RESEARCH ON THE DESIGN AND DEVELOPMENT OF AN ELECTRONIC DEVICE FOR MONITORING AND TRACKING INDIVIDUALS WITH SPECIAL NEEDS

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ABSTRACT: Currently, there is an increasing demand to provide support and assistance to individuals with special needs. In this context, intelligent assistive technologies are becoming increasingly important and can significantly contribute to improving people's quality of life. These technical solutions include wearable devices, environmental sensors, and communication and information technologies that can help in continuous health monitoring and immediate detection of medical issues or emergencies. Furthermore, they can assist in real-time tracking and enhancing the safety of the wearer. The aim of this article is to provide a comprehensive perspective on how monitoring and tracking devices designed for individuals with special needs can be utilized to improve quality of life, along with an analysis of the key challenges that need to be overcome to enable their widespread use.

KEYWORDS: monitoring, tracking, individuals with special needs, assistive technologies, data security.

1. Introduction

This paper aims to examine the importance of intelligent assistive technologies that have the capability of continuous monitoring and real-time tracking, as well as their contribution to improving the quality of life for individuals with special needs. These individuals may include those with neurodegenerative disorders of the nervous system, who experience cognitive and orientation issues (such as Alzheimer's disease, Parkinson's disease, Creutzfeldt-Jakob disease, Lewy body dementia), or young children who are more prone to the phenomenon of wandering.

The article provides an overview of the current situation of individuals with special needs and the challenges they face in their daily lives. It explores how intelligent assistive technologies, such as wearable devices and environmental sensors, can assist in continuous health monitoring and immediate detection of any medical issues or emergencies. The importance of real-time tracking and enhancing the safety of the wearer is emphasized.

Finally, the paper presents the objectives pursued and the approach taken to provide valuable and relevant information for the academic and professional community in the field of assistive technology for individuals with special needs as described above.

2. The current state of assistive technologies for monitoring and localization for individuals with special needs: a statistical study on people with disabilities and recent advances in the field

The safety and well-being of individuals with special needs are major concerns in our society [1, 2, 3], whether it pertains to protecting those with cognitive and orientation issues or young children who are at a high risk of wandering. These individuals face a range of challenges

in their daily lives, including difficulties in navigating both indoor [1] and outdoor environments, as well as difficulties in autonomously managing their health. They are often exposed to the risk of accidents or other medical issues, and their care sometimes requires additional efforts from families and caregivers. Despite the daily challenges faced by individuals with special needs, the development of intelligent assistive technologies represents a promising solution to improve their quality of life [2, 3]. Wearable devices, environmental sensors, and communication and information technologies can continuously monitor health status and promptly detect medical issues or emergencies. Real-time tracking can provide increased security for individuals with cognitive and orientation issues. These intelligent assistive technologies can be tailored to the needs and capabilities of each user, regardless of their level of ability or experience, significantly enhancing people's lives and providing them with independence, safety, and comfort every day.

2.1. Statistical analysis of the situation of individuals with disabilities in Romania

In Romania, disability is measured in correlation with the concept of general activity limitation. This concept refers to the limitation of a person's usual activities as a result of health problems experienced in the past six months and is used by Eurostat to assess the level of disability in all European Union member states. According to the latest statistical data **[4]**, approximately a quarter of the population aged 16 and over in Romania has disabilities. Among them, individuals with severe activity limitations represent 6% of the population (1.2 million people). As of December 31, 2019, the total number of people with disabilities reported by the National Agency for the Rights of Persons with Disabilities, Children, and Adoption (ANDPDCA) through the county general directorates for social assistance and child protection, as well as the local sectors of Bucharest, was 846,354 people. Out of this total, 97.92% (828,792 people) were under the care of families and/or living independently, while 2.08% (17,562 people) were in public residential social assistance institutions for adults with disabilities coordinated by ANDPDCA. At that time, the disability rate reported in relation to the population of Romania was 3.82% per 100 inhabitants, with the South-West Oltenia, South-Muntenia, and North-West regions having the highest rates. In terms of counties/municipalities, the highest number of people with disabilities was recorded in Bucharest (69,392 people registered as of December 31, 2019), followed by Prahova County (37,836 people registered at the same date), while the lowest number was registered in Covasna County, with 6,332 people at the end of 2019. Among the total number of people with disabilities, women represent 53.08%, and 72.45% of adult individuals with disabilities are over 50 years old. Specifically, the data analysis by age groups shows that 53.76% are individuals aged between 18-64 years (418,473 people), and 46.24% are over 65 years old (359,947 people).

The degrees of disability are: severe, moderate, mild, and slight. At the end of 2019, the number of people with severe disabilities represented 39.92% of the total (an increase compared to 39.05% in 2018), those with moderate disabilities accounted for 48.80% (compared to 49.75% on December 31, 2018), while those with mild and slight disabilities accounted for 11.28% (compared to 11.20% on December 31, 2018) [4].

Current legislation defines barriers or obstacles as factors in a person's environment that, by their absence or presence, limit functioning and create disability. It also includes factors such as inaccessible physical environments, negative attitudes towards disability, poor services, systems, and policies, as well as the lack of assistive technologies and devices, among the possible barriers [4].

Furthermore, the UN Convention on the Rights of Persons with Disabilities emphasizes that parties should take effective measures to ensure the mobility of persons with special needs. It encourages entities producing assistive devices and technologies to consider all aspects related to the mobility of persons with disabilities [7]. Although there is a national emergency call service for people with hearing or speech disabilities, its use is not monitored, and the personnel involved in emergency interventions are not prepared to meet the needs of persons with disabilities. Emergency action plans of the Department for Emergency Situations (DSU) do not provide specific procedures for people with disabilities, except for delegating individuals responsible for coordinating risk management for this group [5].

Considering the increasing need to provide support and assistance to individuals with special needs to enable them to lead safe and protected lives within the community, the use of intelligent monitoring and tracking technologies, developed in the form of electronic devices, is becoming increasingly important. These technologies can significantly contribute to improving their quality of life and that of those around them [6].

2.2. The current state of development of electronic monitoring and localization devices for people with special needs

Official figures show that in the past 30 years, there have been a total of 83,754 cases of missing persons, including children and adults, out of which 2,418 individuals have disappeared and have not been found. Among the over 83,000 missing persons, over 52,000 were under the age of 18 at the time of disappearance. Almost 400 children have never been found [9]. These alarming numbers highlight the importance of ongoing efforts to develop efficient monitoring and localization technologies to prevent such unfortunate situations and increase the chances of finding missing individuals with minimal effort and cost. As disappearances can have serious consequences for the individuals involved and their families, it is crucial to pay increased attention and properly address such cases, with monitoring and localization devices being useful tools in prevention and resolution efforts.

The current stage of development of electronic devices aimed at improving the lives of people with special needs is continuously evolving. There is a growing demand for current monitoring technologies to include wearable devices with GPS capabilities for location tracking, alongside health assessment devices such as heart rate monitors and smart blood pressure monitors. Additionally, there is an increase in the use of mobile applications and wearable devices for monitoring various parameters [8]. Overall, the development of assistive technologies for individuals with special needs focuses on improving accessibility, autonomy, and independence for users, as well as easing the tasks of caregivers [6].

3. Conceptual and detailed design of the electronic monitoring and localization device for people with special needs

In identifying the main issues and requirements related to the development of an electronic monitoring and localization device for individuals with special needs, several aspects can be highlighted. Firstly, the device users are individuals with extremely limited abilities, which means that the product needs to be accessible and tailored to their needs, with an ergonomic and intuitive design. A suitable solution to meet these requirements could be a bracelet-like device that can be comfortably worn on the wrist. Additionally, an important aspect is the durability and water resistance of the device, as it will be exposed to wear, moisture, and

shocks. Moreover, special attention must be given to data security, as the information collected by the device is sensitive and needs to be protected against unauthorized access **[10]**. The accuracy and reliability of the localization system are crucial aspects because the device needs to provide precise real-time information about the user's location. Sufficient battery autonomy is also necessary to enable the device's usage for an extended period. Lastly, another important requirement is the integration of the device with other existing technologies and services, such as mobile applications or data monitoring and management platforms, as well as integration into the national emergency system (e.g., 112).

These are just a few of the major issues and requirements that need to be considered in the development of an electronic monitoring and localization device for individuals with special needs.

3.1. Conceptual Design of the Device

To develop a monitoring and localization device for individuals with special needs, it is advisable to use a combination of methods that take into account the specific needs of the users and the technical requirements of the product. The Six Sigma method or DMAIC (Define, Measure, Analyze, Improve, Control) can be utilized to reduce variability and eliminate errors in the device's production process, ensuring optimal performance. The Failure Mode and Effects Analysis (FMEA) method can be employed to identify and prevent potential risks associated with device usage. Based on three pillars - empathy, ideation, and experimentation - the Design Thinking method is suitable for understanding user needs and creating innovative solutions that address those needs. Additionally, the PEST(LE) analysis can be utilized to evaluate external environmental factors such as political, economic, social, technological (legal and ecological) factors that may impact the product's usage. Last but not least, testing prototypes and beta versions of the device by end-users can provide valuable feedback to consider their needs and adapt the device's design and functionality.

It is important to mention that these methods need to be adapted to the specific needs of the product, and the chosen method should be continuously evaluated to ensure the device is efficient and meets the requirements and needs. Moreover, multiple technological solutions will be implemented to contribute to the development of the electronic monitoring and localization device for individuals with special needs.

Firstly, a detailed analysis of user needs and requirements will be conducted, and appropriate technologies will be identified to fulfill those requirements. State-of-the-art sensors capable of continuous monitoring of movements and accurate localization of the user will be employed to enable real-time tracking. Additionally, a wireless communication system will be developed to transmit data from the device to a control center. This system will utilize cutting-edge technologies and facilitate real-time data transfer without the need for cables or physical connections.

Furthermore, an intuitive user interface will be implemented to allow device customization based on the wearer's needs and the caregiver's preferences. Regarding durability and water resistance, high-quality materials that can withstand daily usage and environmental factors will be utilized. The device will be designed to withstand extreme environmental conditions such as rain and humidity.

All of these technological solutions are implemented with a single purpose in mind: to create an electronic monitoring and tracking device for people with special needs that is durable

and easy to use. The end result is a product that meets all user requirements and can be used with confidence in any situation.

3.2. Detailed design of the device

In this section, ideas and specific technical concepts will be explored to develop a monitoring and localization system suitable for individuals with special needs. The detailed design of the product will involve both hardware and software aspects.

To begin with, the identification of hardware components for the monitoring and localization system is necessary, including sensors, communication devices, localization devices, and a data processing unit. Additionally, specific requirements of individuals with special needs must be taken into account when establishing features such as product size, weight, how it will be worn and used, and the interaction of the monitoring and localization device with other medical devices and systems used by the user, such as pacemakers, cardiac stimulators, hearing aids, implantable defibrillators, insulin pumps, implantable pain pumps, neurostimulation electrodes, epilepsy monitoring electrodes, etc. Another key component of the detailed design is the software. This will include the development of monitoring and localization algorithms, user interface, and how collected data is stored and managed. Consideration will also be given to the software's compatibility with other devices and systems. Additionally, security and confidentiality aspects of personally identifiable data collected by the device will be taken into account, ensuring that they are protected and managed in accordance with legal and ethical requirements **[10]**. Finally, the detailed design will involve a series of tests and improvements to optimize the product for the special needs of the individuals who will use it. These tests may include evaluating the reliability, accuracy, and precision of the monitoring and localization device in a variety of different environments and situations.

4. Conceptual and detailed design of the application for the electronic monitoring and localization bracelet for people with special needs.

This chapter presents the conceptual and detailed design of the application for the monitoring and localization bracelet for individuals with special needs. The conceptual design represents the first stage in the development of the application, where key aspects of functionalities and user interactions are detailed. Furthermore, the detailed design is presented, which focuses on the concrete implementation of the functionalities and technical details of the application.

4.1. Conceptual design of the application

This section details the process of conceptual design for the application of the monitoring and localization bracelet for individuals with special needs. This process is divided into two stages: requirements definition and functionality definition of the application. The first stage involves establishing the application requirements based on the goals and specific needs of the assisted individuals. To accomplish this, a detailed study of end users and application use cases is conducted, and the most important security and confidentiality requirements are identified and analyzed to protect personal data in accordance with legal provisions. The second stage consists of defining the functionalities of the application, which will be designed to meet the previously established requirements. Consideration will be given to facilitating access to information, ease

of use, and the application's ability to adapt to various specific user needs. Finally, the conceptual design of the application will be carried out, taking into account the latest technologies and software development standards to ensure optimal functionality and user-friendly experience for the end users **[11]**.

4.2. Detailed Design of the Application

Following the conceptual design of the application for the electronic bracelet for monitoring and locating individuals with special needs, we have moved on to the detailed design phase of the application. The detailed design of the application involved a thorough analysis of the requirements and functionalities needed to achieve the established goals. This process entailed creating a coherent and well-structured design that enables users to quickly and easily access the application's functionalities.

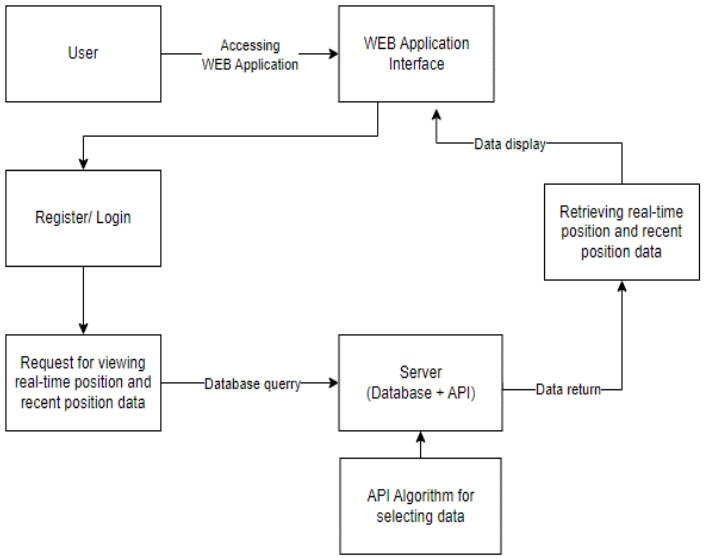

Fig. 4.1 Application architecture.

Firstly, a thorough analysis of the requirements and needs of the end users, specifically individuals with special needs and their caregivers, was conducted. Based on the obtained information, a detailed list of functional and non-functional requirements for the application was developed. These requirements were grouped and prioritized based on their importance to the users.

Based on the established requirements, an architecture diagram of the application (fig. 4.1) was created, and its main functionalities were defined. User interface considerations were taken into account, and an intuitive and user-friendly interface was developed to allow users to quickly access the application's functionalities.

Within the application interface, special sections were designed for different categories of information. These sections are divided into pages as follows:

- Home page, which will contain information about how the system works;
- Register page (fig. 4.2): It will contain a form that users need to fill out with their information;
- Login page (fig. 4.3), which contain a form for user authentication;
- Forgot password page: it will assist users in recovering their password;
- Get data page (fig. 4.4): It will display real-time and recent position information;
- About page: It will provide information about the team that developed the system
- Contact page: It will display contact details.

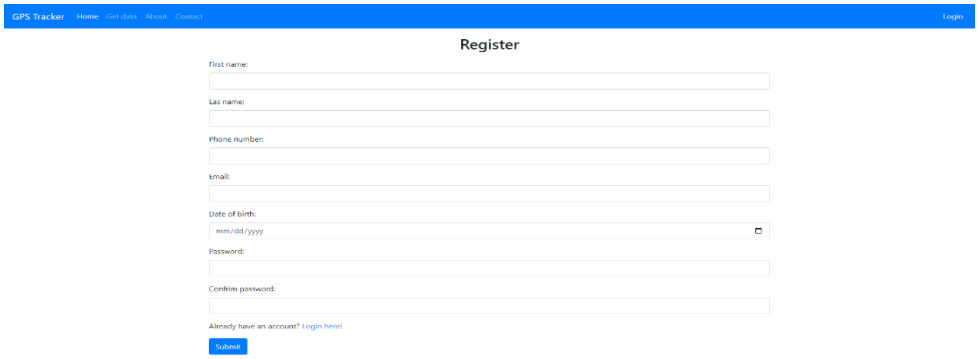

Fig. 4.2 The registration form

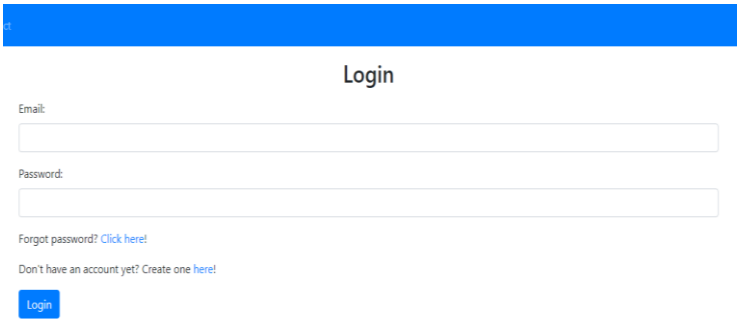

Fig.4.3 The login form

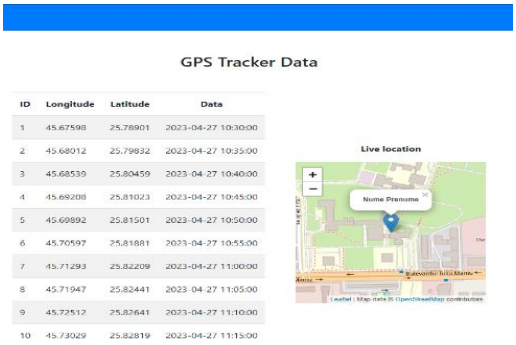

Fig. 4.4 Displaying data in the WEB aplication

Furthermore, we have created a detailed plan for the development and implementation of the application, which included prototyping, source code development, and testing the application in various scenarios and usage conditions. Throughout this process, we have employed best practices and utilized the latest technologies available in web application development [11]. Additionally, the detailed design phase also involved the development of algorithms necessary for key functionalities of the application, such as user registration and access management, as well as monitoring and locating individuals with special needs. The detailed design of the application is a crucial process in developing an efficient and user-friendly application that meets the needs of the end-users and contributes to enhancing the quality of life for individuals with special needs and their caregivers. This phase allows developers to implement each functionality of the application in detail, ensuring a smooth and efficient user experience for the bracelet users.

5. Conclusions

This study has highlighted the importance of developing an electronic monitoring and tracking device for individuals with special needs, such as dementia patients and young children. By implementing this device in the form of a wristband, an efficient and easy-to-use solution can be provided for families and caregivers to ensure a high level of protection and safety. One of the main advantages of the device presented in this research is the use of GPS and GSM technology, which allows for precise and real-time tracking of the monitored individual through the wristband. Additionally, the main requirements related to this device, such as durability, resistance to environmental factors, and protection of personal data, have been identified. To meet these requirements, efficient technological solutions have been proposed, such as the use of

water-resistant and shock-resistant materials, as well as the implementation of encryption technologies to ensure data security.

In the future, further research is needed to develop and improve this monitoring and tracking device, in order to expand its use globally and adapt it to the specific requirements of different categories of individuals with special needs. Furthermore, the development of new, more advanced security technologies is important to protect the personal data of those who use this product. In this regard, the implementation of user authentication and encryption solutions is possible, as well as the development of artificial intelligence technologies that can prevent risky situations for individuals with special needs. All of these can contribute to improving the quality of life for these individuals and their families, as well as increasing the level of safety in the communities in which they live.

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