An analysis of the perception of intelligence by different stakeholders in the Ambient Assisted Living domain

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***Abstract*—This paper analyzes the perception of Artificial Intelligence of different stakeholders in Ambient Assisted Living creations. This perception has been widely addressed in the area of Human Robotics Interaction, but less in the Ambient Assisted Living. The study includes some insights in the industrial creation of such systems, but it focus in on a survey to Artificial Intelligence students, the future creators of these solutions; and a qualitative analysis of end-users reaction when asking about their impression about using intelligent technology. A conclusion is that early adopters tend to see AI everywhere, while industrial engineers hardly feel the need to pointing out explicitly the intelligence within. A reason for this could be the conservative stance of end-users, mostly older people, that do not understand the benefits and it may even act as deterrent. On the other hand, professionals, such as physiotherapists, are more positive towards the role of intelligence, and start imagining possible applications, just as the students in AI.**

I. Introduction

The development of Ambient Assisted Living (AAL) is a multidisciplinary one where experts from different disciplines get together in order to improve the quality of the daily living of people and, in particular, those with special needs. As researchers in this area, we have concerns about the functionality such systems ought to provide and how it is perceived by the end-users. Current approaches for developing such systems are highly driven by how end-users interact with the inventions. This is the user-centric approach that is evolving to a co-creation scenario [1]. Modeling the scenarios, as in [2], can help to foster discussion about how we want the system to be. In particular, it makes sense to wonder how intelligence is used, how it is perceived by the different stakeholders, and if it is positive or not to be explicit about the presence of intelligence in one's invention.

The stance of the paper is a social science based one, which differs from personal views of AI contributions, such as [3], or more general reviews of what is AI according to textbooks, such as [4]. When the problem is to determine what is the perception of an issue, readers should get rid of the bias of their own believes about such issue. And approaches to capture the perception of intelligence, should follow social sciences based techniques, instead.

That humans do invent intelligence and tend to assume there is some even when there is not, has been known for a while. Brooks [5] put this idea in words: the intelligence is in the eye of the beholder. Besides, the concept of intelligence changes along the years. What is considered as intelligent in the 90's may considered quite usual in the 21st century.

After all, humans are very sensible to the perception of intelligence. They are very likely to show biased opinions depending on external factors. Works in psychology have identified how we perceive different intelligence on people depending on how they dress [6], or their bodily movements [7], to cite some. It would not be a surprise if subtle changes in our systems may make others think that a behavior is more or less intelligent.

In fact, an active area in the study of human perception of intelligence is Human Robotics Interaction (HRI). Duffy [8] discusses, but not explores empirically, how, by making robots look more human (e.g. through shape or by making them execute typical human actions such as walking), robots are perceived to be more intelligent. The goal would be achieving social interaction (hand shaking, dialogues, and more complex interactions). Sabanivic [9] uses observational studies to analyze interactions with humans in the open, concluding that the physical context of the interaction matters, that gaze is part of the communication, and that robot to many interactions are needed.

HRI is not ambient intelligence, though some conclusions could be reused. Most HRI results require an embodiment of the intelligence a.k.a. the robot. In ambient intelligence, there are networks of distributed sensors and actuators, and there is not necessarily a visible body to interact with. Nevertheless, HRI results are relevant to Ambient Assisted Living, though grounding them is needed. In particular, there are misconceptions on technology related to AAL as seen by experts, practitioners, and end-users. For instance, if users think there is intelligence in an AAL facility, do they perceive the AAL system as a better one?

Nededless to say that intelligence is a word frequently occurring in the academy papers. However, industry does not

share this attitude. If patent registries can be regarded as a one representative of industrial view of AAL, a likely hypothesis is that it does not care much about what is intelligence anyway in the AAL. Within this broad area, activity recognition problems are quite frequent in the AAL literature and one can find many patents about this. Classifying and recognizing activity patterns has a wide and varied use in different devices and monitoring and tracking systems [10] and is a frequent topic in ambient intelligence. Focusing in on this specific topic, a set of patents were obtained from Google Patents service looking for keywords related with “activity recognition” or “body movements”, and combined with others such as “daily living” or “patient”. First pages of queries were inspected looking for highly related patents to the attention of patients. This filtering led to *46 relevant patents*,though limited to european and EEUU registries. Only five patents did cite intelligence explicitly as part of the invention. In the few patents that explicitly identify artificial intelligence, there is no distinguishing characteristic with respect to other patents that perform a similar function. This is a minor revision, but it is instructive preliminary analysis of how ”intelligence“ becomes less a buzz word in the patent literature. For the current paper, it is a good starting point to wonder if there is a path from early practitioners towards this final situation, where functions that need to be characterized as intelligent by people,are no more extraordinary than a mathematical function when they become experienced practitioners. This justifies some groundwork on AAL to check the prejudices of early practitioners of artificial intelligence.

Similarly, technology aversion [11][12][13] plays an important role in the co-creation of AAL inventions. Some analyses from the literature produce informing evidences for understanding how intelligence is perceived. To these, this paper wants to contribute with a qualitative analysis obtained from interviews made to Parkinson patients and health professionals.

Our conclusions on both sides of the study can be summarized in a very different attitude between the early practitioners (very enthusiastic about AI) and the end-users (indifferent or with some aversion). Also between the academy (aiming to create intelligence every time) and the industry (forgetting about the intelligence itself and focusing more on the services). The work makes extensive use of social sciences methods and contributes with qualitative analysis of the results.

The paper does not contain a dedicated related work section because it has been preferred to distribute the references along the report. Section II addresses the perspective of early practitioners obtained through some surveys and short experiments. Section III reviews some interview transcripts and the literature to gain some insights in how end-users and experts perceive the intelligence. Section IV includes the conclusions of the paper.

II. Perceived intelligence by early practitioners

To address the perception of intelligence by early practitioners, a survey has been conducted to undergraduate students of the Computer Engineering Degree at Complutense University of Madrid. The survey combined open questions and scale-like questions. They have been asked about the presence of intelligence in different contexts. The survey was conducted into two different days. In the first day, 23 students were asked during a class, and then 33 undergraduate students participated in an online survey. The second day, 28 participated.

A. First day

The first day of the Smart Systems subject, 23 undergraduate students were asked to provide with an example of artificial intelligence application they knew. For this survey, a microblogging tool was used. No format was assumed, just a limitation of 170 characters. The professor graded each answer following this scoring criteria: 0 (wrong concept, badly expressed), 1 (wrong concept, but well expressed), 2 (right concept, but badly expressed) and 3 (right concept and correctly formulated). The results are presented in figure 1.

All students declared that they did not have any experience in artificial intelligence. Therefore, it is of significant meaning that 86% of students provided examples that included, at least, an understanding of artificial intelligence that the professor approves.

Thus, considering their inexperience in the area of artificial intelligence, it is evident that they should have received some kind of training or instruction from some agent of socialization, either family, peers, mass media or some kind of formal or informal education. This hypothesis could be reinforced by the fact they chose a computer science degree.

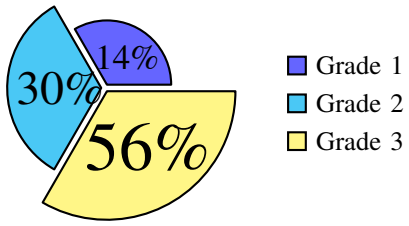

Figure 1. Grades received when suggesting an example of application of IA. The higher the grade, the better.

After the mentioned exercise of spontaneous examples of artificial intelligence, 33 students of two degree subjects, Smart Systems and Software Engineering, filled in a survey in which they were asked if they thought that six concrete devices had some artificial intelligence within. Answers followed a Likert Scale - a unidimensional scaling method that is one of the most commonly used scales in survey research [14]. For each question, the researchers formulated a statement that respondents had to evaluate: *Do you agree with the idea that Artificial Intelligence is used in the following examples?*

1) Algorithm of recommendation of a portal of films.
2) Fall detector for older adults.
3) Global Positioning System.
4) Cardiac pacemaker.

5) Controller for the body position and body movement in a video game.
6) Watch with location services for older adults.

The question aimed to explore the perception of the implicit AI in different devices, most of them directly related with AAL applications. Second and fifth devices were written thinking about sensors used to identify bodily positions in different contexts (gaming vs fall detection). Third and sixth devices used location services in general (just thinking about GPS) and in a AAL context (location services for older people). Fourth question was a control one. Since it was assumed a cardiac pacemaker ought not to involve a relevant amount of AI in general, respondents were expected to disagree. The first question was a control one too, but a positive control this time. It was intended to provide a positive answer about the use of AI in a classical film streaming service used at home.

It was expected that an expert would strongly agree to the presence of AI in the first, second, fifth, and have concerns about the sixth (a watch with location services can have multiple uses); and disagree/strongly disagree in the fourth case. The students' performance was different. In general, the students, see figure 2, identified correctly the objective presence of AI in the positive examples. In the case of the algorithm of recommendation, there is a 75.8% expressed partial or strong agreement while none of them selected strong disagreement. The percentage of right answers in the fall detector is even higher (84.9%). In the last of the objective AI examples, the controller of the body position and movement of a video game, there is a 15.2% of partial disagreement, but right questions are still considerably higher with 78.8%.

These positive results were lower in effectiveness than the results obtained from the open question from figure 1. Our conclusion is that students have a correct knowledge of success cases of AI techniques. However, when asked to evaluate a particular case, such as the chosen devices, some of them still fail to recognize the presence of AI.

Control questions returned unexpected results, as shown in figure 3. The GPS device received the same amount of votes to the agreement (total & partial agreement) with 39.4% and disagreement (total & partial) with 39.4%. The cardiac pacemaker is less evident, but it showed anyway a 51.5% of agreement (total & partial) and a 36.4% disagreement (total & partial). In the watch device, the votes are mostly positive (45.4% of votes) though there is a surprising uncertainty of 27.3 & of votes.

It is natural to have doubts when answering the last question about the role of AI in a watch. However, the variety of answers for the GPS or pacemaker cases was unexpected. Even though respondents were not questioned about the reason why they had chosen this answer, we elaborated an hypothesis: students were biased to think there was AI. The specific application to the health or medical area or its appearance in the context of an AI survey, as well as other intervening variables that are out of researchers' control, may have fostered those false positives. This could be the case of the watch locator for older adults, associating it with other smartwatches' characteristics that were not mentioned in the survey statement, such as emergency help or activity recognition. Something similar could have happened to students in the GPS case. Some students may have thought of driving or city map applications and how they guide them, which could be regarded as an intelligent behavior. Other possible explanation is that they think about GPS just as the satellite network.

In either case, many students decided there was AI in those devices, almost as many as the ones deciding there is not. Whatever the reason, we interpret these false positives as a tendency to observe AI in any case. This would fit the theory that our perception of intelligence can be affected by the context and other variables, as in the effect of how we are perceived differently depending on how we dress [6].

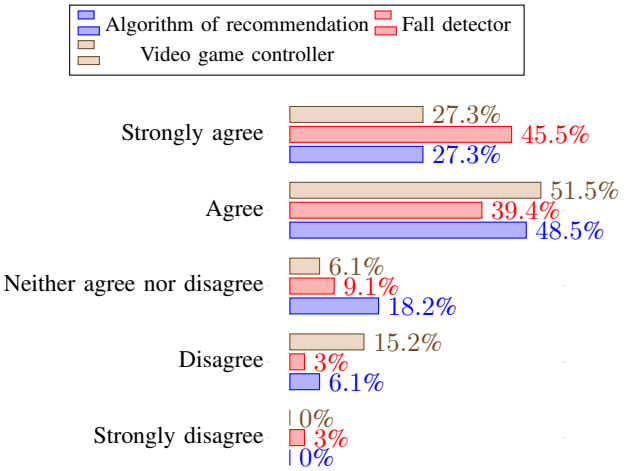

Figure 2. Expected positive cases in perception of AI presence.

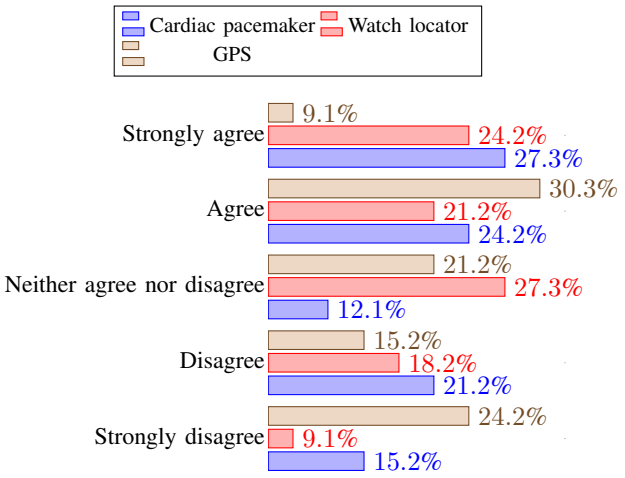

Figure 3. Expected negative cases in perception of AI presence.

B. Second day

While the first day the effort was focused on text based questions, this time a visual/auditive stimulus was used. This experiment aims to proof that a system providing the same functionality may convince observers to involve more or less or more AI depending on how it is presented.

The experiment subjects were a group of 28 students of the Smart Systems subject, most were from 20 to 25 years old. They were shown the same video twice, though the second time it involved additional voice tracks. The students were informed about what the videos were about. Both videos depicts a case of midnight sleep disorder which may happen to those developing Alzheimer's disease. In both cases, the informing text is the following: *A person wakes up in the middle of the night. When he/she gets up, the lights turn on as this person moves from one place to another. It is decided that he/she may not be aware of what is doing and the person is asked if he/she is disoriented.*

Students were asked "Do you agree with the idea that Artificial Intelligence is applied in this scene?". Students watched the first video and answered the question. Then, the second video was presented followed by the same question again.

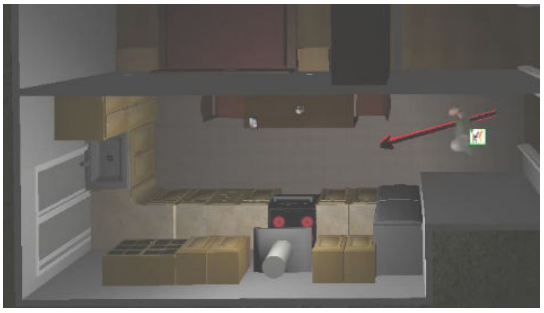

Figure 4. Fragment of the video used for the experiment.

Both videos represented the same course of action and, visually, were identical and looked like the figure 4. The differences between the first and the second video where the background dialog as follows:

- Video 1: Opening text: "The patient wakes up"
  - Audio: (after a time) "It seems that you are disoriented"
- Video 2. Opening text: "The patient wakes up"
  - Audio 1: "Let me turn on the light of this room"
  - Audio 2: "I turn on the light of the bathroom"
  - Audio 3: "You are wandering and it is 3 a.m."
  - Audio 4: "It seems that you are disoriented"

The answers are presented in figure 5. It should be remarked that the video depicted exactly the same scene. Only the second added three more audio tracks providing hints on what was being done. For instance, if the lights in the first video just lighted on, the extra audio indicated in the second video that lights were going to be lighted on.

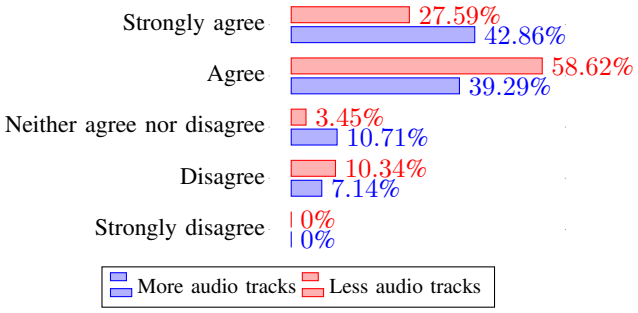

Figure 5. Perception of AI using videos with textual and audio information. 28 participating students.

The sum of those students who strongly agree that there is AI in the video plus those that only agree is roughly the same (86.21% first video against 82.15% in the second). However, the decisiveness in strongly assessing the presence of AI technology, changes remarkably, from a 27.6% in the first video to a 42.9 % in the second one.

It could be concluded that a 15% of the undergraduate students were deceived by the voice audio of the second video, or more if the transference of votes from disagree to neither both is accounted. The same functionality, when explained by an artificial voice, led the students to believe the AI was more relevant in the second video than in the first.

III. End-users attitudes towards intelligence in AAL

The end-users for AAL can be just anyone, but it is frequent that engineers focus on older people. This is a concern because the attitude of older people is more sensible towards technology and we expect Artificial Intelligence to be specially challenging to understand and to welcome.

A first analysis (section III-A) has been made reusing interviews obtained from project (Name omitted for the sake of blind review). This provides an insight on the reaction towards the intelligence on behalf end-users.

Then, a second analysis (section III-B) focused on the literature was made. There is an relevant amount of results on technology aversion in the literature. However, the specific topic of intelligence, its perception and reaction towards it, is not so common.

A. Analyzing interviews

In a past project about AAL that involved Parkinson's patients and other end-users (SociAAL Social Ambient Assisted Living, TIN2011-28335-C02-01)[15][16], 27 in-depth interviews were conducted to gather qualitative data about the Parkinson's disease. Some interviews involved more than one individual, but, in total, there were 5 Parkinson's disease experts (two neurologists, two psychologists and one physiotherapist), 13 Parkinson's patients (stages 3 and 4 of the Hoehn

and Yahr scale) and 9 caregivers [17]. Those semi-structured, in-depth interviews included questions about the daily lives, main symptoms and limitations, activities of the caregivers and the perception of Ambient Assisted Living technologies. The youngest interviewed individual patient was 59 and the eldest one was 75. Half of them were male and half were female. All patients and caregivers lived in the Community of Madrid (Spain) with different social and cultural backgrounds.

For the present paper, we have analyzed in greater depth the transcriptions of these interviews to know of their stance towards intelligence. Interviewers were social scientists who were involved in the project, so they had knowledge that intelligence played an important role in the systems to be developed. The interviews were semi-structured ones, with a script oriented towards knowing more of their needs and how technology could aid them. Sometimes, the interviewer asked directly the interviewed about the role of some intelligent technology.

The transcriptions were reviewed looking for mentions of "intelligence" and "intelligent". These terms were used in 10 of the 27 interviews (6 interviews with patients/caregivers and 4 interviews with professionals, one of them with two professionals at the same time). None of the patients or caregivers brought this topic in, and, in all cases it was the interviewer who do did it. When talking with the experts, the result was the opposite in two of the three cases. Once the topic appeared, the reactions were different.

Patients or caregivers do not answer using those terms "intelligent" or "intelligence" when they are suggested by interviewers. All of them belong to either lower middle class or upper middle class. Furthermore, if the topic of artificial intelligence was addressed, some patients and caregivers associated it with high cost ("That's for people that have a lot of money", "But that is not accessible to all", "Nobody would give financial help for that"), distant future ("It sounds like a house of the future") and other personal circumstances ("I can't be left on my own"). Nevertheless, a patient maintained that he agreed with all ways to keep up-to-date and a caregiver -a patient's wife- claimed she would be capable of getting used to such a system.

When considering experts, three of five had reactions towards the term "intelligence". Two used pro-actively the word "intelligent" without being questioned, and one was asked about the "intelligence" directly.

The interviewer asked a physiotherapist about the interest of an intelligent system. The physiotherapist answered that it was a great idea, but then she questioned to what extent it was useful, for instance, to perform activities instead of the patient, because it was good for the patient to exercise themselves. However, the assistance oriented towards monitoring and to actively remind the patient was more positively received. In one case, the therapist started playing with the idea and imagining things an *intelligent house* could do.

A psychologist used the word "intelligent" but was reluctant to elaborate and immediately grounded the term to things done within projects this psychologist was involved into (identify patient's situation to recommend physical exercises, handwriting analysis, cognitive training). She knew of the subject and the necessary technology. A neurologist also used the word "intelligent" when referring to adaptability (amount of medicine an intelligent pump system has to supply, or apps with smart-phones that have access to multiple sensors). In both cases, the question was a generic one about their prior knowledge on relevant technologies for AAL, like domotics.

The first conclusion is that words like "intelligence" or "intelligent" are not likely used by patients or caregivers, but by interviewers and experts. Also, that experts can be already familiar with the term and that it is inherently associated with technology. They do not elaborate too much about it, but, with the exception of the physiotherapist, the neurologist and the psychologist seem more aware of what it really can do. They identify specific functions and catalog them as intelligent ones because of the presence of capabilities like adaptiveness, handwriting recognition, or sensor processing capabilities, to cite some.

Patient and caregivers are less receptive to words like "intelligence" or "intelligent". As it has been shown, they do not use it despite the social class they belong to. They tend to think it is something expensive and do not elaborate much about what they can do with it. This may be related with the technology aversion which will be analyzed in section III-B .

B. Analyzing the literature

It is hard to evaluate how much intelligence contribute to the technology aversion identified by the literature. The factors and barriers for the acceptance of technology for Ambient Assisted Living that were collected in the interviews to Parkinson's patients coincided with the results of previous researchers [11][12][13].

Among the scientific literature gathered, Peek et al. [13] carried out a systematic review of 16 articles, obtaining as a result 27 factors of acceptance in the pre-implementation stage of technology for aging at home. These factors are summarized by the authors in six items [13]: "concerns regarding technology (like cost, privacy and usability); expected benefits of technology (like safety and perceived usefulness); need for technology (e.g., perceived need and subjective health status); alternatives to technology (e.g., help by family or spouse), social influence (e.g., influence of family, friends and professional caregivers); and characteristics of older adults (e.g., desire to age in place)".

Intelligence requires data obtained from the user contexts. Jaschinski and Allouch's [12] study expounds on these technological concerns related to privacy for personal information, security, possible intrusion of too visible devices or constant surveillance. Other barrier that is gathered by the authors is the lack of user control reinforced by elderly people's technological inexperience that leads to technology anxiety. Finally, and according to this compilation, intelligent technologies "cannot and should not replace human assistance and human interaction", especially in aspects related to personal care tasks, leisure activities and most health related tasks [18].

IV. Conclusions

Addressing the role of intelligence in a area like Ambient Assisted Living ought to be a concern in a development. This work has contributed with an analysis of the perception of intelligence from two perspectives: as it is perceived by the future creators of AI technologies, and as it is perceived by other stakeholders of these systems (end-users and experts). This research was made within the context of Ambient Assisted Living systems, i.e., systems that aim to assist users to improve the quality of their daily living.

The end-users have shown unemotional reaction when someone uses the word "intelligent". They have assumed it is expensive and do not incorporate that word into their responses. Being people of 59 and older, this may seem natural. The experts' opinion is more positive and in two of the cases the experts pro-actively brought the topic of intelligence in a very accurate way. In these cases, experts had prior knowledge because they were working in similar areas.

This stance contrasts with the new practitioners and engineers, that enthusiastically tend to see intelligence everywhere. However, the industry, when registering inventions, do not highlight the intelligence they incorporate in the devices. They prefer most of the time to focus on the capability without concern of whether this brings intelligence or not.

From the social sciences view, the population of this study is a minimal one. Despite the size, the results are still better that one's intuition about the problem and can be of some value when addressing an AI related project. They can foster additional thinking about this issue so that engineers do not assume different stakeholders (developers, end-users, and experts) share the same view on AI. More results are still needed, but these are inspiring enough to continue this research.

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References

[1] M. Pallot, B. Trousse, B. Senach, and D. Scapin, "Living lab research landscape: From user centred design and user experience towards user cocreation," in *First European Summer School" Living Labs"*, 2010.

[2] P. Campillo-Sánchez and J. Gómez-Sanz, "Modelling and simulation of alzheimer's disease scenarios," *Procedia Computer Science*, vol. 83, pp. 353–360, 2016.

[3] L. Deng, "Artificial intelligence in the rising wave of deep learning: The historical path and future outlook [perspectives]," *IEEE Signal Processing Magazine*, vol. 35, no. 1, pp. 180–177, 2018.

[4] S. J. Russell and P. Norvig, *Artificial intelligence: a modern approach*. Pearson Education Limited,, 2016.

[5] R. A. Brooks, "Intelligence without reason (ai memo no. 1293)," 1991.

[6] D. U. Behling and E. A. Williams, "Influence of dress on perception of intelligence and expectations of scholastic achievement," *Clothing and Textiles Research Journal*, vol. 9, no. 4, pp. 1–7, 1991.

[7] N. A. Murphy, "Appearing smart: The impression management of intelligence, person perception accuracy, and behavior in social interaction," *Personality and Social Psychology Bulletin*, vol. 33, no. 3, pp. 325–339, 2007.

[8] B. R. Duffy, "Anthropomorphism and the social robot," *Robotics and autonomous systems*, vol. 42, no. 3, pp. 177–190, 2003.

[9] S. Sabanovic, M. P. Michalowski, and R. Simmons, "Robots in the wild: Observing human-robot social interaction outside the lab," in *Advanced Motion Control, 2006. 9th IEEE International Workshop on*. IEEE, 2006, pp. 596–601.

[10] D. Figo, P. C. Diniz, D. R. Ferreira, and J. M. Cardoso, "Preprocessing techniques for context recognition from accelerometer data," *Personal and Ubiquitous Computing*, vol. 14, no. 7, pp. 645–662, 2010.

[11] H. Hawley-Hague, E. Boulton, A. Hall, K. Pfeiffer, and C. Todd, "Older adults perceptions of technologies aimed at falls prevention, detection or monitoring: a systematic review," *International journal of medical informatics*, vol. 83, no. 6, pp. 416–426, 2014.

[12] C. Jaschinski and B. Allouch, "S.: Ambient assisted living: benefits and barriers from a user-centered perspective," *Proceedings of Ambient*, 2014.

[13] S. Peek, E. J. Wouters, J. van Hoof, K. G. Luijkx, H. R. Boeije, and H. J. Vrijhoef, "Factors influencing acceptance of technology for aging in place: A systematic review," *International Journal of Medical Informatics*, vol. 83, no. 4, pp. 235–248, 2014.

[14] R. D. Wimmer and J. R. Dominick, *Mass media research*. Cengage learning, 2013.

[15] M. Arroyo, L. Finkel, and J. J. Gomez-Sanz, "Requirements for an intelligent ambient assisted living application for parkinson patients," in *International Conference on Practical Applications of Agents and Multi-Agent Systems*. Springer, 2013, pp. 441–452.

[16] I. García-Magariño and J. J. Gómez-Sanz, "An ontological and agent-oriented modeling approach for the specification of intelligent ambient assisted living systems for parkinson patients," in *International Conference on Hybrid Artificial Intelligence Systems*. Springer, 2013, pp. 11–20.

[17] M. A. Menéndez, T. C. López, and L. F. Morgenstern, "El tecno-cuidado en hogares con mayores dependientes con enfermedad de parkinson," *Teknokultura*, vol. 11, no. 1, pp. 143–165, 2014.

[18] J. Van Hoof, H. Kort, P. Rutten, and M. Duijnstee, "Ageing-in-place with the use of ambient intelligence technology: Perspectives of older users," *International journal of medical informatics*, vol. 80, no. 5, pp. 310–331, 2011.