POPULATION AGEING AND ICT
An exploratory review of technology innovation trough digital applications

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Abstract: The multidimensional process of physical, psychological, and social change produced by population ageing affects not only the quality of life of elderly people but also of our societies. Some dimensions of population ageing grow and expand over time (e.g. knowledge of the world events, or experience in particular situations), while others decline (e.g. reaction time, physical and psychological strength, or other functional abilities like reduced speed and tiredness). Information and Communication Technologies (ICTs) can help elderly to overcome possible limitations due to ageing. As a particular case, biometrics can allow the development of new algorithms for early detection of cognitive impairments, by processing continuous speech, handwriting or other challenged abilities. Among all possibilities, digital applications (Apps) for mobile phones or tablets can allow the dissemination of such tools. In this article, after presenting and discussing the process of population ageing and its social implications, we explore how ICTs through different Apps can lead to new solutions for facing this major demographic challenge.

1 INTRODUCTION

Population ageing has become one of the major challenges for the future of our societies. In Europe, in the last three decades, birth and death rates have gradually decreased while life expectancy has significantly increased. The Eurostat's population projections suggest that the number of older persons in the EU-27 will increase to such an extent that there will be barely two persons of working age for each person aged 65 or more by 2060 (Eurostat, 2013). Beside persistently low fertility rates, strongly linked to the progressive inclusion of women in the labour market, improvements in the quality and availability of health care are likely, at least in part, to explain the process of population ageing.

The emergence of the so-called "information society", "knowledge society" or "network society" – a society characterised by a widespread dissemination and use of new information and communication technologies (ICTs) in all spheres of life as well as by an increasing technological capacity to store and exchange more and more information in an almost instantaneous manner – has taken place at the same time.

Currently, ICTs affect not only the way our societies are organized but also how we obtain the information, work, communicate, understand and interact one with each other. More than 50 percent of the European population uses Internet daily, though around 30 percent have still never used it at all. Moreover, elderly and disabled persons face particular difficulties in benefiting fully from new digital content and services. Since more and more daily tasks are carried out online, everyone requires enhanced digital skills to participate fully in society (Digital Agenda for Europe. A Europe 2020 Initiative, 2014a) Exclusion from information or knowledge-based society on the basis of age, gender, origin or socio-economic status represents a new form of social exclusion, the so-called digital divide (Csatells, 2004; van Dick, 2012) This new form of social inequality requires an appropriate response from state-based and international institutions, which must take into consideration the global development of new technologies in order to distribute their benefits to the whole society, including the elderly population. Accordingly, the EU Digital Agenda through its Pillar VI aims to achieve a better distribution of ICT equipment and use, and thus tackle the digital divide at the European level (Digital Agenda for Europe. A Europe 2020 Initiative, 2014b).

This work focuses on providing an exploratory analysis of two basic issues: the population ageing and the arrival of the Information Society, with the aim of investigate how biometric technology through ICTs can be used in order to improve the quality of life for elderly people.

This paper is organized as follows: After this introduction, ICT and ageing are presented in section 2, while section 3 is devoted to Independent Living Services overview. Section 4 focuses on Biometrics for health and an overview of apps for health and diagnosis are presented in section 5. Finally, conclusions are presented in Section 6.

2 ICTs AND AGEING

A radical change in disease and death patterns has occurred in deep relation with population ageing. Improvements in medications, rehabilitation and health systems have contributed to a delay in disability and death as well as to a shift from infectious and parasitic diseases to chronic and degenerative diseases. This global epidemiological change is more pronounced among the elderly, degenerative and chronic diseases being their primary diagnose or cause of death.

Among EU's main mortality causes, we could mention cardiovascular diseases (such as coronary heart disease), hypertension, stroke, diabetes, cancer, chronic obstructive pulmonary disease, musculoskeletal conditions (such as arthritis and osteoporosis), mental health conditions (mostly dementia and depression), blindness and visual impairment (World Health Organisation 2011).

Population ageing represents both, a physical and social process. From a biomedical perspective ageing is the final stage of the life cycle of a human being, which after a variable period of time leads to his/her death. But it is not only age that marks individuals as elders. It is also a social construct resulting from a social agreement to allow individuals to stop working after a certain number of years or a determined age. Various scientific advances have created a scenario where the final stage of human life might be extended to unexpected limits. For example, a person may nowadays retire around the age of 62 and die around the age of 85.

According with the World Health Organisation, active ageing refers to "continuing participation in social, economic, cultural, spiritual and civic affairs, not just the ability to be physically active to participate in the labour force. Older people who retire from work and those who are ill or live with disabilities can remain active contributors to their families, peers, communities and nations" (World Health Organisation, 2014 Specific policies have been designed to allow elders to remain independent and active as they age, while prevention policies have tried to improve their quality of life as well as to balance family and state's role when caring for people in need of assistance.

In this scenario is where we can place the Independent Living Services (ILSs), which are presented in the next section.

3 INDEPENDENT LIVING SERVICES (ILS)

Independent Living Services (ILSs) have been designed to assist people in gaining independence as well as communities in eliminating barriers to independence. ICT-based Independent Living Services enable people to lead a more independent and participatory life through the use of ICTs. A Life Course Approach to Active Ageing assumes that older people are not a homogeneous group and that individual diversity tends to increase with age (World Health Organisation, 2012) Interventions that create supportive environments and foster healthy choices are important at all stages of life. As individuals age, degenerative and chronic diseases become the leading causes of mortality and disability across the world. These diseases are more common in the later life cycle and are costly for individuals, families and states. Yet, many of these diseases are preventable or can be postponed.

According with the Europe 2020 strategy, the Innovation Union initiative aims to improve framework conditions and access to finance for research and innovation so as to ensure that innovative ideas can be turned into products and services that create growth and jobs. In terms of population ageing, Europe needs to work on the detection and diagnosis of age-related diseases and also on the development of medicines and treatments to prevent these diseases.

Innovative solutions, including ICT technologies can play a crucial role because they have the potential to provide high-quality, personalized medicine and health (social) care, while increasing the efficiency of our health-care system.

European Commission's support for innovative research in the health care sector has been strongly affirmed in order to develop:

- New medicines
- New treatments or diagnosis tools
- New institutional or organizational approaches
- New solutions that allow a better quality of life for the elderly

4 BIOMETRICS FOR HEALTH

Biometric systems, given their potential to collect any kind of information about any biological organism or system, have been widely and mainly studied for its use in security applications. As such, most scientists have restricted discussions about biometrics to these kinds of projects. Nowadays, other applications such as biomedicine, psychology and/or forensic applications are using biometric information in order to get innovative solution and better results. However, most solutions today operate on different methods like the use of multivariate processing that can reach specialised systems to provide possible better conditions for image processing.

Today, people are living longer than ever, largely due to the last advancements in medical technology. Many of the most recent life-saving applications entail technological solutions that can also be used in our everyday lives. Those who are not familiar with biometrics or another related area of information technologies usually think of biometric programs as either based on fingerprint data or iris scanning. While these (as well as computer image processing of facial features) have been the basis of biometric security advances, they are not the only ways to collect and use data about a specific person. Some new biometric programs are now using information that is more abstract, what we might call "physical-behavioural" information, to identify a certain individual. A great example is the new development of a seat that can tell who is sitting in the seat by measuring the weight balances and other signals that come from a sensor-equipped pad showing data related to spinal alignment, body mass and balance and positioning tendencies. These advancements bring technological devices ever closer to our hearts - literally - as well as to our eyes, skin and other organs. As such, biotechnology, or the integration of technology with the human body, is becoming more and more widespread.

4.1 Cognitive impairments as an example

Biometrics focused on people includes a large group of applications, being the most important health and safety ones. While both fields have traditionally been approached separately, there are interactions between them.

With the increasing of life expectancy, problems related to cognitive impairment become every day more important. All those impairments are clearly visible from the measurement of behavioural biometric signals (voice, signature, writing, gait, etc.). Moreover, the aging of individuals affects recognition rates of biometric security systems.

In health biometrics our interest is to have quantitative measurements to indicate the state of health of the person. Especially in the case of diseases for which there are no biological markers and in which early diagnosis is difficult and is usually made from examination of the cognitive abilities of the individual. In such cases, a computer -based analysis and signal processing can significantly improve the assessments made by experts from the health, since most of the time their assessments are more qualitative than quantitative.

In biometric measurements we are interested with robust features along the time, and stable against changes in health. Therefore, the objective should be to address biometrics from a global point of view taking into account the natural process of ageing in order to adjust the systems that can help us to early detect cognitive impairments.

Various researchers have explored different solutions to help on the early diagnose of Alzheimer's disease (AD) using continuous speech signal (Lopez-de-Ipiña et al., 2013a). They have analysed non-invasive methods based on continuous speech and used them for designing an automatic system that can provide medical doctors another point of view for the early diagnosis of AD.

On the other hand, Emotional Temperature (ET) is presented as a new parameter, combined with other traditional speech parameters, which can improve and facilitate the early diagnosis of AD (Lopez-de-Ipiña et al., 2013b).

Handwriting signals have also been used for cognitive impairment detection. For example, some authors have explored in-air and pressure information recovered by a graphical tablet which provides up to 5 different parameters: azimuth angle, elevation angle, pressure, X-coordinates and Y-coordinates (Faundez-Zanuy et al., 2013). Online drawings performed by elderly people (control group) and AD patients can be used in order to design a non-invasive system for dementia diagnose.

5 APPLICATIONS

5.1 Health Apps

A wide range of health applications have been developed across the world in order to help out different user groups.

Health applications represent a technological tool to help informing and supporting people in the self-management of their health and wellbeing. Some of these apps can prove to be extremely useful for elderly people in terms of self-empowerment and self-care. They may thus endorse an active and healthy ageing for this group of users. This general panorama of existent health apps serves us to identify and classify useful and reliable apps by user groups. Scrutiny of these apps also helps us to discover their main characteristics, their strengths and their weaknesses in order to promote innovative and efficient apps for the elderly people.

The following health apps are of general use. The main users are the patients (actual and potential), the social inclusion agents (family, medical professionals) and, in some case, both patients and social inclusion agents. These apps include various functionalities like:

- To improve communication, access patient's medical records or supply information on different symptoms or disabilities in case of accident or emergency;
- To optimize doctor patient communication;
- To raise awareness of end-of life issues;
- To access general medical information and assist in navigating around basic healthcare issues;
- To help improving attendance in consultation and offer medical guideline (pathologies, medications, dosages, interactions, dose calculation tools, diagnostic comparisons);
- To store, share and track medical records;
- To help take medication on time and keep track of the medication;
- To help manage pain and track medications, side effects, symptoms of pain, and triggers;
- To locate pharmacies in the user's local area and communicate directly with a chosen pharmacy, to enquire whether products are in stock;
- To assist in diverse exercise activities;
- To self-diagnose symptoms, find doctors and facilities, and connect to hotlines;
- To monitor movement and determine the lightest sleep phase for wakening-up;
- To locate accessible toilets while travelling around.

5.1 Diseases and Disabilities Apps

These health apps have been developed for different users in case of particular diseases or disabilities. Most of these apps have been designed mainly for patients' use (e.g. actual and potential patients):

- To help cope with daily living;
- To assist with diagnosis, treatment and care;
- To help travelling around, for example, in the case of disability mobility;
- To provide patient information;
- To help detect, rate, track and improve disease/disability through self-monitoring;
- To cope with society's attitudes to disease/disability, for example, in the case of chronic fatigue syndrome, communication disability, deafness, etc.;
- To improve communication, for example, in the case of communication disability, deafness or visual impairment;
- To provide information on nutrition and diet, for example, in the case of diabetes, inflammatory bowel disease or kidney disease;
- To help remember, manage and organize everyday lives, for example, in the case of mental health problems.
- Some health apps have been designed only for caregivers' use (e.g. carers, parents, family, friends and medical professionals):
- To help cope with daily living;
- To offer support for symptoms and disabilities.
- Other health apps have been designed to serve both patients and caregivers:
- To provide patient information;
- To assist in diagnosis, treatment and care.
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	Patients	Caregivers	Patients and caregivers
Accident and Emergency/Addiction	In Case of Emergency (Android, Blackberry)	BHF PocketCPR, ICE (Android, Apple); Pocket First Aid & CPR (Android, Apple);RCP & Asfixia (Android, Apple); Trygfonden Hjertestart [Tryg Foundation Heart Start] (Apple); U-Turn (Android, Apple)	112 Iceland (Android, Apple)
Doctor-Patient Communication			Fodspor [Footprints] (Apple, Android); Medipal (Apple, Android); Tyze (Apple)
End-of-life issues	Legacy Organiser (Apple)		5 things to do before I die (Facebook)
Exercise	Body Fitness Pro (Android); CardioTrainer (Android); Global Corporate Challenge (Apple, Android); Healthy from O2 Health (Apple); Nike+ Running (Apple, Android); Pedometer (Apple, Android); Yoga Poses (Android)		
General Healthcare information	HealthTap (Apple, Android)	IDoctus (web, iphone / ipad, android)	FarmaciaPlus (Apple)
General Medical Information			mediLexicon (Apple, Android); Speed Anatomy Lite (Quiz) (Apple, Android)
Medical Records			Capzule PHR (Apple); MyMedRec (Apple)
Medication Reminders	Dosecast (Apple, Android); Dr.DRIN; Med Minder (Android); OATBook (Apple); Pill Reminder Pro (Push Notifi cation) (Apple); Pillboxie (Apple); Refi lls App (Apple); RxmindMe Prescription (Apple)		Pillbox (Apple)
Pain	My Pain Diary (Apple): Chronic Pain Management (Apple, Android); Pain Care		
Pharmacy finder	Apo-App (Android)		
Self Diagnosis	iTriage (Apple, Android); WebMD (Apple, Android).		
Sleep	Sleep Cycle Alarm Clock (Apple)		
Toilet finder	Accessible Toilet Guide (Apple); Porselensguiden [Toliet Guide] (Apple, Android); Toilet Finder (Apple, Android); Wheelmate (Apple)		

Table 1. General Healthcare Apps

	Patients	Caregivers	Patients and caregivers
Alzheimer	AlzNav (Android); Brain Map (Apple); BrainyApp (Apple); Lumosity Brain Trainer (Apple)	Alzheimer App (Android, Apple); MobiCare (Apple)	
Ankylosing Spondylitis	Back to Action (Android, Apple)		iAnkylosingSpondylitis (Apple).
Anxiety and stress	Colour Therapy Anti Stress (Android); Headspace (on-the-go) (Apple, Android); Live Happy (Apple); Stress Tips (Android, Apple)		
Arthritis	ArthritisID (Apple); Pauseboogie fra Gigtforeningen (Android, Apple); RheumaTrack (Android, Apple); Tip Share (Android, Apple)		
Asthma and Allergy	MyAsthma (Android, Apple); Pollenvarsel (Android, Apple); Sussex Air (Android, Apple)		AsthmaPulse (Apple); AsthmaTrack (Apple)
Cancer	Borstkanker [Breast cancer] (Apple); Cancer iOncolex (Apple); Ovarian Cancer Symptom Diary; Skin Scan (Apple); UMSkinCheck (Apple)		Ecco CanCer (Android, Apple)
Chronic fatigue syndrome	ActiveME (Apple); CFSMapp (Android, Apple)		
Communication Disability	HelpTalk (Android); Phrase Board (Apple);Predictable (Apple); Proloquo2Go (Apple); SmallTalk Aphasia – Female (Apple); SmallTalk Intensive Care (Apple); SmallTalk Pain Scale (Apple); Speak it! Text to Speech (Apple); Talkforme (Apple); Verbally (Apple)		
Continence	Bladder Pal (Apple, Android)		
Deafness	Dragon Dictation (Apple); Hearing-Check (Apple); myFriend Mobile (Android); Sorenson BuzzCards (Apple); SoundAMP R (Apple); Subtitles (Apple); Tap Tap (Apple)	Sign 4 Me—a Signed English Translator (Apple)	
Diabetes	CarbFinder (Apple); Carbs & Cals (Android, Apple); DAFNE Online (Android, Apple); Diabetes UK Tracker (Apple); OnTrack Diabetes (Android)Glucose Buddy—Diabetes Helper (Apple); Glucose Companion Free (Apple); HelpDiabetes (Android); iBGStar Diabetes Manager App (mmol/L or mg/dL) (Apple);		Journals of the American Diabetes Association (Apple);
Disability/Disability Mobility	Body Language – Expressions (Android); Dragon Search (Apple); Everyday Social Skills (Apple); Survival Signs & Words HD (Apple); Accessibility (Android, Apple); My DisabledGo London (Apple); Wheelmap (Andorid, Apple)		

Fibromyalgia	FibroMapp (Android, Apple)		
Heart	Blackouts Checkapp (Apple); iBP Blood Pressure (Android, Apple); Instant Heart Rate (Android, Apple); Know Your Pulse (Apple)		Blood Pressure Log (Android)
Inflammatory Bowel Disease	Colonoscopy Prep Assistant (Android, Apple); myIBD (Android, Apple).		
Kidney disease	KidneyDiet (Android, Apple); RENAL TRKRR (Android, Apple)		
Mental health problems	Angry Birds (Andorid, Apple); Mobilplanforalle (Apple, Android); Qcard (Appl); T2 Mood Tracker (Apple, Android).	Buddy (http://bit.ly/NjERtK)	Cognitive Diary CBT Self-Help (Android)
Neurological conditions			NeuroMind (Apple, Android)
Parkinson's disease	PD Life (Apple)		Parkinsons (Apple)
Stroke	FAST Test (Android, Apple)		
Visual Impairment	BIG Launcher (Android); LookTel Money Reader (Apple); VizWiz (Apple); Zoom Plus Video Magnifier (Android)		VisionSim by Braille Institute (Apple)

Table 2. Disease and Disability Apps

6 DISCUSSION AND CONCLUSIONS

As presented in section 5, there are various apps designed to help persons manage their health, diseases and disabilities, but also to assist caregivers and doctors in their daily activities.

Biometrics, even if it has originally been used for biometric identification of individuals and devoted thus to security applications, can be also used in healthcare. The goal would be to identify health problems (risky situation, impairment, body's feature, etc.) that can be faced through innovative technological solutions. For example, specific technology can be used for identification of cognitive impairments, as presented above. Speech or handwriting are just some of biometric traits that can be used, as presented in section 4, but also image processing, gait or others are also good candidates. Of course, biometric traits that significantly degenerate in time are not good candidates for healthcare digital applications, and neither uncomfortable procedures for elderly people like retina scan or others.

This article explored different uses of ICTs for maintaining or enhancing an active and healthy ageing and wellbeing, and provided an exploratory analysis of existent digital applications that elderly people can use in this aspect. The presented apps provide different services and help elderly people to improve their living conditions. Tables 1 and 2, even if not exhaustive, provide valuable information of existent health apps, according to the interested user.

In this scenario, biometrics has been presented as a technical tool to be considered for developers in order to design new apps using signal processing algorithms for health biometrics. For example, speech processing, handwriting, image processing and gait represent possible and interesting fields for further investigation and technology development.

Future work will include the design of new apps adapted to elderly people, and also the study of hardware devices (cheap and easy to manage) that could allow increasing the type of recorded biosignals. Arduino and Raspberry Pi will be explored to perform biometric and medical applications where body monitoring is needed. In these devices many kind of different sensors can be used: for example, pulse, oxygen in blood (SPO2), airflow (breathing), body temperature, electrocardiogram (ECG), glucometer, galvanic skin response (GSR - sweating), blood pressure (sphygmomanometer) or patient position (accelerometer).

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