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MIRATAR: A virtual caregiver for Active and Healthy Ageing *

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Abstract. Despite the technology advances in the field of virtual assistant and activity monitoring devices, older adults are still reluctant to embrace this technology, specially when it comes to employ it to manage health-related issues. This paper presents a work in progress for a virtual caregiver, based on the Internet of Thing paradigm, that employs different technological solutions for information gathering and intervention delivery. The ultimate goal of this virtual caregiver is to support people empowerment to actively contribute to frailty and multimorbidity management and risk mitigation. To this end, user acceptance and willingness to use the propose solution has to be ensured. This work in progress starts with the hypothesis that by embedding the proposed technology in a smart mirror device will improve user acceptance and willingness to use. This paper presents the vision and overall architecture and future work will address the evaluation of user acceptance and the use intention.

Keywords: Active and Healthy Ageing · Frailty and multimorbidity · Smart mirror

1 Introduction

The work in [7] defines care as "*the provision for the health, welfare and social well-being and needs of societies*". Care is therefore what eventually holds society

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together, and without which life could not be sustained [11]. According to the Report on care work and care jobs for the future of decent work of the International Labour Organisation [4], there are 381 million workers in the global care workforce, most of them women working informally, representing 11.5% of the total global employment. Despite its relevance, this work is characterised for being unpaid or low-paid. This contrasts with the fact that, care works are, according to the UN Human Development Report [21], what drives market economies.

Spain is one of the few EU State Member countries that have decided to leverage the care economy in its recovery plan to face the COVID-19 crisis. The Spain's Recovery, Transformation and Resilience Plan proposes [12], specific measures to modernise and strengthen social services, such as developing "*new networks of tele-assistance, modernise dependency care systems and develop new residential infrastructure that facilitates the autonomy of elderly people and dependents, and the reorientation of the long-term caregiving system towards less institutionalised, more customer-centric model which is better connected with the primary healthcare network*".

The digital transformation of the care economy demands a step-change from a disease to a person-centred care model, in which the focus is moved from hospital care to home and community care [19]. This paradigm shift is particularly important for frailty and multimorbidity patients because they require regular care and supervision that, when not appropriately delivered, lead to acute episodes and hospital readmissions. According to the WHO [20] "*at least 80% of all heart disease, stroke and diabetes and 40% of cancer could be prevented*" by tackling the most common risk factors underlying the most prevalent chronic conditions, such as unhealthy diets, physical inactivity, hypertension or obesity.

Frailty and multimorbidity (understood as the condition of suffering from two or more chronic conditions) are the most relevant challenges faced by healthcare systems. Whereas improvements in acute care are close to its maximum, people die due to a range of other conditions like frailty and chronic diseases that could be avoided through better prevention policies and more effective care [13]. Multimorbidity is indeed very prevalent, reaching up to 90% of people over 65 [13]. This is, at the same time, very challenging because different professionals are involved in the treatment, medication is complex and involves polypharmacy with high risks of drugs interfering one to each other, or poor medication adherence. On the other hand, frailty, defined as "*a medical syndrome with multiple causes and contributors that is characterised by diminished strength, endurance, and reduced physiologic function that increases an individual's vulnerability for developing increased dependency and/or death*" [18], presents a community-dwelling older adult's prevalence of 12%, although in people aged 90+ it may be higher than 35%. Frailty is gaining attention as an important predictor of health outcomes in older adults. More specifically, this factor has been associated with death, institutionalisation, falls, reduced mobility, hospitalisation, and increased dependence in basic and instrumental activities of daily living [2]. More importantly, frailty, is potentially reversible with appropriate healthcare and lifestyle interventions, such as exercise [10], diet [16], polypharmacy control, or thera-

pies against isolation. For all these reasons, frailty is actually considered the cornerstone of Geriatric Medicine and Healthcare for older adults [1].

The use of innovative technologies, such as wearable devices or virtual assistants, can play an important role in supporting the management of the aforementioned risk conditions. There are, however, limitations in the state of the art of such technologies that call for further research so that they can be successfully employed by older adults already dealing with multi morbidity and frailty. In this sense, off-the-shelf devices and Apps can be found for physical activity and weight management such as those of Fitbit [22], Apple Watch [3], Google Fit [17] or Xiaomi MiFit [8]. They all offer a range of functionalities for user engagement, monitoring, reminders for promoting a healthier lifestyle, etc. Most of these commercial solutions offer open APIs, so that third party applications can access the data they collect. So, efforts can be focused on what to do with the data rather than how to collect them. However, a recent study [15] concluded that there is little evidence that wearable devices, by themselves, could improve health outcomes in chronic patients, although they could improve motivation and physical activity. Most studies to date focus on healthy individuals rather than on those already suffering from a chronic condition or multimorbidity. On the other hand, the role that virtual assistants can play in improving motivation, engagement, and leading sustainable behaviour change may be essential for individual empowerment. From a technological point of view, voice assistants like "Hey, Siri", "Ok, Google" or "Alexa" are fully operational and have revolutionised the way we manage the interaction with our nearby devices and daily routines. However, little is known about both the willingness to use these assistants for health-related purposes and the aspects that contribute to their acceptance for these other purposes.

This paper presents a work in progress intended to provide a virtual caregiver to supports people empowerment to actively contribute to frailty and multimorbidity management and risk mitigation. To this end, the main risk factors negatively contributing to older aldult's health will be monitored, so that future risks can be predicted in advance, and appropriate interventions can be undertaken to prevent or mitigate them. The virtual caregiver proposed here, known as MIRATAR, runs on an innovative platform: a smart mirror. Mirrors, and more specifically their reflection, help us build our sense of self. For this reason, MIRATAR plans to exploit the human fascination for mirrors and the role they can play in enabling self-awareness. User acceptance and willingness to use is expected to be improved thanks to use of such a platform. Moreover, the smart mirror platform will run software solutions that will provide the virtual caregiver with the skills and required information to guide individuals towards an improved self-awareness and self-management of health.

This paper focuses in presenting the most relevant aspects of the virtual caregiver and it is organised as follow. First, Section 2 presents the vision for the MIRATAR virtual caregiver. Section 3 describes the most relevant technical details of the implemented virtual assistant. Finally, Section 4 presents the main conclusions drawn from this work in progress as well as the future works still

needed to effectively achieved a comprehensive platform for frailty and multimorbidity management and risk mitigation.

2 MIRATAR concept and vision

MIRATAR concept understands that a technological platform for integrated care, centred on frailty and multimorbidity management and risk mitigation has to address multiple dimensions and different roles, with different requirements. Figure 1 summarizes the MIRATAR vision.

Individuals or older adults will be willing to use the platform because it helps them to develop a greater sense of autonomous self-governance, and control over themselves and their condition. This will in turn drive change in behaviours towards healthier lifestyles, helps them in the management of chronic conditions and, ultimately, it gives them the assurance that any risk will be early identified and therefore addressed and treated timeously. Although the platform is particularly aimed at providing care for patients with chronic diseases and multi-morbidities, its use should not be limited to those suffering from disease. Instead, it should be an active and positive support for all individuals to achieve and sustain healthier lifestyles. Because individuals, especially those already retired from work, develop their lives around the home environment, MIRATAR have focused on providing solutions for the home context. More importantly, the home context should be the place where integrated care, required by chronic patients, should be carried out, in a self-managed manner or assisted by caregivers. This will not only contribute to the sustainability of the healthcare system, but more importantly to the quality of care received. In case it turns out that a person cannot be cared for at home anymore, the platform will be equipped with the possibility to warn about the risk that this moment might be near and provide information, to enable the users to instigate an informed discussion with their caregivers, physicians and close-ones early on. Due to the option to include data/information collected through the monitoring of health and lifestyle parameters, hospital admission might be reduced, and hospital discharges might be accelerated. This will not only help save cost but also enable better resource planning that can help save lives. Caregivers, healthcare professionals, and service providers will also be users of the MIRATAR platform. Caregivers and professionals will benefit from using the platform because of the relevant information it provides about the individual health and lifestyle. Medication intake, vital signs, physical activity performance are some of the aspects that both health and care professionals and caregivers will be interested in. The platform does also provide a place where to exchange information and knowledge with other professionals as well as to learn new evidence-based health and care pathways. Service providers will interact with MIRATAR in a double way, as service provider and data consumer. The platform should therefore implement the appropriate governance mechanisms to ensure that individuals, those who own the data, control, and manage who has access to their data. This will be

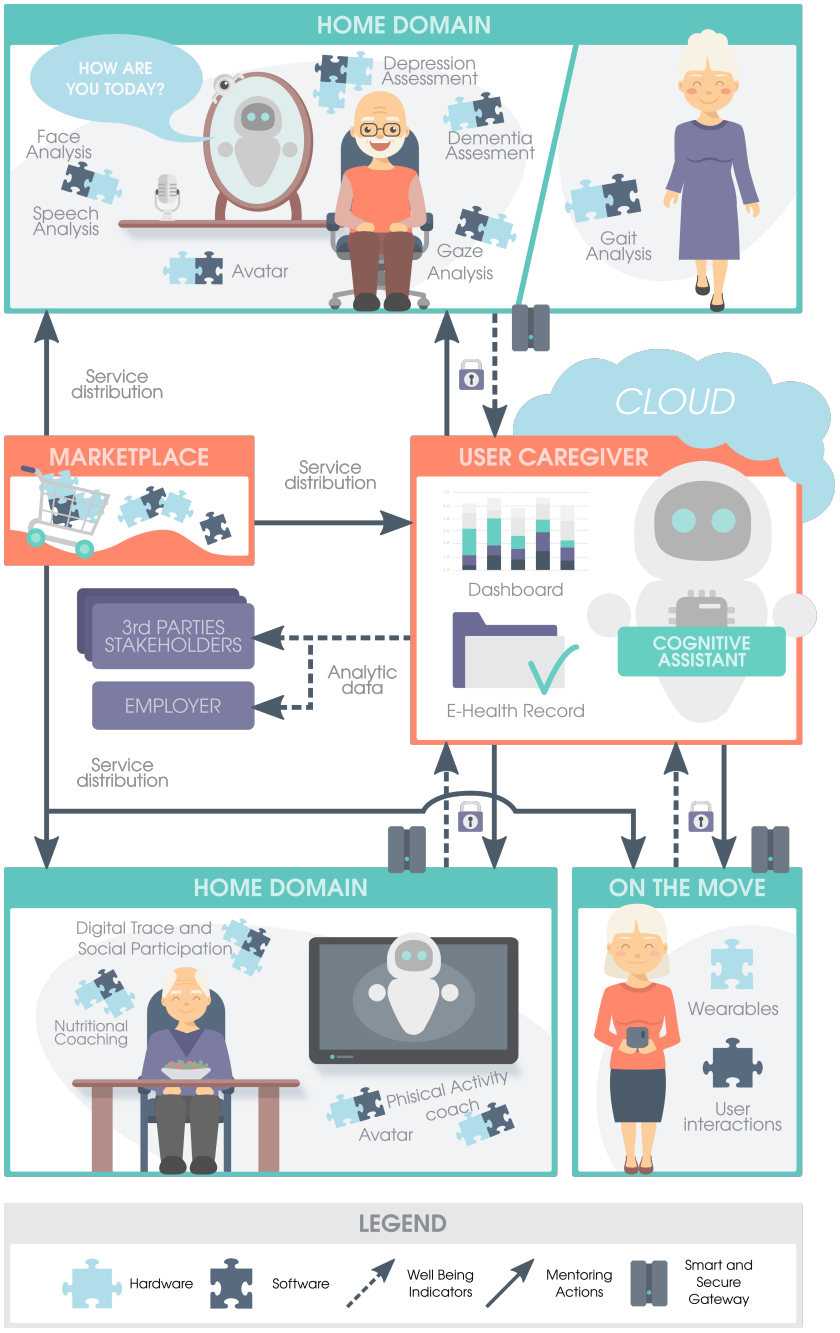

Fig. 1. MIRATAR vision

accomplished by an approach based on smart contract technology to ensure that individuals' privacy and legal rights are always in place.

The MIRATAR caregiver will provide a set of monitoring and actuation digital services capable of collecting information and acting through a large number of hardware devices and software services. These unobtrusive intuitive services will be tailored to older adults, using a user-centred approach aimed to avoid attention theft and physical impediments. The MIRATAR caregiver, installed at the cloud level, will hold a comprehensive overview of the individual's health state, patterns, profile, historic record, etc. The cloud-based solution is not however the only computational model considered by the architecture. The fog and edge level are also considered to address the actuation requirements (at the fog level) and the individual behaviour identification (at the edge level).

3 The MIRATAR virtual caregiver

The virtual caregiver needs information from wearable and environmental devices, whereas simultaneously it needs to run interventions supported in these devices. This is what traditionally has been referred to an Internet of Things (IoT) ecosystem. Such ecosystem has to be orchestrated by an interlocutor as there are different technologies involved in and, due to privacy and security concerns, the use of third party-clouds is not desired, nor even possible under certain circumstances. The role of the interlocutor will be played by a smart and secure gateway that, embed in the smart mirror as the one depicted in Fig 3, will have access to all technologies either wore by the user or deployed at the home environment. Fig 2 outline the different technologies the virtual caregiver will be equipped with. There are two different data flows. There are technologies intended to gather information about the user life style and state of health. Moreover, there are other technologies that are intended to deliver interventions (represented with dashed lines).

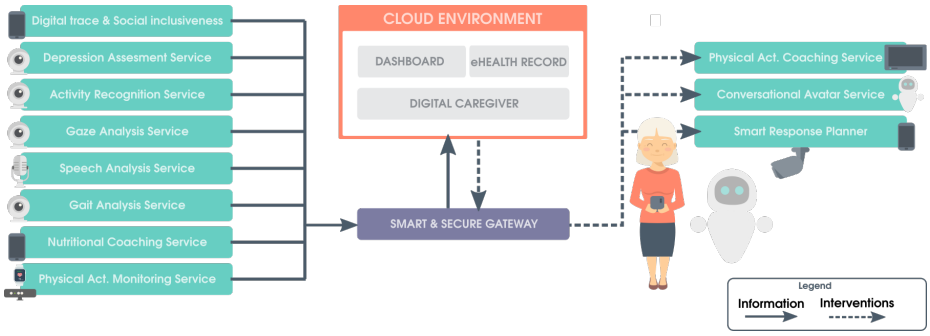

Fig. 2. The virtual avatar architecture

Based on the idea that the current healthcare approach, more disease oriented, has to evolve to a health promotion and disease prevention approach, this work spins around the idea that individuals should be responsible for their own health. To this end, individuals are encouraged to actively participate, assisted by innovative ICT technologies, in improving their health, well-being and quality of life. Key to achieving this will be promoting the development of greater personal autonomy in those individuals to take personal responsibility and accountability, by empowering their appreciation of their critical as well as experiential interests as part of their self-governance.

Verbal communication is gaining credit as an intuitive way of interacting with technology so, this approach stands out as a potential approach to successfully contribute to health self-management and self-governance. For this reason, the virtual caregiver has to be enhanced with conversational capabilities. This results in an innovative and multimodal assistant that will not only work on the smart mirror device but also in devices like phones, tablets, or desktop environments. This novel approach to delivering interventions intends to overcome the lack of engagement of traditional virtual assistants.

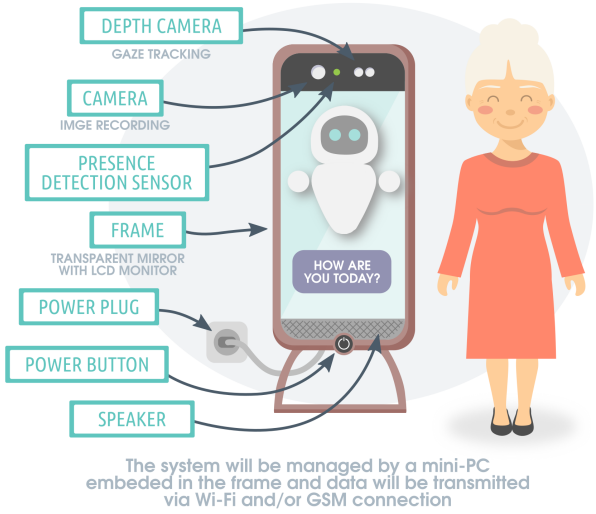

Fig. 3. The virtual avatar running in the smart mirror platform

The implementation of the virtual caregiver is supported in an open source toolkit known as Rhasspy [3]. There are different reasons supporting this option, in comparison to other solutions of the state of the art, which are compared and listed in Table 1 [6]. The same privacy and security concerns mentioned earlier

[3] https://rhasspy.readthedocs.io/en/latest/

when justifying the need for a smart and secure gateway is stated here to support the choice of open source solutions, running offline, over those commercial options requiring the use of an external cloud.

The proposed virtual caregiver assistant based on Rhasspy converts voice commands or requests into events, afterwards catered by the different services running on the smart mirror. It is therefore necessary to translate voice command into texts to which end the Deep Speech engine [5] has been employed. A dataset was collected, in Spanish language, employed to train the model. To this end, Fsticuffs [14] has been employed to train the intent recognition system. Further details of the voice assistant implementation and workflow are described in [9].

Table 1. Voice assistant comparisons

Assistant	Cloud-based	Works online	Open source
Google	Yes	Yes	No
Azurev	Yes	Yes	No
IBM	Yes	Yes	No
AWS	Yes	Yes	No
Houndify	Yes	Yes	No
Wit.ia	No	Yes	No
Vosk	No	No	Yes
Picovoice	No	No	Yes
Rhasspy	No	No	Yes
Snowboy	No	No	Yes
Almond & Ada	No	No	Yes
MyCroft	Yes	Yes	Yes

4 Conclusions and future work

The adoption of the MIRATAR virtual caregiver will empower individuals to take an active role in managing their health as well as to take responsibility in adopting healthier lifestyles in a sustainable manner so that changes can be adopted into the daily life of the individual. Nonetheless, these changes in habits and lifestyles will not necessarily offer immediate results, but rather these will be experienced in the long term and as a result of having lived a healthier, more self-directed life. This will eventually have an impact on the way individuals, health and care professionals and service providers interact. Also, adopting personalized and new health and care pathways will have an impact on the delivered quality of care. Overall, health systems will be less overwhelmed for different reasons. The knowledge and understanding of how frailty and multimorbidity interact will improve due to the data collected thanks to the proposed solutions. Moreover, machine learning and big data analytic will lead to relevant insights about how diseases behave, interact, or evolve. This will enable a better care and therefore, preventive measures that avoid, delay or minimize the associated risks.

MIRATAR will also impact the quality of services provided to society, in general, but more specifically to those that live in rural areas, hit by the depopulation phenomena. People living in these areas have to travel to access health services. For this reason, the innovative services proposed in this project, spinning around the smart mirror platform, are intended to provide at-home universal access to care.

Finally, future works are addressed to collect quantitative impact on health and well being that the proposed solution can have in older adults. To this end, a pilot study is expected to be conducted under the SHAPES project to evaluate such impact as a result of having used the proposed technology over a period of time.

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