Mem. S.A.It. Vol. 96, 44

Memorie della

Towards an inclusive future: technologies and methods for Active and Healthy Ageing and Developmental Disorders

A. Carboni[1], M. Magrini[1], F. Pardini[1]

Institute of Information Science and Technologies "Alessandro Faedo" - ISTI-CNR – Area della Ricerca CNR, via G. Moruzzi 1, Pisa, 56124, Italy e-mail: andrea.carboni@isti.cnr.it

Received: 29-10-20204; Accepted: 20-01-2025

Abstract. This article presents an overview of the technological advancements and research initiatives in the fields of Active and Healthy Ageing (AHA) and Autism Spectrum Disorder (ASD). Through the integration of IoT platforms, AI-based systems, and sensor networks, several projects have demonstrated significant improvements in quality of life for elderly individuals and children with developmental disorders. In this article, we will reference projects conducted by the SiLAB laboratory of ISTI-CNR in these two fields, which are united by the shared emphasis on inclusiveness and the application of similar technologies. These initiatives emphasize personalized approaches to healthcare, rehabilitation, and monitoring, highlighting the potential of technology in creating inclusive environments. The article also consider the implications of European regulations, such as the GDPR and the AI Act, for projects dealing with sensitive data, stressing the importance of stakeholder engagement and ethical considerations in the development of these technologies.

Key words. AHA, AAL, ASD, Artificial Vision, Signal analysis

1. Introduction

The Signals & Images Laboratory (SILab) SiLAB (2024), part of ISTI-CNR ISTI (2024), is an inter-disciplinary research laboratory in computer vision, signal analysis, smart vision systems and multimedia data understanding. Among the various activities, a research line dedicated to supporting vulnerable individuals has been in place for many years. The laboratory has specialized over time in two main areas through numerous projects and activities: Active and Healthy Ageing (AHA) Sixsmith et al. (2014) and Autism Spectrum Disorders (ASD) Howlin (1998).

1.1. Active and Healthy Ageing

Due to demographic shifts in European countries, health and social care have emerged as critical challenges for many nations worldwide. The overall rise in the elderly population relative to the total population impacts both the current and future economic landscape. The scientific community has played a key role in addressing this issue by re-

searching and proposing solutions and technologies under the frameworks of Active and Assisted Living (AAL)Siegel & Dorner (2017) and AHA. These initiatives aim to develop tools and technologies that enhance the ageing process and the well-being of older adults, particularly those in vulnerable situations.

1.2. Autism spectrum disorder

ASD is a neurodevelopmental condition characterized by challenges in social interaction and communication. It is classified as a pervasive developmental disorder marked by a combination of three core impairments: difficulties in social communication, challenges in reciprocal social interactions, and atypical repetitive behaviors. Currently, there are no medications that can cure autism or directly address its primary symptoms; a significant portion of interventions emphasizes behavioral strategies, with the most recognized being Applied Behavior Analysis (ABA) Kanner (1943), which relies on repetitive patterns and reinforcement techniques. Other methodologies, such as the Developmental Individual Difference Relationship (DIR) Pajareya & Nopmaneejumruslers (2011) model, take a different approach. DIR operates on multiple levels of engagement, aiming to mitigate the core symptoms of autism through guidelines that include: (1) fostering connection to combat isolation, (2) promoting communication and flexibility to counter rigidity and persistence, and (3) encouraging gestures to reduce stereotypical and aggressive behaviors. In designing our system, we drew inspiration, albeit not strictly, from the DIR model.

2. Inclusivity and research in Europe

To effectively foster inclusivity in developmental disorders and active aging, it is essential to develop comprehensive services that encompass the design of accessible physical and digital environments, the creation of tailored support programs, and the promotion of a culture of respect and acceptance of individual differences. Several European projects have been instrumental in advancing this goal. The FIWARE FIWARE (2024) platform, for example, facilitates the creation of smart applications that can be customized for different needs, including smart cities and healthcare, while UniversAAL provided an open platform for the development of interoperable, digital solutions for elderly care and independent living. In more recent times, ACTIVAGE ACTIVAGE (2024), focused on using Internet of Things (IoT) technology to create smart environments that support older adults in maintaining their independence and improving their quality of life, while PlatformUptake.eu PU.eu (2024) analysed and supported the large-scale adoption of european open service platforms through the study of the state of the art and the creation of a platform for the evaluation of the uptake of new or existing platforms. In addition to these projects, there are several European initiatives specifically focused on autism and pervasive developmental disorders. The ASDEU (Autism Spectrum Disorders in the European Union) project Micai et al. (2022), for example, aimed to improve understanding and diagnosis of autism while promoting social inclusion and developing tailored policies. Meanwhile, AIMS-2-TRIALS A2T (2024) and its predecessor, EU-AIMS EU-AIMS (2024), represent major efforts to understand the biological mechanisms behind autism and develop personalized treatments through advanced research on genetics, neurobiology, and behavior. Other notable initiatives are the Activage Association ASSOCIATION (2024), which aims at promoting and drive the implementation and scale-up of products and services targeting Health and Active Living for all ages across Europe, and EaSI (European Association for Social Innovation) EASI (2024), which aims to create a network driven by the motivation of promoting social innovation among its members and finding new solutions for societal problems. By promoting cooperation between public and private sectors, these projects aim to break down barriers, ensuring that individuals with developmental disorders, autism, and the elderly can fully participate in society, with their needs met through both physical accessibility and digital innovation.

3. SILab activities in the field

At the SILab laboratory of ISTI-CNR, a long-standing research line has been dedicated to supporting vulnerable populations. These projects have focused on the use of emerging technologies to develop innovative solutions, leveraging technological advancements that, over the years, have led to the creation of increasingly powerful, non-invasive, and precise tools and sensors. The projects described in this section summarize the laboratory's main research activities in this area, showcasing its contributions to the development of technology-based interventions, particularly children with ASD and the elderly.

3.1. SiDOREMI

Since 2014, SILab has been specialized in the analysis and experimentation of gestural interfaces for the development of an informatics system able to generate sounds, music and graphics closely related with the body movement. SiREMI was an interactive auditory system presented in a playful format, designed to engage children with Autism Spectrum Disorder and their caregivers. A pilot study involved four children (ages 4-8), whose sessions were recorded on video and later reviewed by three psychologists. The psychologists completed observation grids for each session. The results of this pilot study indicate a significant increase in behavioral expressions reflecting relational development. The SiREMI Magrini et al. (2015) project was inspired by the DIR/Floortime model and was based on a video acquisition system using standard RGB video, processed in real-time for sound generation.

Thanks to this experimentation, the importance of transferring the session benefits to a familiar context became evident. To achieve this goal, a home version of the system, SiDOREMI Magrini et al. (2016), was developed in collaboration with the Telecom Italia Foundation TIM (2024). This version, based on more sophisticated technologies, was installed in patients' homes. With this version, families were able to follow the rehabilitative course in a home environment. The data produced during the "game" sessions were sent to a remote server, where they were analyzed by specialists. Furthermore, the home systems offered a video-chat function through which families could communicate directly with specialists. The home installation was completed by a system for monitoring sleep quality. The children involved in the project, who were diagnosed with high-functioning ASD, participated with great interest, and their sensory perception and interaction improved significantly.

3.2. SEMI

The SEMI Magrini et al. (2019) project builds upon the previous work done with SiREMI/SiDOREMI, enhancing it by introducing new modes of interaction, including visual elements. This Multichannel Expressive Interactive System was developed by the SiLAB, in collaboration with the MAiC Foundation in Pistoia. The project's objective was to support rehabilitation by encouraging children to perform various movement patterns in an engaging and enjoyable way. To achieve this, SEMI incorporated a series of interactive games, structured by difficulty levels and tailored to the sensory profiles of individual children. The primary beneficiaries were children aged 6 to 10 years with Autism Spectrum Disorder (ASD) and dyspraxia, who were receiving weekly rehabilitation treatments at the MAiC Foundation. The study was approved by the local ethics committees of each institution and was in accordance with the declaration of Helsinki. Each parent gave informed written consent before inclusion for participation and for publication of the clinical data.

3.3. Intesa

INTESA aimed to develop a suite of personal and personalized services to ensure the well-being of vulnerable individuals by incorporating highly configurable innovative technologies and enhancing their functionalities with advanced research and development capabilities in the fields of e-health, e-inclusion, sen-

sor networks, and data mining. The project involved the development of interactive software systems, designed in an exergame style, to stimulate the cognitive and motor skills of the users involved. The experimentation was conducted on a sample of individuals in a nursing home. Interaction with the system was contactless, through the real-time acquisition and analysis of videos from cameras equipped with depth sensors. The services were designed to be modular and independent but to utilize a common interface connected to a software platform dedicated to data collection and analysis. This platform was capable of identifying vulnerability conditions early and preventing their deterioration by monitoring changes in the individual's functional, clinical, cognitive, and psychological state.

3.4. ACTIVAGE

The H2020 ACTIVAGE initiative aimed to create the first "IoT for Active Ageing" ecosystem in Europe. AIOTES, the ACTIVAGE IoT ecosystem suite, integrated services that monitored daily activity and mobility, ensuring safety, security, and comfort within homes. AIOTES was deployed across existing IoT platforms and evaluated in twelve deployment sites across nine European cities by measuring specific KPIs (Key Performance Indicators) related to quality of life, economic impact, acceptability, and usability, involving approximately 8,000 end-users. Each deployment site developed a range of solutions, including exergames, sleep analysis systems, lifestyle monitoring, health monitoring, and the provision of personalized services for the people involved. These solutions were subsequently integrated into the AIOTES platform. The results of ACTIVAGE were also incorporated into various H2020 projects that leverage artificial intelligence for personalized early risk detection or integrated care assistance. In the H2020 PlatformUptake.eu project, AIOTES was selected as one of the 8 most significant platforms in the AHA/AAL research field.

3.5. PlatformUptake.eu

The PlatformUptake.eu project aimed to deliver an inventory of the state of the art and analyze the use of open service platforms in the Active and Healthy Ageing domain Carboni et al. (2023). This included both open platforms, such as UniversAAL and FIWARE, as well as partly-open or proprietary platforms developed by industry, and addressed the interactions between these platforms. To measure the impacts of such platforms and enhance their adoption, the project proposed a methodology for monitoring open platform development, adoption, and spread across Europe. It listed key factors that determined success or obstacles to their uptake by end-user groups, as well as the evolution of their ecosystems and stakeholder networks.

4. Stakeholder roles and data protection

European regulations such as the GDPR (General Data Protection Regulation) GDPR (2024) and the recent AI Act AI-ACT (2024) have significant implications for projects involving vulnerable individuals or the elderly. The GDPR is the primary regulatory framework for the protection of personal data in the EU. It imposes strict obligations on all organizations that collect, process, and store personal data, with direct implications for projects handling sensitive data concerning vulnerable individuals or the elderly. The AI Act, currently in the final stages of approval, is the first comprehensive regulatory framework for artificial intelligence in the EU. This regulation classifies AI systems based on their risk levels, imposing specific requirements for those deemed "high-risk" which could have a significant impact on fundamental rights, particularly for vulnerable groups such as the elderly or individuals with disabilities.

A proper definition and identification of stakeholders is crucial in the context of European projects involving vulnerable individuals or the elderly, especially considering regulations like the GDPR and the AI Act. This process is essential for several key reasons, in-

cluding compliance with regulations and the protection of rights, safeguarding vulnerable populations, personalizing and improving services, and managing risks. Engaging all key stakeholders not only improves project governance but also ensures that the proposed solutions are ethical, transparent, and genuinely beneficial for the end users.

Another important and often overlooked factor is the difference between privacy regulations and the perception of privacy by end users. GDPR is designed to protect personal data and ensure that the fundamental rights of EU citizens are respected in the processing of their personal information. However, the perception of privacy by users can be influenced by various cultural, social, and cognitive factors, which can significantly differ from the protections that regulations aim to provide. For instance, in AHA projects, particularly when cameras or wearable devices are involved, systems may fully comply with privacy regulations from both technological and legislative perspectives. However, they are often met with suspicion by users, which can lead to a decline in the quality of the data collected. A limited understanding of the technologies involved, the culture of consent, the perceived value of data and trust in technology can lower the perception of privacy in users. There is often a discrepancy between what regulations seek to guarantee and how users perceive the protection of their privacy.

5. Conclusions

The research and technologies discussed in this article illustrate the critical role that innovative systems play in improving the lives of vulnerable populations, particularly the elderly and individuals with developmental disorders. Several projects showcase the potential for AI and IoT platforms to enhance healthcare, rehabilitation, and daily living through personalized, non-invasive interventions. However, the success of these initiatives relies heavily on adherence to European regulations like the GDPR and AI Act, which ensure the ethical use of data and protection of individual rights. A key takeaway is the necessity of involving all stakeholders in the design and implementation phases to ensure the solutions are both effective and ethically sound, paving the way for a future where technology-driven inclusivity is a standard practice.

References

A2T. 2024, AIMS 2 Trials website, https://www.aims-2-trials.eu, accessed: (05/10/24)

ACTIVAGE. 2024, ACTIVAGE CORDIS website, https://cordis.europa.eu/project/id/732679/, accessed: (05/10/24)

AI-ACT. 2024, AIACT reference, https://artificialintelligenceact.eu/the-act/, accessed: (05/10/24)

ASSOCIATION, A. 2024, ACTIVAGE ASSOCIATION, https://activage-association.org, accessed: (05/10/24)

Carboni, A., Russo, D., Moroni, D., & Barsocchi, P. 2023, Frontiers in Digital Health, 4, 934609

EASI. 2024, EASI website, https://easi-socialinnovation.org, accessed: (05/10/24)

EU-AIMS. 2024, EU-AIMS, https://cordis.europa.eu/article/id/308441-euaims-towards-personalised-approaches-for-autistic-people/it, accessed: (05/10/24)

FIWARE. 2024, FIWARE website, https://www.fiware.org/foundation/, accessed: (05/10/24)

GDPR. 2024, GDPR reference, https://eur-lex.europa.eu/eli/reg/2016/679/oj, accessed: (05/10/24)

Howlin, P. 1998, (No Title)

ISTI. 2024, ISTI website, https://isti.cnr.it/, accessed: (05/10/24)

Kanner, L. 1943, Nervous Child, 2

Magrini, M., Curzio, O., Carboni, A., et al. 2019, Applied Sciences, 9, 3081

Magrini, M., Salvetti, O., Carboni, A., & Curzio, O. 2016, in Computer Vision–ECCV 2016 Workshops: Amsterdam, The Netherlands, October 8-10 and 15-16, 2016, Proceedings, Part II 14, Springer, 331–342

Magrini, M. et al. 2015, Autismo e disturbi dello sviluppo, Erickson

Micai, M., Ciaramella, A., Salvitti, T., et al. 2022, Journal of autism and developmental disorders, 52, 1623

Pajareya, K. & Nopmaneejumruslers, K. 2011, Autism, 15, 563

PU.eu. 2024, PU website, https://www.platformuptake.eu, accessed: (05/10/24)

Siegel, C. & Dorner, T. E. 2017, International journal of medical informatics, 100, 32

SiLAB. 2024, SiLAB website, https://si.isti.cnr.it/, accessed: (05/10/24)

Sixsmith, J., Sixsmith, A., Fänge, A. M., et al. 2014, Social science & medicine, 106, 1

TIM, F. 2024, Fondazione TIM, https://www.fondazionetim.it, accessed: (05/10/24)