IoT for active and secure aging with Alzheimer

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***Abstract*— The expectancy of live has been extended in modern societies becoming a symbol of civilizational progress, with technology supporting medical research and healthcare improvements. In technological domain, diagnosis and monitoring benefit from data collection from the most diverse sources. Along with specific medical equipment, data sources are available in what is becoming a sensor rich environment. The concept of Internet of Things refers to the sensing and communication devices that are becoming pervasive in modern societies. The present work proposes the usage of multiple data sources to support reasoning and decision for people with aging associated health conditions. Beyond ensuring safety and risk avoidance it is aimed to support active aging while stimulating healthy behaviors and social inclusion. The proposed architecture focus on monitoring and reasoning over available data sources to ensure risk assessment and adequate response to health risks internal or in the environment. Beyond risk it is aimed to promote active living, good habits and socialization thus ensuring active aging in daily routines, leisure and work. The proposed framework deploys a coach, or a companion that is always present and manifest only when needed. The decision process reasons based on clinical directives and situation awareness to determine risky situations for a citizen with cognitive vulnerabilities and react according to such reasoning promoting safety for elder citizens and comfort for carers and family thus supporting active and healthy aging for the target population.**

I. INTRODUCTION

Worldwide, nearly 44 million people have Alzheimer's or a related dementia. Only one in four people with Alzheimer's disease have been diagnosed. Alzheimer's and other dementias are the top cause for disabilities in later life [1]. In what regards to American citizens, one in nine over 65 has Alzheimer and An estimated 5.4 million Americans have Alzheimer's disease meaning that in 2015, more than 15 million family members and other unpaid caregivers provided an estimated 18.1 billion hours of care to people with Alzheimer's and other dementias, a contribution valued at more than $221 billion [2]. In what regards to technological devices, they are becoming pervasive cheaper and efficient in performing physiological measurements and one of their fast-growing appliances are those in the healthcare domain as they are associated with safety, ease of use and cost reduction. diverse types of devices can provide information about our position and some physiological parameters are read analyzed and displayed. That is the case of GPS data and measurements of the heart frequency (HR) or even oxygen saturation.

But when is the unfortunate case of someone in our family or close friend become diagnosed with Alzheimer or other kind of dementia we don't know what to do. The obvious action is to look at the internet and try to figure what can be done to help that person, in essence to provide help so that the person does not get lost in some memory loss episode.

When looking for such solutions, a person is confronted with some devices which, by themselves are useful for what is really needed, to ensure safety and not only provide readings, as is the case of the fitness bands [3][4] or even specific wearables for elder tracking [5]. Another type of options are the complex services where a person buys a tracking equipment and afterwards pays a monthly fee ensuring, solely, that when a person gets lost the service will issue a warning to selected personal either caregivers or family [6][7].

Figure 1 Alzheimer patients will

The problem that stands out of existing solutions is that none of those products and services will in fact guarantee safety and protection and none of those solutions will operate outside the logic of tracking a person's path and determine if a distress signal should be sent. Unless user is willing to pay a significant price added with a monthly fee. Research will figure if with existing technology it is possible to develop a solution that ensures safe monitoring and safety alarms while not depending on monthly subscriptions and with an affordable price. The Alzheimer association and published research points to 60% of dementia patients will wander at some point in life. Tackling this problem is one of the objectives of the hereby reported research in the scope of the Carelink

AAL Project, as the the losses of memory can promote wandering and putting themselves at risk as in the carelink presentation video, (a capture in Figure 1)[8].

II. Research Strategy

By knowing the potential of the devices already available in the market, and being developed, it would be interesting to research the possibility of using commercial devices, and others specifically customized, to provide support and safety to elders.

The research strategy aims to provide a credible response to the questions; Someone in my family (or myself for that matter) was diagnosed with Alzheimer, what should I do? Is it too risky to go on with a normal life or there is hope and support for a safety living after such diagnose?

In addressing such questions research aims to propose a solution that could use different types of devices, publicly available, commercial or customized in the direction of promoting safety by detecting anomalies or abnormal behavior and selectively actuate to the person and, according to risk assessment, send warning messages to clinical staff, family or informal carers.

III. Units

The methodology to conduct such research is based on the before mentioned questions and requisites. This methodology consists in developing an architecture that, once instantiated, will allow the usage of devices to ensure permanent tracking of location and risks, for the person with diagnosed dementia, and will actuate properly in case of anomaly detection according to a customized decision support system.

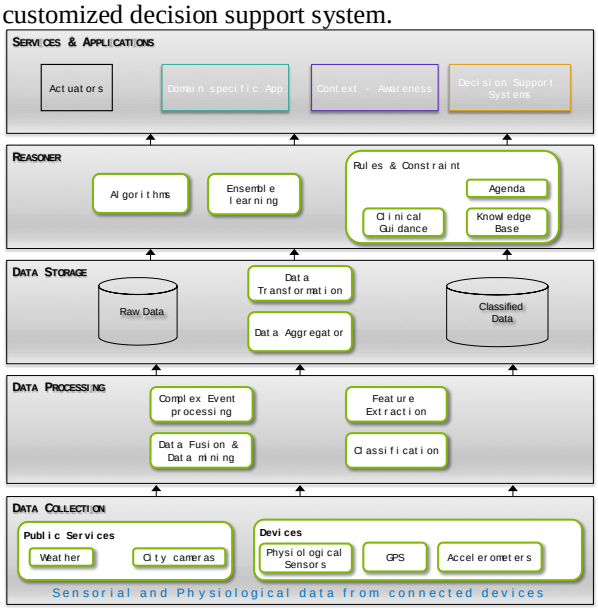

Figure 2 - Architecture based on IoT towards elder security

The proposed architecture is based on a lower layer of Data Collection that uses devices, as those in the market, performing physiological measurements (e.g. heart-rate, SpO2) and other measurements as position with GPS sensors and accelerometers to determine falls or long static conditions. Publicly available sources of information as the weather reports and street city cameras (e.g. beach cams) can provide additional information about the risk in walking along an, otherwise pleasant, sidewalk. The next layer, Data Processing, makes use of the sensor data, or even the fusion of data from several sensors, allowing complex event processing towards the extraction of features and classifies them so that some known artifacts are becomes useful for reasoning.

These approach is not static and it is aimed some type of learning for improvement of the system. In that way, it is important to record raw data from sensors so that data mining and machine learning algorithms can eventually generate information that makes the system more useful and more predictive of risky situations. Along with raw data it is important to aggregate data and transform it so that information from complex event processing, as those resulting from data fusion and data mining, will be classified and stored establishing new information records for the usage by the next layer, the Reasoner. In this layer, known algorithms can be used for supervised learning, looking for known risks but also unsupervised learning can be applied so that new markers can be discovered. Ensemble learning provides that those machine learning algorithms that, together will produce indicators, markers, signals that can be of major use in detecting anomalies and risks. This is done taking in account what can be considered an agenda of normality where known events are recorded and accessible to the reasoner (e.g. previewed displacements, usual paths of displacement, medication schedules) thus avoiding false positives. A knowledge base is essential to link with known medical knowledge on the pathologies. This knowledge may produce known parameters that, otherwise, would wrongly become alarms or bad assessments (e.g. knowing typical ECG ranges for this age or for patients with dementia can avoid triggers for, otherwise, alarming situations). It is of most important that all this process is guided by clinical advisors so that last decision on what is to be observed and regarded is taken by a responsible medical specialist that has a final word (e.g. Heart rate boundaries to be respected or acceptable SpO2 levels). All these processes will sustain a set of rules that will be used and constrains applied so that an evaluation of risk is taken and provided by the reasoner stage. This overall processing and reasoning activity will ensure that sources of information will be analyzed in the proper context and that in real-time the assessment ensures that viable behaviors are taken within normality. That sort of assessments will enable that, outside that boundary of normality, events will trigger alarms and signal the upper layer of services and applications.

In the upper level, diverse applications can be deployed and executed according to the needs (e.g. for an active person or for an advanced pathology progression). It is possible to design Domain Specific applications that can be used for clinics where patients are hosted or for patient use at hospital within the short timing of medical interventions or for continued monitoring of people in

mild states while continuing a normal life. All those cases are supported by timely Context Awareness of what is happening, what is supposed to happen and what cannot happen according to current circumstances. Context will change the alert mode for applications to become active or neutral (e.g. to know if the person is with caregivers, alone at home or in public or if the circumstances are not favorable). That will determine the level of response and the adequate type of response according to the specificity of the context and the results provided by the Decision Support System (DSS). The DSS will use information received from the Reasoner to act appropriately, being that the activation of a local alarm, the communication with parents and carers or other activity considered proper due to the circumstances.

The research methodology developed this architecture that is able to support different instantiations according to different patients in different circumstances. It is aimed to cover the wide variety of ways of life that should be possible to support, ranging from almost autonomous life to live in a specific care institution. Based on the proposed architecture, will be possible to structure different technological setups able to provide monitoring, reasoning and activate the adequate responses, either locally, providing warnings and guidance to the person, but also remotely to family and caregivers as needed. It is important to avoid repetitive false warnings along with disturbances of a normal living that would let the system useless or to be removed due to its contribution to problems instead of solutions.

The developments hereby reported include partial instantiation of the proposed framework. Development was made based on mobile applications using a specific GPS simulator that supports the creation of roots and deviations so that the system can be trained [9]. The simulation of tracks allows extensive and intensive testing of wrong path determination in lab, without the need to send people to the field. Machine learning was used along with heartrate and sensor data so that a more complete assessment would prove to be less wrong about identifying distress situations and both communicate with the user and report to caregivers and family. In this process, it was assumed that the mobile phone is still the most important device for such developments since most of devices in the market include a set of sensors of use for physiological and location measurements, including accelerometers that provide information on falls usually related with accidents. It is also important to keep in mind that those are temporary measures since other devices can be used in specially designed setups and those could become expensive solutions in an early stage but less expensive in massive production thus cutting costs.

The developments hereby reported are not part of a closed work but progress shows that it is worth to follow this line of thinking and development. Position, identification of falls, heartrate and deviation from path all can be used for monitoring and insurance of good practices and safe patient monitoring while providing confidence to caregivers.

IV. SOLUTION AND DISCUSSION

Technology is present in many aspects of our life and can be used for different age groups even for those less keen to technology. It is therefore possible to use technology to ensure security and safety, sometimes without devices being noticed or actively manipulated. Research hereby reported manages to track and monitor deviations to usual tracks and it determines the severity of falls along with heartrate variations. This allows a more accurate evaluation of situations of risk and therefore issuing less false alarms to family and carers that would provoke stress and, ultimately, disregard and lack of timely response in situations that in fact become of emergency. The developments and testes performed so far are strongly encouraging towards the proposed holistic solution for those with diagnosed dementia where Alzheimer is one of the prevalent pathologies in Europe and in most developed countries around the world. Social and human concerns are at the center of this research as, by specificities of the disease and the human diversity, it is necessary to address different options for device's geometry and for operational characteristics such as robustness, visual aspect and wearability. For instance, it is likely that women will prefer bracelets or similar garments instead of other wearable devices such as pocket belts or smart clothing. It is also important to take notice of the technical aspects such as battery life and time to charge and way of charge (e.g. charge on the move, wireless charging docks). In line with this thought is the concern of different types of acceptance of the disease and the behavior towards technology. In these profiles, it is noted that some people may fear to be monitored and tracked as a menace to their freedom. That is why it is important to ensure that, in some cases, the system becomes vigilant and monitors parameters that could signal risk and only provide feedback or alarm if there is a clear identification of a risky situation. In other cases, a more complete follow up of the track could become a need to avoid disappearance and associated risks for life. It is to notice also that some other patients become stubborn and refuse to adopt the proposed approaches in any circumstances. Some others may fear to be tracked and that it will constitute risk for them or expose them to invasion of privacy. This way it becomes imperative to assume a human centric posture in designing and conceiving this type of technological setups. This is what is done within Carelink project with multiple interactions with patients and carers to ensure that those who are the final users and the carers are listened and taken in account while developing technological solutions. Those outcomes result, for instance, in the need to propose different profiles supported by different optional devices. This way it becomes possible to reach a major audience and be able to uphold human diversity even in sickness. In that direction solution encompass profiles so that technology will adapt to different people's needs and a reasoner will improve the adaptability to a certain person in her stage of the disease. In overall, t is aimed to continue fostering the most customize less expensive solutions thus allowing a wider audience with reliable monitoring and safe response, promoting the autonomy of elder citizens with diagnosed dementia or similar cognitive impairment.

V. CONCLUSIONS

The present work consists in a framework that is able to accommodate different approaches for the same goal; to ensure the safety of Alzheimer patients. This objective, in a broad sense, can be applied to other kinds of dementia or pathologies with similar cognitive limitations where it is necessary to ensure safety either at home or in going outside. In order to accomplish such goal, it is necessary to use technological skills to monitor several aspects of a person's life, while ensuring privacy and security of that same technology. A key benefit of the proposed system is that reasoning makes risk assessment and only disclose the needed information while risk is detected thus ensuring privacy. The proposed system alerts the person, in a first stage, and later sends warning signal to selected caregivers or family. The proposed architecture is modular and open to integrate different components in each of the modules or layers. It is therefore possible to conclude that the proposed work covers most of the cases where a person can be exposed to risk and that timely help can be provided based on the issued warnings. It is also important to notice the modular and scalable dimension of the proposed work, allowing us to conclude that it provides ground for multiple configurations adaptable to the diversity of users at different stages of progression of the pathologies considered in this study.

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