Personalised Visualisation of Home Monitoring and Treatment Adherence with AI2EPD

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Abstract. This paper presents AI2EPD, a platform oriented to healthcare professionals for monitoring therapeutic adherence in assisted living environments. The system combines home sensors with inference models to estimate adherence to activities defined in an individualised therapeutic contract. The focus is on the design and evaluation of different forms of visual representation of adherence levels, with the aim of facilitating clinical interpretation and decision making. Through multiple interfaces developed, different visualisation strategies are explored and tested in a study with healthcare professionals. The results suggest that the way data is presented has a significant impact on the perceived usefulness of the system, highlighting the need for representations adapted to different clinical profiles. This approach reinforces the role of soft technologies and interactive systems in supporting patient-centred clinical decision making.

Keywords: therapeutic adherence · home sensors · data visualisation · clinical interfaces · fuzzy logic · therapeutic contract · assisted living

1 Introduction

Adherence to treatment is a key determinant in the clinical outcome of patients with chronic diseases, neurodegenerative disorders or conditions requiring long-term follow-up. The literature has consistently shown that poor adherence is associated with a higher rate of hospital readmissions, poorer symptom control and a considerable increase in healthcare costs. Despite its importance, its assessment in clinical practice still presents significant challenges, especially in home-based settings where direct supervision is limited [16].

In recent years, advances in the field of environmental monitoring and assisted living systems have led to the development of technologies capable of continuously recording certain indicators of everyday behaviour. Among them, activity

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recognition (AR) has gained prominence as a viable strategy to infer indirect compliance with therapeutic guidelines. Detecting when a patient has cooked, rested adequately or maintained their hygiene routine allows us to estimate, with a certain degree of certainty, their level of commitment to the established treatment [6,13,14].

At the same time, there has been a growing interest in incorporating assisted decision-making models to transform raw data into clinically relevant information. Key to this is not only the collection of data through sensors, but also its appropriate representation. The information must be adapted to the different professional profiles - doctors, nurses, therapists - and provide understandable visualisations that favour both timely analysis and patient follow-up [8,11].

This paper presents `AI2EPD`, a modular platform oriented to healthcare professionals, which allows a personalised monitoring of therapeutic adherence at home. The platform relies on a set of non-intrusive sensors deployed in the patient's home (detection of movement, doors, steps, etc.), and on a previously defined therapeutic contract that specifies the expected activities. From these elements, representations of daily adherence are constructed using fuzzy logic-based inference models [15]. In contrast to other approaches that focus exclusively on the accuracy of event detection, `AI2EPD` is oriented towards the clinical visualisation of information. Different interactive interfaces have been designed to explore adherence levels from different approaches: temporal, categorical and global. These interfaces have been evaluated by healthcare professionals in order to identify the most effective form of representation to support clinical decision-making in non-face-to-face care contexts [8].

The paper is structured as follows. Section 1 introduces the motivation and context of this work, highlighting the challenges of monitoring treatment adherence at home. Section 2 reviews previous studies in activity recognition and information visualisation in healthcare. Section 3 describes the architecture of the proposed *AI2EPD* platform, including the sensors used and data processing infrastructure. Section 4 details the design principles and visual components of the user interfaces. Section 5 presents the evaluation procedure and the results obtained from healthcare professionals. Section 6 discusses the implications of the results and preferences observed. Finally, Sect. 7 summarises the main findings and outlines future work directions.

2 Related Work

Adherence has been widely recognised as an essential component in the treatment of chronic diseases and in the success of long-term interventions. Several studies have shown that poor adherence is directly related to poorer clinical outcomes, increased hospitalisations and higher healthcare costs [6,9,10,12].

However, its objective measurement in home settings remains a challenge, especially in older or cognitively impaired patients [4].

In this sense, activity recognition approaches have emerged as a viable alternative to infer patient behaviour from their interaction with the environment.

These systems can identify patterns of daily life - such as sleeping, eating or leaving the house - through the use of environmental sensors, wearable devices and signal processing techniques [5,18].

Hybrid architectures combining PIR, aperture and humidity sensors with devices such as smart wristbands or smartphones have been proposed to improve the granularity of detections, thus facilitating a more accurate assessment of therapeutic behaviour [1–3].

In addition, some work has addressed the use of fuzzy inference or machine learning models to translate detected activities into indicators of adherence. Although these approaches show promising results, in many cases the representation of the information is limited to aggregate metrics or specific alerts, without sufficient attention to their clinical utility [6,7].

Furthermore, the design of visual interfaces for healthcare professionals has received relatively little attention in the field. The way in which data is presented can significantly influence the perception of the system, confidence in the results and the integration of the tool into the clinical workflow [13,17]. Although there are proposals for dashboards and interfaces in hospital settings, the visual representation of adherence in assisted living settings remains an under explored area.

This proposal sits at the intersection of these approaches, integrating home-based sensors, contextual inference and visual interfaces adapted to diverse clinical profiles. In particular, the focus is on how information representation can facilitate decision-making in non-face-to-face care settings.

3 System Architecture

The *AI2EPD* platform is based on a distributed architecture that uses environmental sensors and location devices to monitor the patient's daily behaviour in their home environment. This infrastructure is designed to be non-intrusive, low-cost and easily scalable.

3.1 Environmental Sensors

- **Aqara Door and Window Sensor:** Wireless magnetic sensor that detects opening and closing events of doors or windows. It uses the Zigbee protocol and offers a battery life of more than two years with a button-type battery.
- **Aqara Motion Sensor P1:** Passive infrared (PIR) motion sensor, with a detection angle of up to 170 ° and a range of 7 m. Sensitivity and time delay between detections can be configured. It also incorporates a luminosity sensor and communicates via Zigbee 3.0.
- **Aqara Temperature and Humidity Sensor:** Environmental measurement sensor that records temperature and relative humidity. It is accurate to within ±0.3°C for temperature and ±3% for humidity, and integrates easily with the home's Zigbee network.

3.2 Network Infrastructure and Sensor Management

Communication with the Zigbee sensors takes place via a USB ConBee II coordinator connected to the central Raspberry Pi, which acts as the control node. This unit runs the Home Assistant environment, from which the sensor network is managed, events are received and the collected data is structured.

All events generated by the sensors are published in real time on different MQTT topics, which allows decoupling data acquisition from post-processing. This architecture facilitates the integration of new devices and the extension of functionalities.

3.3 Location and Presence of the Patient

- **Raspberry Pi 4 Model B:** Several units are deployed in different rooms, each acting as an anchor node to estimate patient location. These units are equipped with low-cost Bluetooth USB adapters and wireless connectivity.
- **Xiaomi Mi Band 3:** Smart bracelet worn by the patient, which emits Bluetooth signals detected by Raspberry Pi. The RSSI (Received Signal Strength Indicator) is monitored to infer the patient's stay.
- **Local processing and hybrid inference:** Before being sent to the cloud, the data collected by the anchors are processed locally using hybrid models. This step allows reducing signal noise and obtaining the location of the patient in the monitored environment.

4 User Interface

The adherence visualisation module of the *AI2EPD* platform has been developed using the **Django** framework, with the aim of providing a clear, intuitive and useful experience for healthcare professionals. While the system includes complete functionalities for the management of patients, therapeutic contracts, sensors, dwellings and authorised personnel, this section specifically describes the design of the interfaces to represent the level of compliance with the therapeutic contract.

The design has been guided by the principles of user-centred design and established standards in the literature for effective information representation in clinical environments. Different visualisation strategies, both categorical and temporal, have been applied to facilitate decision-making in non-face-to-face monitoring contexts.

Each interface includes key components aimed at facilitating clinical interpretation: patient identification and the evaluation period, including the start date in the system and summary data; an activity panel displaying, for each activity, the expected goal, the current recorded value, and a completion percentage, with the aid of color codes and status labels (e.g., Compliant, Partial) to enable rapid assessment; horizontal bar charts that allow immediate comparison of adherence levels across categories such as physical activity, rest, hygiene, nutrition, and

medication; detailed tables containing precise quantitative values (goal, daily average, current value, completion percentage) along with status indicators; and a textual summary that translates numerical adherence data into qualitative assessments, using expressions that are easily interpretable by healthcare professionals (e.g., "very good adherence", "irregular hygiene", "excellent treatment engagement"). A key feature of the system is the ability to generate adherence summaries on different time scales, including daily, weekly and monthly reports. In addition, the user can set a customised date range to suit specific situations, such as one-off assessments, clinical reviews or specific phases of the therapeutic intervention. This flexibility facilitates longitudinal monitoring and comparative analysis of the patient's evolution.

All these representations have been designed to ensure fast, standardised visualisation that is compatible with the different levels of technological expertise of healthcare staff. Attention to visual design, the use of icons and colour schemes help to reduce the cognitive load during data review and support smooth integration into clinical assessment routines.

5 Evaluation of Display Interfaces

In order to determine which of the developed visualisation options is most useful and effective for clinical decision-making, a questionnaire was designed and applied to healthcare professionals. The questionnaire focuses exclusively on the representation of information related to adherence, as this is considered the most critical aspect in the process of remote patient follow-up.

The questionnaire, entitled 'Assessment of patient data display interfaces', was implemented digitally and consists of a series of structured items that allow both quantitative assessments and open-ended responses to be collected. Each participant is presented with several interfaces (named Interface 1, Interface 2, etc.) corresponding to different visual strategies applied on the same set of real data: summary cards with percentages, horizontal bar charts, coloured tables with status indicators, and generated narrative reports.

For each interface, ratings were requested on a 5-point Likert scale on the following aspects:

- Clarity in the presentation of information.
- Ease of understanding the fulfilment of each activity.
- Perceived visual attractiveness.
- Degree of completeness of the information presented.
- Preference for maintaining that format or opting for a different one.

In addition, two open questions were included for each interface to identify the most valued elements and possible areas for improvement:

- Which part of the interface did you like the most?
- What would you improve or change?

Finally, at the end of the questionnaire, a general question on the preferred type of visualisation was incorporated, allowing the participant to select from the available options: individual cards, bar charts, colour-coded status tables or narrative report. A field for additional comments was also provided.

6 Discussion of the Results

In order to identify the most suitable interface for representing adherence in clinical settings, a comparative evaluation of four different visual approaches was carried out: a table with colours and status (Interface 1), Fig. 1, a narrative report (Interface 2), Fig. 2, a combination of progress bars with textual summary (Interface 3), Fig. 3, and a system of individual cards with percentages (Interface 4), Fig. 4.

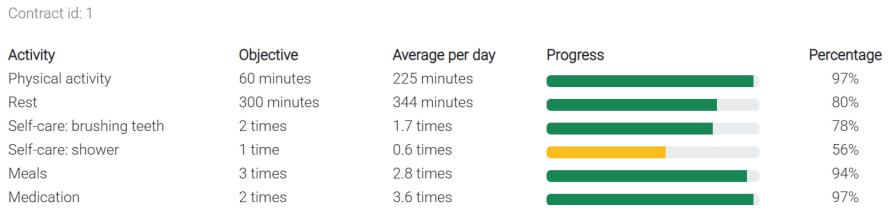


Fig. 1. Interface 1.

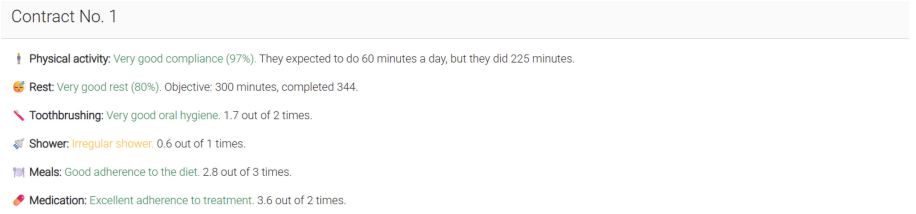


Fig. 2. Interface 2.

Each participating professional rated the four interfaces independently, answering the same questions for each. The dimensions assessed included clarity, ease of interpretation, visual appeal, completeness of information and preference of use, all measured by Likert-type scales from 1 to 5 points.

The results show that the table-based interface was the highest rated in terms of clarity (4.75/5), visual appeal (5.00/5) and completeness (4.75/5), and also received the fewest suggestions for improvement. The narrative report (Interface 2) was also highly rated, being notable for its ease of interpretation (4.25/5) and

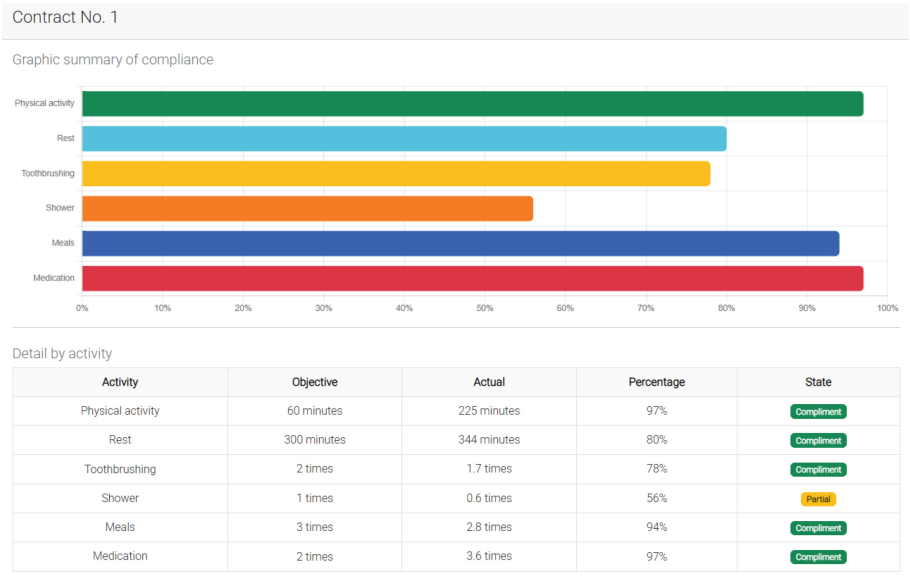


Fig. 3. Interface 3.

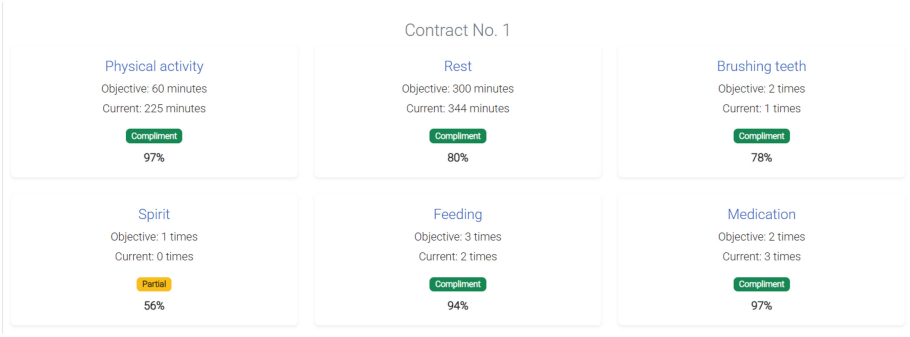


Fig. 4. Interface 4.

aesthetics (4.50/5), although some participants indicated that it was slightly overloaded with information.

The mixed interface (progress bars and explanatory text) showed intermediate scores in all categories, with a mean of 4.0 for clarity and ease, and 3.75 for visual appeal. The cards interface, while perceived as complete (4.50/5) and relatively clear (4.00/5), scored lower on visual appeal (3.75/5) and received more suggestions for aesthetic improvement.

Finally, participants were asked to select their preferred type of visualisation. The most chosen options were the narrative report and bar charts, followed by cards and the coloured table. This result reinforces the need to offer multiple

forms of representation, adapted to different professional profiles and clinical scenarios.

Overall, the results show that clarity of presentation, together with the ability to synthesise relevant information for decision-making, are key aspects when designing interfaces oriented towards healthcare professionals in adherence monitoring platforms such as *AI2EPD*.

7 Conclusion and Future Work

This work has presented *AI2EPD*, a platform aimed at monitoring therapeutic adherence using home sensors, activity-based inference and visualisations for healthcare professionals. Through the deployment of non-intrusive sensors, the use of hybrid inference models and the design of interfaces, the aim is to offer a tool that facilitates clinical decision-making in non-face-to-face care contexts.

The results obtained in the evaluation of different visualisation interfaces have shown that, although there are general patterns of preference, such as the clarity of the tables or the interpretability of the narrative report, there is no single ideal representation for all users. The ratings show subtle but relevant differences, and some interfaces, such as cards or mixed views, were well received by certain professional profiles. In this context, it is concluded that a clinical decision support system such as *AI2EPD* should not impose a single form of data representation. On the contrary, it should allow the user to choose between different visual alternatives, or even configure their view according to their needs, experience or time of the process. EThis flexibility is key to encourage the real adoption of this type of technology, avoiding the need for professionals to adapt to a single interface that does not always align with their cognitive or functional preferences.

As future work, we plan to incorporate automatic personalisation mechanisms, as well as to expand the tests with a larger number of participants and clinical contexts, in order to validate the usefulness of the system in other real home care scenarios.

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