A Multi-agent System in E-Health SystemImplementing EBDI model

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Abstract:
Agent technology has seen tremendous expansion in recent years in various disciplines, particularly in the domain of E-health. where The discipline of medicine is distinguished by its complexity, dynamism, and variety. Different challenges occur in healthcare (increasing cost of care, population growth, and lack of caregivers). so the features of Intelligent Agents (proactivity, intelligence, sociability, and autonomy)are a suitable choice to solve many challenges in this domain because the major success criteria were the natural translation of real-world medical concerns into electronic life. also, these characteristics result in lower operating costs and the automated execution of activities in various Agent-based systems, As a result, intelligent applications based on Agent Technology may be able to deliver better health care than the traditional medical system. In reality, One of the most intriguing aspects of contemporary health care is the prospect of automating basic activities such as monitoring patients' conditions and giving quick assistance in emergency circumstances. The implementation of multi-agent systems (mas) in the healthcare field has also paved the way for new applications such as socialized and customized healthcare models. As a result, this paper attempts to create a multi-agent system as well as an agent-based system for the hospital. and this article explains how the use of EBDI-based software agents and jade framework can help to automate various processes while also improving patient service.
Keywords: Multi-Agent System, E-health, JADE, EBDI.

Introduction

Because human health is the main issue and central point for all human activities. As a result, a lot of the focus and people's attention is geared toward healthcare and social well-being.where healthcare is an open environment defined by shared and dispersed decision-making and care administration. in which case Complicated and various types of information must be transmitted across a variety of clinical and other locations, as well as coordination between groups of health care professionals with very different skills and duties,to meet the information demands of patients and health care providers.in this setting, the Healthcare software solutions must work well. In healthcare environments, practitioners seek information that is both quick and error-free.

as well as ensuring that the software systems' recommendations or decisions are secure and dependable [1,2,3].

So, according to Isern, Sánchez, and Moreno (2010), computerization is one of the breakthroughs that has proven how it influences people's lives by offering collaborative, automated, and assistive healthcare Multi-Agent Systems are the natural choice for unpredicted and open environments explored by heterogeneous models with their interactions, enterprise-wide range, effectively processing in randomly changing environments, rapidly increasing data quantity, and intelligent agents have added value to their main job. [4,5,6]

The use of automated agents has been proposed for a variety of medical and health-related issues, including decision support systems, senior older care, self-treatment, and automatic health observing access to patient's records and treatment information while taking into account patient confidentiality, societal, legal, and ethical concerns. One of the multi-agents system's tasks and difficulties is the design and execution of healthcare services. A multi-agent system appears to be an acceptable means of providing automated medical knowledge most relevant for the chosen user profile utilizing information retrieval and analysis from scattered and perhaps heterogeneous sources. [1,7,8]

Without adhering to any single standard data definition, the goal of this document is to investigate effective approaches to developing a technical framework as the foundation for personalized smart E-Health management and future clinical decision support systems (CDSS) for patients, medical practitioners, and the healthcare domain experts.

1. Motivation

the health care field dynamic various challenges faced in healthcare (population growth increasing cost of care and lack of caregivers). therefore, intelligent software with Agent Technology can deliver the best health care than the traditional medical system.

and also to: enable surgeons, nurses, and health professionals to gather and track patient data regularly, optimize treatment choices, maximize hospital quality, and help them control procedures.

1. The concepts of agent

A developing area for manipulating and executing basic or complicated issues is an agent-based system, which is part of Artificial Intelligence.

1.1 Definition of an agent

A computer program that works on behalf of its user or owner is known as an agent (an agent is mainly a particular software component). The following characteristics must be present in an agent: (Autonomous, Pro-activity, Reactivity, Communication, etc.).

Agents have a variety of qualities that aid in the completion of a task. An autonomous agent may adapt to and learn from its surroundings. It may also react to changes in its surroundings and make decisions to achieve its objectives.

There is general agreement that the agent's fundamental quality is independence, or the capacity to operate without the involvement of people or another model. Furthermore, the importance of certain characteristics is dependent on the agent's space.[6,9]

Figure 1:displays a high-level view of the agent's surroundings. An agent takes information from its environment as well as a repertoire of possible behaviors and then responds to alter it. In general, the agent is not capable of complete control of its surroundings in the realm of probable difficulties.

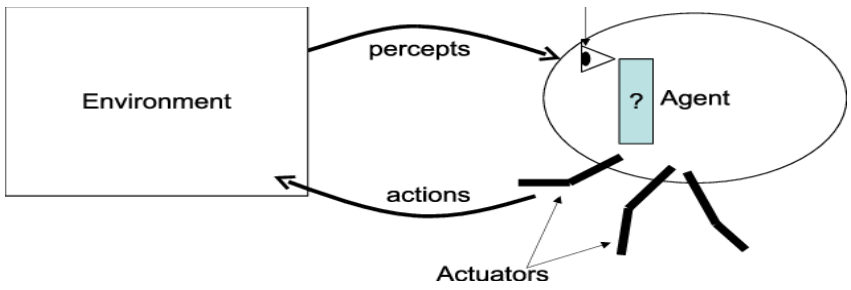


Figure1:The original agent-environment diagram presented in [10].

A multi-agent system is a system that combines several agents (MAS). These multi-agent models can simulate complex systems and generate the capacity of agents with competing or similar interests to work together. These agents may communicate directly or indirectly with one another (through operating in an environment). As a result, the same action taken repeatedly in the same context seems to have mixed effects. Failure is also a possibility, which implies that the reaction elicited by the agent may not provide the desired impact in its whole [6, 11, 12,13]

The main idea underlying MAS is to establish communication and cooperation among agents so that they can collaborate to complete the task at hand. The most common uses of MAS are in telecommunications, the internet, robotics, and medical sector applications, among others.[12,13]

The goal of this study is to lay out a path for future researchers to follow to discover the essential concept underlying the usage of the multi-agent system in the medical sector.[6,13]

3.2.characteristic of Intelligent Software Agents

An intelligent agent is a piece of software that has the following properties:

1. Situated: It means that it does exist in an environment
2. Autonomous: It means that it is independent, controlled externally
3. Reactive: It means that it can respond to the potential changes in its environment
4. Proactive: It persistently pursues the tasks and goals
5. Flexible: It has multiple techniques and ways of achieving the goals.
6. Robust: It means that whenever it faces a problem or in case of any failure it has the ability to recover from a failure. [14]

Figure2: Characteristicof Intelligent software Agent

3.3 multi-agent systems(mas):

is a system in which several agents work together to solve It is made up of a range of agents who communicate with one another and coordinate their knowledge/action to achieve a goal or make a decision[3]. Agents communicate with one another via a set of specific connection languages known as agent connection languages, and they generally do so by switching messages sent over a computer network structure. Where agents collaborate in the system to achieve common goals within the framework.[15,16] the Agents' collaboration will raise processing speed and increase consistency and dependability, as well as improve accuracy and efficiency of performance Through its unique characteristics such as knowledge base and information However, in the most frequent scenario of a multi-agent architecture, the agents would operate or services on behalf of clients or possessors with a variety of goals and motives.

To interact successfully, agents must be able to collaborate, coordinate, and bargain with one another in the same way that we communicate [17,18]. As a result, it is capable of rapidly and easily responding to changes [6,9,17,19].

The supplied mission is divided into sub-tasks, furthermore, each agent's output is dependent on the assigned work for it. which is combined with the output of another agent to create a bigger task. All an agent might be modeled in a various task of a multi-agent system.

3.4 EBDI (Extensible Beliefs Desires and Intentions) Definition

That the suggested EBDI offers a highly appropriate structure to the construction of embedded intentional software that continually observes or/and monitors its surroundings and acts following its situated BDI, which is based in normative settings. [11,20,21]EBDI presents methods for improving an agent's decision-making processes such that the highest-paying action is chosen[3].

•Beliefs: are service information obtained and/or accessible from a variety of sources, such as the domain, environment, or other services' beliefs.

•Desires: depict the state of affairs in an ideal world, that this frequently increasing the services have aimed. through comparing a system’s beliefs group (monitored system states) in opposite its desires, the system discovers is not similar and triggers a collection of intentions [22,23].

• embedded(Situated) intentions are a set of actions that a system can do in a particular scenario to achieve its stated objectives and/or to process the mismatch among the system’s objectives (desires) and the system's surroundings (beliefs)

• Normative intents are a collection of activities done to ensure a certain group of rules, including duties (deontic), as well as the rule's acting is monitored before a specific intention is carried out. Also, preserve the integrity of emerging rules.

•Utility intents are a set of activities that work together to improve goal-oriented intentions[7]

This means that an agent may have many competing intentions at any same time. In the first case, there may be a disagreement over whether the conduct was intentional or not.

As the agent seeks order to conform with its norm group (ontology), the general norm group (shared ontology), and its duties to itself and another agent, the more deliberate conflict will arise. Several of these competing intentions may even be incompatible.

Methods for improving an agent's decision-making processes so that the action with the best reward for the system is taken have been researched on occasion. Defining and using functions that add a sense of action benefit, on the other hand, is extremely difficult. A very high (even infinite) number of perception-action pairs may be included in the full specification, which may change from one job to the next [23,24].

by comparing between the BDI model and the EbdI model we have seen that The BDI model's flaw is that it fails to adapt to changes in a changing environment. In the case of an unforeseen scenario, the purpose cannot be carried out since there is no law in place to deal with it. And to find agents in a larger world, maybe with numerous complicated duties for which that an agent has to achieve it. This will also provide a wider range of programs that may be relevant, as well as demonstrating the real strength of the EBD model, which is flexible in dynamic situations and reconsiders when necessary, thus we choose to apply this model to E-health.

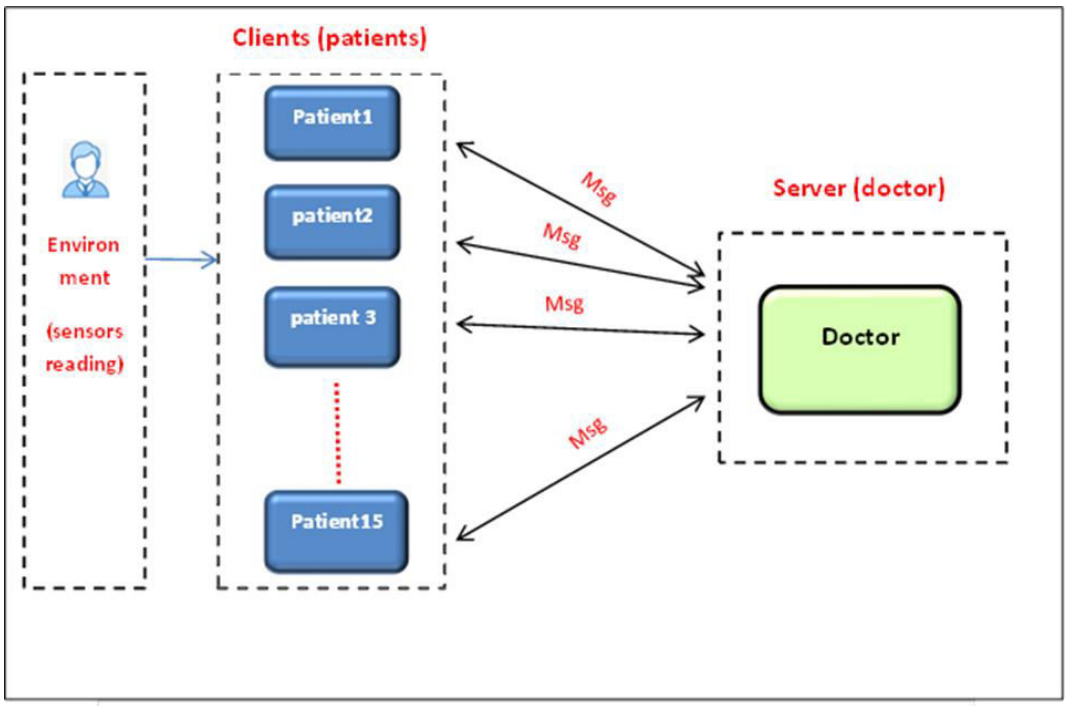
2. SYSTEM OVERVIEW

The proposed system uses a multi-Agents (an agent proposed to be used in this system is the EBDI model)the proposed system as (Clients and server)structure(figuer3) below

this suggested system is aimed to implement EBDI model in the E-health system for monitoring and deciding the appropriate plan of treatment for the patients based on the information that comes from monitoring the patient state by reading the sensors (oxygen, blood glucose, and temperature, blood pressure, and the pulse Rate,.... based on E-health.)After filtering these readings, the system will determine which treatment plan is most suited for the patient's current state.

the primary components for the proposed system, There have been two stages to the system's operation. The first stage is including some steps which are (The sensors are read first, then filtered, and given an alert if there is a problem).

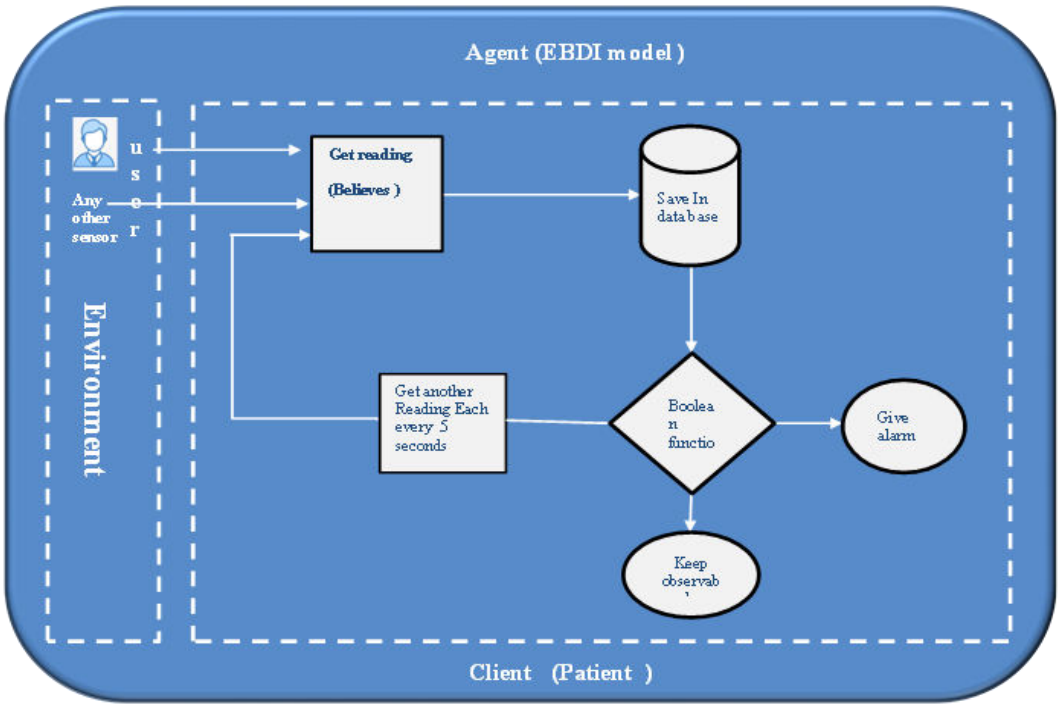
The second stage also including some steps which employ the K_mean algorithm(This approach was used to cluster the data .) first and fuzzy logic(to measure the membership for each vector to the cluster center) to determine which treatment plan to apply based on the information gathered in the previous stage.



Figure(3) : the over view of the proposed System

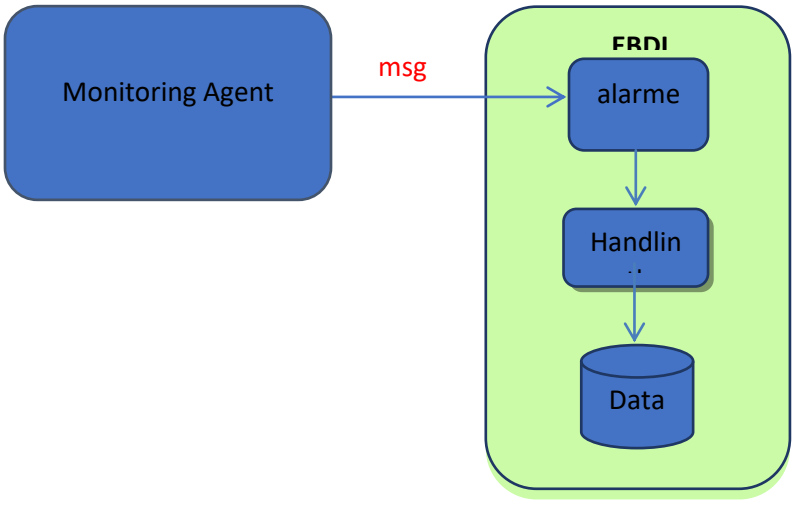
Agents deal with surroundings by detecting an input, applying a function, and taking action, as shown in figure (3).

4.1 The function of Monitoring Agent: is in charge of gathering data from a file, filtering it, and issuing an alarm (send message to the administer agent)when there is an abnormal state for any one of the sensors' reading; it also records sensor readings in a database (MySQL) table named "patients." This stage is carried out automatically. The Monitoring Agent function is shown in(Figure 4). The process of collecting the Sensor's reading happens every 5 milliseconds, which means that every reading by the clients is monitored and checked, and the system's database is constantly updated without the users' participation.



Figure(4):describe the monitoring Agent work

4.2 The function of Administrator Agent: The Administrator Agent in charge of reading alarms from the monitoring agent, receives this alarm and saved it in the database, and computes the membership for each alarm to each cluster center. Figure (5) shows the Administrator Agent function.



Figure(5)the administer agent

5 Experimental and Results

5.1 simulation Environment

The suggested system is mainly dependent on JADE ("Java Agent Development Framework") is a software environment for building multi-agent systems that use a pre-defined, programmable, and expandable agent paradigm. It's one of the most popular frameworks for developing agents. It's fully written in Java and makes use of Java libraries.

It now represents one of the most popular agent-oriented middleware solutions. Jade lets developers focus on the business logic of their systems rather than the specification of agent communications and interoperability when building multi-agent systems since it provides domain-independent infrastructure.

A multi-agent Jade platform provides a graphical user interface (GUI) for the administration of agents from a distance.

Figure 6 depicts the look of the JADE platform, which was used during the testing period.

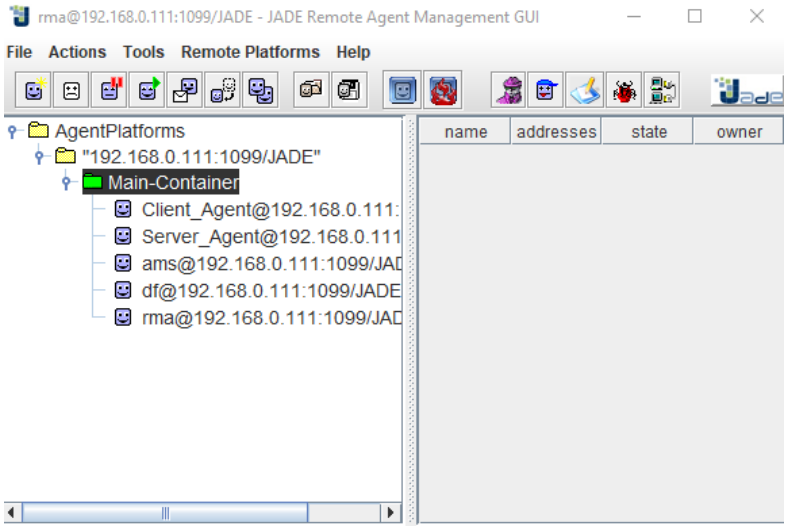


Figure 6:The Simulation jade framework

5.2 Simulation Settings

A specified job For each agent, in the proposed system, which consists of multiple agents, has been simulated according to the table1 below.

No	Name agent	Number agent
1	Client (patient) agent	1 – 15

Table 1. The number of agents during thetest

2	Server (Doctor) agent	1

The fig.7 below shows a test which was run on the Jade Platform the process of implementing the system, where we observe a client agent filtering the sensors reading after saved these values in the database and display them in the table shown in the client interface and it showed the flow chart for each sensor so this agent gives the patients' name and it the state if normal or not and

decided which sensors are abnormal this information about the patient is displayed in a green color when the normal state and if any one of these readings is abnormal then this information about the patient is displayed in a change to red as shown below.

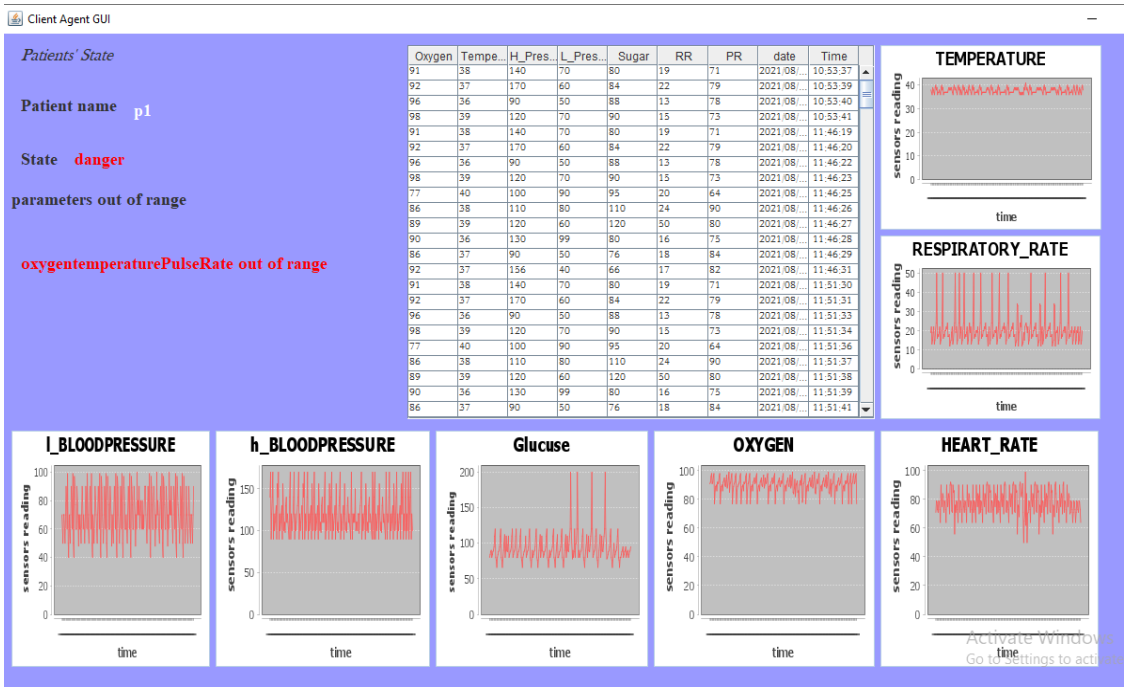


Figure 7: The Client (patient)GUI when the system applied

and in the same manner, according to the server agent when receives the message (alert from the client agent) at the abnormal states the interface for the server-side has the same components of the client agent as shown in (figure 8 _b).

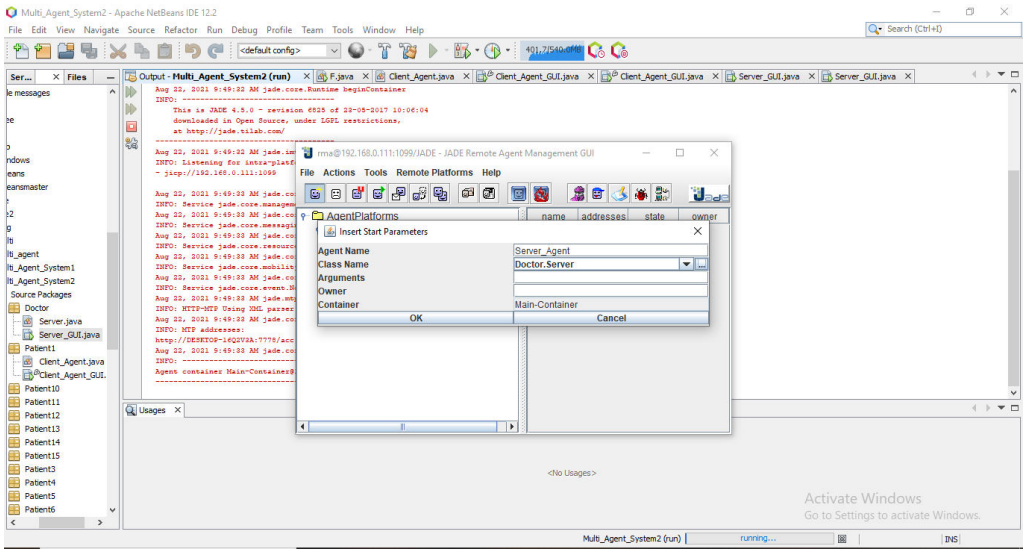


Figure 8_a: invokesThe Server (Doctor) agent

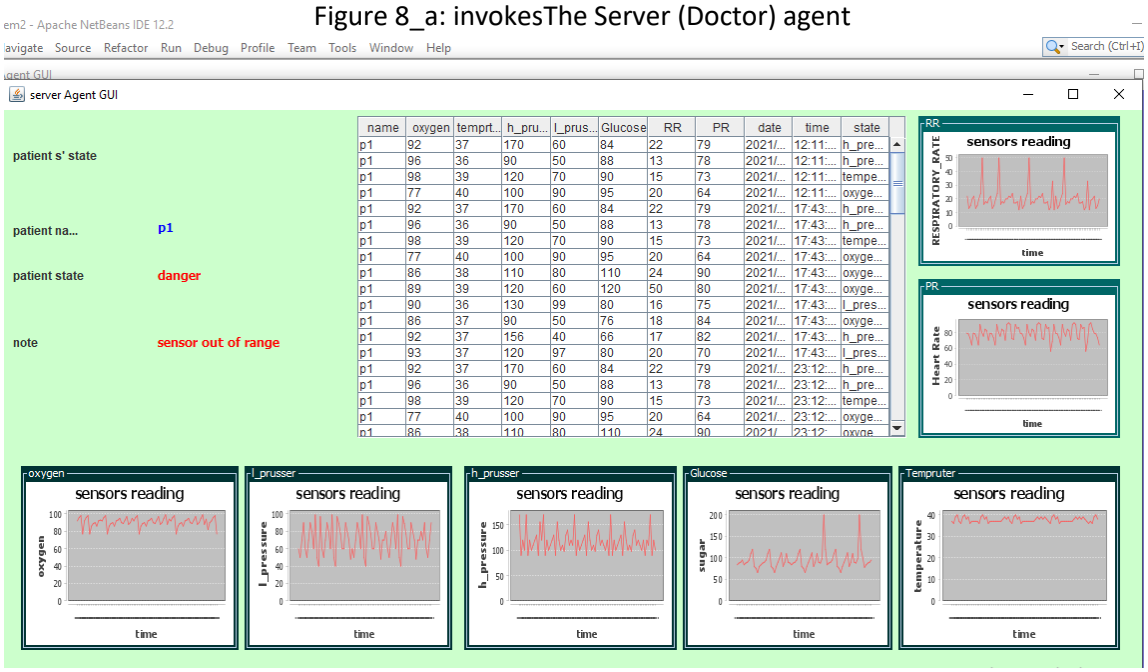
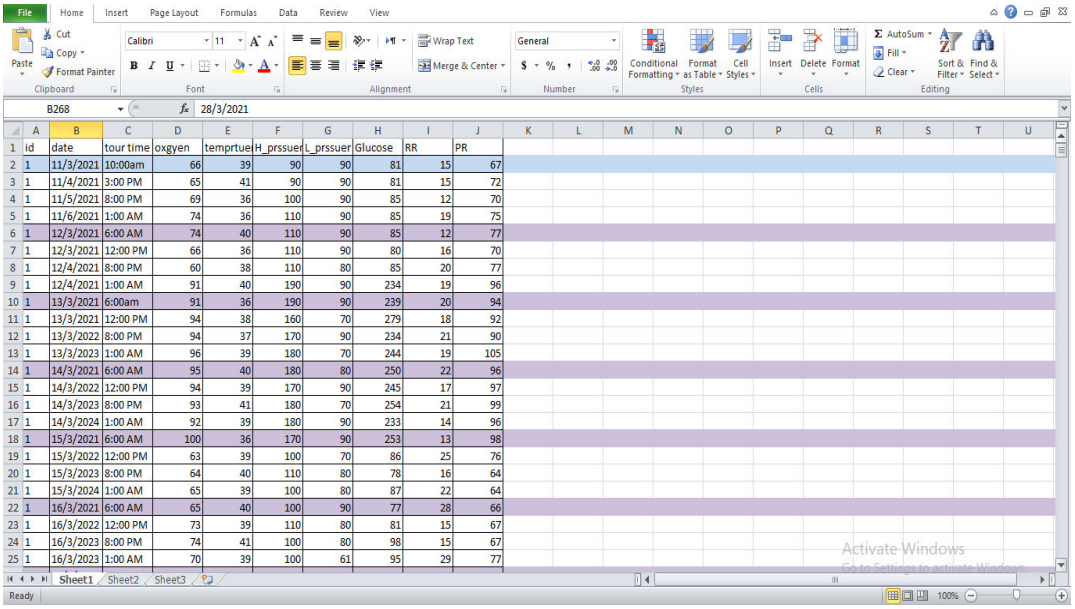


Figure 8_ b : The Server (Doctor)GUI when the system applied

also, the client agent achieves the clustering process to the sensors' reading (in our proposed system it is applied on 900 samples each sample have seven features (oxygen, temperature, high pressure, low pressure, glucose, respiratory rate(RR), and pulse rate(PR))) by using the k_mean algorithm to compute the clustering center which is the client agent depending on them to decide which the appropriate treatment plan for each sample of sensors' reading by computing the membership to these sample to the cluster center.



id	date	tour time	oxgyen	temprtue	H_prssuer	L_prssuer	Glucose	RR	PR
1	11/3/2021	10:00am	66	39	90	90	81	15	67
1	11/4/2021	3:00 PM	65	41	90	90	81	15	72
1	11/5/2021	8:00 PM	69	36	100	90	85	12	70
1	11/6/2021	1:00 AM	74	36	110	90	85	19	75
1	12/3/2021	6:00 AM	74	40	110	90	85	12	77
1	12/3/2021	12:00 PM	66	36	110	90	80	16	70
1	12/4/2021	8:00 PM	60	38	110	80	85	20	77
1	12/4/2021	1:00 AM	91	40	190	90	234	19	96
1	13/3/2021	6:00am	91	36	190	90	239	20	94
1	13/3/2021	12:00 PM	94	38	160	70	279	18	92
1	13/3/2022	8:00 PM	94	37	170	90	234	21	90
1	13/3/2023	1:00 AM	96	39	180	70	244	19	105
1	14/3/2021	6:00 AM	95	40	180	80	250	22	96
1	14/3/2022	12:00 PM	94	39	170	90	245	17	97
1	14/3/2023	8:00 PM	93	41	180	70	254	21	99
1	14/3/2024	1:00 AM	92	39	180	90	233	14	96
1	15/3/2021	6:00 AM	100	36	170	90	253	13	98
1	15/3/2022	12:00 PM	63	39	100	70	86	25	76
1	15/3/2023	8:00 PM	64	40	110	80	78	16	64
1	15/3/2024	1:00 AM	65	39	100	80	87	22	64
1	16/3/2021	6:00 AM	65	40	100	90	77	28	66
1	16/3/2022	12:00 PM	73	39	110	80	81	15	67
1	16/3/2023	8:00 PM	74	41	100	80	98	15	67
1	16/3/2023	1:00 AM	70	39	100	61	95	29	77

Figure 9:the file contained patients' data before clustering

```
K_Means_Algorithm N_clusters=5  vector_size=7  N_points900
Centroids finalised at:
Cluster center 0= (76.8129,39.1727,87.4388,83.0935,222.795,32.1439,80.2662)
Cluster center 1= (66.3919,38.3581,164.5135,92.5811,115.0405,29.9595,92.0946)
Cluster center 2= (98.0573,39.2293,178.3885,80.3185,182.5541,21.0764,91.9809)
Cluster center 3= (88.2761,39.0821,171.4925,77.3134,248.3358,22.1045,80.7985)
Cluster center 4= (66.4262,38.8907,95.7869,81.1803,94.5137,21.4918,72.8033)
BUILD SUCCESSFUL (total time: 16 seconds)
```

fig.9 is represented the Result of clustering center

A test of the system was carried out, the results are presented in the graphs, the x-axis represents the time, and the y axis the sensors' reading (for each reading there is a graph). the normal range for each reading is displayed in table2.

Sensors' reading	**minimum value**	**maximum value**
Oxygen	95	100
Temperature	36	37
H_ pressure	100	130
L_ pressure	60	90
Glucose	80	120
PR / HR	60	100
RR	12	24

Table (2):shows the Standard Value for the vital parameter for patient

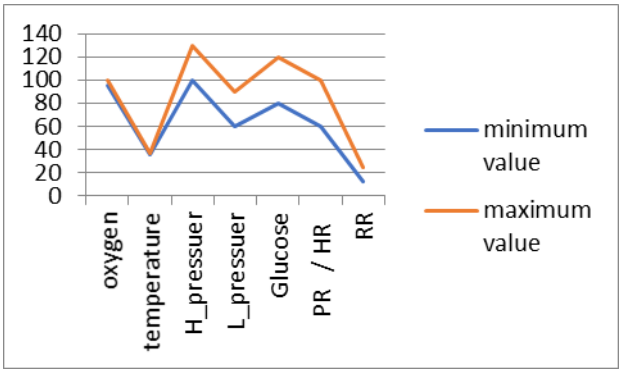


figure (9)A graphic chart showing the natural range vital parameter **reading** values

6.Conclusions

The use of an agent in conjunction with an E-health system is crucial. Also, when the agent possesses key qualities such as autonomy, sociality, adaptability, etc., and these properties are necessary to enable such systems, it might increase the performance of the systems as a whole. Using Multi-Agents to automate the different stages of the system, such as monitoring, analyzing, and categorization of patient data, and making crucial choices instead of people (Doctor, nurses,...) is a recommended approach for E-health systems

In this study, we offer a healthcare framework for developing an intelligent decision support system using EBDI reasoning agents. The suggested solution may be used to offer patients healthcare tracking services. The prototype enables the automated exchange of a patient's essential healthcare data with their physicians and caretakers. Patients may also use this system to determine the severity of their disease at any particular time by looking at the readings from their sensors.

The EBDI method provides intuitive abstraction as well as a collection of formal tools, such as goal deliberation strategies. The goal of our research was to apply a situated and well-developed EBDI agent framework (by using Jade) to the healthcare setting. We demonstrated how the EBDI technique readily fits with the context of patient status monitoring in a restricted scenario. We've also mentioned how natural it would be to broaden the suggested framework to make it more realistic. also, We've discovered that Jade is a highly useful tool.

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