



HAL
open science

Co-designing a falls detection device: combining concerns for human motion and elders needs

Karine Lan Hing Ting, Dimitri Voilmy, Guillaume Dessinger, Vincent Gauthier, Jean-Louis Dillenseger, Guy Carrault, Jean-Marc Laferté, Alain-Jérôme Fougères

► To cite this version:

Karine Lan Hing Ting, Dimitri Voilmy, Guillaume Dessinger, Vincent Gauthier, Jean-Louis Dillenseger, et al.. Co-designing a falls detection device: combining concerns for human motion and elders needs. Workshop Visual user interfaces for human motion, ACM AVI 2020 International Conference on Advanced Visual Interfaces, Sep 2020, Island of Ischia (virtuel), Italy. hal-03082662

HAL Id: hal-03082662

<https://hal.science/hal-03082662v1>

Submitted on 18 Dec 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Co-designing a falls detection device: combining concerns for human motion and elders needs

K. Lan Hing Ting^{1*}, D. Voilmy^{1*}, G. Dessinger², V. Gauthier³, J-L. Dillenseger⁴, G. Carrault⁴, J-M. Laferte⁵, A-J. Fougères⁵

¹Living Lab ActivAgeing, ICD/ROSAS/M2S, Université de technologie de Troyes (France)

² CRRF COS Pasteur, Troyes (France)

³ Neotec-Vision (France)

⁴ LTSI, Université de Rennes1.(France)

⁵ Ecam-Rennes (France)

karine.lan@utt.fr

Key words: *Falls, Ambient Assisted Living, Elderly empowerment, Human Motion Analysis, Participatory design*

1. Introduction

To address the major public health problem of falls among the elderly (WHO, 2011), the interdisciplinary project PRuDENCE proposes a new low-cost device. Based on depth and/or thermal sensors (Halima et al., 2019; Zoetgnandé et al., 2019), the device makes it possible, on the one hand, to detect falls and prolonged presence on the ground and, on the other hand, to prevent the risk of falling by analysing the activity of individuals. In addition to the detection performance characteristics demonstrated during tests in nursing homes, the device proposes to contribute effectively to the overall objective of preventing loss of autonomy.

2. Previous work

Among the growing applications and research interest around Human Motion Analysis (cf. Bandera & al., 2019 for details), are new application fields, like Ambient Assisted Living technologies. In the context of an ageing population, AAL technologies can play an important role in helping elderly people achieve healthy ageing and maintain their autonomy. Indeed, falls or risk of falling, manipulation issues or motion impairments are among the key causes of autonomy loss among the elderly population. Thus, motion evaluation becomes an important feature for these systems.

Among possible Human Motion Analysis solutions are autonomous systems to monitor the status and activities of a person, without interfering with them. Autonomous tools – that evaluate human motion, whether in their daily life activities, performing motion clinical tests or in case of falls detection – will have to be precise, and yet, will avoid imposing any constraints on the elderly user. E.g., no special environments, markers or garments. Ideally, the point of view from which motion sequences are captured should not be imposed. This is to allow the performing of these evaluations, from any monitoring camera, in the person's environment, e.g. her home (Bandera & al., 2019), especially in the use case of falls. The PRuDENCE falls detection device features these characteristics.

3. Research questions, methods and insights

The project's research questions focus, in a complementary way, both on i) technical viability and detection performance as part of the sensors' development and calibration (Halima et al., 2019; Zoetgnandé et al., 2019), and ii) on use and utility, adopting a living lab approach (Lan Hing Ting et al., 2020), that is iterative, participatory (Blomberg & Karasti, 2012), and human-centred (Bannon, 2011).

From a technical perspective, the development research included the evaluation of the performance of the developed depth and thermal sensors in detecting falls and prolonged presence on the ground. Using the same protocol developed for previous research (Bandera & al., 2019), the experiments of Motion Capture were made at the Movement analysis platform of our Living Lab. Human movements – like falls, accelerations, daily activities – were captured simultaneously in 3 ways : i) the developed sensors ii) a precise a Vicon Nexus 1.8.5 MoCap system based on markers, iii) external video cameras. While the video analysis allowed saving and contextualization of the data capture session for later use, as a way of “visualizing” and making sense of the data, the sensors' data have been compared with the Vicon's data in order to characterize capture errors from the former. This comparison was useful

to inform the improvements made to the detection algorithms. Results from this Human Capture experiment show that the proposed sensors are adequate to be used in this scenario of falls detection.

From a human-centred design perspective, a living lab approach was used in order to ensure the relevance of the design ideas. Coherent with a human-centred approach, aiming not only at designing a potentially life-saving device, but one which also adds to the dignity and empowerment of the elders concerned (Bannon, 2011), the first step has been a qualitative needs analysis. The ethnographic observations and in-depth interviews focused on understanding people's gait problems – their concerns, activities, values, daily constraints, aspirations – in 2 contexts: independent living at home, and fall prevention training in a rehab centre. More generally, following the participatory approach adopted, different stakeholders with different perspectives were actively involved in the different design and evaluation tasks: elderly people themselves and their carers; health professionals (general practitioners, geriatricians, pharmacists) and rehabilitation professionals (physiotherapists, Adapted Physical Activity Teachers). In particular, observations of multi-professional "falls prevention workshops" with patients at risk of falls, allowed to understand the multifactorial causes of falls, as well as their consequences in all their complexity. The knowledge gained made it possible to usefully "inform" the design of the system and to improve its quality in a reflexive manner.

Based on these insights and the sensors prototypes, the next step has been to examine usefulness and acceptability issues during participatory workshops. Two of them brought together elders, caregivers (informal and professionals), clinicians, and researchers/engineers developing and building the sensors, and one was organized among rehabilitation professionals. The objective was to enrich and inform the design process with different point of views, competencies, perspectives, to prospectively and collaboratively build functionalities and scenarios that are desirable, useful, technically feasible, at a reasonable cost, and last but not least, which succeeds in empowering elders at risk of falling.

3. Understanding values to inform design

Falls prevention at the rehabilitation hospital participating in this research, rely mainly on patients' awareness and knowledge of the multifactorial causes of falls, and that they learn the techniques to get up by themselves without exterior help in case they fall. Discussions about elders empowerment and responsibility for themselves during workshops reveal stakeholders' reluctance about some assistive technologies. For them, too much materialization of assistance is neither educational nor preventive, and seriously limits the elders capacity to act. If one constantly needs a third party, whether an assistive technology or a person, is this really autonomy? Therefore, the values that emerged as important for stakeholders concerning the PRuDENCE device as an assistive technology, are: Individual freedom, independence, free will, while avoiding relational dependency. The device must combine the following characteristics: Adaptable/configurable (the user is in "control"), non-intrusive, discreet, efficient, durable (no false alarms, breakdowns), accessible – both from financial and usability perspectives, e.g. voice interaction – reassuring, accountable.

Interestingly concerning the workshop's issue of "visualization", what is considered desirable in this falls prevention device is precisely the fact that it is "transparent". Contrary to wearable devices or connected objects associated to follow-up apps with visual interfaces (Lan Hing Ting et al., 2020), the device is discretely installed in the home (small white boxes that match the environment). Its main perceived advantage is that "you don't have to think about it", users say. Thus, the absence of "interaction" – having no visual feedback or monitoring on the human movement data that the sensors are capturing with the device – is precisely what is expected and desired (especially when one knows that false alerts can be common with these types of sensors). However, the *sine qua non* condition is the trust in the visualization performance of the sensors, on their side, the sensors are actually detecting the human activity or sudden movement efficiently, so that falls can be detected successfully.

In the case a user falls, research is underway concerning the interaction design possibilities that would be in line with the important values that stakeholders expressed, mainly voice interaction and reassurance effect.

Conclusion

In this paper, we discussed the central importance of achieving both technical performance and putting elders needs at the centre of all design considerations. This way, a falls detection device like this will succeed in being useful for falls prevention and elders' empowerment, contributing to elders' autonomy, decision-making, and patient education.

Acknowledgements

The authors warmly thank “Les Amis du Living Lab” and our colleagues from CRRF COS Pasteur – specially Dragos Ghitiu, Anaïs Seguin, Adeline Delancret, Caroline Halm and Mattieu Detroy – as well as the patients for their participation in this research.

Bibliography

Bandera J.P., Marfil R., Romero-Garcés A., Voilmy D., (2019) *A new paradigm for autonomous human motion description and evaluation: Application to the Get Up & Go test use case*, Pattern Recognition Letters, Volume 118, 2019, Pages 51-60, ISSN 0167-8655

Bannon L., *Reimagining HCI: toward a more human-centered perspective*. Inter-actions 2011;18(4):50–7.

Blomberg J, Karasti H (2012) Ethnography: positioning ethnography within participatory design. In: Routledge International Handbook of Participatory Design :, Routledge International Handbooks, pp 86-116

Halima I., Laferté J-M, Cormier G., Fougère A-J., Dillenseger J-L.. *Sensors fusion for head tracking using Particle filter in a context of falls detection*. 1st International Conference on Advances in Signal Processing and Artificial Intelligence (ASPAl' 2019), Mar 2019, Barcelona, Spain. (hal-02096336)

Lan Hing Ting K., Dessinger G., Voilmy D., *Examining Usage to Ensure Utility: Co-Design of a Tool for Fall Prevention*, IRBM, 2020

World Health Organization, *Global health and ageing*. World Health Organization; 2011.

Zoetgnandé YWK., Fougères A-J, Cormier G., and Dillenseger J-L. *Robust low resolution thermal stereo camera calibration*, Proc. SPIE 11041, Eleventh International Conference on Machine Vision (ICMV 2018), 110411D (15 March 2019);