS can recall its own performance and adjust its behaviour to avoid making the same mistakes it has made in the past. A CBR system should be able to solve fresh problems by reasoning from analogy with previous cases.

10. Conclusions and Future Work

Computing based on knowledge Machine learning, artificial intelligence, and data mining paradigms provide e-learning systems with additional intelligence capabilities, allowing them to behave more intelligently. For acquiring, updating, managing, and displaying knowledge, knowledge engineering provides reliable computational tools. These methods provide users with learning mechanisms that aid in the induction of knowledge from unstructured material. Rough sets, fuzzy logic, and case-based reasoning are examples of data mining techniques that provide users with learning processes that aid in the induction of knowledge from raw data. Ontological engineering is a promising approach for creating effective e-learning systems that allow for knowledge sharing, refinement, search, and reuse. Furthermore, the coming together of artificial intelligence, data science, machine learning, educational technology, and web science is allowing for the development of a new generation of web-based intelligent e-learning systems. Such web-based technologies can improve online learning, training, and education procedures.

We envision the following directions for future work: (i)using behavioural biometrics technology for user authentication / identification (this technology is based on user data of electrocardiogram and electroencephalogram bio-signals); (ii)investigating the use of ontological engineering approach in developing SLSs that provide learners with intelligent browsing and searching support in their requests for relevant medical material on the internet of this century; (ii)the use of ontological engineering approach in developing SLSs that provide learners with intelligent browsing.

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