Assistive Technology for Risks Affecting Elderly People in Outdoor Environment

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Abstract: Risk situations may affect elderly people during outdoor Activities of Daily Living. The gravity of this problem becomes more significant with the rapidly growing number of elderly people around the world. Assistive technology is a promising solution to enhance safety of elderly people in outdoor environment. It plays an essential role in providing them with a higher quality of life and autonomy. In this paper, we present the result of our study on major risk factors that affect elderly people during outdoor activities. We also discuss existing assistive technology across recent work related to outdoor risks. In addition, we provide a framework for existing assistive technology that addresses outdoor risks. To the best of our knowledge, this is the first review about major risks that affect elderly people in outdoor environments, and that describes technological solutions in the domain of ambient assistive technology.

1 INTRODUCTION

Elderly people are subject to variety of risk situation in Activities of Daily Living (ADL). The gravity of this problem becomes more significant with the growing number of elderly people in the society. The number of people aged over 60 is expected to increase from 605 million to about 2 billion between the years 2000 and 2050, which represents an increment of aging population from 11% to 22% (of the whole world population). Due to the advance in healthcare systems around the world, people live longer and the number of elderly people is increasing constantly. Therefore, researchers are paying a special attention toward condition of elderly people including work on: understanding the population, their needs, challenges faced, and risks in ADL.

Aging is associated with cognitive and physiological decline, which causes activity limitations and participation restrictions (Helal et al. 2008). Consequently, elderly people become less active and more prone to social isolation and loneliness, which complicates their health situation and causes premature mortality (Yang et al. 2013). On the other hand, participation in activities has promising benefits at physical, sociological and psychological levels (Sugiyama and Thompson 2006). It can result in lower risk of dementia and improves well-being (Morrow-Howell et al., 2014). Moreover, physical activity slows down progression of diseases, and it is in general a promoter of health. Increasing participation in social activities improves cognitive abilities for aging people (Krueger et al., 2009), and consequently leads to higher Quality of Life (QoL). However, elderly people face hazards and barriers that prevent them from being active and performing outdoor ADL, including physical, psychological and social barriers (Barnsley et al. 2012; Wennberg et al. 2010).

There is no consensus on the definition of outdoor environment, open environment, hazard and risk in the literature. In this paper, an outdoor environment is considered to be any environment outside home, including open-air areas. “Risk” and “Hazard” are generally used interchangeably in the literature. Inspired from the work of Marzocchi (Marzocchi et al., 2012), we consider in this paper, Risk as “the probability that a negative consequence can occur in a given period of time following a specific adverse event.” Hazard as “a source of danger” (Abdulrazak et al. 2015).

We can classify the existing interventions to reduce the consequences of risks affecting elderly people in two categories: (human and technological interventions). The human intervention includes health and social assistance, provided by caregivers or relatives accompanying an elderly people. This

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approach may have negative impacts on elderly people including emotional impact (e.g. since it reduces the privacy space of elderly people) and economical impact (e.g. it is often associated with a cost to the person, family or the health system). The technological intervention, on the other hand, involves all Information and Communications Technology (ICT) (including hardware, software, devices, systems, etc.) that have been developed to assist elderly people. Two common terms are interchangeably used in the literature to identify this technology: Assistive Technology (AT) and Gerontechnology.

Recent advances in ICT (e.g., mobile and pervasive technologies (based on context awareness), internet of things, cloud computing, sensor networks) enabled the creation of new categories of solutions that may assist elderly people in ADL. Emerging research on technologies to assist elderly people with disabilities addresses a broad variety of needs. In the health care domain, it has been applied for the development of divers solutions including wearable medical devices, smart environments, applications for safe navigation, or assistance applications in case of an accident or crime (Helal et al. 2008). Although these technologies are useful for risk assistance, their acceptance/rejection depends on several factors, including personal, environmental, psychosocial or economical. High attention has to be paid to the design of the interaction between human and the machine (Abdulrazak et al. 2012).

Based on our literature study, we have identified the most frequent risks as: fall, wandering, health issues, infection, hygiene, nutrition, crime, abuse, and traffic accidents. The most addressed risks by ICT are fall, wandering, and health issues. In this paper, we review these three major risks, and discuss related assistive technology. To describe the progress made in this domain, we searched and matched real work and existing technology for each risk. Our goal is help readers to better understanding the recent progress in assistive technology. To the best of our knowledge, this paper is the first review on assistive technology related to risks faced by elderly people in outdoor ADL.

This paper is organized as follows. After this introduction, Section 2 introduces the methodology followed in our research. Section 3 describes the three major risks that elderly people face in outdoor environment (i.e., fall, wandering, and health issues). Section 4 presents Assistive Technology systems that help elderly people in risk situations. In this section, we review and enlist the assistive technologies that have been developed to provide assistance for the three major risks. We also introduce our framework of risk related existing assistive technology. Finally, Section 5 concludes the paper.

2 METHODOLOGY

Our goal in this paper is to provide a review of the major risks and dangerous situations affecting elderly people in outdoor environment and how technology may help them, rather than a systematic review. We present in this section the methodology we used to identify the major risks that affect elderly people in outdoor environment, and to review the existing research on assistive technology for these risks. Our methodology is based on the literature identified through a search on the following databases: PubMed, ScienceDirect, IEEE Xplore and Google Scholar. These are the main databases that catalogue the research on risk factors faced by elderly people in outdoor ADL and the related assistive technology.

- We searched PubMed for the following terms: ‘‘risk factor,’’ ‘‘danger situation,’’ ‘‘hazard,’’ “emergency,” ‘‘outdoor,’’ ‘‘barrier’’ and ‘‘frailness.’’ The choice of these terms in PubMed is motivated by the fact that this database is specialized in human/ medical factors.
- The ScienceDirect, Google Scholar, and IEEE Xplore databases were searched for combinations of the terms ‘‘elderly people,’’ “assistive technology,” “teleassistance,” “mobile health,” “pervasive healthcare” and the terms listed above. The choice of these terms and databases is motivated by the fact that these databases are more technology related.

Based on reading of the abstracts retrieved from databases, we identified articles that describe risks and hazards that affect elderly people. We also identified potential assistive technology that may support elderly people in these risk situations.

We disregarded in our study articles that discuss research related to elderly people in other contexts (e.g., studies on chronic diseases, disabilities or other minor risks with no existing related assistive technology). For each article in the resulting set, along with other articles cited in the resulting article set, we identified how major risks affect elderly people in their ADL. We also extracted devices systems or applications that may assist elderly people facing such risks, and identified the three main addressed risks. We then iteratively clustered the risks and assistive technology until we arrived at the categorization described in this paper, as well as our framework for existing assistive technology related to outdoor risks.

3 MAJOR RISKS IN OUTDOOR

Various hazards cause risks for elderly people outdoor. We identified the three major risks addressed in the literature as: fall, wandering and health. These three risks (and others) may precipitate the following common consequences:

- **Physical**: imply injury and impairments.
- **Psychological**: include fear of further hazards and risks, distress, and embarrassment.
- **Social**: imply loss of independence, mobility and social ties, as well as high probability to move into residential/health/care facilities.
- **Financial** and **Medical**: include higher cost and medical efforts linked to the handling of the risk situation. This burden can be on personal financial, relative and health systems.
- **Governmental** and **communitarians**: imply hospital admissions (e.g. number of beds) and health insurance cost.

These undesirable risk consequences affect elderly people widely. Therefore, research and industry present various practical solutions to detect, prevent, assist in risk situation, and to alleviate the consequences.

Risk situation may have numerous causes and factors. Inspired from World Health Organization (WHO) International Classification of Functioning disability and health (WHO-ICF 2002), we can highlight three major factors: personal, health and environmental.

- **Personal** factors may include age, sex, education level, social involvement and previous accidents (risk faced situations).
- **Health** factors include medical/genetic problems such as visual and cognitive impairment, reduced sensation, and use of medications.
- **Environmental** factors comprise all the contextual information on the visited environments, including hygiene, pollution and weather condition, obstacles, lighting level, floor leveling and walking surfaces.

Following, we discuss each of the three major risks separately.

3.1 Fall

Fall can be considered as the possibility of an involuntary and sudden change in position, causing an individual landing at a lower level such as the floor, the ground, or an object, with or without injury (David Butler-Jones 2005).

Fall is the most common and frequent risk that elderly people face in outdoor ADL. In fact, a Canadian study revealed that 65% of falls among elderly people occurred outdoors, while they are walking on a familiar route (David Butler-Jones 2005).

Personal factors that may cause fall include mainly age and previous falls. Health factors include chronic medical problems such as, reduced sensation, muscular weakness, and diseases as stroke. Environmental factors comprise poor lighting, sliding floor and slippery surfaces (Kelsey et al. 2010; David Butler-Jones 2005; El-Bendary et al. 2013).

In addition to the common consequences presented above, psychological consequences include extreme fear of further falls (El-Bendary et al. 2013) and social consequences are limited outdoor activities.

3.2 Wandering and Disorientation

Wandering can be considered as a psychomotor instability that leads an elderly people to move toward unspecified destination. Disorientation is referred to as getting lost because of missing referential points (Finkel et al. 1996).

Wandering is more frequent for elderly people because of memory impairment, particularly those who have dementia or Alzheimer disease (Perälä et al. 2013; Yamada et al. 2014). Around 35.6 million people live with dementia through out the world (According to the WHO). Wandering concerns 11% of independent people and 28% of those who need occasional help (Beauvais et al. 2012).

Wandering and disorientation may lead elderly people to dangerous situations while performing outdoor activities. In situations where elderly people are disoriented or lost, they become more frightened (Douglas et al. 2011), and subject to abuse (Goergen and Beaulieu 2013).

In addition, wandering has social and psychological consequences including fidgety of elderly people and anxiety of relative/family, as well as high risks of losing independence and transferring to special facilities to ensure safety.

3.3 Health Issues

Health issue is defined as the state in which the person is unable to function normally without pain. Health issues are often defined as physiological malfunctioning and impairment (Brubaker 1990).

Health issues are an unwelcome accompaniment to advancing age for the majority of elderly people. Most elderly people suffer from a variety of symptoms and at least one chronic disease (Brubaker 1990). The most known diseases are the cardiovascular system disease (e. g., heart attack), the respiratory system diseases (e.g., Bronchitis), diabetes mellitus, hypothermia, hypertension, mental problems (e.g., Alzheimer and Parkinson's diseases) (Hellström et al. 2004, Ludwig et al. 2012). In Europe, cardiovascular diseases cause 45% of deaths among people aged 75 years or younger (Ogorevc and Lončarevič 2014).

These medical conditions are highly prevalent among elderly people, and may affect them severely till causing death. The improvement of healthcare systems around the world has enabled elderly people to living longer. However, this phenomenon is associated with an extreme burden on healthcare system budgets and shortage in medical specialized caregivers (Helal et al. 2008).

4 ASSISTIVE TECHNOLOGIES

Embedding artificial intelligence in ICT, employing context-awareness approaches, and connecting heterogeneous devices have a wide potential of utilization in different outdoor situations (Doukas et al. 2011; Rashidi and Mihailidis 2013).

- Sensor devices (e.g., Global Positioning System (GPS), RFID, accelerometer, bio-sensors) allow acquisition of contextual data;
- Various mobile and wearable computing devices (e.g., personal computers, smart phones, tablets) facilitate context collection, aggregation and processing;
- Applying artificial intelligence techniques allow quantification and detection of human behavior;
- Approaches for positioning, monitoring, orientation, navigation, and communication enable continuous outdoor assistance of elderly people.

Combination of these technologies can be used to develop new types of assistive pervasive technologies for elderly people. The progress of assistive technology is continuous until establishing digital smart environments that are sensitive, adaptive, and responsive to human needs, habits, gestures, and emotions (Acampora et al. 2013). Advances in the development of technologies have the potential to extend the assistance from indoor (e.g., home, office, care facility) to outdoor, and provide a continuum of assistance in an Open Smart Environment (Abdulrazak and Roy 2011; Abdulrazak et al. 2011).

The building of an open smart environment to assist elderly people outdoor requires the integration of computational methodologies (Algorithms) and ambient intelligence (Doukas et al. 2011). There are three main areas of research interest in this domain.

- **First (monitoring and sensing)**: design and develop technology for remote monitoring and sensing, in order to identify instantly and accurately the contextual environmental changes, through the use of sensors, mobile and software tools for automated data collection and their analysis.
- **Second (risk detection),** design and develop technology for early detection of hazards, risks and accidents, to trigger an emergency intervention.
- **Third (intervention)**, design and develop tools for: 1) localization of an elderly people; 2) coordination and planning of the intervention; 3) usable and useful human machine interaction for better intervention.

Researchers have more focused on developing assistive technology for home assistance (indoor) (Nehmer et al. 2006) in comparison with outdoor Assistive Technology. The limitation of work on outdoor Assistive Technology is due to:

- The heterogeneity of context information acquired via sensors;
- The lack of standards, and the heterogeneity of the semantics, syntax, languages and protocols used by the various providers in outdoor environments.
- The highly changing and in some cases unstable environmental conditions (e.g., availability of wireless communication, accessibility of network services).
- The complexity of managing the mobility of the user.

- The complexity of building applications that handle the above items.

Outdoor assistive technologies are based on wearable devices to manage risks (such as sensors embedded in clothes, watches, belts, smartphones). Several of the existing solutions are hardware custom based, which increase the cost of development and pricing, as consequences limits the solvability of their market.

The recent developed technology of smart wearable devices (including smart phones, watches and glasses) already integrates numerous sensors, powerful computing, and varieties of communication protocols. The companies that commercialize these devices also provide developers with programming IDEs that facilitate building applications with different aims. This wave of smart devices has enabled reducing the cost of developing applications significantly. Researchers focus more on application rather than hardware. As consequences, numerous existing outdoor assistive technologies have been developed for the major mobile platforms (e.g., iOS, Android, Blackberry) (Klasnja and Pratt 2012).

Assisting elderly people outdoor can be preformed following *) a specific request from user or *) an automatic detection of a situation. The specific request can be an emergency call triggered by user with the help of a simple mobile interface (e.g., panic button) (Abdulrazak et al. 2013; Ferreira et al. 2013). We can illustrate the logic of handling risks using assistive technology in Figure 1. The framework contains multiple phases including data acquisition by monitoring and sensing, data processing, detection of the risk and interventions by calling emergency center or caregivers for example. This framework is detailed for each risk in the following sections.

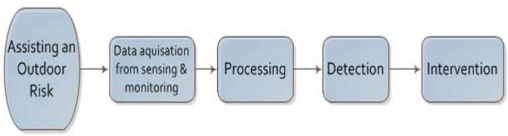

Figure 1: Schema of assistive technology framework.

Following we discuss the outdoor assistive technologies linked to the three risks (Fall, Wandering, Health issues) from the point of view of existing research work, how these technologies assist elderly people, and how it improves their QoL.

4.1 Fall

Use of assistive devices that implement ambient intelligence technology, can promote better handling of fall risk. Diverse methods can be used to detect fall. According Mubashir and Yu (Mubashir et al. 2013; Yu 2008), a fall can be detected by three main techniques, through the use of wearable devices, ambience devices and vision-based devices (i.e. camera). Therefore, use of this technology can detect falls whether they happen in outdoor or indoor environments. However, in assistive technology for outdoor environment, fall detection is mainly done through the use of wearable devices, such as smartphones and sensors. These devices can also help to create support from caregivers to help the elderly people in the best delay. This can be done by using several methods and algorithms to select, and then to communicate with the best available caregivers around the injured person.

An exhaustive review for body worn sensors to detect falls has been made by Schwickert et al. (Schwickert et al. 2013). The authors listed, gathered and discussed a representative published work on fall and body-worn sensors. We present in Table 1 various examples of existing assistive technology that address fall risk of elderly people in outdoor environments. We depict in Figure 2 the logic of

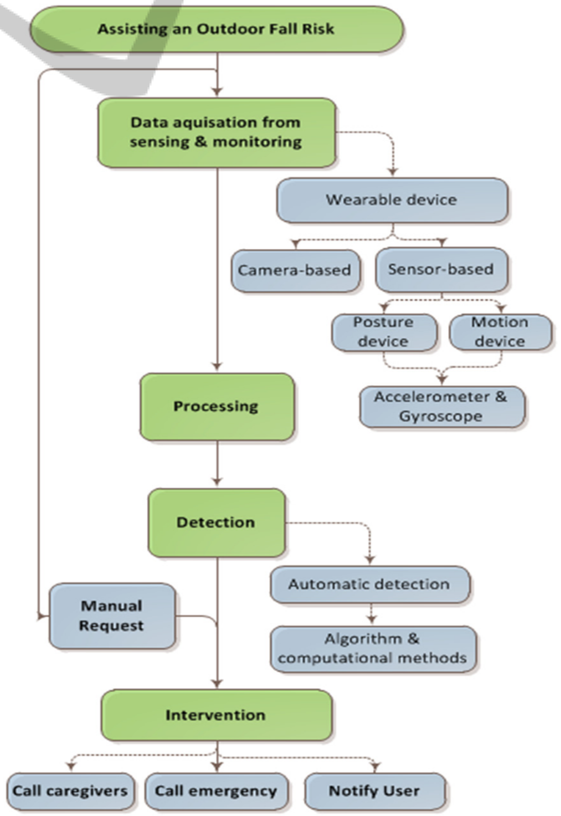

Figure 2: Schema of assistive technology framework for fall risk.

handling fall risks using assistive technology. The data acquisition from wearable devices, such as accelerometer or camera, represents the first phase.

After that, this data is analyzed and processed to detect a fall risk. The detection of fall is obtained from different algorithms and computational methods as many approaches. The last phase is the intervention of caregivers to assist injured person in the best delay. For example, calling and notifying an emergency call center or a family member.

4.2 Wandering

Advances in sensing, monitoring, communication and computing techniques enable safe walking and accurate navigation. Existing solutions for wandering detection are mainly based on GPS. According to (Lin et al. 2014), there are three types of key techniques that were applied in the existing work to assist elderly people in case of wandering in outdoor environment: event monitoring, trajectory tracking, and localization combined with Geo-fence technique.

- The ***first*** technique (event monitoring) is to determine a wandering behavior based on activity monitoring. Through the analysis of these events, we may detect a wandering behavior in case of rhythmical repetition.
- The ***second*** technique (trajectory tracking) detects wandering risk using the trajectory tracking technique, while motion trajectories differ from trajectories patterns that the elderly people are supposed to take.
- The ***third*** technique (localization combined with Geo-fence technique) consists on user localization in outdoor environment and analyzes this location to detect any deviations or boundary transgressions.

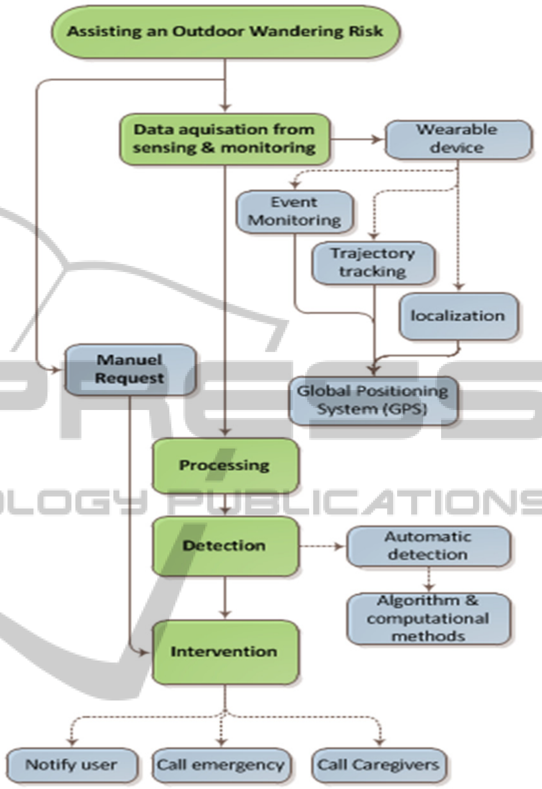

Figure 3: Schema of assistive technology framework for Wandering.

Table 1: Examples of existing assistive technology (AT) for fall risk.

Techno.	Assistive Technology	Ref.
App. and accelerometer sensor	Smartphone-based fall detection applications (app) that monitors the movements of user, recognizes a fall, and automatically sends a request for help. The applications are based on smartphone embedded sensors (e.g. three axial accelerometer, motion). An adaptive threshold algorithm is used to distinguish fall. In case of fall, prerecorded emergency contacts (e.g., relative, caregiver) are contacted by phone call, SMS and email.	iFall (Sposaro and Tyson 2009)
		MyVigi (Beauvais et al. 2012)
		PerfallD (Dai et al. 2010)
		E-FallD (Cao 2012)
		A smartphone-based (Abbate et al. 2012)
		FallAlarm (Zhao et al. 2012)
Body sensor network	Wearable motion detection device using tri-axial accelerometer or/and Gyroscopes to detect and predict falls.	Accurate, Fast Fall Detection (Li et al. 2009)
		HMM (Tong et al. 2013)
Watch-worn based on sensor	The detector is easy to wear and offers the full functionality of a small transportable wireless alarm system.	SPEEDY (Degen et al. 2003)
Wearable camera	An activity classification system using wearable cameras is used to detect falls. Since user wears the camera, monitoring is not limited to confined areas. It extends to wherever user may go (indoor and outdoor)	(Ozcan et al. 2013)

Table 2: Examples of existing assistive technology (AT) for wandering risk.

Techno.	Assistive Technology	Ref
App, GPS and GIS	**GPS based systems** to detect wandering risk. These systems enable caregiver (or family members / volunteers) to register safe zones for user. If the user moves outside the safe zones for a predetermined time, the system infers wandering situation using various algorithms (e.g., Bayesian). These systems may have various features including: navigate user home after detecting a wandering risk, send notifications to caregiver containing user-location (by phone call, SMS and/or email), establishes a line of communication between user and caregiver, as well as a web site with real-time localization map. These systems can be: • Based on worn GPS sensor (e.g., on Shoes, belt, watch): These systems are hardware custom based. The worn part is mainly composed of a GPS sensor and signal transmission modules to transfer the position coordinates to a central monitoring station. The central monitoring station is in charge of processing the risk (e.g., **GPS-Shoes, Digital Angel**). • Based on a GPS sensor integrated in a smart device (e.g., smartphone, smart glasses, smart watch): In this case, the devices have processing resources and the risk is often processed/detected by an app (e.g., **iWander** and **MyVigi**).	(Sposaro et al. 2010) (Beauvais et al. 2012) (Lin et al. 2006) (Parnes 2003) (www.gpsshoe.com)
App and camera	**DejaView** is a camera-based system designed to aid recall of daily activities, plans, people, places, and objects. It senses (using the camera) the user's surroundings and inferring context. The system then unobtrusively cues a user with relevant information, helping them orientate themselves and aiding both their prospective and retrospective memory.	(De Jager et al. 2011)
App, Camera and worn laser device	**Camera based systems** to remotely guide users. The systems provide navigation aid in complex and unknown areas. These systems are often composed of camera, compass and GPS. The remote center (caregiver location) can manually or automatically interpret user-data to infer the user status. In case of assistance need, the caregiver can remotely access the scene of the user using the user worn camera. These systems also enable caregiver to guide/direct the user by speech or by laser-projected arrows.	(Tervonen et al. 2014) (Xiao et al. 2013)

We depict in Figure 3 the framework used to develop outdoor wandering risk related assistive technology. This model represents the four main phases: data acquisition from wearable devices, data processing, detection of the wandering risk and the intervention to assist elderly people such as making an emergency call or a caregiver call. We also present in Table 2 examples of existing technological solutions to handle wandering risk.

4.3 Health Issues

Health issues are both numerous and dangerous for elderly people, some of them may cause death if they are not handled immediately through ubiquitous assistance services.

The outdoor assistance starts by integrating sensor infrastructures capable of detecting changes in the health conditions. Providing healthcare services in outdoor environments is mainly performed with the help of wireless technology, sensors and wearable devices (often named WBSN: Wearable Body Sensor Network). The sensor network is made of wearable biosensors and actuators that are interconnected to gather the patient's functional and contextual parameters. These sensors can vary depending on the type of data that we want to collect, e.g., Electrocardiography(ECG), Electroencephalography

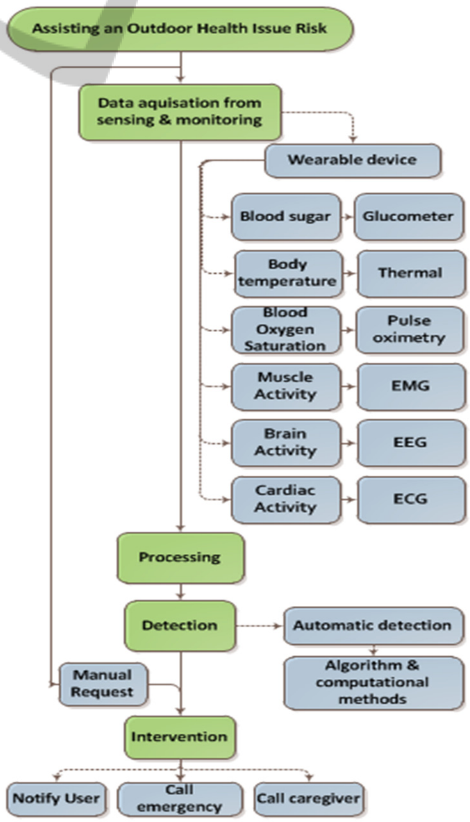

Figure 4: Schema of assistive technology framework for Health issues.

(EEG), Pulse Oximeter Oxygen Saturation (SpO2), heart and respiration rates, blood pressure, glucose level, body temperature, spatial location, among others. In addition, these WBSN systems also consist of a mobile-based unit that implements some applications with the use of built-in sensors (e.g., camera, GPS, and accelerometers), which can serve to assist elderly people in some risks (Chiarini et al. 2013). These mobile-based units connect with the body sensor network forming a system together.

The use of pervasive computing and ambient intelligence technology offers good opportunities to enable ubiquitous assistance and support elderly people in these emergency situations (Taleb et al. 2009; Acampora et al. 2013). This technology enables self-health management (Mamykina et al. 2008). E.g., applications developed for diabetes patients enable self-manage and help to identify situations that require necessary interventions (El-Gayar et al. 2013). Furthermore, using wireless technology and wearable devices allows notifying elderly people about their health status, and also alert medical personnel and people nearby of the emergency situation.

Table 3: Examples of existing assistive technology (AT) for health issues.

Health issues	Techno.	Functionality of the system	Ref.
Cardiovascular	Custom mobile health monitoring unit and wearable ECG sensors	A custom mobile health monitoring system using WBSN. The system is based on ECG connected to a network hub or a 3G phone for cardiac arrhythmias detection. The used real-time ambulatory ECG detection algorithm enables diagnosis for cardiac arrhythmia events. In case of emergency, it establishes a direct interaction between user and service providers.	(Li et al. 2014)
	WBSN, Wearable ECG and Android app.	A mobile health monitoring system using WBSN and Android phone. The system operates similarly to the previous one. The Android phone (in the case of this system) processes the data and detects abnormal situation (alarm). The phone also forwards the alarm (with ECG data) to a cloud Alarm Server, which pushes the messages to doctors' phone.	(Guo et al. 2013)
Cardiac and Hypertension	WBSN and Android app.	**iCare** is a mobile health monitoring system using WBSN and smart phone. Similarly to the previous systems, this one monitors the health status (Cardiac and Hypertension) of elderly people and provides tailored services for each person based on personal health condition. When detecting an emergency, the smart phone automatically alert pre-assigned people (who could be a family member or a friend) and call the emergency center.	(Lv et al. 2010)
Diabetes	Mobile app. and peripheral sensors	A mobile phone application designed for self-care management of people with Diabetes Mellitus type 1. The system enables to keep notes of personal data (e.g., pre-measured glucose levels and blood pressure, food and drink intake, physical activity). In case of feeling unwell or an emergency, user can press a button to transmit immediately his/her position with the personal data to both an emergency call center and an attendant physician.	(Mougiakakou et al. 2009)
Respiratory	WBSN (Wristband sensors and pulse-oxymeter) and Smartphone app.	**SweetAge** system is WBSN base on wristband sensors and pulse-oxymeter connection to a smartphone via Bluetooth. It enables to tele-monitor vital signs (i.e., oxygen saturation, heart rate, near-body temperature). The system displays an alert in case of abnormal respiratory situation (a measurement is outside the predefined range). The system instructs users to contact their health care provider in case of need.	(Pedone et al. 2013)
Parkinson	On-body acceleration sensors	A WBSN composed of on-body acceleration sensors to assist people with Parkinson's disease. The system measures user movement and automatically detects Freezing Of Gait (FOG) by analyzing frequency components inherent in movement. When FOG is detected, the system generates a rhythmic auditory signal to stimulate user to resume walking.	(Bächlin et al. 2010)
General	Mobile app. (and bracelet in the future).	**iHELP** is a mobile application mainly designed for heart attack risk, but could be extended to other risks. It offers a quick and easy sending of multiple SOS alarm messages to family members, friends, professional rescuers and all users of iHELP mobile application within a radius of 300 meters (The radius can be configured).	(Ogorevc and Lončarevič 2014)
	WBSN and mobile app.	**PEACH** integrates various bio-sensors in a WBSN (including blood pressure sensors, respiration sensors, and skin conductivity sensors) to detect alterations of physical conditions and dangerous health situations. It assists user by quickly create an ad hoc rescue groups of nearby volunteers.	(Taleb et al. 2009)

This technology allows care cost-saving, because mobile technologies have a great potential to transform healthcare and clinical intervention, especially in assisting elderly people with chronic diseases to live independently (between $1.96 billion and $5.83 billion in saved healthcare costs worldwide by 2014 (Chiarini et al. 2013)). Just a simple example on how to face the shortage of expert caregiver, the task of a nurse that monitors the health status of an elderly person each day can be alleviated by using body sensor network system. These solutions usually work in indoor and outdoor environments. Table 3 depicts well-known existing systems created to assist elderly people in diverse health issues, including cardiovascular, diabetes, hypertension, and Parkinson diseases.

Following, we exemplify the technological part that consists of different technique phases illustrated in Figure 4 as a framework procedure, to reach the whole goal of assistive technology.

5 CONCLUSIONS

Nowadays, there is great pressure to handle the situation of ageing people in our society, since most of them live alone and with no accompanying family member. Therefore, a solution as moving to healthcare facility can take place to support and provide care to them, however some negative emotional and economic impacts may arrive and at the end this solution may not be the best. Thus, assistive technology is an advantageous option for elderly people. This population sector is vulnerable to several major risks. We presented in this paper the results of our study on risks affecting elderly people in outdoor activities of daily living. The results of our study reveal that the most addressed risks by ICT are fall, wandering, and health issues. We reviewed in this paper these three major risks, and discussed related assistive technology. We also proposed a framework that illustrates the logic of handling risks using assistive technology.

The recent advances in pervasive, mobile and wearable technologies opened new perspectives to enhance elderly people quality of life, by assisting them in activities of daily living. We have presented in this paper interesting representative examples of recent assistive technology linked to outdoor risks. Still, these solutions are fragmented and more research on combined ubiquitous assistance services is needed to cover the need spectrum of elderly people. An interesting proposition could be an integrated service platform that accommodates safety assurance, health support services, and daily activity assistance. Such platform could take care of anomalous events detection, daily activities tracking/assistance, and health status monitoring. (Lin et al. 2012). This platform could leverage stationary sensors deployed in living environments and mobile sensing artifacts carried by elderly people. In this context, our team aims to provide elderly people with a comprehensive assistive system that manages risks. We are working on extending our mobile platform named PhonAge (Abdulrazak et al. 2013) to manage risk situations. We also are working to cover lager spectrum of risks that affect elderly people such as, nutrition, crime, and infection.

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