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A Real-Time Hospital Selection Framework for Multi-Chronic Disease Patients in Telemedicine

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ABSTRACT

The development of an integrated healthcare system has become a personally important issue in the healthcare industry because of the rapid increase in the prevalence of several chronic diseases. The provisioning of personalized healthcare service (PHS) is one of the challenges facing researchers in the fields of telemedicine and the Internet of Medical Things (IoMT) and is related to several issues. One of the main issues is providing the remote patients with the required pre-hospital services which includes the determination of the patient's emergency level and selecting the proper hospital. This study aims to improve the provisioning of personalized healthcare service for the multi chronic disease elderly patients who use telemedicine system through utilizing medical sensors and non-sensors IoMT devices, That includes determination of the patient's emergency level (triage level), identifying the disease, and selecting the proper hospital in terms of availability and location. The proposed framework called Multi Sources Healthcare Architecture-2 (MSHA-2). The proposed framework accommodated the patient with different contingency levels based on seven medical devices, namely, sensors for blood glucose, blood pressure, ECG, SPO2, body temperature and respiratory rate and input medical texts. The framework proposes two computational algorithms to achieve the required tasks. The simulation of the framework is proposed in Baghdad, the capital city of Iraq, as the real physical locations for 34 private and governmental hospitals are determined using Google map coordinates. The appropriate hospital for the patient was identified in accordance with the patient's coordinates, which were taken from a GPS sensor. According to common evaluation performance criteria, the proposed framework outperformed two benchmark models and obtained 90% of the total services, whereas the benchmark studies obtained 45% and 45% respectively. This study proposes a unique advance healthcare solution which supports the healthcare digital transformation plans in Iraq. Selecting the proper hospital to the patient can save patients' lives. Future work will integrate patient medical records and improve hospital selection during disasters to enhance real-time healthcare services.

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1. Introduction

The current health care system mainly focuses on treating diseases after they have been diagnosed. Collecting data on older adults allows for a proactive approach to assessing their chronic conditions rather than an emotional approach. Since the 20th century, the number of people aged 65 years and older with chronic diseases has been increasing, and this will continue to increase [1]. The number of patients is expected to increase due to the ageing of the population. By 2030, it is projected that 1 in 6 people in the world will be aged 60 years or over. Furthermore, 80% of older people will be living in low- and middle-income countries by 2050, making healthy ageing a truly global priority[2]. The world health organization (WHO) declared that the stated non communicable diseases (NCDs), such as heart disease, chronic respiratory disease, and diabetes, are the leading cause of death in Eastern Mediterranean Region[3]. In addition to that, WHO also reported that one of the challenges in Iraqi healthcare system is the high population growth rate which is increasing by 3.5% annually[4].

Given the advancements in technology and the challenges of scalability, personal health services (PHS) are currently revolutionising the field of healthcare around the globe. Transforming healthcare from within the hospital into (PHS) that are centred around an individual wherever he/she is located as pre hospital services, has a positive effect on minimising hospital visits. Consequently, the number of patients in Emergency Departments (EDs) in the hospitals is reduced, thus providing the ability and considerable time to the medical staff to deliver services to urgent-care patients in sudden disasters and accidents, such as car accidents and gun violence [5]. In addition to the patient's need for home care, which has proven positive effects on various health conditions, due to the decrease in the rate of hospitalization of patients through early detection and prevention of complications through monitoring patients' vital signs and symptoms, where health care providers can intervene proactively[6]. PHS refers to developing a treatment plan in reference to disease severity and physical location for the remote patients [5]. The remote management of the elderly with chronic diseases by using new technologies such as Internet of Medical Things (IoMT) that provide high-quality healthcare can significantly reduce EDs visits [7]. Figure 1 shows the application of the (IoMT) technology in healthcare within the structure of telemedicine system.

A telemedicine system consists of three tiers (Tier-1 is for users to collect data, Tier-2 is the gateway which send the data to hospital, and Tier-3 is for the medical doctors to analyse the data, generate services, and send the services back to the patient [8]. The Internet of Medical Things (IoMT) is a contemporary Tier 1 telemedicine system approach to linking medical sensors such as wearable sensors such as skin contact sensors and applications related to healthcare technology systems over a network connection to provide the ability to remotely monitor healthcare and diagnose and treat patients remotely at different locations [9][10][11].

Relevant studies [8][12] have proposed scalable remote monitoring healthcare models to accommodate the increasing in the patients' numbers. However, these studies have several weaknesses as the hospital physical location, patient location, patient's request time, and patient's vital signs were not addressed. Therefore, there is urgent need for telemedicine framework that address those limitations to provide the remote patients by PHS as a pre-hospital service which includes determination of the patient's emergency level (triage level), identifying the disease, and selecting the proper hospital in terms of availability and location. Because of its importance in areas of the care setting such as remote patient monitoring, the use of communication between patients and healthcare providers, and the use of medical IoT devices to monitor vital signs. Thus, making a diagnostic decision and choosing the appropriate hospital based on the analysis of data collected from the patient [13]. Because this preserves the lives of patients, especially those who are exposed to a critical health condition that requires medical intervention, the hospital closest to the patient's location is selected to ensure the patient's rapid arrival to the hospital.

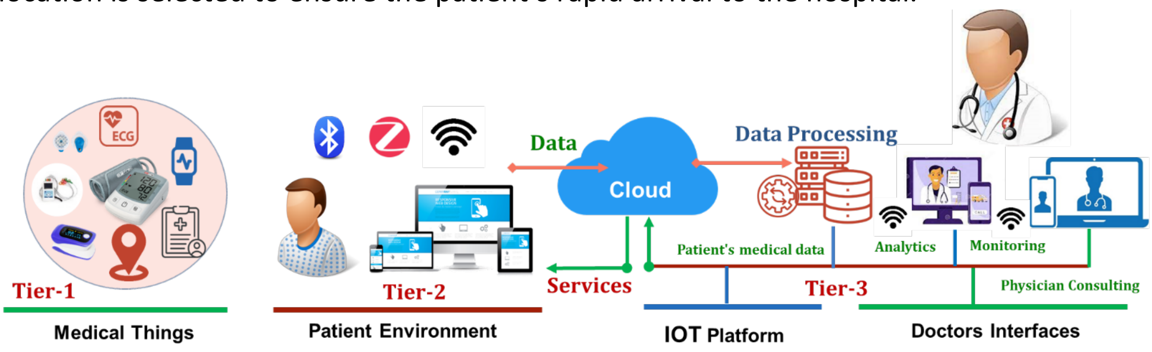


Fig. 1. Internet of Medical Things (IoMT) based telemedicine system

This paper organized as the following: section 2 presents the literature review analyses, while section 3 demonstrates the system design and illustrates all the components of the proposed framework along with the medical guidelines. Section 4 shows a detailed results for the evaluation of the proposed model and finally section 5 discusses the limitation of the study and shows the research potential of the future works.

2. Literature and Related work

Personalisation in healthcare involves defining a treatment plan that is in line with the gravity of the disease and the contextual factors of the patient, such as medical history, activity, and lifestyle. Intelligent diagnosis helps develop a personalized treatment plan because it accurately describes the condition of the patient and the status of the disease[14][15]. The dynamic extraction and timely analysis of the useful and relevant information of the patient increase treatment accuracy [16].

Many studies have examined the delivery of integrated healthcare services in the home and hospital environments based on various variables. Therefore, a variety of requirements must be considered when creating integrated healthcare system. The study in[17] aimed to provide the integrated and PHS to help for offering an efficient care to patients with chronic diseases and to measure the risk of multiple sclerosis (MS). In [18], a personalized healthcare monitoring system comprising data mining, a decision support system and context awareness, was used to facilitate diagnosis, treatment, and healthcare in accordance with an individual's genetics and lifestyle. Another study [19] described an end-user development tool for the personalisation of context-dependent assistance by nontechnical users in the ambient assisted living domain. In particular, the applications for remotely monitoring and assisting elderly people at home through sending multimedia messages and reminders. Moreover, the study in [14] claimed that the provision of a personalized service is a fundamental challenge to the healthcare and is related to the issues of the expansion of an ageing population (i.e., the increase in demand for healthcare services and physician visits via the Internet and telemedicine).

In telemedicine systems, providing personalized services to a patient is an essential part of telemedicine because it is the process of treating a patient. Personalisation means understanding the needs of each individual/user and addressing those needs in a specific context[20]. Reducing the waiting time for remote patients through accurate diagnosis is an important process to consider when providing PHS to remote patients [8]. The most relevant studies that explored the provision of

PHS in remote healthcare monitoring frameworks with IoMT based on various features are presented in Table 1.

Table 1
The literature survey on remote healthcare monitoring frameworks with personalized healthcare services based on IoMT

Priority Issue	Personal Services Provision Issue	IoMT / IOT	Hospital Location	Patients Request Time	Patient's Location	Heterogeneous Variables	Comments and Limitations	Ref
YES	YES	NO	NO	YES	NO	YES	Hospital profile and patient's location were not addressed	[8]
YES	YES	NO	YES	NO	NO	YES	Hospital profile and patient profile were not addressed	[12]
NO	YES	IoT	NO	NO	NO	NO	Data collection was not considered vital signs and environmental elements	[20]
YES	NO	IoT	NO	NO	NO	YES	Need to increase the heterogeneous sources	[21]
NO	YES	IoT	NO	NO	NO	NO	Need to increase the heterogeneous sources	[22]
NO	YES	IoT	NO	NO	NO	YES	Need to provide recommendations focused on the user at the right time	[23]
NO	YES	IoT	NO	NO	NO	NO	Need to be remotely domain	[24]
NO	YES	NO	YES	YES	NO	NO	Limited to monitoring and need to increase the heterogeneous sources	[25]
NO	YES	IoT	NO	YES	YES	YES	Difficult to be perfectly implemented	[26]
YES	YES	IoMT	YES	YES	YES	YES	Overcome the limitations in the relevant studies.	Proposed Framework

The critical analysis for the literature illustrates the strength points for the recent relevant studies. However, despite all the benefits and advantages that they dispense, these systems and frameworks exhibit some limitations that are concerned with the provision of PHS. The most relevant studies [8][12] have proposed scalable remote monitoring healthcare models to accommodate the increasing in the patients' numbers and provide a treatment plan. However, these studies have several weaknesses (1) the distance between patient's location and the hospitals' physical locations were not considered. (2) the patient's request time was not considered. This variable is critical as there are many private hospitals, in Eastern Mediterranean Region, that cannot admit patients in night. (3), other limitations related to the context of the hospital and patient's information profiles. Existing frameworks do not consider patient location, request time, or hospital capacity. This study addresses these gaps by introducing an improved hospital selection model.

3. Research Methodology

3.1 Conceptual Framework

The proposed framework Multi Sources Healthcare Architecture 2 (MSHA-2) is a new improvement design for our previous design (MSHA) [27]. The components of the (MSHA-2) design is presented in Figure 2.

The framework is composed of three tiers. Tier-1 considers the IoMT devices tier whereas data from medical sensors, manual inputs (text) and a GPS sensor are collected. In this tier, the IoMT technology gives the patient all the abilities to use different devices that are applicable to be utilized in our proposed framework, for example the patient may use blood pressure sensor or the barometer instrument. All data that will collect from Tier 1 will be forwarded to Tier 2 via wired or wireless devices, such as Wi-Fi, Bluetooth, or ZigBee [27].

Tier 2 (the gateway) includes personal devices (smartphones, PDAs, and laptops) that process the raw data that collected from Tier 1 devices and send them to Tier 3 which is the hospital server (including cloud, server, database and IoT processing platforms) through Internet protocols, Wi-Fi, or GSM. When the patient's data reaches the cloud /server of the hospital (Tier-3), the medical services generating procedures are initiated. (MSHA-2) includes two algorithms that are proposed to be implemented in hospital server (Tier-3) sequentially.

Algorithm-1(Triage Algorithm) to triage/classify the patients to the proper medical emergency level. It is developed based on the Combined method of Dempster Shafer Theory (DS) and Fuzzy Clustering Mean (FCM)[7]. The outcomes of the triage algorithm are (1) patient's triage level which consider the patient emergency level, and (2) Initial assessment and prediction for the patient's chronic disease. Then MSHA-2 initiates the hospital selection algorithm which is proposed and developed based on the FCM method and it is implemented to provide the patient by the required hospital based on the time and availability. Finally, MSHA-2 sends set of notifications to the patient, patient's family, and hospital front desk. The MSHA-2 conceptual framework is illustrated in Figure 3.

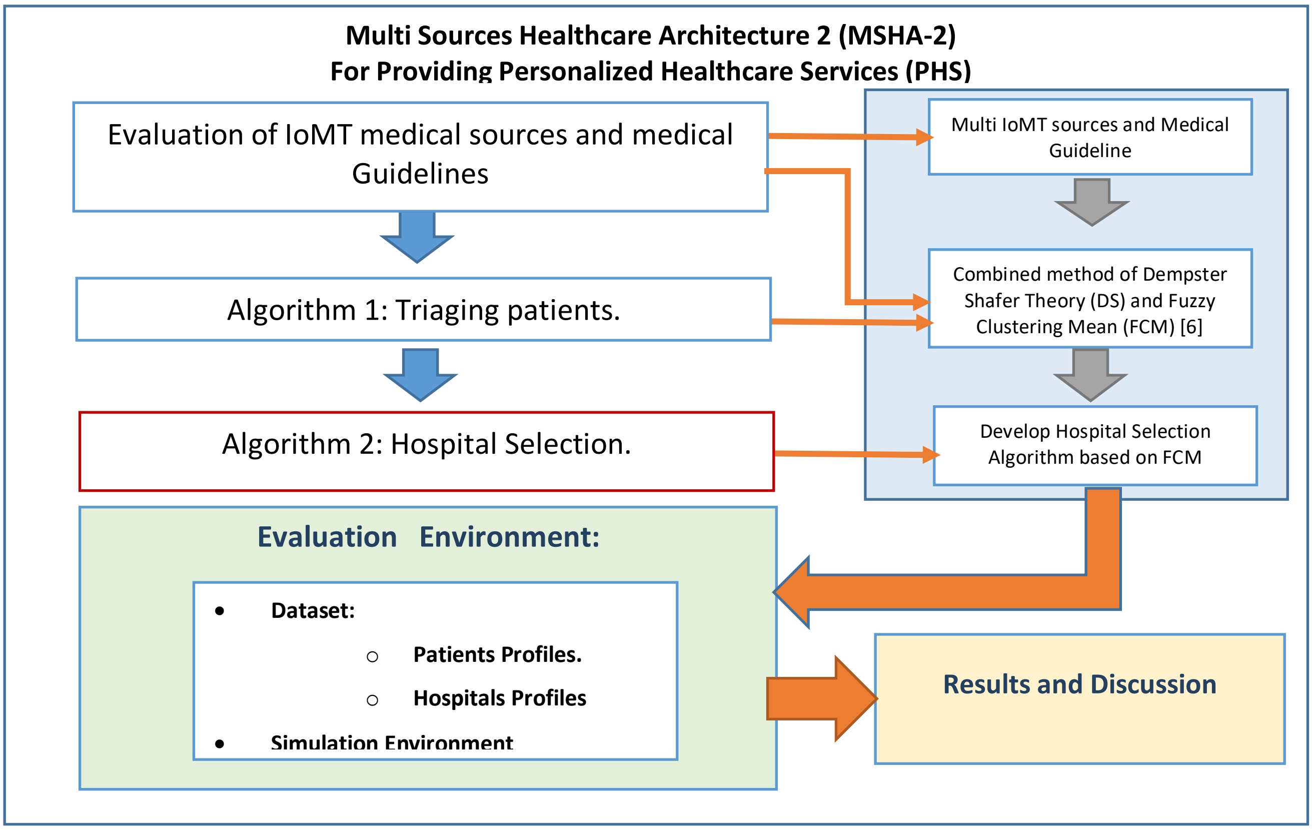


Fig. 2. Conceptual Framework for Providing Personalized Healthcare Services (PHS) with Considering Patient's Emergency Level, Patient's Location and Hospitals' Locations

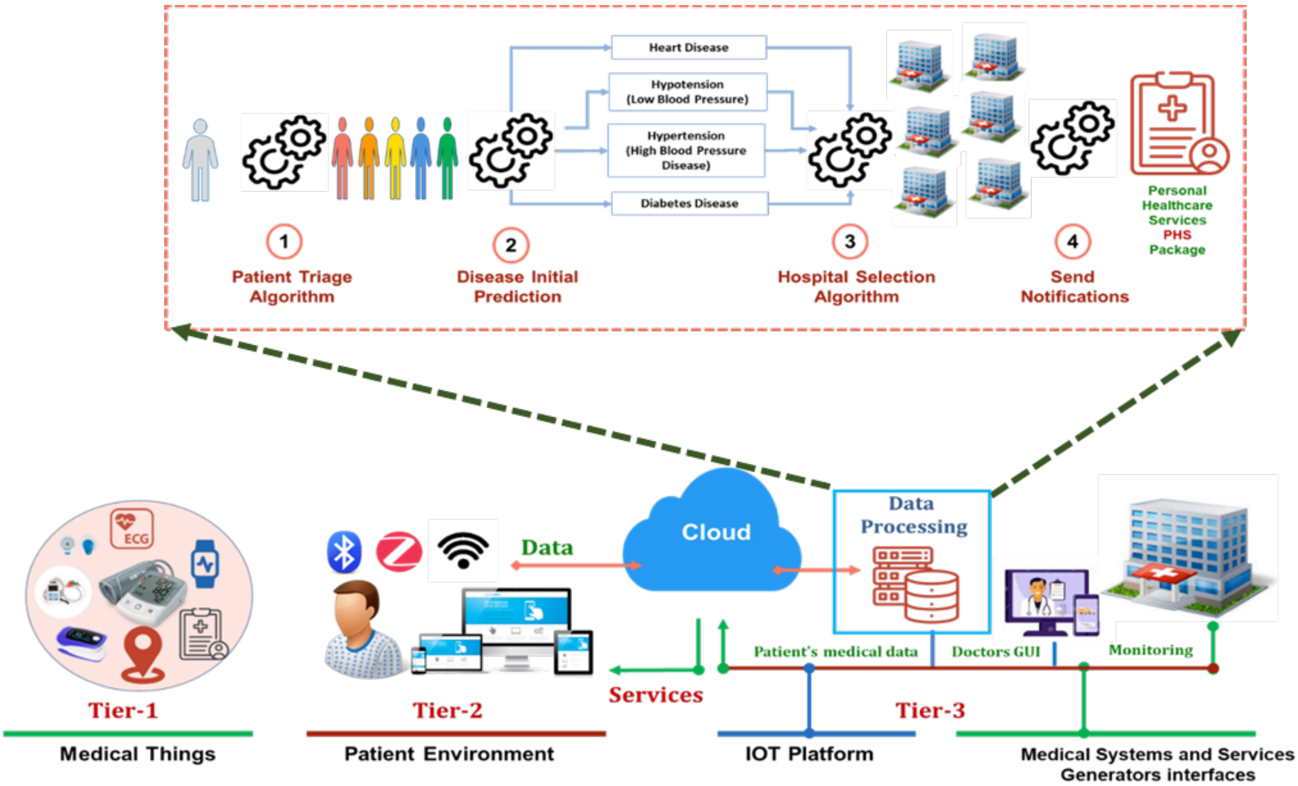


Fig. 3. Proposed personalized healthcare services (MSHA-2) framework

3.2 Evaluation of the Number and Type of IoMT sources

The type of IoMT medical sensors/sources used in Tier 1 is the main factor in determining the number and type of medical features that can be used in Tier 3. The relevant remote triage framework [8][28]uses seven sensory features from three types of medical sensors (ECG, SpO2 and blood pressure sensors) and four non-sensory features as utilized in our previous studies and presented in Table 2. However, to overcome the challenges encountered with the ageing of the population and the suffering of elderly patients from multiple chronic diseases, more IoMT sensory and non-sensory inputs are utilized as presented in Table 3. Although collecting this number of features is difficult and complex, it is crucial for improving PHS, which is also one of the main contributions of this study.

Table 2
The triage medical guidelines used in MSHA-1 [8][28]

			Medical Guideline triage: levels					Measurement Unit
			Risk	Urgent	Sick	Cold Case	Normal	
Input Variables	ECG Sensor	Heart Rate (Rhythm)	≥ 130	≤ 40 Or 111-129	41-50 Or 101-110	50-59 Or 91-100	60-90	Beat per minute
		QRS width			> 0.3		<0.3	second
		ST Elevation			Yes		No	
		R-R		Irregular		Regular		
	Spo2 sensor	SpO2	< 80	<81- 90	91-95		96-100	%100 per cent
	Blood Pressure sensor	High B.P.	22 <=	21.9-18	17.9-14		11-14	Hg
		Low B.P.		11<=	11-9		6-9	Hg
	Text	Rest?			Yes		No	
		Palpitation?			Yes		No	
		Shortness of Breath?			Yes		No	
		Chest Pain?			Yes		No	

Table 3
New utilized IoMT sensor and non sensors features and their triage medical guidelines used in The proposed Framework MSHA-2

			Medical Guideline triage: levels					Measurement Unit
			Risk	Urgent	Sick	Cold Case	Normal	
Input Variables	Blood sugar sensor	Hyper-glycaemia	<400	301-400	121-300		80-120	mg/Dl
		Hypo-glycaemia	> 50	50-59	60-79		80-120	mg/dL
	Respiratory Rate	RR	> 35 OR < 8	31-35	26-30	-	8-25	Respiratory per minute
	Temperature	T	-	>40 OR< 32	38.1-40 OR 32-34	-	34.1-38.0	°C
	Text	Mobility	Stretcher		With help	Walking		
		Extreme Thirst?		Yes			No	
		Blurred Vision?		Yes			No	
		Urinate?		Yes			No	

3.3 Algorithm 1: Remote Triage algorithm

The first service that can be provided to the remote patient is the extraction of the triage level from the vital sign data collected from medical sensors and text data. In this tier, the data, after being received from Tier 2, are processed to extract five levels of triage (risk, urgent, sick, cold case and normal) in reference to a medical guide that contained readings and a medical range for each triage level as shown in Tables 2 and 3. A brief description of the proposed algorithm in terms of triage level is presented as pseudo-code in Figure 4.

```
Input:
  • j1 in range (0, 4)  [range of each feature] // triage categories (5 categories)
  • j in range (0, 18)  [features of patient]  // number of overall features (19 features)

Output:
  • triage level (risk, urgent, sick, cold case, normal)

for j1 in range(0, 5):  # j1 is number of column
    f = []  # f is row in  f1
    for j in range(0, 16):  # j is number of row
        f.append(self.matrix[j][j1])
    f1.append(f)
state = 'Normal'  # health condition
for x in f1:  # x is each row in f1
   m = 0
    i = 0
    for x1 in x:  # x1 is each feature in each single row
        m = m + x1  # summation the value(0 or 1) in each row
        i += 1
    if m > 0:  # if the result of summation more than 0
        if f1.index(x) == 0:
            state = 'Risk'
            break
        elif f1.index(x) == 1:
            state = 'Urgent '
            break
        elif f1.index(x) == 2:
            state = 'Sick'
            break
        elif f1.index(x) == 3:
            state = 'cold case'
```

Fig. 4. Pseudo code of remote triage algorithm

3.4 Algorithm 2: Hospital Selection algorithm

After determining the patient's triage level in algorithm 1, the patient who has normal or cold-case triage level can be stay in home and no need to transfer to hospital, while the patient who has sick, urgent or risk triage levels should be sent to hospital. Selecting the appropriate hospital is one of the most important services provided to the patient to preserve his/her life. Hospital profiles from 34 hospitals located in the City of Baghdad were formulated and presented in Table 4.

Table 4
Hospitals profiles for 34 hospitals in the City of Baghdad

NO.	name	Type	location (coordinates)	
			X	Y
1	Al karkh general hospital	Governmental	33.3509719	44.36410349
2	Yarmouk Teaching Hospital	Governmental	33.29423637	44.3523279
3	Ibn Al-Bitar Hospital for Cardiac Surgery	Governmental	33.32737028	44.38863574

4	Al karama Teaching Hospital	Governmental	33.33073804	44.37995969
5	Abu Ghraib General Hospital	Governmental	33.30463224	44.1816617
6	Al Tarmiyah General Hospital	Governmental	33.66492063	44.39062888
7	Al Mahmoudia General Hospital	Governmental	33.07661884	44.36363372
8	Al Kadhimiya Teaching Hospital	Governmental	33.38036629	44.32549774
9	Al Furat General Hospital	Governmental	33.27467959	44.27106742
10	Al-Hakim Hospital	Governmental	33.3704063	44.2785936
11	Ibn Sina Hospital	Governmental	33.3120456	44.40641604
12	Ibn Al-Khateeb Hospital	Governmental	33.22565249	44.51161529
13	Al Sheikh Zayed General Hospital	Governmental	33.31657769	44.42845336
14	Al-Kindi Teaching Hospital	Governmental	33.34758324	44.4101878
15	Al Mada'in General Hospital	Governmental	33.10840935	44.57363135
16	Martyr Al-Sadr General Hospital	Governmental	33.37901496	44.46430927
17	Al-Numan Teaching Hospital	Governmental	33.36254821	44.35256153
18	Al Zafaraniyah General Hospital	Governmental	33.26935986	44.48823579
19	Al Wasti Teaching Hospital	Governmental	33.31873347	44.43204037
20	Ibn Al-Nafis Teaching Hospital	Governmental	33.31817762	44.42824236
21	Baghdad Teaching Hospital	Governmental	33.35496319	44.39097969
22	Al-Saadoon Hospital	Private	33.31809185	44.42161653
23	Al Raahibat Hospital	Private	33.30801841	44.42288797
24	Al-Jarah Hospital	Private	33.31466929	44.4263935
25	Al Jadriya Hospital	Private	33.29394773	44.42277633
26	Al Arabi Hospital	Private	33.31394837	44.43450492
27	Al Banuk Hospital	Private	33.39998856	44.40250358
28	Al Manar Hospital	Private	33.3475289	44.4311779
29	Al Karkh Hospital	Private	33.31856812	44.32442143
30	Al Masarra Hospital	Private	33.35563401	44.35260077
31	Royal Hospital	Private	33.32275847	44.32407028

32	Al Qima Hospital	Private	33.95883255	44.26655055
33	Al-Harthyia Hospital	Private	33.311172	44.36487504
34	AL-Belad Hospital	Private	33.30264179	44.36773234

Selecting the appropriate hospital for the patient is dependent on three sequential variables, which are: (1) patient's request time, (2) patient's triage level and initial diagnosis for the chief complains, and (3) patient's physical location, as presented in Figure 5.

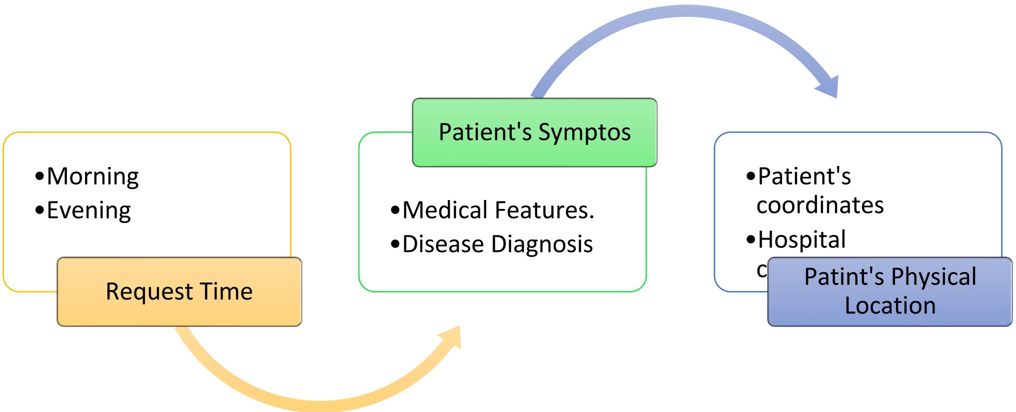


Fig. 5. Hospital selection Procedure

Considering the patient's request time, the hospitals are selected in accordance with the availability of the ED given that EDs in some private hospitals are closed at the evening in Baghdad city. Therefore, request time is the first variable in hospital selection algorithm. Request time divided the hospitals profile in the database into two lists, namely, morning (08:00 am to 07:00 pm) and evening (24/7). According to the request time, if the request time is in the morning, the morning hospital list is selected. This list includes all the hospitals (governmental and private). However, if the request time is in the evening, the evening hospital list is selected which includes only the government hospitals. After selecting the hospital profile list, the second variable which is the chief complaint is considered.

In Baghdad city we have different specialist hospitals. According to the variance of the patient's medical emergency features that determined based on Table 2 and Table 3, we can conclude the initial diagnosis for the patient. All the medical features represented in Table 2 and Table 3 are related to the three common chronic diseases (heart, blood pressure and diabetes). So, based on the critical patient's features and hospital specialist, the hospital list is refined and filtered. Then the patient's physical location is considered as the final variable. The nearest hospital is chosen by selecting the shortest distance between two coordinates, the patient's coordinates, and hospital's coordinates in the hospital list. The patient's coordinates are taken from a GPS sensor and compared with the hospital's coordinates that already taken from Google map and stored in the hospitals profile in Tier-3 database. The distances (d) between the patient's coordinates and hospital's coordinates are calculated using the 'Haversine' formula [29] as shown in Equation 3.1:

$$a = sin^2(\Delta\emptyset/2) \ + cos\,\varphi 1 \cdot cos\,\varphi 2 \cdot sin^2\,\Delta\lambda \,/\, 2) \qquad (3.1)$$

$$\mathrm{c} = 2 \cdot \mathrm{a}\tan 2(\sqrt{a}, \sqrt{(1-a)})$$

$$d = R.c$$

Where φ is latitude, λ is longitude, R is earth's radius (mean radius = 6,371 km);

Finally, when the nearest hospital is selected, the proposed framework sends ambulance to the patient who has (sick. urgent or risk) triage level. In addition to that, the proposed framework initiates the notification procedure whereas three notifications will be composed and sent. First notification will be sent to the registration staff in the selected hospital to inform them to be prepared to the patient, then second notification will be sent to the patient him/herself and the third notification will be sent to the patient's family to get acknowledged as the patient in urgent or risk triage level need immediate support while he/she is waiting for the ambulance.

4. Results

4.1 Dataset

MSHA-2 was evaluated by using the most reliable and relevant medical database [30], which contains numerous datasets that have already utilized in our relevant studies. Moreover, the values of the new medical features that presented in Table 3 were generated randomly within the consideration of medical guidelines ranges and added to the simulation. The evaluation dataset includes 580 patients who showed symptoms of different triage level. All the patients' dataset and vital signs are presented in Appendix A. Hospitals profiles presented previously in Table 4. While, Figure 6 illustrates their distributions using green landmarks locations icon in Baghdad city centre according to Google map.

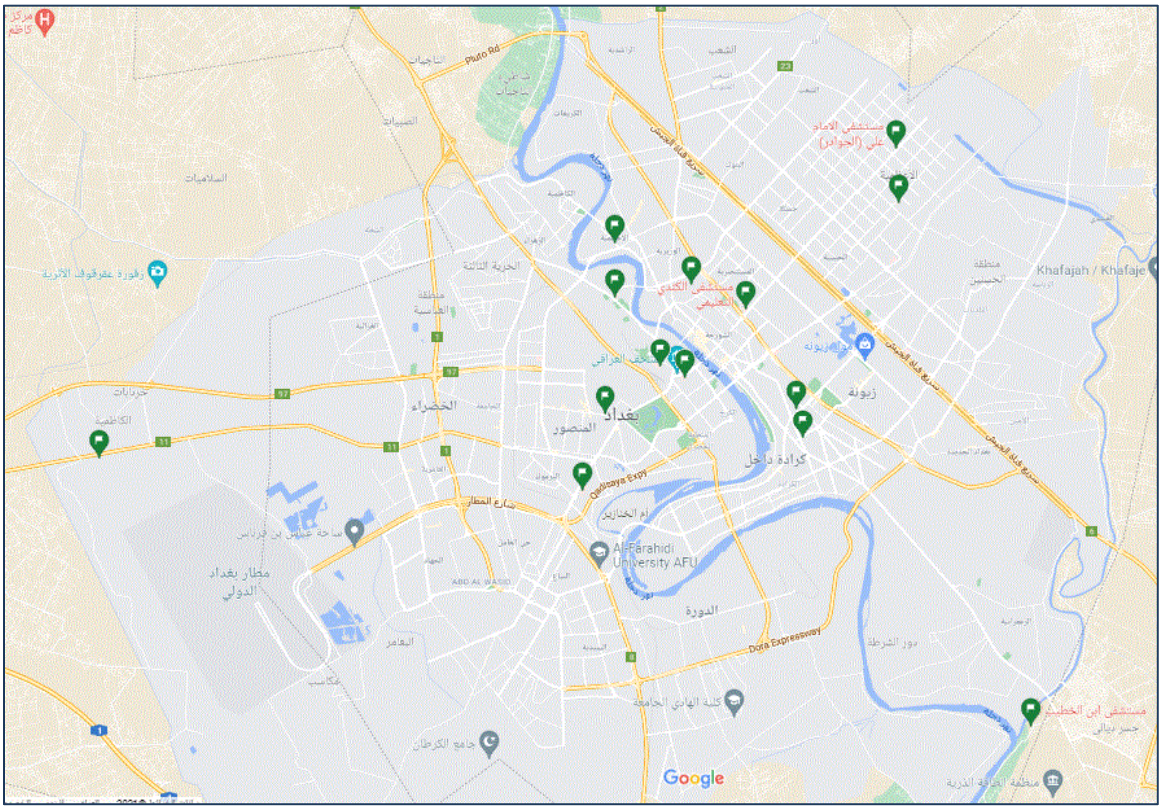


Fig. 6. Locations for sample of the hospitals in Baghdad city using google map

4.2 Simulation Setup

The proposed framework (MSHA-2) was implemented and evaluated in PyCharm 2021.2 (Community Edition) simulation environment on Windows 2010. The development codes were written in Python programming language. The simulation was started by collecting patient's medical data from dataset and displaying the data through a GUI (Figure 7). In real-time implementations, the patient uses the GUI to enter his/her data.

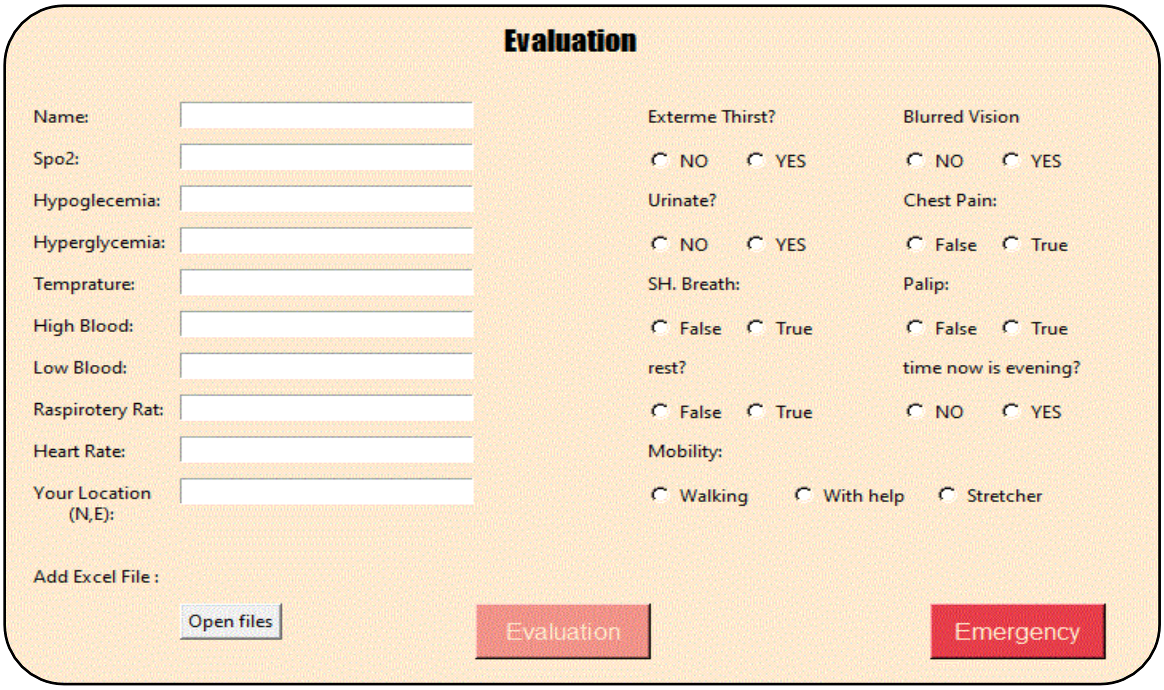


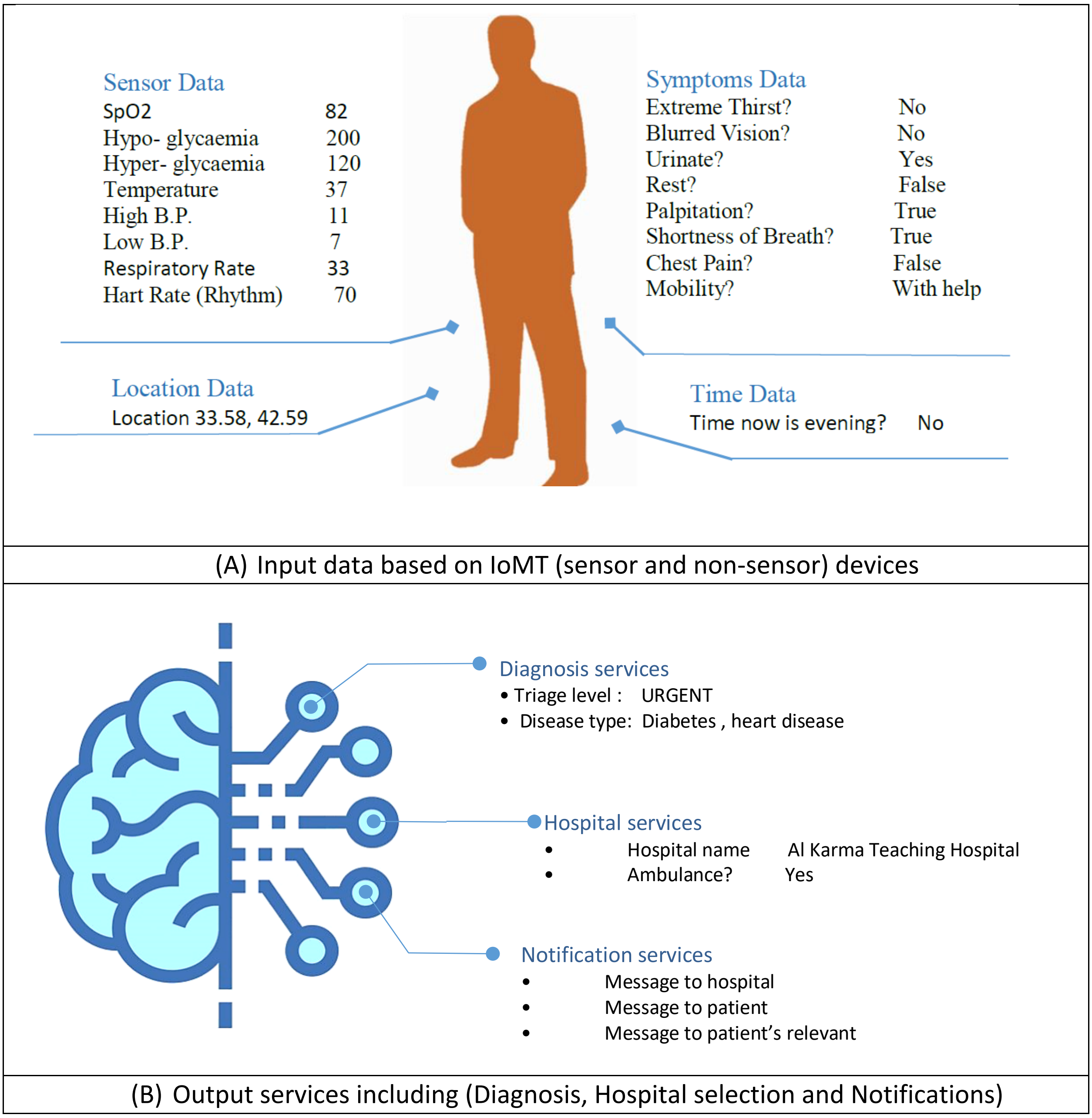
Fig. 7. Grafical User Interface (GUI) for entry data

4.3 Computational Results

To present the comprehensive analysis and the ability of MSHA-2 in determining the triage level, providing the proper hospital and medical services to a wide range of the patients who are different in their variables and medical features, the computational results are presented through three patient scenarios. Those scenarios are different in the patient's emergency level which were (urgent, sick, and cold case) respectively.

4.3.1 Scenario (1): Urgent triage level

Urgent level means the patient need to be transfer to the nearest hospital to get the fast medical services. The system determines the hospital based on the proposed algorithm and send ambulance to the patient based on his/her physical location. In addition to that, the system sends notifications to the patient, hospital, and patient's family respectively. The inputs parameters of the patient, and the output services are shown in Figure 8, respectively.



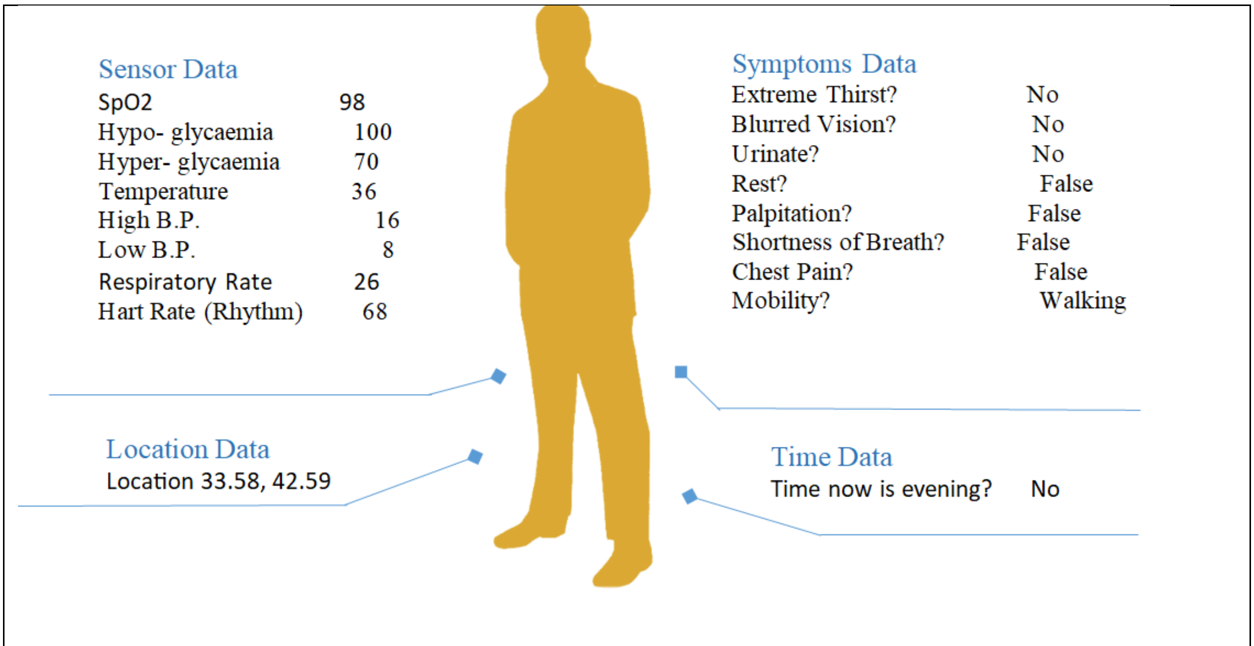
(A) Input data based on IoMT (sensor and non-sensor) devices

(B) Output services including (Diagnosis, Hospital selection and Notifications)

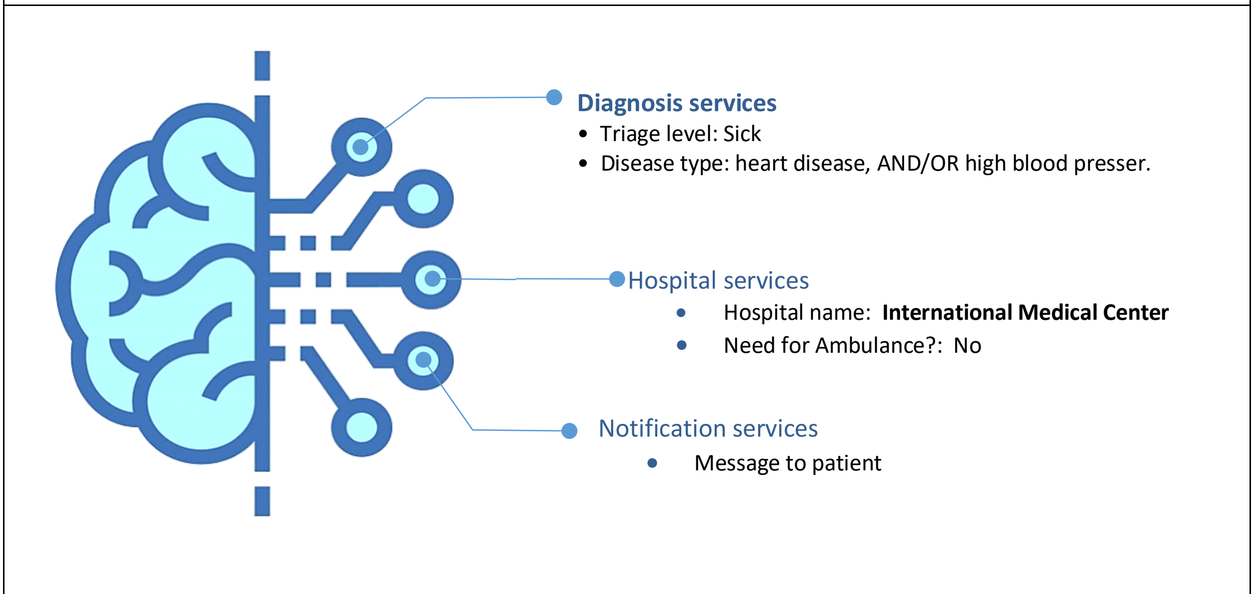
Fig. 8. (A) inputs data, (B) outputs services based on MSHA-2 for Urgent Emergency level in scenario (1)

4.3.2 Scenario (2): Sick triage level

Sick triage level means the patient has minor pain and there is no urgent need to send an ambulance. Therefore, the system determines the nearest hospital based on the proposed algorithm and sends notification to the patient. In this scenario the patient should go to the hospital. No more notifications are needed for the hospital and patient's family. The patient, the input parameters, and the output services are shown in Figure 9, respectively.



(A) Input data based on IoMT (sensor and non-sensor) devices

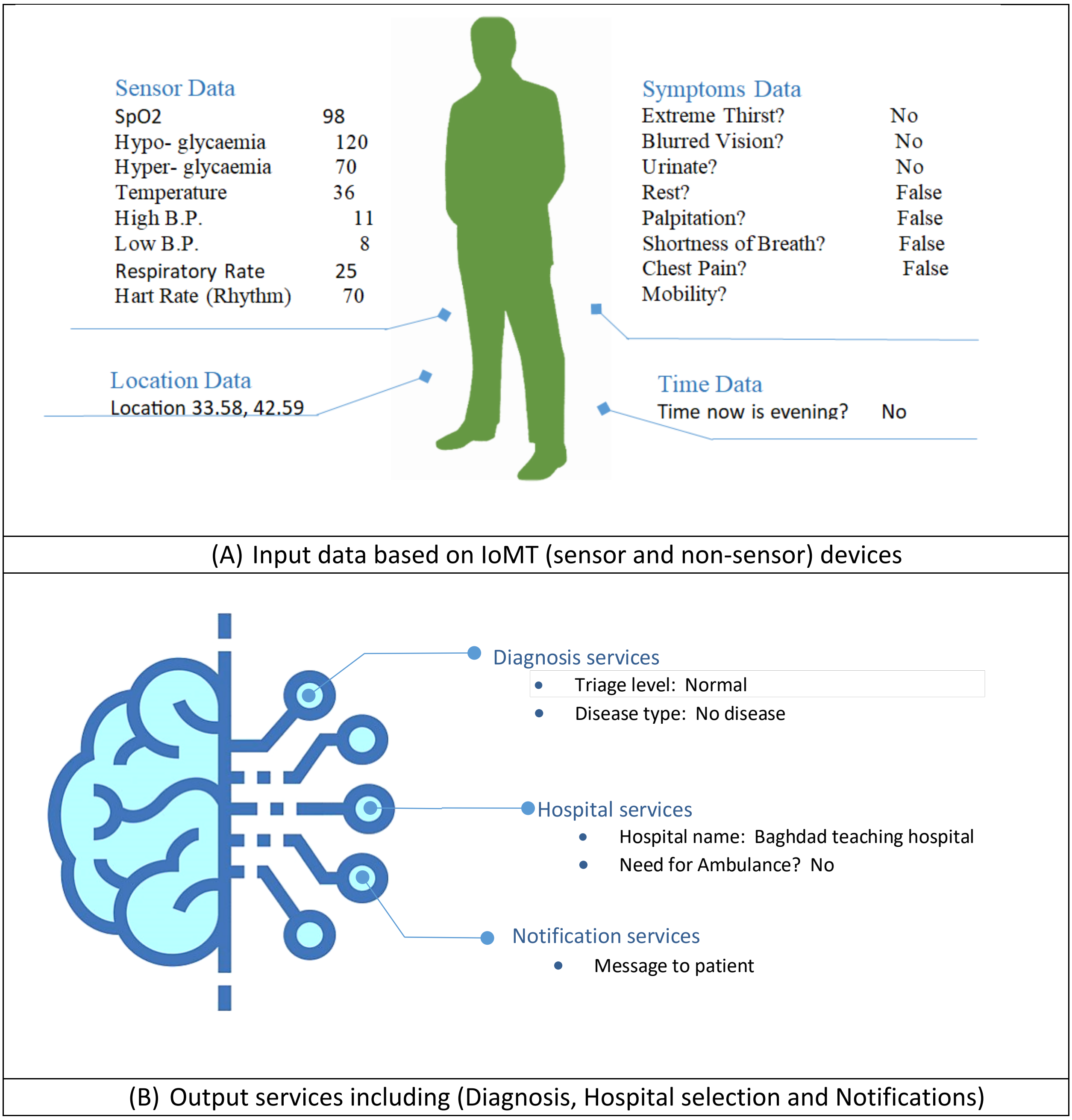


(B) Output services including (Diagnosis, Hospital selection and Notifications)

Fig. 9. (A) inputs data, (B) outputs services based on MSHA-2 for Sick Emergency level in scenario (2)

4.3.3 Scenario (3): Normal triage level

Normal means the patient has no major medical emergency case and he/she is normal. Therefore, MSHA-2 sends notification to the patient. In this scenario, there is no need to the patient to go to the hospital. The patient stays at home and keeps monitoring his/her vital signs. No more notifications needed for the hospital and patient's family. The patient the input parameters, and the output services are shown in Figure 10, respectively.



(A) Input data based on IoMT (sensor and non-sensor) devices

(B) Output services including (Diagnosis, Hospital selection and Notifications)

Fig. 10. (A) inputs data, (B) outputs services based on MSHA-2 for Normal Emergency level in scenario (3)

4.4 Comparison with Benchmark Studies

The aim of this section is to validate MSHA-2 performance and quantify the algorithms superiority over previous relevant methods in the same field [8][12]. Table 5 shows the comparison with Benchmarks.

Table 5
Benchmarking MSHA-2 with relevant studies based on common research

Criteria		[8]/2020 /Benchmark 1	[12]/2019 /Benchmark 2	Proposed MSHA-2
Telemedicine Applications		√	√	√
Scalability		√	√	√
Triage Levels		√	√	√
Heterogeneous Sources	Medical Sensors	√	√	√
	Text-Frame	√	√	√
	Nonmedical Sensors	X	X	√
Multiple Chronic Diseases	Heart Disease	√	√	√
	Diabetes	X	X	√
	High Blood Pressure	X	X	√
	Low Blood Pressure	X	X	√
Patient's Location	Location	X	X	√
Request Time	Day/Night	X	X	√
	Waiting time	√	X	X
Hospital Selection	Nearest Hospital	X	X	√
	Hospital Type	X	X	√
	Number Of Services	X	√	X
	Ambulance	√	√	√
Notifications	Patient	√	√	√
	Patient's Relatives	X	X	√
	Hospital	X	X	√
Total Points		45%	45%	90%

MSHA-2 and the benchmarks models have 20 common criteria in the research scope. Therefore, we set a numeric evaluation system to get a numerical evaluation performance. As shown in Table 5, MSHA-2 outperformed the two benchmark models. MSAH-2 obtained 90% of the total services and standards set, whereas the two studies for comparison obtained only 45% and 45% respectively. The benchmark models have only two main strength points compared to MSHA-2. Benchmark [8] considered the patient's waiting time, while benchmark [12] considered the type of medical services. In contrast, MSHA-2 contributions were illustrated by considering (1) multi-chronic disease patients based on IoMT sources, (2) patient's request time, (3) patient's location, and (4) hospitals' physical locations. Improving the performance of MSHA-2 by considering patient waiting time and identifying the optimal services package for each patient (doctor's specialist, warding room, hospital resources, medications, and other services) based on the patient's context-aware and medical status are set to be potential future work in our PES research directions.

5. Conclusion

The objective of this research is to develop a telemedicine framework based on IoMT technology and computational algorithm to provide the remote patients by healthcare services. The provided services are specifically in line with the patient's health symptoms and condition which considered more personalized healthcare services PHS.

Those services include triage level determination, hospital selection and package of notifications. The proposed framework Multi Sources Healthcare Arckitecture-2 (MSHA-2) is a new extension version for our previous proposed framework MSHA. (MSHA-2) consisted of several sequential stages that started with the collection of sensory, non-sensory and location information in Tier 1 followed by data transmission to the server in Tier 2. While, in Tier 3, the proposed framework provided PHS in the form of home monitoring services (monitoring, notification and messages to the patient and his/her relatives), pre-hospital services (triage level and initial disease type determination and hospital selection) and hospital services (sending an ambulance). These solutions can improve PHS for patients and give them an independent lifestyle and help them anytime, anywhere.

The results showed that MSHA-2 worked with high efficiency to preserve the life of the remote patient by providing the proper services. The most important factor in preserving the patient's life was by choosing the appropriate hospital and then sending an ambulance which accelerate the provisioning of medical services.

The Recommendation for future work includes considering patient waiting time and identifying the optimal services package for each patient by considering (patient's medical record, and medications) based on the patient's context-aware and medical status. In addition to that, considering the structures of affiliated hospitals, such as the numbers of hospital departments, capacity of emergency departments (EDs), doctors, nurses, and beds need to be addressed. Further research is needed to develop robust AI models by integrating AI and machine learning algorithms into personalized healthcare systems to effectively analyse remote monitoring data, identify patterns, and provide actionable insights to healthcare professionals. this suggested research direction is important in choosing alternative hospital in the event of overcrowding in the patient number in different cases such as disaster scene.

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References
[1] Gingras, Guillaume, Mehdi Adda, Abdenour Bouzouane, Hussein Ibrahim, and Clémence Dallaire. "Iot ambient assisted living: Scalable analytics architecture and flexible process." *Procedia Computer Science* 177 (2020): 396-404. https://doi.org/10.1016/j.procs.2020.10.053

[2] World Health Organization (WHO), "WHO Calls for Urgent Transformation of Care and Support Systems for Older People," October 1, 2024, https://www.who.int/news/item/01-10-2024-who-calls-for-urgent-transformation-of-care-and-support-systems-for-older-people.

[3] M. Rivki et al., *Health and Well-Being Profile of the Eastern Mediterranean Region: An Overview of the Health Situation in the Region and Its Countries in 2019* (World Health Organization, no. 112, Regional Office for the Eastern Mediterranean, 2019), https://iris.who.int/handle/10665/348133.

[4] Department of Health Systems Development (HSD) and Department of Information, Evidence, and Research (IER), *Iraq: Health Systems Profile* (World Health Organization, 2019), 1–2, https://applications.emro.who.int/docs/Country_profile_2013_EN_15388.pdf.
[5] Park, Eunjeong, Ji Hoon Kim, Hyo Suk Nam, and Hyuk-Jae Chang. "Requirement analysis and implementation of smart emergency medical services." *IEEE Access* 6 (2018): 42022-42029. https://doi.org/10.1109/ACCESS.2018.2861711
[6] Aminuddin, Raihah, Nor Afirdaus Zainal Abidin, Khyrina Airin Fariza Abu Samah, Edzreena Edza Odzaly, Siti Feirusz Ahmad Fesol, and Asma Zubaida Mohamed Ibrahim. "Telehomecare: a Comprehensive Analysis of Its Relevance and Impact." (2024). https://doi.org/10.37934/araset.39.1.183191
[7] Alam, Muhammad Mahtab, Hassan Malik, Muhidul Islam Khan, Tamas Pardy, Alar Kuusik, and Yannick Le Moullec. "A survey on the roles of communication technologies in IoT-based personalized healthcare applications." *IEEE access* 6 (2018): 36611-36631. https://doi.org/10.1109/ACCESS.2018.2853148
[8] Salman, Omar Hussein, Mohammed Imad Aal-Nouman, and Zahraa K. Taha. "Reducing waiting time for remote patients in telemedicine with considering treated patients in emergency department based on body sensors technologies and hybrid computational algorithms: Toward scalable and efficient real time healthcare monitoring system." *Journal of Biomedical Informatics* 112 (2020): 103592. https://doi.org/10.1016/j.jbi.2020.103592
[9] Das, Arun, Paul Rad, Kim-Kwang Raymond Choo, Babak Nouhi, Jonathan Lish, and James Martel. "Distributed machine learning cloud teleophthalmology IoT for predicting AMD disease progression." *Future Generation Computer Systems* 93 (2019): 486-498. doi: 10.1016/j.future.2018.10.050. https://doi.org/10.1016/j.future.2018.10.050
[10] Abdel-Basset, Mohamed, Victor Chang, and Nada A. Nabeeh. "An intelligent framework using disruptive technologies for COVID-19 analysis." *Technological Forecasting and Social Change* 163 (2021): 120431. https://doi.org/10.1016/j.techfore.2020.120431
[11] Julee Choudhary, Birendra Kumar, Sundararajan Ananiah Durai, and Nabihah Ahmad. "Smart Microfluidic Devices for Point-of-Care Applications." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 114, no. 1 (2024): 119-133. https://doi.org/10.37934/arfmts.114.1.119133
[12] Albahri, Ahmed Shihab, Osamah Shihab Albahri, A. A. Zaidan, B. B. Zaidan, M. Hashim, M. A. Alsalem, Ali H. Mohsin et al. "Based multiple heterogeneous wearable sensors: A smart real-time health monitoring structured for hospitals distributor." *IEEE access* 7 (2019): 37269-37323. https://doi.org/10.1109/ACCESS.2019.2898214
[13] Moreira, Ailton, César Quintas, Tiago Guimarães, and Manuel Filipe Santos. "Multichannel mobile companions for personalized healthcare opportunities and challenges." *Procedia Computer Science* 220 (2023): 838-843. https://doi.org/10.1016/j.procs.2023.03.112
[14] Qi, Jun, Po Yang, Geyong Min, Oliver Amft, Feng Dong, and Lida Xu. "Advanced internet of things for personalised healthcare systems: A survey." *Pervasive and mobile computing* 41 (2017): 132-149. https://doi.org/10.1016/j.pmcj.2017.06.018
[15] He, Shuqing, Bo Cheng, Haifeng Wang, Yuze Huang, and Junliang Chen. "Proactive personalized services through fog-cloud computing in large-scale IoT-based healthcare application." *China Communications* 14, no. 11 (2017): 1-16. https://doi.org/10.1109/CC.2017.8233646
[16] Han, Soyeon Caren, Luke Mirowski, and Byeong Ho Kang. "Exploring a role for MCRDR in enhancing telehealth diagnostics." *Multimedia Tools and Applications* 74 (2015): 8467-8481. https://doi.org/10.1007/s11042-013-1613-7
[17] Jeong, Sangjin, Seonghwan Kim, Daesun Kim, Chan-Hyun Youn, and Yong-Woon Kim. "A personalized healthcare system for chronic disease care in home-hospital cloud environments." In *2013 International Conference on ICT Convergence (ICTC)*, pp. 371-376. IEEE, 2013. https://doi.org/10.1109/ICTC.2013.6675375
[18] Yu, Lisha, Wai Man Chan, Yang Zhao, and Kwok-Leung Tsui. "Personalized health monitoring system of elderly wellness at the community level in Hong Kong." *IEEE Access* 6 (2018): 35558-35567. https://doi.org/10.1109/ACCESS.2018.2848936
[19] Corcella, Luca, Marco Manca, Jan Egil Nordvik, Fabio Paternò, Anne-Marthe Sanders, and Carmen Santoro. "Enabling personalisation of remote elderly assistance." *Multimedia Tools and Applications* 78, no. 15 (2019): 21557-21583. https://doi.org/10.1007/s11042-019-7449-z
[20] Su, Chia-Rong, Jeyhun Hajiyev, Changjui James Fu, Kuo-Chin Kao, Chih-Hao Chang, and Ching-Ter Chang. "A novel framework for a remote patient monitoring (RPM) system with abnormality detection." *Health Policy and Technology* 8, no. 2 (2019): 157-170. https://doi.org/10.1016/j.hlpt.2019.05.008
[21] Mohammed, K. I., A. A. Zaidan, B. B. Zaidan, Osamah Shihab Albahri, M. A. Alsalem, Ahmed Shihab Albahri, Ali Hadi, and M. Hashim. "Real-time remote-health monitoring systems: a review on patients prioritisation for multiple-chronic diseases, taxonomy analysis, concerns and solution procedure." *Journal of medical systems* 43 (2019): 1-21. https://doi.org/10.1007/s10916-019-1362-x

[22] Kaur, Pavleen, Ravinder Kumar, and Munish Kumar. "A healthcare monitoring system using random forest and internet of things (IoT)." *Multimedia Tools and Applications* 78 (2019): 19905-19916. https://doi.org/10.1007/s11042-019-7327-8
[23] Devarajan, Malathi, V. Subramaniyaswamy, V. Vijayakumar, and Logesh Ravi. "Fog-assisted personalized healthcare-support system for remote patients with diabetes." *Journal of Ambient Intelligence and Humanized Computing* 10 (2019): 3747-3760. https://doi.org/10.1007/s12652-019-01291-5
[24] Chen, Min, Jun Yang, Jiehan Zhou, Yixue Hao, Jing Zhang, and Chan-Hyun Youn. "5G-smart diabetes: Toward personalized diabetes diagnosis with healthcare big data clouds." *IEEE Communications Magazine* 56, no. 4 (2018): 16-23. https://doi.org/10.1109/MCOM.2018.1700788
[25] Tan, Seng-Keong, Siew-Chin Chong, Kuok-Kwee Wee, and Lee-Ying Chong. "Personalized healthcare: A comprehensive approach for symptom diagnosis and hospital recommendations using AI and location services." *Journal of Informatics and Web Engineering* 3, no. 1 (2024): 117-135. https://doi.org/10.33093/jiwe.2024.3.1.8
[26] Liu, Quanchen, and Pengzhu Zhang. "Panoramic and Personalised Intelligent Healthcare Mode." *Journal of Shanghai Jiaotong University (Science)* 27, no. 1 (2022): 121-136. https://doi.org/10.1007/s12204-021-2274-8
[27] Jagadeeswari, V., V. Subramaniyaswamy, Re T. al Logesh, and Varadarajan Vijayakumar. "A study on medical Internet of Things and Big Data in personalized healthcare system." *Health information science and systems* 6, no. 1 (2018): 14. https://doi.org/10.1007/s13755-018-0049-x
[28] Salman, Omar Hussein, Mohd Fadlee A. Rasid, M. Iqbal Saripan, and Shamala K. Subramaniam. "Multi-sources data fusion framework for remote triage prioritization in telehealth." *Journal of medical systems* 38 (2014): 1-23. https://doi.org/10.1007/s10916-014-0103-4
[29] Scipts, Movable Type. *Calculate distance, bearing and more between Latitude/Longitude points*. 2019.
[30] Salman, Omar H., Mohammed I. Aal-Nouman, Zahraa K. Taha, Muntadher Q. Alsabah, Yaseein S. Hussein, and Zahraa A. Abdelkareem. "Formulating multi diseases dataset for identifying, triaging and prioritizing patients to multi medical emergency levels: Simulated dataset accompanied with codes." *Data in Brief* 34 (2021): 106576. https://doi.org/10.1016/j.dib.2020.106576