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Using Smart Wearable Devices for Supporting Patients Affected by Dementia in Rural Areas of Calabria

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Abstract

The improvement of health and social care needs the introduction of shared solution at transnational level. The SI4CARE (Social Inno- vation for Integrated Health Care) project is a transnational initiative within the Adriatic-Ionian regions aiming to develop strategies to improve the current status of health and social care. The project member Municipality of Miglierina, a small rural town in Calabria, is developing a pilot action related to the use of wearable device for monitoring people affected by dementia together with the project partner Ra.Gi.. Ra.Gi. is a non-profit organization dedicated to assisting people with dementia in day care centers and so-called dementia-friendly communities. The pilot is based on the use of smart wearable devices to monitor these patients during their daily lifetime. This paper focuses on the design and implementation of the system discussing the proposed application, the strengths and weaknesses. We report results from a pilot experiment showing the

effectiveness of this approach. Finally, the possibility of extending the experiment to the other Adriatic-Ionian region is presented.

1 Introduction

The Adriatic and Ionian (ADRION) region is defined by territories bordered by Adriatic and Ionian seas. It currently has more than 70 million people living in cities and rural villages spanning a sizeable geographic scenario, from oceans to internal mountains. The European Union has defined an ad hoc strategy which involves nine countries, four EU Member States (Croatia, Greece, Italy, Slovenia) and five Accession Countries (Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia) (please visit the at www.Adriatic-Ionian. eu for detailed information). In particular, the analysis of the status quo in the Calabria region revealed many remote villages do not have physicians. Moreover, public transportation are pretty absent, and the weather makes private transportation hard during the winter. So, telemonitoring may avoid moving people by moving data. In this case, physicians may monitor important parameters reducing the need for in-person consultations.

The analysis of the demography across these regions demonstrates the relevant increase of adults and, more in-depth, the rise in people affected by declining functional capacities, thus needing the help of long-term care services [1, 2, 3]. Even though many patients with dementia do not need long-term care, the SI4CARE project aims to design a transnational strategy for helping people who cannot access long-term care for many reasons (living in remote areas, absence of caregivers, as well as the impossibility to pay for long-term cares in some countries).

People presenting this problem need long-term care systems and continuous monitoring to avoid injuries during everyday activities. In particular, it has been shown that these people's families also need help since the whole effort to care for dementia-affected people is vast. In the Calabria region, few centers, managed by public or non-profit organizations, offer the possibility of a daily-time stay for people, thus helping both diseased people and their families. More recently, in Italy and Calabria, some non-profit organizations and municipalities are experimenting with the so-called dementia friendly communities, i.e.,

developing a novel model of communities where people with dementia may experience an unprecedented lifestyle [4].

The possibility of giving some freedom to diseased people needs the introduction of intelligent systems for monitoring the position and vital parameters of the patients.

Developing healthcare services with a high level of innovation requires integrating artificial intelligence, and technological and social solutions [5].

While ICT and AI are two fundamental pillars for developing efficient solutions, the need for Social Innovation arises from creating social value with practical impacts on society, aggregating needs and interests, increasing civic participation and strengthening social cohesion.

The Miglierina Municipality and the RaGi non-profit organization have designed a pilot project based on an innovative platform that integrates wearable devices and software solutions to fulfill the needs of people and families. Such a solution is based on wearable devices monitoring people affected by dementia within the daily centers and dementia-friendly communities [6, 7, 8].

Some recent works demonstrated that telemonitoring of some physiological parameters is an effective solution [6, 9, 10, 11]. The project aims are twofold: supporting the families and people with dementia, and Testing of such project in the care of people affected by dementia. The decision support system developed within the project will evaluate the output of the pilot.

1.1 Novelty and Impact of the work

The key points of this work are the following:

- we implemented a pilot project related to the use of telemedicine in the Adriatic Ionian region;
- the use of such project within the care of people with dementia;
- the integration of computational methods and data gathered from wearable devices.

2 The SI4CARE Project

The SI4CARE project aims to develop an ecosystem for applying Social Innovation in the Adriatic Ionian area to innovative healthcare services. Such services will be delivered mainly to older adults and people with cognitive disorders.

The project wants to develop a single transnational strategy implemented in regional action plans and pilots. The results and benefits of the projects are monitored through an ICT Decision Support System.

The SI4CARE project brings together public and private healthcare providers, users and associations, academia and social entrepreneurs, voluntary associations, NGOs, and public administrations to design shared solutions. Social Innovation should be primarily used in the healthcare system in a coordinated way to offer services and develop new models to better respond to unmet/ poorly met needs of societies, more effectively than the traditional approach, with the beneficiaries/end users as players of their need-satisfaction since they are triggered and engaged in finding solutions and answers. Stakeholders will get actively involved in a broader, transnational network of actors and experts in social Innovation and its application to the healthcare sector. A shared approach that the SI4CARE project will create and promote within the healthcare sector will boost national and regional social Innovation to improve healthcare services for the aging population in the ADRION Regions.

3 Materials and Methods

3.1 Wearable Devices

The selection of wearable devices has been performed considering all the wearable devices actually in use in Italy and certified by the health-care system [12, 13]. Then from the available ones, the scientific committee of MoM has selected those presenting the possibility to easily export data and presenting as functionalities: the tracking of patients, the monitoring of heartbeat. Finally, the wristbands produced by the SiDLY enterprise (namely SiDLYCare PRO) https://www.hospital. sidly.eu/, actually certified as medical devices have been selected [1]. This device might be used in the regions of the other partners, thus making the

project repeatable. The strength of this bracelet is the absence of pairing devices (like smartphones) since it is equipped with GPS and GSM transmitters. The whole system comprises the wrist-bands, a mobile application, and a telecare platform for the management of the wristbands.

SiDLYCare PRO wristbands continuously monitor the physiological parameters of the patients. The bracelet is also able to connect patients with caregivers or families by means of an internal telephonic system connected to mobile phones and data networks. A clear SOS button on the top of the bracelet sends an alert message by means a registered phone call, a text message, and through the web management system.

SiDLYCare PRO has the following functions as summarised in Table 1:

- A fall detector able to send a customised alarm;
- A detection for exit of predefined and highly customizable geographical areas;
- Measurement of heart rate and blood oxygen saturation level (SpO2);
- A pedometer to measure the activity;
- A barometer to measure environment quality;
- Medicines reminder.
- A SOS button able to establish a two-way voice call and to send alert call with the GPS position to caregivers;
- Battery status warning;
- Monitoring of battery and network status.

User position is monitored by means of an equipped global positioning system (GPS) sensor. It enables the bracelets to detect user position. The manager of the system can define a region on the map, so the system sends a position when the user moves away from the defined area. The bracelets are also able to detect falls and they react by sending an alarm. Finally, the user may invoke an SOS alarm, and the system also detects the position and sends the coordinates to the manager or family/caregivers.

3.1.1 Data Protection and Privacy

Caregivers signed an informed consent for data management. Data are stored in the cloud of the vendor of the bracelets.

3.2 Parameters

We collect the following parameters through the bracelet:

- Heart Rate and SpO2;
- Activity;
- Environmental parameters measurement (barometer);
- Monitoring of falls;
- Monitoring of presence within the area.

An ad hoc defined questionnaire is also given to family and caregiver to monitor both the status of patients and the perceived satisfaction by the family.

3.3 Data Managing and Analysis

Data sent by the sensors are stored in the secure cloud provided by the bracelet vendor. An ad hoc defined software module extracts anonymised parameters and integrates them with the user questionnaire to perform advanced analysis. Data are collected and stored in a GDPR-compliant cloud. A customized script extracts the parameters of patients to be processed by further modules. Currently, the software module has two main analysis functions:

- Analysis of clusters of patients;
- Automatic identification of class patients.

The application is built on top of a My-SQL database. Data analysis is implemented on top of the Python libraries for data analysis sklearn and PyTorch. The project's current plan considers the possibility of predicting falls or other events of interest on the basis of the analysis of the time series of vital parameters. We plan to learn a convolutional autoencoder to predict adverse events, or simply events that should be reported, based on the time series

analysis. Finally, we aim to support the well-being of the patients through intelligent monitoring of the parameters of patients.

3.4 Experimental Setup

We initially selected ten patients from the set of patients of the Ra.Gi. All patients were affected by dementia and they were assisted in the Ra.Gi. center. We monitored each patient continuously and we revealed the following parameters:

- Hearth Rate;
- Blood SpO2;
- number of steps for each day;
- alert for possible felt to the ground;
- stay in the allowed area.

3.5 Patient's Characteristics

We want to point out that there is no way to select the sample due to the limited number of patients actually in care in the RaGi facilities. So, we select patients actually in care. Table 2 summarises patient characteristics. The Ra.Gi. onlus is a non-profit organization and patients are assisted on a social program and the SI4CARE project is related to social innovations. This project do not impact on any previous therapy.

4 Results and Discussion

We here discuss the realised architecture depicted in Figure 2. MoM was responsible for designing and implementing the architecture. MoM consigned the SiDLY wristbands to RaGi Onlus, who gave them to the patients. Patients were monitored during their stay at the center

for the time interval of monitoring. The system has been fully implemented and tested in the preliminary version. The system has been released to final users, who are starting to collect data.

5 Conclusions

The SI4CARE project aims to design novel strategies for health and social care. Municipality of Miglierina is a local partner of the project. Together with the stakeholders, MoM designed and developed a pilot project for people with dementia. Some results of the project demonstrate the effectiveness of such an approach which could be extended in the other regions. There exist two main challenges that should be considered: the need to train healthcare professionals and the requirements of economic, financial and organizational resources.

6 Declarations

6.1 Acknowledgments

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Sokratis G. Papageorgiou (1st Department of Neurology Aiginition University Hospital Athens), Efthalia Angelopoulou (1st Department of Neurology Aiginition University Hospital Athens), Dimosthenis Pavlou (School of Topography and Geoinformatics University of West Attica), Jovanka Vuceti´c, Public Health Center Tivat, Montenegro.

6.2 Conflict of Interest

The Authors declare that there is no conflict of interest.

6.3 Funding

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Figure 1

Figure 1: SiDLYCare PRO bracelets

Figure 2

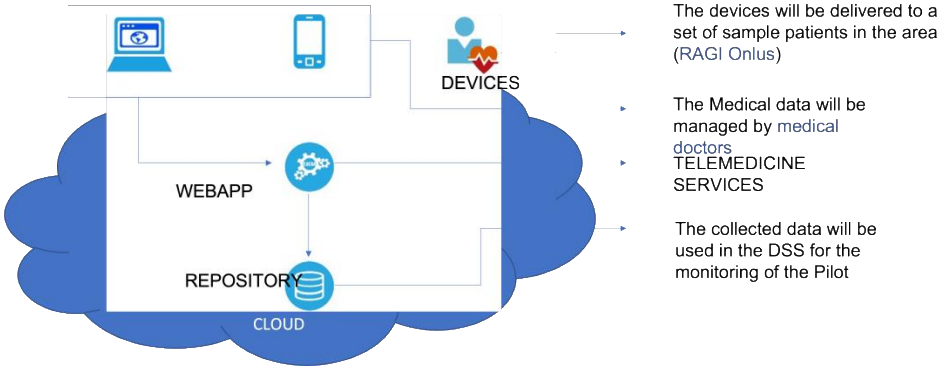

Figure 2: Figure depicts the main modules of the system. A set of patients has wearable devices. The device sends the parameters to the clouds where they are stored and analysed. Caregivers monitor patients through a web portal. Such data are used to monitor the project by means of a decision support system. Finally, data are also analyzed by means of data mining and machine learning algorithms.

Figure 3

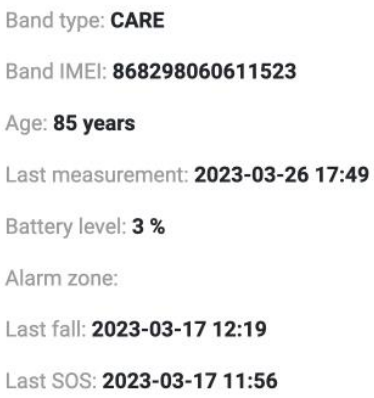

Figure 3: The screenshot of the system showing the status of a patient

Table 1

Table 1: SiDLY Bracelet characteristcs

Dimensions	51mm x 33mm x 15mm
Weight	41g
Autonomy	48 H after full charge
Charging time	3 hours
Type of charge	Induction
Call Protection	Only authorised numbers
Waterproof	It can be used in the shower or bath

Table 2

Age	79.04 ± 5.54
Sex	60% Males 40 % Females
Disease	Alzheimer's Disease (66%), Vascular Dementia (33%)

Table 2: Patient's Characteristics

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