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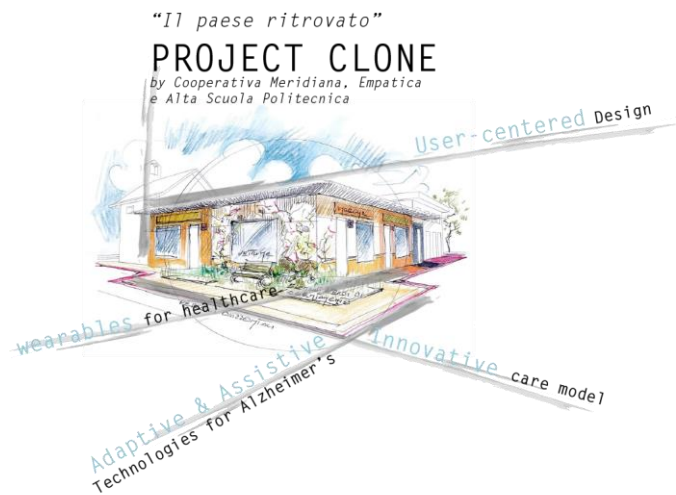
CLONE

Executive summary

Alzheimer's Disease (AD) is the most frequent form of dementia [1] that compromises the main cognitive functions of an individual. The most critical symptoms of Alzheimer's are crises, namely behaviours entailing psychomotor agitation and psychological alterations (such as aggressiveness). The frequency and randomness of crises require patients to be continuously supervised, which affects significantly their quality of life and causes substantial burden to caregivers, who provide physical and emotional support to patients on a daily basis [2]. The necessity of continuous assistance drives families to move their loved ones inside skilled facilities, which, in turn, imposes high costs on national healthcare systems.

This project aims at exploring the application of remote monitoring technologies to detect the onset of crises in patients affected by Alzheimer's. This system would entail the use of a wearable device to measure specific physiological parameters on the patient and would allow to signal the necessity of caregivers' intervention when needed, replacing the need of continuous assistance.

In particular, CLONE project brings two novel contributions towards this direction. On the one hand, it provides the first dataset of physiological parameters measured on Alzheimer's patients, that allows to look for potential relationships between physiological trends and the onset of crises. On the other hand, it proposes the design of a new smart wristband called Eclipse, which is the first wearable device specifically designed to fulfil the peculiar needs and vulnerabilities of Alzheimer's patients and their caregivers.



Caption Example (image dimension: 10,5x7 cm)

Key Words

Alzheimer's, Assistive Technologies, Wearables, Data Analysis, User-centred Design

**Project description
written by the
Principal Academic
Tutor**

This research work aims at investigating new technologies and tools to facilitate the monitoring of fragile people in the Ambient Assisted Living (AAL) context: in such a context, technologies for indoor localization are typically used to locate people and/or objects inside buildings; wearable devices allow the collection of physiological data of the patients/users; home control devices can be exploited to provide environmental/contextual data.

The CLONE project focuses on Alzheimer's patients, and analysed available technologies and methodologies facilitating their monitoring at "Il Paese Ritrovato", the first Italian village for the treatment of Alzheimer's disease. Il Paese Ritrovato is inspired by the pioneering experience of the care center Hogewey in the Netherlands and is organized as a small village, where patients lead an almost normal life, but in a protected context where they can get the necessary treatment.

In particular, CLONE tackled an important challenge: detecting possible crises of Alzheimer's patients from the analysis of physiological data collected by means of a wearable device. The project has pursued two novel paths towards this direction. On the one hand, the collection of the first dataset of physiological parameters measured on Alzheimer's patients through the use of a wearable device in a controlled environment. On the other hand, the realization of the first wearable device able to monitor those parameters and whose design features are specifically centred on the needs of Alzheimer's patients and people around them.

**Team description by
skill**

DESIGN TEAM

Marie Toldo: Marie analysed the requirements of the users through personas and scenarios. She also participated in the ideation of the new wearable Eclipse and performed the prototyping of the device through an iterative 3D printing process, up to the development of the final concept. Finally, she contributed to the evaluation of the final concept and to the assessment of its technical feasibility.

Ece Yuyar: Ece carefully analysed the users' requirements through personas and scenarios. She also provided an active contribution to the ideation of Eclipse. Finally, she performed detailed research on the most innovative materials for medical wearables and selected the materials for each component of Eclipse.

Maria Giulia Grillo Pasquarelli: Maria Giulia conducted a deep research on Alzheimer's disease and its main symptoms. She also contributed to the definition of personas and scenarios, to the ideation of Eclipse and to its final evaluation.

TECHNICAL TEAM

Pietro Crovari: Pietro drafted the Operative Protocol and the other legal documents for the experimentation. He also participated in the deployment of the IT infrastructure inside Residenza San Pietro. Finally, he carried out a preliminary analysis on the data collected, up to the extraction of a selected set of features.

Afnan Imtiaz: Afnan worked with Pietro to draft all the necessary documents for the experimentation and to deploy the IT infrastructure inside the clinic. After that, he entirely developed the server infrastructure of the system.

MANAGEMENT TEAM

Sara Bianchi: Sara carried out a deep market research on wearable devices, with a particular focus on medical wearables. She evaluated the alternatives and selected the E4 wristband from Empatica as the most suitable device for the experimentation. She also participated in the analysis of the economic feasibility of Eclipse and in its performance assessment.

Francesco Amato: Francesco conducted a detailed research on Alzheimer's and its main symptoms. He also analysed the state of the art for Assistive Technologies, with a focus on monitoring technologies for the treatment dementia. He also contributed to the assessment of the economic feasibility of Eclipse and of its relative performance with respect to other medical wristbands on the market.

Goal

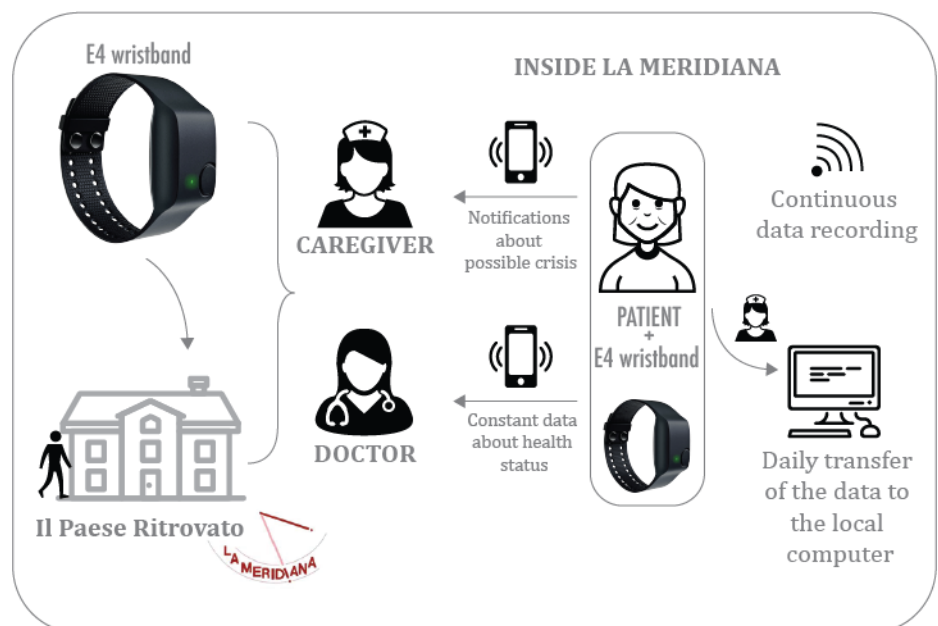
The main partner of this project is Cooperativa La Meridiana, an association targeted to elderly people that operates with clinics and nursing homes. In particular, in February 2018, La Meridiana inaugurated Il Paese Ritrovato, a pioneering village for the treatment of Alzheimer's disease. Inside Il Paese Ritrovato, non-invasive cutting-edge technologies are implemented for the invisible monitoring of Alzheimer's patients, with the aim of improving their quality of life.



Il Paese Ritrovato – Cooperativa La Meridiana

Inspired by Il Paese Ritrovato, project CLONE focuses on Alzheimer's and aims at investigating how technology can help reshaping the treatment of the disease. Among all the alternative directions of research, this project tackles the problem of crises, namely any behaviour entailing psychomotor agitation or psychological alterations. These are the most burdensome and dangerous Alzheimer's symptoms, as in many instances they are related to an aggressive or hostile behaviour.

In this challenging context, project CLONE aims at exploring the application of remote monitoring technologies able to detect the onset of crises in Alzheimer's patients. worn by the patient.



General Framework of Project CLONE

It aspires to develop a system that remotely detect crises through the analysis of physiological parameters measured by a non-invasive wearable device. A system like this would have the potential to alleviate the psychological burden suffered by caregivers, improve clinical knowledge, enhance safety and promote freedom of movements for the patients, all outcomes that are particularly relevant for the future of dementia care. Moreover, if applied in private contexts, monitoring technologies can also guarantee fragile people a longer permanence in their homes, with consequent long-term benefits for both them and their families and lower costs on national healthcare systems.

Understanding the problem

Alzheimer's Disease (AD) is the most frequent form of dementia [2] and can be defined as a severe progressive neurologic pathology in which the main cognitive functions of an individual are compromised. The likelihood of developing Alzheimer's increases significantly with the age. Therefore, the constant ageing of population has led to a much wider diffusion of the disease, which has become one of the biggest challenges of modern society. The World Alzheimer's Report [3] estimated that 46.8 million people worldwide were living with dementia in 2015, number that will almost double every 20 years, to 74.7 million in 2030 and 131.5 million in 2050.

Among all the symptoms of Alzheimer's, crises are considered particularly critical as they often involve aggressive behaviours. Crises become more frequent and random as the disease progresses, compromising the autonomy of the patient who needs to be continuously assisted. The necessity of continuous monitoring and the intensity of these symptoms, causes a strong burden on caregivers. Many studies reveal that they face dramatic increases in emotional stress and depression as AD progresses, which translates in more frequent health problems [4].

The high level of stress suffered by those providing help constitutes the main reason why families decide to move their loved ones inside skilled facilities. The early institutionalizations of the patients and the high number of caregivers needed to assist a single patient imposes significantly high costs on national healthcare systems and will soon become a problem for worldwide economies.

Exploring the opportunities

Assistive Technologies (AT) are considered one of the most promising available solutions for reshaping dementia care [2]. Indeed, they can help in reducing the burden on public finances through the delay or obviation of institutional care for PWD (People With Dementia). AT has also the potential to decrease the psychological burden on caregivers while enhancing quality of care [5] and increasing staff members' satisfaction in their work [6]. The number of publications in literature regarding AT for dementia has been considerably increasing in the past few years, as the disease is one of elderlies' problem most studied in the field of assisted technology care [7].

Wearable devices represent one of the most popular typologies of AT [8]. Indeed, medical wearables already cover a significant share of the overall market and are expected to grow exponentially, reaching more than 17.8 billion US dollars in 2021 [9]. Among the medical devices, some aim at gathering information on specific diseases, such as "Valedo" and "Lumo Lift" for skeletal system diseases, "PIP" for detection of stress level and "Embrace" for epilepsy. However, none of them currently addresses specifically Alzheimer's or other types of dementia.

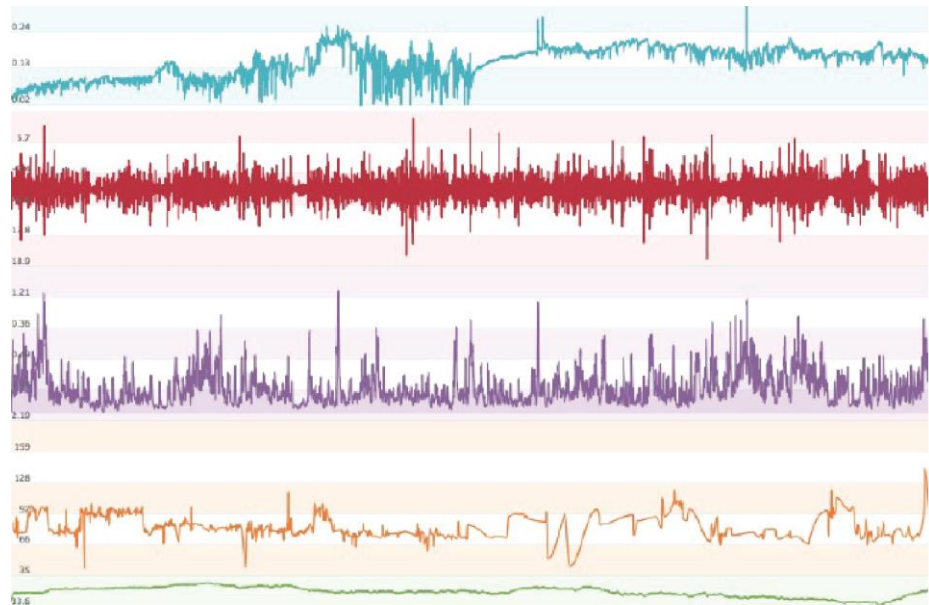
Project CLONE aims at developing a system able to remotely detect the onset of crises through the analysis of physiological parameters measured by a wearable device worn by the patient. However, looking at the state of the art, two main elements are missing. On the one hand, although several parameters have been assessed as relevant for Alzheimer's crises, there are still no evidences in literature about clear relationships between physiological parameters' trends and the onset

of crises. On the other hand, the market lacks a wearable device specifically addressing needs and vulnerabilities of Alzheimer's patients and their caregivers.

Generating a solution

Project CLONE brings two novel contributions to the application of remote monitoring technologies for the treatment of Alzheimer's and, specifically, for the detection of Alzheimer's crises.

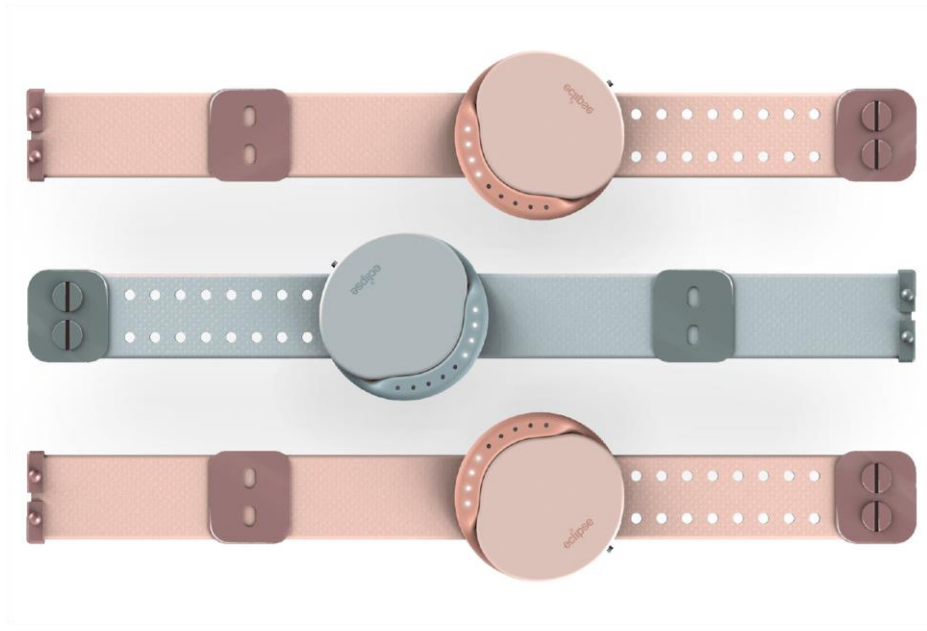
The first contribution consists in the generation of a dataset of physiological parameters measured on elderly affected by Alzheimer's. The dataset resulted from an experimentation conducted in Residenza San Pietro – a nursing home in Monza – where patients were equipped with a smart wristband, the E4 from Empatica¹. The data analysis subsequently performed allowed to extract from the data collected a selected set of features. They represent the ideal input for training multiple types of machine learning models, that may allow to look for potential relationships between physiological trends and the onset of crises. No analogous studies are present in literature even though research in this field is considered increasingly essential. The experimentation also showed the technology is sufficiently mature to be adopted in nursing homes environments and not only in simulations performed in laboratory, in terms of economical cost, reliability and ergonomics, both for the device itself and for the computer interfaces.



Data extracted from the Empatica E4 Wristband during a recording session

On the other hand, the experimentation conducted in the nursing home entailed the interaction of doctors, caregivers and patients with a technologically advanced device. Several aspects regarding their interaction with the E4 wristband emerged as critical, suggesting the necessity of a dedicated product. Eclipse, the second contribution of this project, is the first wearable designed to specifically fulfil needs and vulnerabilities of Alzheimer's patients, compensating for the lack of Alzheimer's specific wearables on the market. It embeds a particularly wide set of sensors while maintaining a non-intrusive design, overcoming the trade-off between features and intrusiveness. Several design features contribute to make the product unique including the attachable battery, that allows charging the device without interrupting the monitoring of the patient. Differently from the majority of AT for dementia [8]. Eclipse is a successful user-centred concept specifically developed inside a context that made evident the needs of the users and their verification.

¹ <https://www.empatica.com/research/e4/>



Eclipse Final Design

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