Transforming Elderly Care through Ethical and Social Evaluation of Intelligent Activity Recognition Systems in Nursing Homes *

Alicia Montoro Lendínez[1 [0000−0003−0498−605X]], Carmen Linares[1], Ana Perandres[3], Alfonso Cruz[3], José Luis López Ruiz[1 [0000−0003−2583−8638]], Chris Nugent[2 [0000−0003−0882−7902]], and Macarena Espinilla[1 [0000−0003−1118−7782]]

[1] University of Jaén, Department of Computer Science, Jaén, Spain
[2] Ulster University, Department of Computer Science, Belfast, UK.
[3] Ageing Lab Foundation, Spain.

Abstract. With the continuous increase in life expectancy, the demand for nursing home professionals to care for the older adults is growing. To address this challenge, smart systems, including intelligent activity recognition systems, have been developed to monitor individuals and assist both the older adults and their caregivers. However, the ethical evaluation of these systems using frameworks such as the dignified and positive aging (DPA) model is often overlooked. This article presents a social evaluation of the ACTIVA system. The ACTIVA system is an intelligent multiple users activity and location recognition system, all in real time. This system makes use of fuzzy rules for activity monitoring and has been tested in a nursing home with activities such as going to the toilet, showering, sleeping, opening or closing wardrobes or being out of a room. This paper presents the social evaluation through rigorous evaluation of the ACTIVA system using the DPA model to monitor in real time the location and activities of multiple users. This research aims to improve older adults care in nursing homes through the responsible integration of intelligent activity recognition systems, emphasising the importance of considering ethics when deploying such technologies in healthcare. The study's findings have significant implications for the future development and implementation of these systems, promoting dignity, positivity, and improved well-being for the older adults population.

Keywords: Intelligent activity recognition system · Real-time monitoring · Social · Ethical evaluation · Healthcare technology

1 Introduction

It is clear that life expectancy is increasing all the time. A consequence of this is that the number of older adults is also increasing. Therefore, nursing homes will be home to many older adults and the demand will be increasing [1].

However, it is important to look for solutions that help both older adults and care professionals with the aim of a dignified and positive ageing such as the

* Grant PID2021-127275OB-I00 funded by MCIN / AEI / 10.13039/501100011033 and by "ERDF A way of making Europe".

ACTIVA system. The ACTIVA system is an intelligent multiple users location and activity recognition system [8] based on the use of fuzzy rules [3,2]. For this purpose it is necessary to use of different sensors and the ACTIVA app. The main objective of the ACTIVA system is to improve the quality of life of older adults who are in a situation of dependency, increasing their sense of security in their families, in the user and in the caregiver. It also aims to reduce the stress level of carers [6].

It is important that smart systems such as ACTIVA are evaluated from different approaches, usually from a technical point of view. In particular, the ACTIVA system has already been evaluated by Sustainable Development Goals (SDG) [9]. The ACTIVA system has been tested for one month with older adults and their carers in a nursing home in Alcaudete, Jaén for this social evaluation.

For this reason, this work presents a social and health care evaluation using the model of Dignified and Positive Ageing (DPA). The DPA model [4] is an evaluation with ethical overtones where the rational method, the uncertainty evaluation process, the results of the evaluation and aggregation process and the software tool are evaluated [5]. Therefore, this contribution is focused on glimpsing and evaluating the benefits and shortcomings that social services and home help service professionals find in the functionality of the ACTIVA intelligent system. The valuable feedback obtained from this evaluation will be utilized to inform and enhance the development of future activity recognition systems, ensuring they better cater to the needs and preferences of both older adults and their caregivers.

The article is structured as follows.In the Section 2 it is shown the ACTIVA system in detail. The Section 3 is shown using the DPA model. Finally, the conclusions extracted are presented in the Section 4.

2 ACTIVA: A Intelligent system for activity recognition

The ACTIVA system is an intelligent system for activity recognition. The system monitors in real time the location and activity of the user within a room and reports possible anomalies in the activity carried out by the user. Specifically, it performs location and time-based activity recognition of multiple users using fuzzy rules and time windows [2,3]

All the data collect from the sensors in the intelligent core is processed in real time, allowing each patient to be visualised from the ACTIVA app. In addition, the location, the activity being performed and the degree of danger of the activity and the battery percentage of the bracelet are displayed to alert the caregiver to charge it. It also has a history where you can consult the activities that have been carried out. The activities set to be monitored are the following: showering, using the toilet, opening or closing the wardrobe in the room, sleeping or being out of the room. To carry out the monitoring of the activities, motion, vibration and opening and closing sensors have been installed in the different locations of the room such as the shower, the toilet, the wardrobe or the bed. In addition, a wearable device, such as a wristwatch, has been used to locate the user [7].

3 Evaluation with DPA model

This section shows the results of the evaluations carried out using the DPA model. The DPA model [4] allows the evaluation of initiatives and practices of companies, organisations and professionals, which aim to promote a dignified and positive ageing process in the population.

The principles and criteria that make up the DPA model are guidelines for the practices and attitudes of professionals and organisations that promote the goal of creating dignified and positive ageing. There are 5 principles and each principle has certain criteria associated with it as shown in Fig. 1.

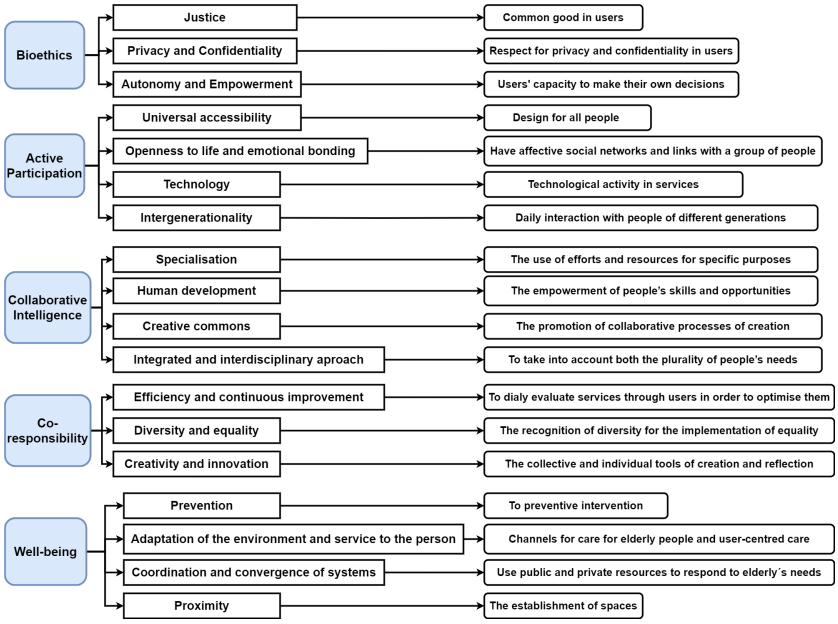

Fig. 1: Principles and criteria of the DPA model

A total of 5 professionals have evaluated the incorporation of this ACTIVA system in the nursing home using the DPA model. The quantitative evaluation, where 1 is indicated if the criterion is totally fulfilled, 0 if it is not fulfilled and 0.5 if it is partially fulfilled and the qualitative evaluation, where feedback is given by the professionals (social workers, caregivers and nursing home directors) on the intervention of the ACTIVA system in relation to the principles of the DPA model.

3.1 Bioethics

The criteria of *justice and privacy* and *confidentiality* have been assessed at a quantitative level with index 1 indicating full compliance with the intervention.

The criterion *autonomy and empowerment* has been evaluated with 0.5 which indicates that it is partially fulfilled and could be encouraged .

Regarding the qualitative level, the opinions of the people interviewed in relation to the criterion *justice* indicate that the ACTIVA system complies with it because it "respects the framework of the Organic Law on Personal Data Protection", guaranteeing the right of all people to have their rights respected. In the criterion of *privacy and confidentiality*, they also consider it to be met, highlighting "individualised attention". In the criterion of *autonomy and empowerment*, respondents consider the "technology invasive and limits the autonomy of users" due to the suggestions they make about changing habits so that the sensors can correctly collect information on the activity carried out by the user. Suggestions include, for example, raising or lowering the toilet seat or opening or closing cupboard doors.

3.2 Active participation

On a quantitative level, the criterion *openness to life and emotional ties* is fully met with index 1. The criterion *intergenerationality* is not met at all with index 0. And the criteria *universal accessibility* and *technology* are almost fully met with respect to the criteria with indicators of 0.9 and 0.8 respectively.

In relation to the qualitative level, the participants found that all criteria are fulfilled with the exception of *intergenerationality*, as contact with people belonging to other generations is something to be implemented. The criterion of *universal accessibility* is fulfilled due to the ease of access to all services for all users. The criterion of *openness to life and emotional ties* is identified by the fact that the ACTIVA system "encourages physical activity" and is a tool for social inclusion in the digital world that helps "cohabitation units to strengthen and maintain emotional ties". Finally, the criterion of *technology* needs to be improved because "the technology is not mature" and "does not fully facilitate the daily activity of users and workers".

3.3 Collaborative intelligence

On a quantitative level, the criteria *specialisation* and *focus and interdisciplinary* are fully developed. The criteria *human development* and *creative commons* are indicated 0.8 and 0.5, respectively, and can be further encouraged.

With regard to the qualitative level, the people interviewed find the criterion of *specialisation* a "greater degree of maturity so that in practice there is complete specialisation" and an increase in the quality of the service. In *human development*, the opinion is positive, with certain points regarding "efficiency in the strengthening of capacities", such as "improving the development of care teams". In the criterion *creative commons*, the need to reinforce commitments, mutual responsibility and collaboration between service professionals in order to generate an improved exchange for the care service is highlighted. Lastly, in the criterion *integrative and interdisciplinary approach* it is noted that the ACTIVA system is used to improve well-being and quality of life, but it would be advisable

to "reinforce it through knowledge exchange" and "technological improvements in the system".

3.4 Well-being

On a quantitative level, the criterion of *coordination and convergence of systems* has been evaluated with 1. The criterion of *prevention* has obtained an index of 0.95. Finally, the criteria of *proximity* and *adaptation of the environment and service to the person* are fulfilled, but could be reinforced.

In relation to the qualitative level, in the criterion *prevention*, the people interviewed evaluate it positively because "it facilitates the monitoring of the user" and "possible falls are detected and prevented" with the aim of promoting independent and autonomous living. In the criterion *proximity*, the people interviewed gave an almost positive evaluation due to the clarity of the communication channels, however, they pointed out that the senders of the communication do not have a specific action manual with indicated guidelines. The criterion of *coordination and convergence of systems* is evaluated positively due to "the coordination of tasks favoured by the ACTIVA system", but the need for "the data to reach the users" is pointed out. Finally, the criterion *adaptation of the environment and service to the person* highlights that the ACTIVA system "is not totally adapted to the life of the users" and that it is therefore necessary to promote the flexibility of the system by adjusting it to the needs of each person.

3.5 Co-responsibility

On a quantitative level, the criterion of *efficiency and continuous improvement* is fully met. The criteria of *creativity and innovation* and *diversity and equality* have been evaluated with indexes 0.8, both of them.

With regard to the qualitative level, in the criterion of *creativity and innovation*, it has a positive evaluation because it innovates in certain spaces and services such as residential homes and because it is a product in development and maturity, it is easier to adapt it to the target users. In the criterion of *diversity and equality*, the people interviewed think that the ACTIVA system is "a non-discriminatory technology" because it takes into account the diversity of the population and focuses on intervention with equality criteria. Finally, in the criterion of *efficiency and continuous improvement*, the evaluation was positive because the "monitoring of the ACTIVA system and its continuous evaluation" have helped to optimise the system and its possible continuity over time.

4 Conclusions and future works

This paper has presented a comprehensive social evaluation of the ACTIVA system using the DPA model. The results revealed that the ACTIVA system fulfills most of the criteria associated with the various principles of the DPA model with a score of 1/1 for both active ageing and ageing with dignity. Nevertheless, certain principles, including active participation, collaborative intelligence, and

co-responsibility, require further development to enhance the system's effectiveness. The feedback from this evaluation indicated that the ACTIVA system is highly regarded as an effective and efficient tool for nursing homes. The valuable feedback obtained from these social evaluation will be utilized to inform and enhance the development of future activity recognition systems, ensuring they better carer to the needs and preferences of both older adults and their caregivers.

Therefore, we propose several future directions to address these findings. Firstly, the ACTIVA system should be applied to new residential or community environments to explore its adaptability and effectiveness in various contexts. Secondly, we encourage collaboration between the ACTIVA system and other compatible systems or services to further enhance its capabilities. Additionally, continuous evaluation and improvement of the system's functionalities, ethical considerations, and privacy measures are crucial for its sustained success.

References

1. Envejecimiento y salud. `https://www.who.int/es/news-room/fact-sheets/detail/ageing-and-health`, (Accessed on 07/05/2023)
2. Albín-Rodríguez, A.P., De-La-Fuente-Robles, Y.M., López-Ruiz, J.L., Verdejo-Espinosa, Á., Espinilla Estévez, M.: Ujami location: A fuzzy indoor location system for the elderly. International Journal of Environmental Research and Public Health **18**(16), 8326 (2021)
3. Albín-Rodríguez, A.P., Ricoy-Cano, A.J., de-la Fuente-Robles, Y.M., Espinilla-Estévez, M.: Fuzzy protoform for hyperactive behaviour detection based on commercial devices. International Journal of Environmental Research and Public Health **17**(18), 6752 (2020)
4. Cruz Lendínez, A.J., Rodríguez González, A.: La atención social y sanitaria a las personas en situación de dependencia: costes económicos, sanitarios y sociales del sistema. Index de Enfermería **26**(3), 205–209 (2017)
5. Espinilla, M., Verdejo, M., González, L., Nugent, C., Cruz, A.J., Medina, J.: Challenges of ethical evaluation models for intelligent assistive technologies. an initial ethical model based on linguistic decision analysis. Multidisciplinary Digital Publishing Institute Proceedings **31**(1), 22 (2019)
6. López, J.L., Espinilla, M., Verdejo, Á.: Evaluation of the impact of the sustainable development goals on an activity recognition platform for healthcare systems. Sensors **23**(7), 3563 (2023)
7. M. Espinilla, J. Medina, M.A. Verdejo, J.L Ruiz and A.G. Salguero: ACTIVA (2021), `https://www.safecreative.org/work/2111159810407`
8. Ruiz, J.L.L., Espinosa, Á.V., Lendínez, A.M., Estévez, M.E.: Oblea: A new methodology to optimise bluetooth low energy anchors in multi-occupancy location systems. Journal of Universal Computer Science **29**(6), 627 (2023)
9. Verdejo Espinosa, Á., Lopez, J.L., Mata Mata, F., Estevez, M.E.: Application of iot in healthcare: keys to implementation of the sustainable development goals. Sensors **21**(7), 2330 (2021)