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Not peer-reviewed version

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Posted Date: 2 May 2025

doi: 10.20944/preprints202505.0045.v1

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Article

Smart Decision-Making in Mobile Healthcare Information Systems: An Ontology-Based Approach to Emergency Management

Hela Limam ¹, Hashim Jarrar ^{2,*}, Yasmine Akaichi ³ and Wided Oueslati ⁴

¹ Institut Supérieur d'Informatique, Université de Tunis El Manar, Laboratoire BestMod, Institut Supérieur de Gestion de Tunis University of Tunis, Tunis, Tunisia

² Faculty of Information Technology, Department of Cybesecurity, Middle East University, Amman, 11831, Jordan

³ Computer Science Department, University of Clermont Ferrand, Clermont Ferrand, France,

⁴ Ecole Supérieure de Commerce de Tunis University of Manouba, Laboratoire BestMod, Institut Supérieur de Gestion de Tunis University of Tunis,

* Correspondence: aabh870@outlook.com

Abstract: Saving patients' lives in peril is a crucial task; therefore, it is the primary concern of physicians and caregivers. While heading to an adequate medical institution that must be determined with precision, late response, information overload, and poor decisions may lead to serious, even catastrophic, health consequences. It is even worse if it is known that some areas do not have good medical coverage such as in rural regions. A good solution is to enhance the functionalities of mobile physicians, an ordinary physician in move with any adequate vehicle. They have the role of visiting the patient when requested, providing initial aid, making an initial diagnosis, and caring for a patient while moving to a medical institution when involved. To facilitate efficient on-road decision-making for mobile physicians, this study suggests a medical decision support system that adopts the ontology-driven approach for efficient emergency management. It permits ascertaining and ranking the appropriate medical institutions as quickly as possible, including healthcare resources institutions per the patient's condition determined initially, thanks to the first diagnosis, and continuously evaluated in real-time.

Keywords: mobile health units; ontologies; geographic information systems; health information systems; decision support systems

1. Introduction

Healthcare knowledge management aims to empower providers with current, relevant and efficient healthcare information at their convenience, enabling them to make well-informed decisions on patient care. An important problem worldwide is the need for more medical coverage in wide geographic regions, particularly rural ones, due to the low number of physicians and medical personnel [1]. Worldwide, many thousands of individuals are dead due to inaccurate emergency management characterized by confusion inadequate responses, and inappropriate decisions [2].

According to WHO, there is a global shortage of 18 million healthcare workers, with rural areas being most impacted [3]. As a result, tens of thousands of people die yearly because of poor emergency handling involving confusion, suboptimal responses, and even improper decisions. This shortage leads to the poor emergency response which is said to be claiming thousands of lives that could have been prevented yearly [4]. For example, in low income countries, only 37 % of delivery is conducted under supervision of skilled health personnel; illustrating the access deficit to emergency health care. Similarly, research published in the American Journal of Emergency Medicine also stressed that longer times to respond to emergencies as being general causes of higher mortality rate,

rural areas taking 7-14 minutes longer than urban ones [5]. The more adopted of mHealth solutions is rapidly expanding since the mHealth market is estimated to reach \$12.53 billion [6].

The emergence of mobile devices and location technologies in several domains has drawn the interest of scholars and professionals, demonstrating its practicality in the healthcare sector. By providing distant patients with the convenience of being attended to whenever and wherever they want. Such innovative technology has sparked the development of a new set of health ideas, mostly centered on ubiquitous resolutions [7]. Such advanced technologies allow ubiquitous healthcare applications to overcome temporal and geographical challenges, give more accessibility to healthcare practitioners and open up new opportunities and potentials for supporting and ensuring patient treatment [8].

Keeping an eye on patients takes a lot of time, particularly if they are geographically spread or immediately face an emergency. In every situation, doctors have an ethical and fundamental duty to save the lives of their patients. Saving patients in emergencies when they are geographically far from reach is a task that is primarily based on well-organized and efficient emergency management. Mobile physicians, who usually reach their patients at distant places to provide care and make critical decisions, must respond on time and efficiently to assist people in crucial situations, particularly if they are asked to care for patients away from established medical facilities [9]. It can lessen such issues by acting quickly and effectively to reach the patient and the medical facility. This will increase the patient's chances of receiving treatment and survival. Thus, it is crucial to provide mobile physicians with tools that help them handle crises in urgent or important situations [10]. Furthermore, road circumstances are continually changing; therefore, the mobile physician, on his way to the patient's location and when heading to medical institutions, may encounter complications on the road. These difficulties, such as heavy traffic, road maintenance, signals, etc., may prevent them from reaching the destination within a reasonable time, consequently threatening the patient's life.

To accomplish the goals mentioned earlier and overcome the limitations, an ontology-driven method incorporating road guiding has introduced in a medical decision support system. This system aims to improve the effectiveness of mobile physicians in emergency scenarios by efficiently locating the nearest healthcare facilities to the emergency site and identifying those equipped with suitable medical resources for patient transfer. This system strives to ensure the quick arrival of mobile physicians to their designated destinations through a search engine utilizing an incremental routing algorithm. Approach of this study uses the Delaunay triangulation algorithm to swiftly pinpoint the closest healthcare facility while departing from the emergency scene.

This method [11] takes into account dynamic transformations of the search locations based on the algorithm for a route calculation. It gives correct responses for continuous k-nearest Neighbors (CkNNs) searches pertinent to the road. This is chosen deliberately as it helps in achieving the intended outcomes and accommodates the dynamism in mobility demand by the involved physicians. Regarding this process, the creation of an Ontology with a high expressivity and reasoning ability has been developed. It provides means for description of structured data and relations, which allows the system to define what resources are needed in the medical sphere and whether the required resources are available in the nearest hospitals. Here, each medical resource is annotated to indicate what it shall be used for in order to include another resource in the event that the former is required.

When an emergency call happens, a mobile physician should reach the patient as quickly as possible. They must be prepared to be skilled to evaluate and analyze the clinical data and be able to take speedy and competent decisions to assist their usual or random patients. After reaching the patient, the mobile physician evaluates the patient's medical status and decides whether to treat the patient on-site or to the closest healthcare institution. Though several current systems can locate the nearest hospital, they must determine which facility has the effective medical resources required to meet the patient's demands.

To help the mobile physician make decisions, this study suggests a road guidance ontology-based medical support system that can swiftly retrieve the best medical facility for the situation. The retrieved institution must meet the patient's condition while ensuring the rapid reach of the patient by providing an impediments-free road. Such a system aims to support mobile physician decisions and empower them to form another way of approaching medical emergencies that could benefit many cases in distant regions such as rural areas.

Specifically, this work aims to fulfil the following main objectives:

1. Discover the healthcare institutions neighboring the emergency situations while providing the shorter paths leading to them.
2. Identify necessary medical resources for the patient's condition before visiting a healthcare facility.
3. Identify healthcare facilities with the appropriate medical resources to meet the demands of patients.

2. Related Works

The development of ubiquitous technology allowed people to take care of themselves and complete chores at any time or place. The primary goal of ubiquitous computing is to enable any user using mobile devices to access any data or service from any location. By overcoming time and location limits, the ubiquitous infrastructure will allow us to improve and develop new services that are helpful in the healthcare sector. This is made possible by the rapidly advancing technologies of mobile devices and accompanying mobile applications, which have increased and are altering how people use healthcare facilities. Researchers, patients, application developers, and healthcare professionals have all been paying close attention to mobile healthcare. In this field, mobile devices are used to access healthcare services, wireless networks and sensors are used to monitor various conditions, healthcare personnel make decisions about whether to offer emergency care, etc. Mobile healthcare has played a significant role in expanding healthcare coverage, improving healthcare decision-making, and, most importantly, providing appropriate care in an emergency.

Peri-prosthetic healthcare systems can enhance healthcare services by facilitating ways to get beyond geographical and technology constraints when tackling specific healthcare issues. There are new opportunities to guarantee better patient care and overcome time and space barriers between patients and caregivers with applications for ubiquitous healthcare. In addition to providing access to essential clinical data and services, they guarantee the management of encountered medical problems and enable physicians and patients to move without restriction. Healthcare personnel must respond to ever-increasing emergency needs, and ubiquitous medical systems can assist them. Services which are based on the location are the main components of ubiquitous medical systems, which provide quick and dependable medical services using ad hoc connections [12] to supply information and services to medical actors. In this scenario, mobile doctors are among the users who initiate location searches; therefore, this is assured by replying to their requests. It takes efficient planning, management, and coordination with location-based services for a decision support system to play a major part in successfully handling emergencies.

The literature has several proposals for healthcare solutions that use location-based services. A diabetes monitoring system that allows users to use smartphones to see and manage their psychosocial data and settings at any time and location is provided [13]. By conducting many examinations and transmitting the collected data to an expert system, this kind of technology lessens the likelihood that their health issues will worsen. The technology offers patients in remote places a quick diagnosis based on the analysis of the data that was received. The authors offered an integrated healthcare delivery platform to reduce the risk of injury to participating patients. They can search for a nearby doctor who can contribute to the healthcare process by giving patients various features, finding hospitals and medical centres where patients can be treated, and accessing many medical services at any time and from any position [14].

A system for immediate emergency detection and reaction to serious cardiac situations is shown in [15]. Its primary objective is the timely and appropriate provision of therapy for old and unable individuals suffering from chronic cardiac problems. Three categories exist in this prototype for notifications. The initial one gives the position of the monitored patient; the second is related to an alarm that sounds when the heartbeat of the patient rate goes beyond a certain threshold; and the third is in charge of calling for an ambulance that is equipped to rescue the patient in a serious condition.

The authors of [16] provided a health monitoring system designed for patients with cardiac conditions such as hypertension and arrhythmia. To detect the position of patient in situation of urgency and locate the closest medical facility, activate the emergency healthcare service and this mobile cardiac emergency structure is location-based. The authors of [17] presented an easily portable telemedicine system that is primarily used to treat patients in remote rural regions, focusing on diabetics, heart patients, and accident survivors. The authors of [18] suggested a paradigm for remote patient monitoring. Modelling this environment will allow crucial signals between patients and caregivers in a remote patient monitoring area facilitated by mobile agents. Healthcare professionals may identify and describe severity levels using measured vital sign data, and they can respond accordingly.

Pre-hospital emergency services are managed using a multi-agent decision-making support system [19]. They combine fleet vehicle management with demand, special events, personnel scheduling, and replacements. The suggested approach aims to improve a system for supporting decision-making that helps caregivers intervene in resolving medical cases and displays the outcomes for analytical reasons. In [20], authors used a multi-agent-based approach to address rescue allocation issues in mass casualty disasters while considering the environment's dynamic changes. Hospital, transit, and patient agents are the three primary agents employed to distribute scarce resources. The work of these agents ensures that patients are safely carried to relevant hospitals according to their diagnosis and the seriousness of their illness. The multi-agent decision support system is a complex emergency and disaster management technique that involves a great deal of uncertainty and has strict time constraints [21]. This study has identified the stages of crisis and catastrophe management preparedness, response, and recovery.

In [22], The authors primarily focused on large-scale events that include crowds, such as sporting events, musical performances, festivals, New Year's festivities, etc. If safety precautions are not taken, such situations can lead to total unrest and many victims. In this case, the decision support system uses the ontology area developed for managing healthcare urgency in huge crowds to assist it in deciding what is the best way to assemble people. In [23], a method for handling emergencies centred on controlling emergency vehicles is proposed. Its objective is to reduce the time that elapses between the moment an emergency call is placed and the rescue team's arrival. The rescue team is responsible for transporting patients in urgent or critical situations to medical institutions so they may receive the treatment they need. The solution that is being suggested takes into account the factors associated with route advice that reduce waiting times. The authors in [24] offered a clinical decision support system with various tools to improve clinical decision-making by reducing medical errors and raising the standard and effectiveness of healthcare. According to [11], a ubiquitous help system for travelling physicians is suggested. It is built on a route-guiding technique. Using a Delaunay triangulation (DT), this approach guarantees that mobile inquiries on a road network will discover the closest hospitals. This technique establishes CkNNs on road networks while considering dynamic location changes.

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