ESTADO DEL ARTE DEL PROYECTO: “The Use Of Computational Techniques To Improve Compliance To Reminders Within Smart Environments – Phase 3”

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ABSTRAC: The aim of REMIND is to create an International and Intersectoral network to facilitate the exchange of staff to progress developments in reminding technologies for persons with dementia that can be deployed in smart environments. The consortium is comprised of an International network of 7 academic beneficiaries, 5 nonacademic beneficiaries and 4 partners from Third Countries, all of whom are committed to progressing the notion of reminding technologies within smart environments. The focus of REMIND is to develop staff and beneficiary/partner skills in the areas of user centered design and behavioral science coupled with improved computational techniques which in turn will offer more appropriate and efficacious reminding solutions. This will be further supported through research involving user centric studies into the use of reminding technologies and the theory of behaviour change to improve compliance of usage. Research objectives will be focused within the domain of smart environments. A smart environment can be viewed as having the ability to sense its surroundings through embedded sensors and following processing of the sensed information, adjust the environment through actuators to offer an improved experience for the inhabitant. Even though the availability, cost, size and battery life of sensing technology have all improved in recent years, the uptake of real smart environments has been limited. This is mainly related to the effort required to support the technical deployments and the lack of a business model to support a service provider capable of offering support to a large number of environments. In addition, there is a limit to the amount of scenarios which can be facilitated by such environments; this limit is directly related to the number of sensors available

MARCO TEÓRICO: The present project is based on the thematic axes Sensor Based Systems, Internet of Things, Softcomputing and Quality Function Deployment. These theoretical references cement the precepts that underpin the future developments proposed here. Below is the detailed description of each one. SENSOR BASED SYSTEMS Sensor Based Systems use Wireless Sensor Network - WSN, integrated by autonomous devices (sensors), distributed in a specific area on a large or small scale, with the ability to process and transmit information remotely across the electromagnetic spectrum, in a way effective and without loss of data, for the study of physical variables or environmentalconditions in real time (Buratti et al., 2009).WSN consists of the following components: sensors, sensor nodes, gateway, base station and the infrastructure of the wireless network that facilitates the connectivity between these components. Sensors are electronic devices responsible for capturing physical variables and converting them into electrical signals for further study and analysis.The sensor nodes, sends the data obtained by the sensor to the base station. The Gateway is responsible for linking different networks (a WSN network with a TCP/IP network). The base station collects data obtained by different sensors, and is based on a computer system or an embedded system. WSN has two notable characteristics: (1) capacity of self restoration, ie, in the event that a sensor node fails because its power was exhausted or any damage arose, the network itself will be in charge of finding alternative ways for the transmission of information to the base station; and (2) its integration capability, which allows it to interact with other technologies, whether wireless or wired. According to (Abd-El-Barr, Youssef, & Al-Otaibi, 2005) and (Nack, 2010) the main network topologies that define the distribution design of the nodes and gateway are Single-hop star, Multi-hop mesh and grid, and Two-tier hierarchical cluster. WSN allows the interconnection of several electronic devices (sensor nodes or mote), equipped with computing capacity, moderate cost and low power, which allows its operation without the need of external suppliers, interconnecting each other, without line of sight among them, through the use of different communication protocols such as Bluetooth, Wifi, ZigBee, IEEE 802.15.4 defined in (Standards.ieee.org, 2017) and (IEEE-SA & SOCIETY, 2011), 6LoWPAN (Kushalnagar, Montenegro, Culler, & Hui, 2007), (Hui & Thubert, 2011), (Gaddour et al., 2012), (Cama et al., 2012) and (Proskochylo et al., 2015), and the Constrained Application Protocol (CoAP), from which more information can be found in (Castro Heredia, 2014), (Peniak & Franekova, 2016) and (Mei & Xiao, 2016). These protocols can be integrated into the concept of IoT (Internet of Things) offering a repertoire of new activities in the daily life of the human being. INTERNET OF THINGS IoT The IoT was the name that Kevin Ashton, a researcher at MIT in 1999, coined the digital interconnection of the objects that surround us through the Internet. Providing them with an IP address that allows anyone, from any place and at any time, to access the information and control devices remotely, being able to establish networks of information exchange with other devices belonging to different networks, such as Indicates in (Colina et al., 2016). IoT represents a new evolution of the internet and thanks to its integration with everyday objects capable of collecting and distributing data, for its subsequent storage, pre-processing and analysis; allows you to generate information through the use of BigData tools. Despite the progress being made, there are still unresolved challenges, which threaten to delay the development of IoT, such as: the design of energy sources for feeding billions of tiny sensors, the transition from IPv4 to IPv6 and the creation of norms and standards that allow to regulate the correct operation of the equipments that are projected to future like part of the IoT (Evans, 2011). In order to overcome these problems, new operating systems have been developed, such as Contiki (Contiki-os.org, 2017) and (Farooq & Kunz, 2011), and TinyOS (TinyOS.stanford.edu, 2017), which can operate on embedded devices with limitations of hardware such as memory and computing capacity, providing the opportunity to establish communication between computers with a low power consumption without this affecting the properties of the network. For the implementation of the WSN have developed a variety of hardware platforms called mote, made up of microprocessors or microcontrollers, sensors, memory, radio transceivers and power supply, whether batteries or solar panels. It is essential to keep in mind that the characteristics of each depend on the manufacturer and the market niche to which they focus their products. With the expansion and growth of IoT, different types of motes have emerged, among them Mica2 (Crossbow, 2016), TelosB (MEMESIC, 2016), eKo (eKo PRO Series, 2016), Waspmote

("Libelium," 2011) and Z1 (Zolertia, 2016). Independent of the manufacturer, all have similar characteristics for their analysis and selection, such as operating frequency, power consumption, maximum transmission distance, memory capacity, number of ports for connection of sensors, among other parameters. The main objective is to capture, transmit and receive the data for later storage and processing. Applying techniques for the statistical analysis of the data, which favor the detection and identification of hidden patterns, helping to establish predictions and obtain valid conclusions, to make reasonable decisions regarding the determined behavior of a phenomenon according to (Fuenlabrada de la Vega Trucios & Fuenlabrada Velázquez, 2014). These techniques are, among others, the Kolmogorov-Smirnov test or KS, considered a normality test described in (Soporte Minitab, 2016), (Hugo, 2009), (Clemente, José, & Teresa, 2017) and (Pedrosa et al., 2014), and the Kruskal-Wallis test, described in (McKight, Najab, McKight, & Najab, 2010) and (Soporte Minitab, 2016), which is recommended to be used when populations from which samples were taken Are strongly asymmetrical. On the other hand, to evaluate the performance of the WSN network, a series of metrics are used to help determine network performance, evaluating channel capacity, delay dispersion or Jitter (Li, 2007), packet delay (CISCO, 2008), RTD Round-Trip Delay Time (Docmac, Silva, & González, 2013) and (Karn & Partridge, 1991), delay of buffer (EspañaBoquera, 2003) and (Piñeres-Espitia, 2015), throughput (Bai & Zhang, 2012) and (Olsson, 2014), and network convergence (IXIA, 2014), (Koubaa et al., 2011) and (Clausen & Herberg, 2010). The evaluation of these metrics in a WSN contributes to the identification of the segments where the network is presenting major inconveniences when establishing the communication process and the subsequent transfer of data. Depending on the intrinsic characteristics of the WSN in relation to its field of application, several specific metrics can be implemented to determine the quality of a network link. SOFT COMPUTING Soft computing is a branch of Artificial Intelligence that encompasses various techniques used to solve problems that handle incomplete, uncertain and / or inaccurate information. Soft computing is based on data mining, applying a set of techniques that allows the analysis of large repositories of data collected from different sources (eg WSN). The phases through which these data are passed are preprocessing (load balancing, normalization, operations with data instances), selection and extraction of characteristics, training, classification, grouping, association and evaluation of the quality of predictive processes (among others) . Data mining is a fast-growing area that emerged in 1989 (Xindong Wu, 2014), and has evolved to a large extent, thanks to the presence of artificial intelligence (Mohaghegh, S., 2016), implementing models that allow The detection of patterns from tagged and unlabeled data to a wide variety of applications (He Q., 2016), (Smaili, Mohaghegh & Kalantari-Dahaghi, 2015), (Wen. C, Lv. F, Bao, Z And Liu M, 2016) and (Jones DE, Ghandehari, H. & Facelli, JC, 2016). Pattern Recognition is a branch of computer science, closely related to artificial intelligence, which is responsible for identifying patterns and regularities present in the data, which seeks to build models with capacity for automatic learning. One of the clearest examples of the use of Pattern Recognition is (Benuwa, B., Zhan, Y., Ghansah, B., Wornyo, DK & Kataka, FB, 2016) who discuss motives and principles with respect To learning algorithms for deep architectures. On the other hand, (Lecun, Y., Bengio, Y. & Hinton, G., 2015) states that the Deep Learning allows computational models that are composed of several layers of processing to learn representations of data with multiple levels of abstraction . These methods have drastically improved the state of the art in speech recognition, recognition of visual objects and detection of objects, among others. Deep learning uncovers the intricate structure in large datasets by using the backpropagation algorithm. In addition, deep convolutional networks have brought advances in activities related to image processing, video, voice and audio. (Gutierrez, 2006) suggests that entering this field of computation is a challenge, given the inherent variability in the universal conception of human intelligence. Hence, Artificial Intelligence seeks to generate different tools (devices and computer programs) that support the tasks that require great human ability, to the point that the operation of these simulate intelligent behavior and facilitate the development of life (Huerta, 2009, p.18). QUALITY FUNCTION DEPLOYMENT (QFD) Quality Function Deployment (QFD) is a tool that provides a way of translating the customer requirements into the appropriate technical requirements for each phase of product production (Franceschini, 2016; Büyükozkan and Cifci, 2015). QFD is used to establish how and where product development priorities should be assigned. It also uses the “House of Quality” which is a well-known method to identify the customer needs for the design process and establishes priorities of design requirements to satisfy them (Büyükozkan and Cifci, 2015; Yan and Ma, 2015). The “House of Quality” is comprised of six blocks (Prasad and Chakraborty, 2015): * Customer Requirements (Whats) – A structured list of the customer’s expectations * Technical Requirements (Hows) – A set of important and measurable product or service characteristics or design specifications. * Interrelationships Whats – Hows – A set of symbols of numbers are used to represent the contribution of each customer expectation and technical requirement * Technical Correlation Matrix – A relationship between technical requirements is described to evidence what supports and impedes the product design. * Planning Matrix – In this zone, the customers’ requirements are quantified and prioritized according to their relevance. * Prioritized Technical Requirements – In this matrix, the technical requirements are valued and classified according to their importance. QFD has been widely applied to numerous areas for product development (Sahut and Kucerova, 2015). To implement QFD, it is necessary to apply four steps (Wang and Chen, 2012): * Step 1 – Translate marketing requirements into technical attributes. * Step 2 – Translate technical attributes into part characteristics. * Step 3 – Translate part characteristics into manufacturing operations. * Step 4 – Translate into manufacturing operations into product requirements

ESTADO DEL ARTE: Research objectives will be focused within the domain of smart environments. A smart environment can be viewed as having the ability to sense its surroundings through embedded sensors and following processing of the sensed information, adjust the environment through actuators to offer an improved experience for the inhabitant. People with mild dementia generally exhibit impairments of memory, reasoning and thought. As a result, they require varying levels of support to complete everyday activities and to maintain a level of independence. Yet for many a live-in carer is neither practical nor affordable. According to what is mentioned by (Kane, 2013) Around one-third of people with dementia currently live alone without this caring presence. In (Sugihara, 2015), is presented as problem of dementia, the probability of becoming cognitively impaired increases with age. There is an increasing need for caregivers, who are well-trained, experienced and can pay special attention to the needs of people with dementia. Additionally, it is mentioned technology can play an important role in helping such people and their caregivers. A lack of mutual understanding between caregivers and workers regarding the appropriate use of assistive technologies is another problem. In (chaurasia,2016) a wide range of assistive technologies have been developed to support the elderly population with the goal of promoting independent living. The adoption of these technology based solutions is, however, critical to their overarching success. In our previous research we addressed the significance of modelling user adoption to reminding technologies based on a range of physical, environmental and social factors. In our current work we build upon our initial modeling through considering a wider range of computational approaches and identify a reduced set of relevant features that can aid the medical professionals to make an informed choice of whether to recommend the technology or not. The integration of reminding technologies within the everyday lives of people with dementia has been shown to be a popular approach. Reminders are a core component of many assistive technology systems and are aimed specifically at helping people with dementia function more independently by compensating for cognitive deficits. These technologies are often utilised for prospective reminding, reminiscence, or within coaching-based systems.Traditionally, reminders have taken the form of non-technology based aids, such as diaries, notebooks, cue cards and white boards (Seelye, 2012). These traditional aids have been predominantly employed in order to help those with cognitive limitations to live more independently. Technology-based approaches to reminders have previously taken the form of pagers and audio reminder systems. NeuroPage (Zangwill, 2014) is an alphanumeric pager-based system that sends short messages to a pager, which is operated by a single button that permits a user to acknowledge receipt of the reminder. Neuropage has been evaluated with over 200 patients with a range of cognitive impairments, including dementia, and has been shown to be effective at assisting with prospective memory problems (Wilson, 1997, Wilson,2003, Wilson, 2001). Nevertheless, such 'low tech' solutions have been criticised for their lack of generalisability and inability to modify the solution to suit the needs or preferences of the user (Seeley, 2012). More recently, technology-based approaches have focused on delivering text-based reminders to mobile platforms via email or Short Message Service (SMS) messages. Correspondingly, studies have shown that SMS reminders can have a positive impact across the healthcare setting (Kannisto, 2014) including medication adherence (Vervloet, 2011), clinic appointment attendance (Guy, 2012, McLean, 2014) and patient self-management (De Jongh, 2012). Mobile technology continues to progress at a staggering pace, with many users now owning smartphones. Reminder applications have begun to leverage this new technology in order to deliver reminders using a range of multimedia formats, in conjunction with utilising the smartphone's integrated sensors and wireless communications. Within the research literature a number of smartphone applications have been described that focus specifically on people with cognitive impairments. (O'Neil, 2011) developed the Mobile Phone Video Streaming (MPVS) system, which provides video-based reminders for everyday activities. The application was developed through an iterative design process and evaluated with a cohort of 40 persons with dementia along with their respective caregivers. The TAUT (Technology Adoption and Usability Testing) project (Zhang, 2014) aimed to investigate the issues surrounding the adoption of smartphone-based reminding technologies by people with mild cognitive impairments. Described in (Hartin, 2014), a smartphone application has been developed for the Android platform and is designed to provide the user with an interface to schedule and acknowledge reminders for a range of daily activities. In addition to providing scheduled reminders, the application also records details of the user's interactions, such as when the reminder is acknowledged, the type of reminder and how many reminders the person has missed. These details are subsequently used to assess how well the user is engaging with the application and to provide insight into details regarding how the application is used. Initial results obtained from a study of 30 users over a 6-month period have indicated low rates of acknowledgment of reminders, with 70% of all reminders set being missed and only 15% of missed reminders being attributed to the smartphone being switched off (Cleland, 2014). Other authors as (Casey,2016) presents a brief review of the literature on the usefulness of robots for people with dementia; it also includes an overview of the ethical considerations that inform robot development and a description of a qualitative study which describes how people with dementia other key stakeholders helped to design and shape this robot. The autors (Kasteridis,2016) propose an investigation aimed at Risk of Care Home Placement following Acute Hospital Admission: Effects of a Pay-forPerformance Scheme for Dementia, the autors use English data from 2006/07 to 2010/11, present multilevel logit models to assess the impact of the QOF review on the risk of care home placement following emergency admission to acute hospital. Emergency admissions were defined for (a) people with a primary diagnosis of dementia and (b) people with dementia admitted for treatment of an ambulatory care sensitive condition. In the study carried out, 19% of individuals admitted to hospital with a primary diagnosis of dementia (N = 31,120) were discharged to a care home; of those admitted for an ambulatory care sensitive condition (N = 139,267), the corresponding figure was 14%. Risk factors for subsequent care home placement included older age, female gender, vascular dementia, incontinence, fall, hip fracture, and number of comorbidities. A COACH prompting system to assist older adults with dementia through handwashing is proposed for the authors (Mihailidis, 2008), Who mention that many older adults with dementia require constant assistance from a caregiver when completing activities of daily living (ADL). This study examines the efficacy of a computerized device intended to assist people with dementia through ADL, while reducing caregiver burden. The device, called COACH, uses artificial intelligence to autonomously guide an older adult with dementia through the ADL using audio and/or audio-video prompts. in this investigation six older adults participated with moderate-to-severe dementia. Handwashing was chosen as the target ADL. A single subject research design was used with two alternating baseline (COACH not used) and intervention (COACH used) phases. The data were analyzed to investigate the impact of COACH on the participants' independence and caregiver burden as well as COACH's overall performance for the activity of handwashing. (Kerssens, 2015) present a study for use the personalized technology to support older adults With and Without Cognitive Impairment Living at Home, in this study is tested the feasibility and adoption of a touch screen technology, the Companion, which delivers psychosocial, nondrug interventions to PWD in their home to address individual NPS and needs. Interventions were personalized and delivered in home for a minimum of 3 weeks.

Postintervention measures indicated the technology was easy to use, significantly facilitated meaningful and positive engagement, and simplified caregivers' daily lives. Although intervention goals were met, caregivers had high expectations of their loved one's ability to regain independence. Care recipients used the system independently but were limited by cognitive and physical impairments. In (Begum, 2013) describe a pilot study where a tele-operated assistive robot helps a group of older adults with dementia (OAwD) to perform an ADL, namely making a cup of tea in the kitchen. Five OAwD along with their caregivers participated in this study which took place in a simulated-home setting. The purpose of this study was to investigate the feasibility and usability of a robotic system in assisting the OAwD to perform ADL in a home setting. The findings from this study will contribute to achieve our ultimate goal of designing a fullfledged assistive robot that assists OAwD aging in their own homes. The assistive robots designed for people with dementia mostly focus on companionship. The authors (Nugent, 2011) presents the details of the evaluation of a mobile phone based video reminding system with 4 persons suffering from mild dementia. We gathered 101 days worth of usability data during an evaluation period of 5 weeks along with a qualitative collection of pre and post evaluation questionnaires. The results from investigation present have shown that out of 216 reminders delivered during the evaluation period only 18 of them were not acknowledged by the persons with dementia

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