HCI Preliminary Study and Implementation for a LoRa based SAR System

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Outline

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- Motivation
- Internet of Things
- Search and Rescue
- System Architecture
- HCI Approach and Evaluation
- Conclusion and Future Work

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Introduction

- A large percentage of individuals with dementia are at risk of wandering and go missing.
- Internet of Things (IoT) can benefit vastly the Search and Rescue (SAR) operations.
- For outdoor monitoring systems Low Power Wide Area Networks (LPWAN) can be used
- One of the most important LPWAN technology is the Long Range (LoRa) technology.

Introduction

- The goal of this research work is to create a SAR system based on LoRa using wearable devices.
- A human-centered approach has been followed to understand the stakeholder's requirements and needs, following the Norman Interaction Model and Design Thinking frameworks.
- Heuristic evaluation was conducted, and a small-scale experiment was conducted with a small number of participants and a questionnaire was disseminated to them.

Motivation

- Alzheimer's disease (AD) and other causes of dementia are major public health concerns.
- According to a study, about half of children with Autism Spectrum Disorder (ASD) have attempted to elude parental control at least once and eventually go missing while walking.
- Children with ASD are at a higher risk of serious injury or death as a result of the above action.

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Internet of Things

- IoT is mainly multi-parametric, and for this reason, a plethora of technologies, protocols, and prototypes are used in order to support the notion of IoT.
- The LPWAN technologies come to fulfill the gap between short-range communication technologies and cellular technologies, as their main features are the energy-efficiency, long-range communication, and low cost, usually compromising the latency and throughput.
- LoRa technology is a broader term that consists of two main parts:
  - The first one is called LoRa that defines the physical layer of the technology and the modulation technique.
  - The other part called Long Range Wide Area Network (LoRaWAN) refers to the open specification protocol developed by the LoRa Alliance which is an inclusive community in which any person or organization is welcome to participate.

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Search and Rescue: requirements in terms of the hardware

- First of all, a requirement is that the wearable device that the person should wear.
- Furthermore, all the networking components and technologies such as cellular towers, femtocells, LoRa Gateway should be present
- Another part that is of paramount importance in such systems is localization accuracy
  - One technology that can provide real-time localization with high accuracy is the well-known and widely used GPS.
  - One of the drawbacks of GPS use for SAR scenarios is the fact that is highly energy-consuming.

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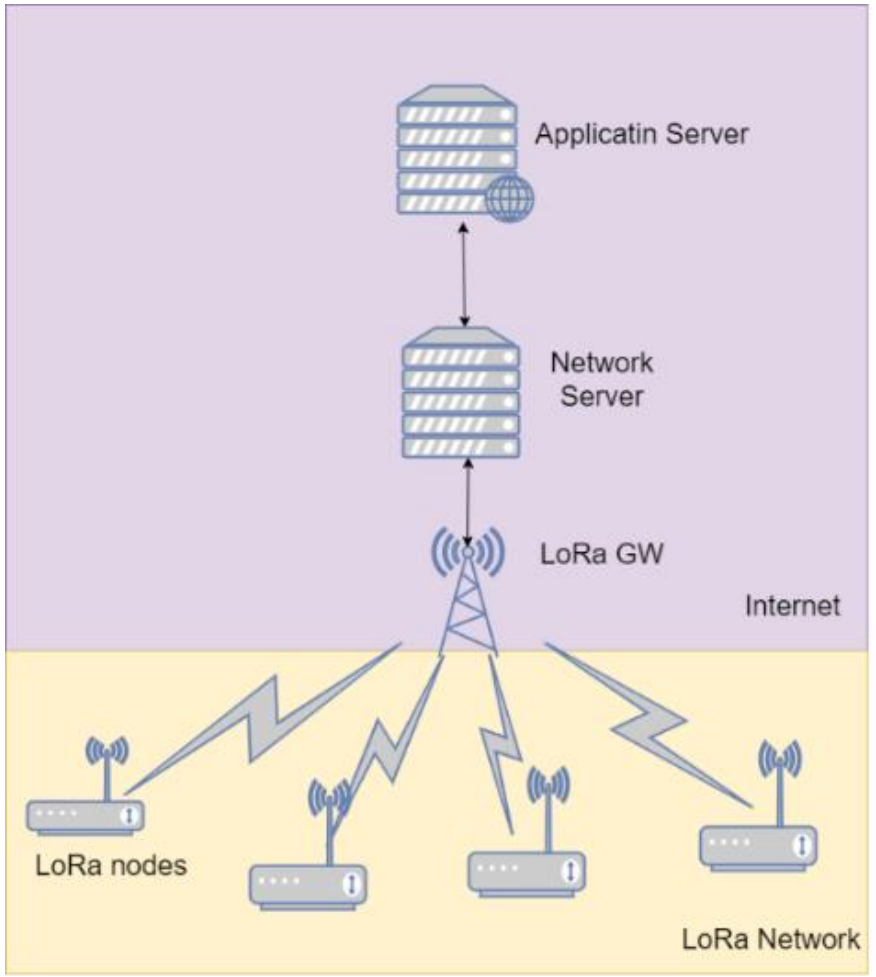
System Architecture

- a) End Devices (ED); in this study the wearable is based on Dialog's DA 14861 platform with a LoRa module integrated.
- b) The Gateway (GW), which is a device responsible for translating the packets transmitted through LoRa to Internet packets and vice versa.
- c) The Network Server (NS) is a server responsible to supervise and set the network parameters.
- d) The Application Server (AS).

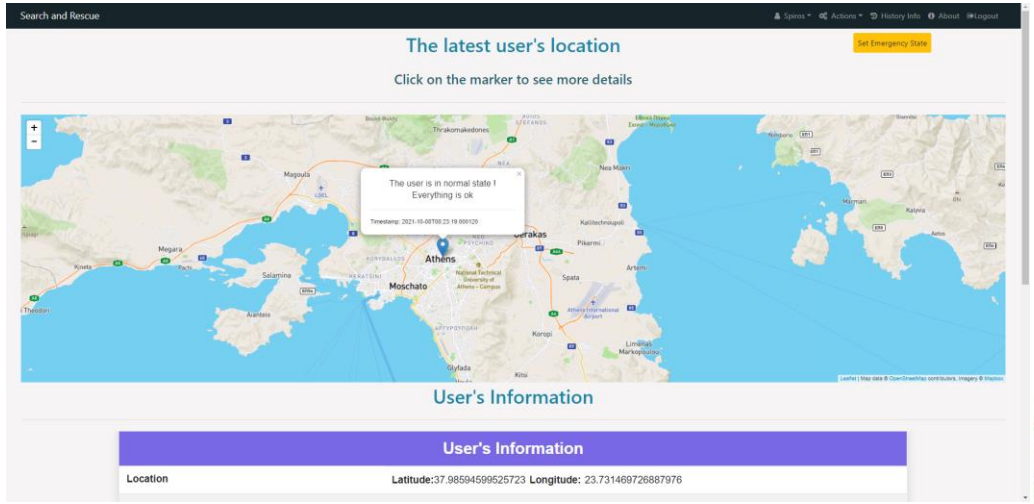


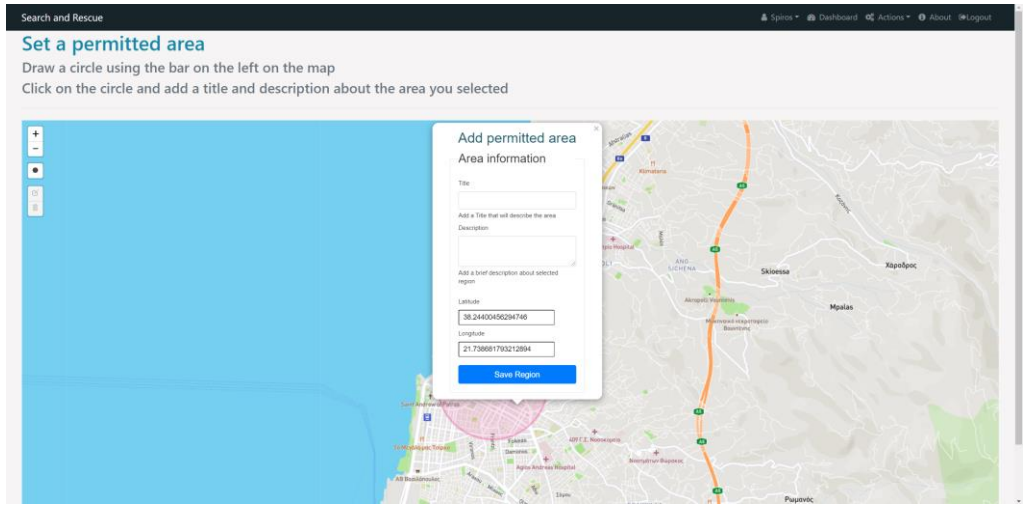
System Architecture: Implementation technologies

- Web application: the main technical aspect of the application is the web framework called Flask.
- Front-end development: HyperText Markup Language 5 (HTML), Cascading Style Sheets 3 (CSS), Bootstrap 4, JavaScript ES6, and jQuery 3.5.1 were used.
- Relational Database Management System (RDMS): SQLite 3 technology has been used.
- Maps in the web application: the Leaflet has been used. The Leaflet is an open-source JavaScript library for creating mobile-friendly interactive maps.

System Architecture: Basic scenario

- The user logs in to the system,
- definition of the allowed region,
- Location monitoring,
- Set the wearable device's state to an emergency/normal state.





HCI Approach and Evaluation: Usability criteria

- The first principle is the visibility of system status.
- Match between the system and the physical world.
- User control and freedom.
- Consistency and standards.
- Error prevention.
- Recognition rather than recall.
- Flexibility and Efficiency of use.
- Aesthetic and Minimalistic Design.
- Help users recognize, diagnose and recover from errors.
- Help and documentation are the last principles.

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HCI Approach and Evaluation: List of the errors during the heuristic evaluation

Problems	Heuristic violated
1. First screen	Aesthetic and minimalistic design
2. Menu actions	Connection between physical and digital world
3. Set a permitted area	Aesthetic and minimalistic design
4. Check the permitted area	Consistency of the system
5. Add permitted area	Help and documentation + navigation
6.Registration of new area, wearables list and addition of wearable device	Error prevention
7. History	Aesthetic design
8. Emergency button	Connection between physical and digital world
9. Emergency state	Visibility of system status
10. Window segmentation	Minimalistic design
11. Redirecting between pages	Navigation
12. Design of pages and menu	Responsive design

HCI Approach and Evaluation: An example of the problems found in the heuristic

Issue	**When the user clicks on the emergency button, the system triggers an alarm that means that one of the subjects with the wearable device on it has been lost. In the prototype form what the system did was to notifying users by making the whole screen red on every page (Figure 6). This change bothered all the participants that did not understand what the meaning of the red color was. This action violated the heuristic of visibility of system status as well as consistency and standards. The red screen when the set emergency state is active disturbs users**
Problem Severity	5
Recommendation	Find an alternative way of showing danger and emergency Figure 7

HCI Approach and Evaluation: Results

- The heuristic evaluation process had great results as the majority of the users feel that the system is not complex.
- In question 8 all of the ten responds were neutral while in the question 9 only 70% of the participants strongly agree (5) about how confident they were with the use of the website when only 30% of the answers were divided into neutral and disagree.
- We calculated the score of the questionnaire, and the score was 72.5. The general guideline for SUS questionnaires classifies it with grade B, which means that the designed system is good and is also greater than the average grade of 68.

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Conclusion

- The need for an IoT-based SAR system has been understood and explained, in order to save the lives of people that have a high probability to go missing.
- The benefits of such a system can be of paramount importance for the person that goes missing, for the peace of mind of the caretakers and the people that are responsible for the people such as in the case of people suffering from dementia or ASD.
- Emerging technologies, such as the LoRa technology can help to create SAR systems due to many factors, such as it can transmit over long distances and keeps the energy consumption at low levels.

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Future Work

- The examination of different wireless technologies such as the Sigfox or 5th Generation networks will be taken into consideration.
- The COVID 19 pandemic is over an ethnographic study should be designed in institutions for people suffering from AD or dementia.
- Another aspect that can be studied and examined is the legal part of the system that concerns people that can not be fully aware of legal concepts, for example, a person who suffers from dementia can not practically agree or disagree if the person that is responsible about the safety has the right to monitor the position and other vital personal information

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