Assistive computer vision: ten years of technological transfer and research with future prospects.

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Currently there is an increasing need for supporting ageing population as the proportion of population aged over 65 years will double by 2060 [1, 2]. According to the Statistical Office of the European Communities (EUROSTAT) by 2060 there will only two working people by one retired in EU countries [3]. Ageing also causes dementia and other mental disorders such as Alzheimer's disease. There will be 14 million people with dementia in EU by 2030 [4]. These facts is forecasted to have a profound effect on economics of the EU countries due to the fact that these countries already spend approximately a quarter of their GDP on social support programs. Moreover, nowadays society experiences the conditions of limited resources. Previous research has also shown that about 35% of people living in care homes could live independently at home or in supported housing by employing technological aids [5]. As the result there are more and more efforts invested into developing technologies aiming at improving quality and reducing cost of the support for elderly people.

One of these technologies is ambient assisted living (AAL) which enhances the quality of life of older and/or disabled people by using information and communication technologies. AAL systems analyse everyday actions of people such as cooking, eating, bathing etc. AAL systems perform actions such as monitoring activities of daily living (ADLs), prevention, detection and management of chronic conditions, mobility assistance etc. Evaluation of this information allows to recognise starting symptoms of dementia or support caregiver's work. There are two main components of the AAL technologies: sensors collecting data and data processors. Magnetic and presence sensors along with pressure mats are used to collect data, even though cameras are also considered. Sensors describe environment, individual and individual-environment interactions. Data processing system should be able to perform well in machine learning algorithms for object classification and other tasks based on input data [6].

However, the challenges related to using cameras observing both an individual and environment still persist: detection of relevant body parts in presence of various objects in surroundings of an individual and body parts occluding each other in the image. As the result there is a change towards egocentric camera perspective which is also supported by emergence of new technologies such as GoPro® and Google Glass™. Another approach is to use an individual facing camera such as Tobii® to track eye movements as people tend to look in direction of their action [7].

Video AAL (VAAL) systems can be used in fall detection as traumas related to falling cause significant financial burden to caregiving system. However, existing approaches for fall detection are still not perfect in real-world conditions. VAAL was also proposed to be useful in number of other approaches aimed at improving life quality of elderly people with chronic health conditions. The research by Poh et al. describes a method for contactless measurement of pulse rate from video [8]. It is also believed that in the cases, where physiological data is not available, changes in the patterns of ADLs can be used as an indicator of health condition alterations. In such systems VAAL can be used to track individual's position and then determine the changes in behaviour by constructing a probability distribution for each pattern. VAAL systems can also be used to improve safety of elderly people both from external dangers, i.e. burglary, or hurting themselves. Increase in research supportive VAAL technologies is also caused by significant reduce in the cost of cameras and great advances in computer vision algorithms [9].

On the processing stage due to large intra-class variation in object detection process most existing algorithms still perform unsatisfactory. Recognition of ADLs is still an unsolved problem, i.e. all existing methods

achieved accuracy less than 50%. The main reason for this is that unconstrained environments posing a number of challenges both on the sensor and processing stages. However, recent research has shown that convolutional neural networks represent an optimistic direction to improve accuracy for unconstrained action detection [6]. There is also a shortage of datasets to improve and test developing models. Privacy issue of obtaining video of ADLs makes it hard to obtain a lot of information.

As dementia is a common problem among elderly people a number of tools has been developed to tackle cognitive issues. Dementia caused by ageing leads to limitations in everyday mental tasks such as planning, information processing, understanding of social cues etc. Alzheimer's disease also causes memory problems and requires 24-hours care at later disease stages. Already developed technologies include aids to support planning and handle attention and memory issues along with the tools to tackle social and behavioural issues. Another popular research topic is the development of robots helping elderly people in independent living, mobility issues and providing companionship to relief social issues. As an example there is Aibo robot by Sony [10]. However, there are number of challenges in developing tools for supporting people cognitive problems. First of all, elderly people have habitual and psychological barrier in using computer and internet. For example, in UK only 42% of people aged over 65 used computer daily [11]. Technologies for the people with cognitive problems should also be easy to use and have reasonable cost.

There are various challenges to be overcome before AAL technologies can be widespread. Firstly, data privacy and protection should be considered. AAL systems capture everyday life of people including their activities at home. This requires clear definitions of data access for all people involved in care to be well thought through. Secondly, there is a dilemma of balance between privacy of people under care and the benefits of support. Studies of focus group's opinion suggest that they would agree to use VAAL if this technology could introduce real difference into their quality of life and safety. On the other hand as image processing and computer vision algorithms progress further VAAL systems will become more and more automated. However, as it was shown users frequently do not understand the difference between automated and man-operated systems. This leads to further psychological barrier in VAAL systems usage [9].

Making assistive technologies more accessible also requires their commercialisation at cost accessible for people aimed by these tools. The variety of problems which could be tackled by assistive technologies lead to relatively small market for each type of device and higher cost as the result. However, there are few ways to make the cost of these devices more accessible for elderly people in the future. Firstly, some problems may be solved by functionality included in mainstream technologies. In this case high volume production could reduce cost. This seems to be a feasible way for some problems such as planning issues as the focus group of mainstream devices also includes ageing population. For example, a dietary assessment tool working by sending photos of food using a smartphone to estimate a size of portion and its nutrition can support independent living or give additional information to caregivers and doctors [12]. Some progress along this was is also currently obvious - smartphones can be used by people with visual impairments. Secondly, specialised devices aimed at issues, which cannot be solved by mainstream devices, can be produced using base components produced to be included in mainstream devices [13].

In recent years there were significant advances in development of technologies for elderly people and people with cognitive issues in general. The developments are mainly supported by progress in computer technologies. However, currently there are still technological and social barriers to be overcome along an ongoing debate on inclusive methods of device design.

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