Location-Allocation of Treatment Centers for Patients with Wearable Sensors

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Abstract. Nowadays, due to rapid population growth, urbanization, and an increase in the aging population, the need for an appropriate healthcare system is of utmost importance. One of the main reasons for the mortality rate among patients is their inadequate access to healthcare facilities. This research introduces a novel approach for patient's allocation. This method is based on equipping patients with smart sensors that have been developed. 8 districts in the city of Kermanshah have been examined in this study. The objective of this research is to expedite services for patients wearing wearable sensors. To achieve this goal, a location-allocation model has been developed for the patients. The results indicate that the integration of the location-allocation model and wearable sensors accelerates the provision of services to patients.

Keywords. Location-allocation, Wearable sensors, Healthcare

1. Introduction

The demand for healthcare services, particularly for the elderly and disabled individuals, is increasing due to the global population growth. The growth of the aging population has led to rising costs of healthcare and increased health-related issues. This has made the traditional healthcare monitoring system inefficient, undesirable, and inadequate (Nayak et al. 2022). Location-allocation analysis aims to find the best location for a set of demand points in a way that addresses supply and demand issues (Efiong 2019). Therefore, when planning healthcare systems, decision-makers should consider goals that involve improving access and reducing costs (Mestre et al. 2014). Wearable sensors can be utilized to achieve this objec-

Published in "Proceedings of the 18th International Conference on Location Based Services (LBS 2023)", edited by Haosheng Huang, Nico Van de Weghe and Georg Gartner, LBS 2023, 20-22 November 2023 Ghent, Belgium.

This contribution underwent single-blind peer review based on the paper. https://doi.org/10.34726/5729 |

tive. Wearable sensors have gained significant interest in the medical field due to their cost-effectiveness, flexibility, lightweight, and biocompatibility (Yi & Xianyu 2022). These sensors measure physiological conditions of the body such as heart rate, respiratory rate, body temperature, blood pressure, and blood oxygenation (Baker et al. 2017). Therefore, with the rapid advancement of technology, wearable sensors have created a new opportunity for real-time monitoring of human performance today.

Considering that the location-allocation model utilizes principles of spatial analysis and optimization, the objective of this research is to increase the reliability of this model through integration with wearable sensors. The research method is as follows: First, patients are equipped with wearable sensors. Then, based on their vital signs and spatial location, the location-allocation model is implemented, and facilities are allocated to the patients in real-time.

2. Materials and Methods

2.1. Wearable sensors

In recent decades, population growth and urbanization have led to significant advancements in the field of healthcare, with wearable sensors being one of them. The present study was conducted in 8 districts of Kermanshah city, where patients are scattered throughout the city. The sensors used in this research are Apple watches. These sensors have the capability to transmit vital signs such as heart rate, oxygen level, and other health-related metrics. The process of transmitting patient information through these sensors is as follows: Firstly, the patient's information is sent to a mobile phone via Bluetooth, and then it is transmitted to healthcare professionals through Wi-Fi. The purpose of this approach is to continuously monitor the patient's health status and provide quick access to their information, including their spatial location, in order to expedite service provision.

2.2. Location-Allocation Model

Once the patients are equipped with wearable sensors, the location-allocation model will be implemented. The objective of implementing this model is to provide rapid access to healthcare facilities for patients who are unable to visit hospitals due to their physical condition. Essentially, the location-allocation model enables us to access the nearest patient in a way that minimizes the distance traveled and, consequently, the time taken to reach them. To achieve this goal, the P-Median model is used, which is a mathematical optimization model for solving facility location problems with the aim of determining the appropriate location for them and providing

services to demand points. The objective function in this model is defined in a way that minimizes the total distance between healthcare facilities and patients equipped with wearable sensors. Furthermore, constraints on the number of open facilities have been imposed, stating that each patient can only be served by the nearest healthcare facility. In this study, facilities are allocated to different patients instantly and in real-time. This is done by determining the type of disease based on patient data and records previously registered, and then appropriate specialized healthcare facilities will be assigned to that specific disease. Equipping patients with wearable sensors tailored to their needs allows each patient to receive more precise and higher-quality healthcare. This approach not only improves access to healthcare services but is also economically effective as it can reduce resource wastage and prevent unnecessary service provision. It also leads to increased flexibility in society, as a facility can provide services based on the best access to a patient's location within a specific area.

3. Results

In this section, the preliminary results of integrating smart sensors and the location-allocation model are examined. The necessary patient data is obtained through wearable sensors. Additionally, information regarding hospitals is extracted using Google Earth software. Since the city of Kermanshah is divided into 8 regions, the allocation of hospitals to patients in each region is investigated.

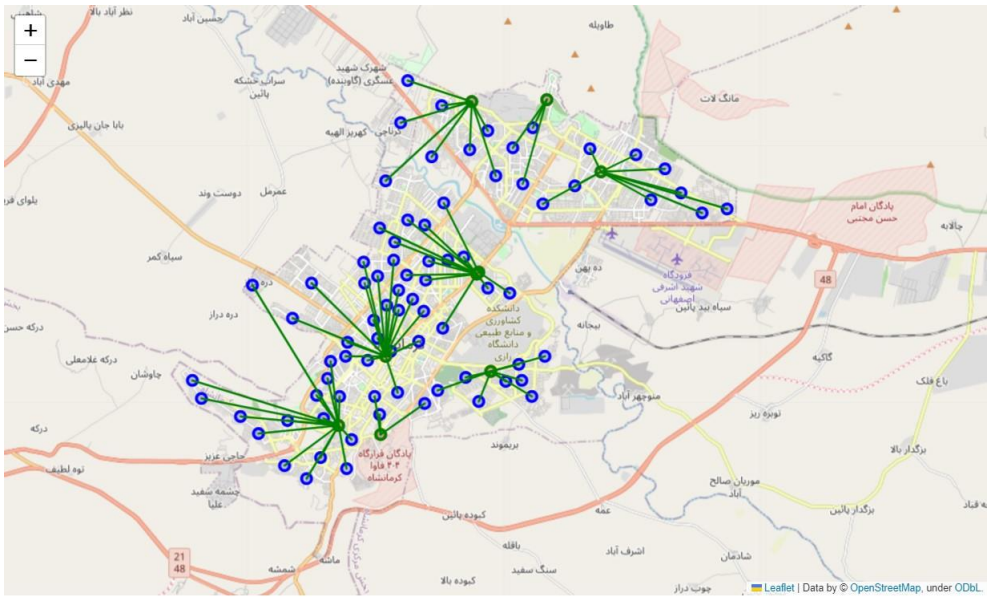

Figure 1. The result of the model implementation in different regions

Figure 1 illustrates the distribution of hospitals and patients at the city level in Kermanshah. Green dots represent hospitals, while blue dots represent patients. As can be observed in Figure 1, patients in each area have been referred to the nearest healthcare center. Unfortunately, within this geographical area, access to online traffic data was not available, and it is recommended for future research.

4. Conclusion

The aim of this study is to allocate patients with smart sensors based on their location. The methodology employed in this research involves equipping patients with smart sensors and then providing services at centers that have appropriate accessibility, taking into account their geographical position and relevant disease-related information. In a novel approach adopted in this study, it is demonstrated that swift service delivery to patients with unfavorable physical conditions can be highly effective in preserving their lives. For this reason, a location-allocation model has been utilized to enable rapid disease diagnosis through wearable sensors and quick access to centers.

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