Virtual Environments and Cognitive Tests for Dementia Diagnosis

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ABSTRACT

Dementia is a syndrome characterised by the decline of mental skills such as memory, reasoning, language or perceptual interpretation. High rate of deaths and high cost for detection, treatments and patient’s care count amongst its consequences. The aim of this work is the creation of low cost and efficient tools to help with the detection of Alzheimer. In addition, current game technologies have proved to be a convenient tool for healthcare due to the flexibility to create certain situations provided by Virtual Environments (VEs). Therefore, our objective is the creation of novel e-health applications, accessible to all patients, using new affordable technologies combined with Human Computer Interaction (HCI) systems and VEs.

KEYWORDS

Alzheimer’s Disease, Dementia, e-Health, Early Detection, Executive Function, HCI, Screening Tests, Virtual Environments

1. INTRODUCTION

Dementia is a syndrome characterised by the decline of mental skills such as memory, reasoning, language or perceptual interpretation. Alzheimer is the most common type; one of the most noticeable symptoms is the difficulty in learning new information. In addition, when the disease advances, there are other symptoms such as disorientation, mood and behaviour changes; confusion about events, dates and places; suspicions about family, friends and caregivers; and difficulty speaking, writing and walking (Alzheimer’s Association, 2016). Dementia is characterized by the decline of mental abilities (Whalley & Breitner, 2009) and the expected lifetime is five years in average (Alzheimer’s Research UK, 2012). According to the World Health Organization 1.43% of the estimated deaths around the world in 2030 will be caused by Alzheimer’s disease or other dementias. One in three people that indirectly die as a result of dementia will be men and the remaining will be women (more women are affected as a result of a gender average lifespan). Dementia is irreversible and it deteriorate over time. Therefore, it is important to detect dementia at very early stages in order to reduce the deterioration speed. Furthermore, early detection is essential in order to allow the patient to obtain more benefits from the treatment and to inform them and their families beforehand about future difficulties. The worldwide cost of dementia estimated in 2010 was US$604 billion (Wimo & Prince, 2010) and it was estimated to increase 85% by 2030. Therefore, it is essential to develop affordable diagnosis and support tools to limit the increasing cost of dementia. One of the proposed initiatives is focused on the implementation of e-health solutions to reduce cost and to make the health systems universally accessible (Lewis, Synowiec, Lagomarsino & Schweitzer, 2012).
When it comes to detecting Alzheimer, different types of invasive and non-invasive tests are available. Invasive methods require obtaining data within the patient’s body. These tests are not always safe and comfortable for the patient and some of them are unbearably painful, such as blood extraction or lumbar puncture (Alzheimer’s Association, 2016; Han, Gruhl, Beckett, Dodge, Stricker, Farias & Mungas, 2012; Kadmiri, 2015). On the other hand, non-invasive tests are harmless and despite the fact that some of them require the use of external devices for a certain period, these methods are more user friendly during the diagnosis process (López-de-Ipiña, Alonso, Barroso, Faundez-Zanuy, Ecay, Solé-Casals, Travieso, Estanga & Ezeiza, 2012). Additionally, most of the non-invasive Alzheimer techniques can be applied at any location, such as at home without the supervision of technology or medical experts.

The most common non-invasive Alzheimer tests for diagnosis are cognitive tests. A well-known problem of these tests is their lack of adaptability according to the IQ of the patient, since most of the tasks that integrate an Alzheimer’s detection cognitive test usually are too simple to evaluate high IQ patients. However, the use of computerised tests helps to create intelligence adaptable cognitive tests (Wild, Howieson, Webbe, Seelye & Kaye, 2008). Moreover, based on the available technology, it is possible to design new types of tests that are more effective using for example virtual environments (VEs). Virtual environments provide additional advantages to cognitive tests, since it is possible to immerse the patient in a controlled situation, (Taekman & Shelley, 2010; Tarnanas, Schlee, Tsolaki, Müri, Mosimann & Nef, 2013; Weibel & Wissmath, 2011).

In this paper, the authors propose novel cognitive and executive function based, non-invasive screening tests for early Alzheimer’s diagnosis implemented as an e-health tool. The remainder of this paper is organised as follows: section 2 describes previous related work on Alzheimer’s diagnosis. Sections 3 and 4 describe a proposed methodology, details on the evaluation process and the obtained results; and in section 5, the conclusions.

2. PREVIOUS WORK

In this section, the authors discuss related work on Alzheimer. Early stage detection has significant importance in reducing the progress speed (Abe, Toya & Inoue, 2013). The main types of tests can be separated to cognitive and non-cognitive ones. Cognitive tests encompass methods that evaluate patients’ cognition. Non-cognitive tests are regarded as all other methods, invasive or non-invasive, used to detect and diagnose dementia.

2.1. Non-Cognitive Tests

Regarding the non-cognitive approaches, in (Alzheimer’s Association, 2016; Han, Gruhl, Beckett, Dodge, Stricker, Farias & Mungas, 2012) some of the methods used to detect dementia are based on defining potential biomarkers. These biomarkers have been proved an accurate indicator of the presence of Alzheimer (Alzheimer’s Association, 2016). Nevertheless, since obtaining these biomarkers require invasive techniques, these tests are usually painful. In addition, they are not validated yet in large groups as an accurate and reliable tool for Alzheimer’s disease detection so they cannot be used in medical clinics (Alzheimer’s Association, 2016).

Other non-cognitive techniques presented in (Unay & Ekin, 2011; Akgul & Ekin, 2010) that provide accurate results are based on Magnetic Resonance Imaging (MRI). These techniques compare the head MRI data of the patient with the corresponding data of patients with Alzheimer. Nevertheless, since acquisition of MR images involves the use of medical equipment that is not easily accessible and
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