Web Platform for Georeferenced Telemonitoring: A Case Study on Elderly Healthcare

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Vol. 03, Issue 02 (2024): August-December
DOI: 10.53591/easi.v3i2.1924
ISSN 2953-6634
Submitted: December 4, 2024
Revised: December 30, 2024
Accepted: January 06, 2025

Engineering and Applied Sciences in Industry
University of Guayaquil. Ecuador
Frequency/Year: 2
Web:
https://www.revistas.ug.edu.ec/index.php/easi/index
Email:
easi-publication.industrial@ug.edu.ec

How to cite this article:
Barboza, O. et al. (2024). Web Platform for Georeferenced Telemonitoring: A Case Study on Elderly Healthcare. *EASI: Engineering and Applied Sciences in Industry*, 3(2), 30–38. https://doi.org/10.53591/easi.v3i2.1924

Abstract The monitoring and management of biomedical variables remain critical areas of focus within the scientific and technological fields. The increasing prevalence of cardiac conditions and the risks associated with geographic disorientation among the elderly population highlight a pressing challenge. This study presents a web-based platform designed to receive real-time biomedical data for assessing patient health status. To achieve this, the variables were simulated to define the necessary data structure. All data generated through an Android-based device were transmitted over a cellular network and stored in a preconfigured Cloud database, enabling the creation of a consultable historical record for future use. The platform was subsequently evaluated by 50 users, who shared their insights and rated aspects such as usability, interface design, and functionality through a detailed survey.

keywords Cardio, Georeferenced Telemonitoring,Web Platform.

Resumen El seguimiento y manejo de variables biomédicas constituye un tema de gran relevancia en los ámbitos científico y tecnológico. En la actualidad, la creciente incidencia de afecciones cardíacas, junto con el riesgo de desorientación geográfica en adultos mayores, plantea una problemática significativa. Este proyecto propone una plataforma web capaz de recibir variables biomédicas en tiempo real para evaluar el estado de salud del paciente. Para ello, las variables fueron simuladas con el propósito de estructurar la información según los requisitos definidos. Los datos simulados, generados a través de un dispositivo con sistema operativo Android, fueron transmitidos mediante red celular y almacenados en la Nube dentro de una base de datos previamente configurada, lo que permite generar un historial consultable a futuro. Por último, la herramienta fue evaluada por 50 usuarios, quienes, a través de una encuesta, compartieron su opinión y calificaron aspectos como la usabilidad, el diseño y los posibles inconvenientes de la plataforma.

Palabras Claves Cardio, Georreferenciado, Plataforma Web, Telemonitoreo.

1 INTRODUCTION

In an increasingly interconnected world, technology-driven solutions based on remote monitoring platforms have emerged as key tools to address various challenges across sectors such as logistics (Tian, 2023), environmental management (Bernabe, Toxqui, González, Lagunes, & Rivera, 2023), security (Zhou et al., 2024), and healthcare (Quintero, Chevel, & Sanmartin-Mendoza, 2024; Pajaro, Puertas, Villate, Estrada, & Tinjaca, 2024; Almtireen, Altaha, Alissa, Ryalat, & Elmoaqet, 2024). These platforms enable real-time data capture, management, and analysis, providing critical information for decision-making and optimizing processes in diverse contexts. Their adaptability and scalability make them ideal alternatives for scenarios requiring constant supervision and immediate response (Jayant, Vincent, Mohana, Moharir, & A R, 2024; Sakheran, Oung, & Lee, 2024; Mussi, 2019).

In general, remote monitoring platforms serve as centralized systems that collect data from distributed sources, process it in real time, and present it in formats that facilitate decision-making. These platforms often incorporate alert mechanisms, historical data visualization, and predictive analytics, enabling users to act swiftly and efficiently in critical situations. The versatility of these systems has driven their adoption across various domains, including transportation (Jeevan et al., 2024), industrial processes (Santhosh, M, Sailakshmi, & Yadav, 2022), and public safety (Novotný et al., 2021).

The platform developed in this work is designed as a flexible and scalable system for real-time data monitoring. It integrates advanced data capture mechanisms with a centralized web-based interface that facilitates data management, visualization, and analysis. The platform incorporates features such as real-time alerts, historical data tracking, and user-friendly dashboards, making it a versatile tool for various applications. Its modular architecture allows for seamless adaptation to specific needs, ensuring its utility across different operational contexts.

In the specific context of healthcare, these platforms play a transformative role in telemedicine by integrating devices capable of monitoring key biomedical variables (Azoui, Idoughi, & Abdelouhab, 2021; P, Prabhu, V, & Reddy, 2022; Salve, Mude, Tarale, & Mahajan, 2024). This study focuses on the development of a remote monitoring system tailored for elderly care. The solution includes wearable devices that capture vital health data such as blood pressure, heart rate, oxygen saturation, and body temperature. These devices seamlessly interface with a web platform designed to centralize data management, generate real-time alerts, and provide historical data for longitudinal analysis, thus enhancing patient care and enabling timely interventions.

The main objective is to design, implement, and validate an integrated solution that combines wearable devices for capturing key biomedical variables with a web platform to centralize the management, visualization, and analysis of the collected data. This innovative platform enables real-time monitoring of critical health data through a simple yet powerful wearable device, such as a wristband, bridging the gap between accessibility and advanced healthcare technology.

The system validation included tests to verify the integrity of data transmitted through the cloud, as well as usability and reliability assessments by users. This case study not only demonstrates the applicability of remote monitoring platforms in the healthcare field but also highlights their potential for adaptation to other contexts, establishing them as versatile tools to address challenges across multiple sectors.

2 RELATED WORKS

In a recent study conducted in 2020 by Sanaguano et al., the focus was on the development of an application for monitoring patients with heart failure within the telemedicine domain. This medical condition presents significant challenges in healthcare due to its complexity and the need for continuous follow-up to effectively manage symptoms and prevent complications (Sanaguano, 2020).

The application developed by Sanaguano et al. offers an innovative solution by enabling remote monitoring of heart failure patients, providing healthcare professionals with real-time information on patients' status outside clinical settings. This continuous monitoring capability can be especially beneficial in detecting early signs of decompensation and taking preventive measures to avoid hospitalizations and adverse events (Sanaguano, 2020).

In addition to monitoring, the application incorporates user-friendly features, both for patients and healthcare professionals. This is crucial to ensure the adoption and effective use of the application by all stakeholders. However, the current development does not yet include sensors for capturing biomedical variables from real patients for real-time data collection.

There are other notable examples of telemonitoring, such as the study conducted by Gallardo et al. in 2019,

which demonstrates how telemedicine can positively impact patients with diabetes and hypertension. In this telemonitoring experiment, promising improvements in patients' health and comfort were observed through the use of technology for remote condition monitoring (Gallardo-Zanetta, 2019).

The findings of this study provided valuable insights into how telemedicine can contribute to the effective management of chronic diseases like diabetes and hypertension. By enabling continuous and remote monitoring, patients can receive more personalized and timely care, which can lead to better treatment adherence and reduced complications associated with these conditions (Gallardo-Zanetta, 2019).

Furthermore, Gallardo et al.'s study emphasized the importance of considering individual patient needs and preferences when implementing telemedicine technologies. By improving patient comfort and experience, higher patient engagement in their own health care can be fostered, which in turn can have positive long-term outcomes. These findings are not only relevant for individual patients but also have broader implications for the healthcare system as a whole. The successful implementation of telemedicine programs can help alleviate the burden on healthcare services while improving patients' quality of life and reducing the costs associated with chronic disease management (Gallardo-Zanetta, 2019).

The work of Camacho et al. represents another important milestone in telemedicine, focusing specifically on cardiac rhythm monitoring in patients with hypertension. Their research, involving the implementation of a specialized monitoring system, provides valuable insights into how technology can enhance medical care and chronic disease management (Camacho Ríos, 2017).

Monitoring cardiac rhythm is particularly relevant due to its crucial role in cardiovascular health, especially for patients with hypertension. By providing a system that allows continuous and remote cardiac rhythm monitoring, Camacho et al. are addressing a significant need in cardiovascular healthcare (Camacho Ríos, 2017).

Table 1 summarizes the reviewed literature. It highlights that telemonitoring solutions have demonstrated a significant impact on chronic disease management by offering continuous and remote monitoring, thus improving personalized care and early detection of complications. These advancements underscore the importance of integrating innovative technology with a patient-centered approach to optimize health outcomes.

Table 1: Relevant Contributions in Telemonitoring

Year	Author	Main Contribution
2020	Sanaguano et al.	Designed a telemonitoring application enabling real-time continuous monitoring of heart failure patients, enhancing the management of critical events. Their approach includes user-friendly functionalities for patients and clinicians but lacks real-time biomedical sensors.
2019	Gallardo-Zanetta et al.	Developed a telemonitoring system that improves personalized care and treatment adherence for patients with diabetes and hypertension. Their contribution highlights the importance of user-centered design to enhance patient comfort and engagement.
2017	Camacho Ríos et al.	Implemented an advanced system for continuous cardiac rhythm monitoring in hypertensive patients, improving early detection of cardiovascular anomalies. Their work optimizes remote supervision of critical health parameters.

3 METHODOLOGY

3.1 Requeriments

The developed project consists of a web platform for patient registration, storage, visualization, and monitoring. First, the platform must have a responsive design and the ability to scale up in the future. Additionally, the platform needs to meet specific design requirements to achieve the stated objectives. Below are the design requirements for developing the web platform:

- Sample patient data via the portable device.
- Store patient data in a database.

- Allow secure access to the web platform by the medical professional.
- Enable medical professionals to register new patients.
- Access historical patient data.
- Display patient statistics using historical graphs.
- Send biomedical variables to a cloud server via the portable device.
- Display patient geolocation on the web platform.

Based on the above requirements, the necessary tools and technologies were sought to develop the web platform as efficiently as possible.

3.2 Technology Selection

In the development of the project, there was a need to use a cloud-based platform. Therefore, popular alternatives such as AWS, Azure, and Google Cloud were analyzed. The selection was based on key criteria such as flexibility, accessibility, documentation, performance, ease of setup, processing, learning curve, and associated costs. After a comparative analysis, AWS was chosen due to its comprehensive approach to infrastructure protection and scalability, as well as its customizable services to meet project needs. Additionally, the team's prior knowledge of AWS services facilitated implementation and optimization. Although other platforms offered free tiers, the combination of these factors positioned AWS as the best option.

For the system development, programming languages ensuring compatibility with project goals and ease of implementation were evaluated. JavaScript, Python, and Rust were identified as relevant choices. The selection of programming languages considered compatibility, documentation, ease of use, scalability, security, and the team's prior experience. JavaScript was chosen for both front-end and back-end development due to its adaptability, extensive documentation, and the team's familiarity with its use. These factors contributed to optimizing time and resources for effective project implementation.

To streamline the project development, back-end and front-end frameworks were considered as they provide structured tools that facilitate the implementation of complex functionalities. For the back-end, options like ExpressJS, Django, and Rocket were evaluated. For the front-end, ReactJS, Flask, and Yew were compared. After a detailed analysis, ReactJS was chosen for the front-end and ExpressJS for the back-end. These frameworks are widely popular, supported by active communities, and offer excellent documentation, simplifying the development process. They also provide flexibility and efficient resource management, making them suitable for the project's specific needs.

For data storage in the web platform, a suitable database engine was selected. The decision was based on prior experience with relational database engines, ease of table structure, and the ability to normalize and relate information from portable devices. Relational databases are robust and less prone to failure since they meet ACID properties (Atomicity, Consistency, Isolation, Durability). NoSQL databases were considered due to their ability to handle large data volumes and high scalability, but they store information in documents rather than structured tables, which could compromise data consistency in projects requiring strict data integrity. After evaluating options such as PostgreSQL, MySQL, and SQLServer, PostgreSQL was selected due to its cross-platform compatibility, scalability, speed, and security, as well as its well-documented status and widespread use, making it the most suitable option for efficient project data management.

For server selection, prior knowledge was the most relevant criterion. The team's extensive experience with NodeJS and ExpressJS far exceeded that with other options, favoring their adoption. Additionally, their native compatibility with JavaScript and efficient handling of asynchronous events were critical, as the project requires executing multiple functions in this format. After comparing NodeJS, Rocket, and Django, NodeJS was chosen due to its cross-platform compatibility, scalability, speed, and popularity within the development community. These characteristics made NodeJS the most practical and efficient choice for project implementation success.

Finally, for developing the application simulating the portable device, compatibility with iOS and Android systems was prioritized. After evaluating options like Flutter, React Native, and NativeScript, Flutter was selected. This decision was primarily based on the team's prior experience, reducing the learning curve and facilitating development. Flutter excels in key features such as cross-platform capabilities, efficient performance, and widespread popularity within the development community, making it the most suitable option for rapid and effective system implementation.

3.3 Telemonitoring System

The structure of the web platform is composed of an EC2 (Elastic Compute Cloud) and an RDS (Relational Database Service) within the AWS platform. The EC2 hosts the servers and other services required for the web application's operation, while the RDS stores the data managed through the web platform. Figure 1 illustrates all the tools used for the development and the general system structure. The system operates by using an emulator developed in Flutter to simulate data generation, which is then sent to a server built with NodeJS and ExpressJS. This server, hosted on an AWS EC2 instance, processes the data and manages the functionality of the web application. The processed data is stored securely in an AWS RDS instance, ensuring efficient and reliable data management. This architecture enables seamless interaction between the emulator, the server, and the database, supporting the overall functionality of the monitoring platform.

Figure 2 shows the detailed operation. The system operates with an emulator on a terminal device, connected via the mobile network, generating data sent to a NodeJS and ExpressJS server hosted on an AWS EC2 Ubuntu instance. This server processes the data and stores it in an AWS RDS PostgreSQL database. Client terminals interact with the system through a web application hosted on the EC2 instance, accessing stored data via secure APIs. The platform enables real-time and historical data visualization, geolocation tracking, and statistical analysis through a responsive interface, ensuring seamless monitoring and efficient data management.

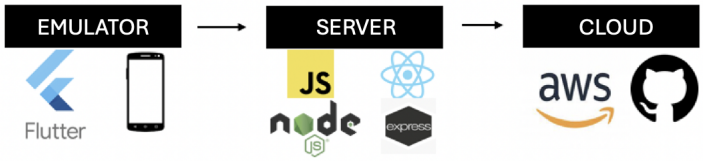

Figure 1: General system structure.

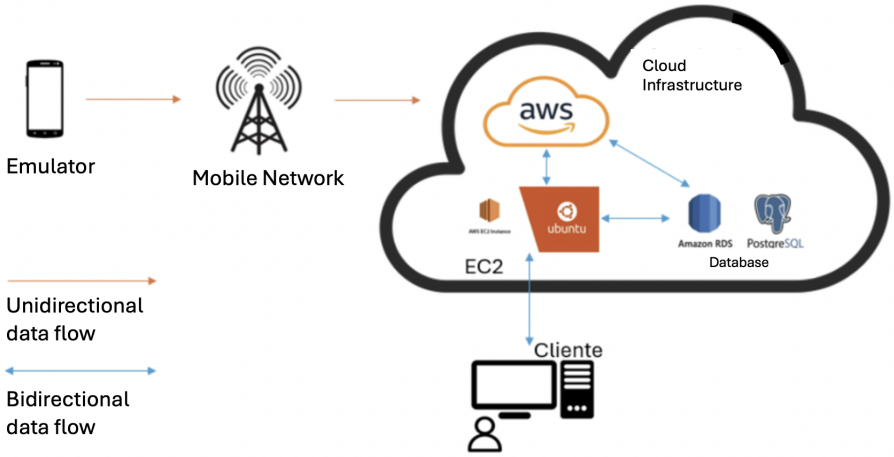

Figure 2: System Block Diagram.

The system includes a server for the web platform and a TCP server to receive information from the portable device. The web platform features a tab for real-time monitoring, displaying biomedical variables as they are sampled, and another tab for querying the database, which serves as the historical storage for biomedical variables and patient locations. Additionally, it includes other tabs for patient registration, portable device assignment to patients, device release, and more.

4 DATA VISUALIZATION

With access granted, regarding the web application, a page was developed to display the biomedical variables received by the platform from the emulated portable device. This view allows users to see these variables and includes a map to track the patient's location. Additionally, it features a selector enabling the selection of multiple patients for simultaneous queries. For each patient, panels displaying one biomedical variable per patient are shown, as illustrated in Fig. 3. The number of panels and lines drawn on the map corresponds to the number of patients being tracked.

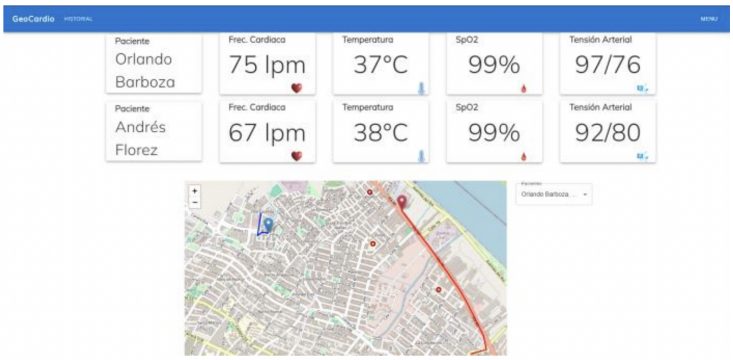

Figure 3: Homepage.

The user will be able to view all patients in real time and access their records, as shown in Figure 4. Users can register new patients and assign them a portable device to monitor their biomedical variables and location. Additionally, the historical data section includes a table displaying all values outside the normal range within the selected date range during a query.

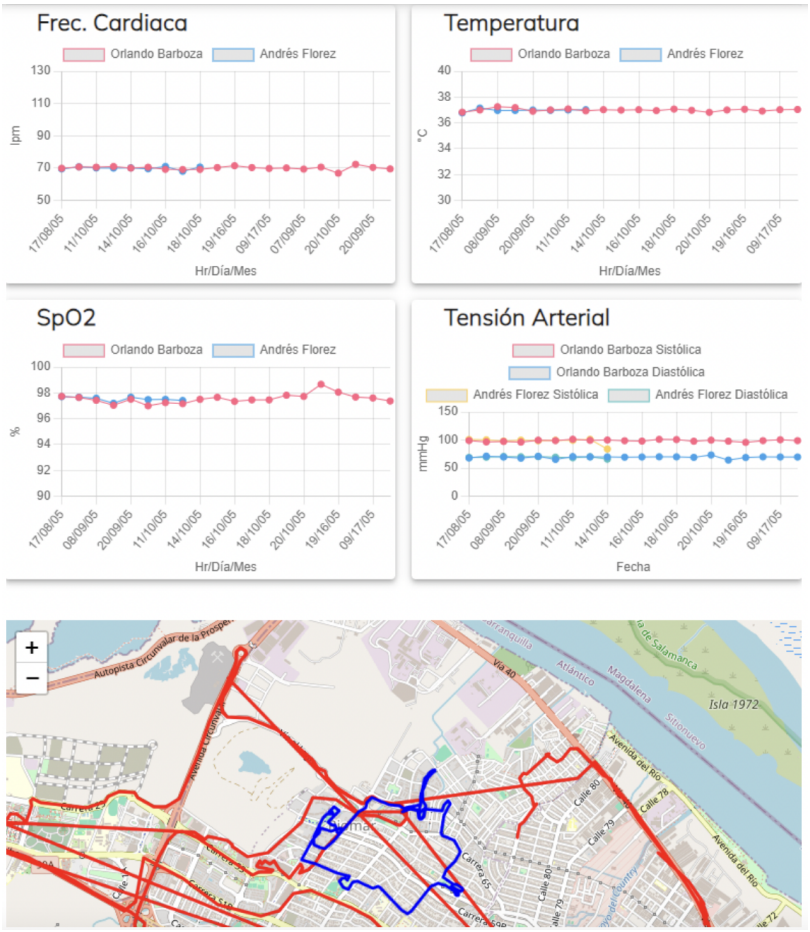

Figure 4: Historical Data Visualization.

USABILITY DATA ANALYSIS

A usability evaluation survey was conducted with 50 people of different ages and education levels to determine if the web platform is perceived as relevant and intuitive compared to other similar tools available on the market.

In the first part of the survey, the goal was to assess how intuitive the page is to use, as well as its overall

appearance. The second part evaluated the platform's relevance compared to other platforms offering similar functionalities.

Regarding real-time functions, specifically the dynamic visualization of each patient's biometrics, the evaluation was conducted in groups of five people. When five people were using the application, the portable device emulator was initiated to send biometric data and location information. Then, the emergency button was activated, and the speed and usefulness of the alert were evaluated in the survey through specific questions.

In the first part of the survey, as shown in Figure 5, at least 81% of respondents found the web application highly intuitive, and its overall appearance was perceived as pleasant. It can be concluded that the page's graphical elements are clear and organized, allowing users to easily read and view information about the page and the patients.

A 29% of users did not consider the application usable, which could be related to a lack of familiarity or proper training. Some users may have experienced difficulties in navigating or understanding certain functionalities, leading to a perception of complexity. However, the results highlight that 71% of users find the application highly usable, demonstrating its overall effectiveness and positive acceptance in the majority of cases.

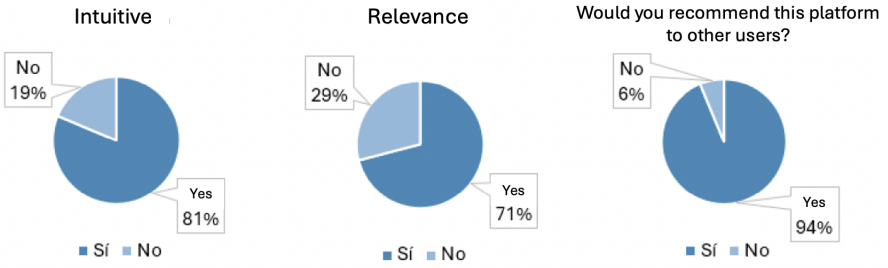

Figure 5: Usability survey results.

CONCLUSIONS

A georeferenced telemonitoring system was developed for elderly adults using AWS tools, JS, ReactJS, ExpressJS, and Flutter through an application that emulates a portable device. The web platform includes vital signs such as temperature, heart rate, oxygen saturation, and blood pressure, which are sourced from the Android application that emulates the portable device. These vital signs are displayed on the dashboard, updating in real-time whenever new data is sent, ensuring that physicians can track the patient's status continuously. Additionally, the dashboard view includes a map, on which patient routes are plotted using polylines.

The web platform is capable of managing all information received from the portable device. A server was developed to handle the data collected from the device and store it in a PostgreSQL database. Once stored, users can access historical views of the information regarding the monitored patients.

The system's functionality was validated through tests involving 10 user groups of 5 participants each, totaling 50 users. Initially, these groups used the web platform, and they were notified whenever the emergency button was activated, ensuring they received alerts indicating that a patient had pressed the panic button. Based on their experience, users evaluated the web platform through a usability and user experience survey.

The main contribution of this work lies in the creation of a technological solution that combines portable devices for capturing biometric variables with a scalable, secure, and adaptable web platform that centralizes data analysis and visualization.

Future work includes expanding the system's capabilities by integrating advanced sensors and certified medical devices to capture a wider range of biometric variables, incorporating artificial intelligence techniques for predictive data analysis, enabling more precise and personalized alerts. Large-scale studies are planned to evaluate the system's impact on patients' quality of life and the optimization of healthcare services. Additionally, exploring applications in other contexts such as environmental monitoring or fleet management, leveraging its modular architecture, is suggested.

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