CARE4ALL-Initial

A new Human-Technology Interaction Concept for Care of People with Dementia

Hans-Joachim Böhme, Frank Bahrmann,
Christian Bischoff, Robert Erzgräber
University of Applied Sciences Dresden
HTW Dresden
Dresden, Germany
{boehme,bahrmann,bischoff, erzgraeber}@htw-dresden.de

Andreas Hermann, Steffi Frimmel
Universitätsklinikum Dresden
Dresden, Germany
andreas.hermann@ uniklinikum-dresden.de
steffi.frimmel@dzne.de

Elmar Gräßel, Catharina Wasic
Universitätsklinikum Erlangen
Erlangen, Germany
{elmar.graessel,catharina.wasic}@uk-erlangen.de

Frank Weber
Cognitec Systems GmbH
Dresden, Germany
frank.weber@cognitec.com

Abstract—**The project Care4All-Initial has been focused on developing and implementing application scenarios for robot assistant since May 2017 in order to improve and extent the care of dementia patients. University Hospital Erlangen, University Hospital Dresden, Cultus gGmbH Dresden, Cognitec Systems GmbH Dresden and Carus Consilium Sachsen GmbH are also involved in this project besides HTW Dresden. Successfully evaluated non-drug therapy concept MAKS (activation therapy for people with dementia – motor-, everyday practical-, cognitive- and social-skills) is a basis for Care4All. An assistance robot is currently being integrated into this therapy concept with its main task to postpone the advanced stages of dementia as far as possible and to help preserve the cognitive abilities of a patient as long as possible.**

The main focus of this article lies in the integration of the robot into this setting, which is based on the individual therapy components and meaningfully integrated robot functions such as autonomous navigation, speech synthesis, people detection and recognition, dialog management, or computer-projected games. The functions will be defined, then implemented and evaluated, adapted and successively expanded in a continuous user oriented process. The robot will observe the patients in order to enable appropriate documentation together with the therapists. The fact that the assistance robot must be embedded during the therapy between therapist and patients by means of suitable human-machine interfaces is a big challenge.

But the assistance robot has much more to offer and is going to be used as a mobile night watchman. It will patrol the corridors of the nursing home in order to detect potentially critical situations such as disoriented residents walking on their own and report these to the nursing staff via a mobile device which is connected to the robot. If such an incident occurs, the robot tries to calm the residents by talking to her/him until a member of the staff arrives.

I. INTRODUCTION

Germany has a high rate of elderly people and currently about 1.6 million German citizens suffer from dementia. This number can rise to around 3 million by 2050 according to forecasts of the German Alzheimer Society. This means that the German health care system has to be prepared for more patients coming to nursing homes and will have to respond to the doubled numbers with a proper strategy.

Figure 1: Robot Anna Constantia is greeting a patient to the MAKS therapy. The robot is equipped with an omnidirectional laser range finder, sonar sensors and a Kinect One RGB-D camera. The robots head/eyes has no sensor function.

In order to face the challenges related to the demographic development there have to be more institutional resources where people with dementia could get proper living assistance such as necessary care, treatments, clinics, nursing homes and as well properly trained nursing staff and doctors.

Technical assistance systems enable modern information and communication technology systems to offer a broad spectrum of possibilities or at least partially compensate for the occurring or progressive loss of cognitive and motor skills. These systems can interact with patients and they could be able to implement preventive, stabilizing or therapeutic functions, which may slow down the symptoms of dementia such as loss of the cognitive and motor skills. Those limitations could appear in the later course of the illness.

Care4All-Initial is based on the successfully evaluated therapy concept MAKS (activation therapy for people with dementia: motor-, everyday practical-, cognitive-, and social-skills) [1]. The main goal of the project is to maintain longer autonomy for patients with dementia by integrating technical assistance systems into this therapy concept and to postpone the need for necessary care as far as possible so that the patient's autonomy will be maintained for longer.

II. BACKGROUND AND AIMS

A. Background and scenarios

The Artificial Intelligence Lab at HTW Dresden has been working with the Cultus gGmbH for several years in order to improve the inpatient care of people with dementia. The main goal of this partnership was to develop and implement potential fields for application of mobile, interactive service and assistance systems in nursing homes in order to relieve the nursing staff and to increase the residents' quality of life. The current project will develop this application scenario by integrating competence from the medical, gerontological and psychological fields of medicine.

Clinic and Polyclinic for Neurology TU Dresden plays also a strategic role in the project, because this are the hospitals in Dresden, which treat patients with motor and non-motor limitations due to neurodegenerative diseases. The main goal of this partnership is to develop methods of human-technology interaction in order to support the specialists during ergotherapy, which can be transferred to use in the nursing home. This interaction used in the Clinic and Polyclinic will be a basis for evaluation and it needs to be adapted according to patients needs as well as to the needs of the nursing staff.

University Hospital Erlangen is very important the project, because the project team around Prof. Gräßel wrote and developed studies about MAKS therapy. Prof Gräßel is also the inventor of this Therapy. The Erlangen group will monitor the whole project and carry out necessary trainings for medical personnel in Dresden.

University Hospital Dresden, Cultus gGmbH Dresden, Cognitec Systems GmbH Dresden and Carus Consilium Sachsen GmbH are also involved in Care4All-Initial and will contribute their state of the art knowledge and research to the implementation of methods for human-machine interaction.

Prof. Gräßel's short quotation from the summary of the Erlangen MAKS study describes the current medical problem very well: "We wait too long. We make everything too late." [2] He describes this problem in the system showing that the main concern lies in the shortage of medical staff and quality therapy time in nursing homes. Prof. Gräßel believes, that focusing on the existing skills and practicing them regularly through targeted support can maintain these skills at their current level for a longer time. This means that the patients could do everyday activities like telephoning and self-washing for a longer period of time than expected. This not only saves time and money, which could be spent for care, but also makes the patients more independent and pleased with themselves.

The publication by Fissler et. al [3] describes that there are clear statements that playing board and card games can have positive effects on the maintenance of general cognitive skills. The same statements have been observed during the cooperation between the Cultus gGmbH and HTW Dresden. Board games, chess or card games are very popular in a nursing home and a robot playing the German card game Skat was already met with high appreciation.

The two robots August the Smart and Anna Constantia (Figure 1) are used in the health care units mentioned in the project. Both robots offer the necessary technical equipment to carry out initial experiments. Anna's platform also offers the possibility that additional sensory and actuator components can be installed on a test basis with little technical effort. Both robots are the commercially available platform Scitos G5 from MetraLabs GmbH Ilmenau[1]. During the project a new platform is planned, which has a smaller footprint than August or Anna and an optimized omni-directional drive, is favored as the basis. Successors of August and Anna will be equipped with at least the same components: interactive head, depth camera, microphone array, and touch screen. Further components like a controllable projector will be added to the design specifications if necessary.

B. Aims

The most important intention of Care4All-Initial is, that it will be focused on all people (relatives, care taker, therapists, doctors) interacting with patients suffering from dementia and the patients themselves. This therapy will be suitable for people with different stadiums of dementia starting from Mild Cognitive Impairment (MCI) up to stronger stadiums. It is very important to include the robot to the everyday practical part of the therapy and during social activities in the nursing home, so that it could be adjusted for the target group and could deal with specified requirements. After the testing of a scenario and having feedback from the nursing staff and patients, the robot will be implemented into the project and can be improved depending on the interactive development process and the results of the evaluation.

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1 MetraLabs GmbH: http://www.metralabs.com/en/industries/mobile-robot-research/

Figure 2: Single image from the video recordings done during a MAKS therapy session. At this time the patients are listening to the news, read by the robot Anna (located in the left fish eye view). The faces of all participants has been blurred to protect their privacy.

The assistance robot is equipped with tools for multi-modal person perception and modeling [4]. So it is able to recognize and track faces and bodies. In future development, being able to recognize a specific person, provides the ability to take care of individual needs of that patient. Care4All-Initial uses a Wizard-of-Oz approach that carries out the direct human-machine communication (the Wizard-of-Oz user interface as used in the early stages by experts is shown in Figure 3), this means that the robot's responses within a dialog are controlled by a hidden expert. The use of a Wizard-of-Oz strategy [5] has already proven to be very effective in several application scenarios, for example in the development of the mobile assistance robot TESARO [6] in the Technical Collections Dresden. Within this process, the robots functions will be automated step by step, relieving the nursing staff to concentrate on therapeutic observations and care.

This is a very efficient way to ensure the correct and effective functionality of a robot required for interaction with people, to perform robust speech recognition or adequate reaction to user intentions.

The robot is programmed to navigate in a known environment so it can see where the obstacles are and it can detect motion [7]. It can detect different body poses and body movements especially in critical situations or characterize movements needed to obtain parameters which can document the advantages of the therapy. These parameters will be evaluated and described in a feasibility study, which will determine usable functions and describe the chosen parameters. Additional motivations with tablets, Kinect 2, or computer projections will accompany elderly people in order to improve the acceptance of motor and cognitive exercises of the MAKS therapy. Suitable functions of the robot, scenarios and settings will be continuously determined, improved, adapted and extended. This will help to perform clinical and nursing experiments and to plan and implement a prototype of a mobile robot platform in the form of a system demonstrator. This platform will be integrated into the daily routine of MAKS therapy in nursing homes and clinics. Further plans include an integration into the health care system in Saxony, where assistance robots in inpatient and home care and in telemedicine networks will be implemented.

III. METHODS

A. Basic hypothesis and questions

The assistance robots will be put onto very specific tasks and after the successful implementation of the project Care4All-Initial they should provide a lot of answers about the usability within the therapy. It is expected to gain the answers about following core questions:

- How can technical assistance be actively integrated into everyday therapy and life of a patients suffering from dementia?

- How can it improve and extend forms of interaction positively influencing the maintenance of the everyday skills?

- Which parts of MAKS therapy are suitable for scenarios of human-technology interaction and to what extent can they be embedded and implemented?

- How can these scenarios be evaluated from a clinical-psychological perspective? How do they have to be designed?

- How can the insights of the silver gaming area be integrated into therapeutic games?

- How will these extended services be accepted by the residents of the nursing home and which parameters can be used to determine or describe acceptance?

Therefore the central question addressed by the project is:

- Will technical assistance be able to maintain or even improve the everyday skills of people suffering from dementia?
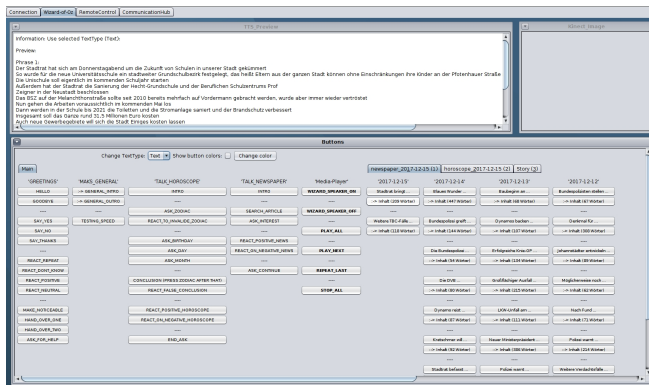
Figure 3: This figure shows a subset of options available to a trained expert during a Wizard of Oz experiment. Each button contains the ability to send a text to the speech synthesis, to perform a command (like projecting an image or video), or to play music.

The answer to this question may rely on the background hypothesis: The necessary degree of activation to achieve a significant effect in the therapy depends on one hand on the level of the stimulation of the patient's environment and on the other on the remaining abilities of the patient.

Each patient is in an individual stage of dementia and need different support. More intensive interaction with robots can be provided during free time activities in order to offer additional support for all the patients.

B.   Core methods and experiments

MAKS Therapy is based on the activation and preserving of motor, practical, cognitive and social abilities of people suffering from dementia. The therapy already takes place in a nursing home of Cultus gGmbH with a group of eight patients in a separate room six days a week for about two hours a day. It activates following core elements in a different ways:

- motor activation: patients are moving in every possible way with and without objects,
- practical everyday activation: patients are performing daily life routine like cooking, baking or crafting,
- cognitive exercises: patients are challenged with digital exercises, puzzles and exercises to activate the mind,
- social activation: patients are informed about the daily news, their horoscope and the menu

Usual therapy begins with a ten minutes warm up ritual such as singing a song together or a small discussion about a daily topic. Afterwards there is a 30 minutes block of motor exercises such as bowling or balancing a ball. After a small break the therapy continues with a half an hour of cognitive tasks developed specially for the MAKS project and presented with computer and projector. The exercises take place in a group and one usual task is to put picture jigsaws together in a right order, so that the patients can see the whole image again. The degree of difficulty can be changed by splitting the image into more or less pieces. The social part of the therapy described below is a concrete example of one week meetings with robot Anna. The degree of interaction with the robot increases daily.
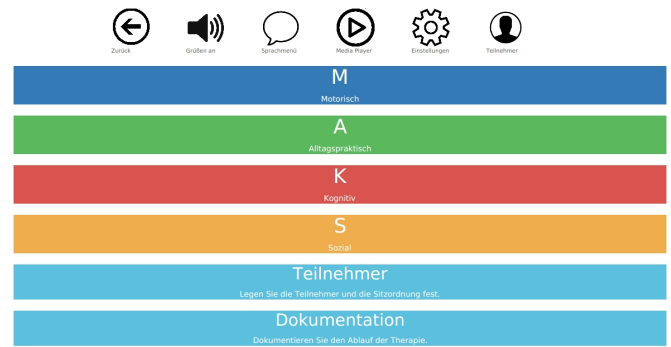

Figure 4: In contrast to Figure 3, this figure shows the newly developed user interface, designed to be controlled not by an expert but by the therapists. All functions that were previously available in the experts view are incorporated into this web application. The user interface is mainly meant to be controlled on a touch screen device.

- 1st day: the therapy starts with a video recording of the social part of the therapy without the presence of the robot,
- 2nd day: the robot welcomes the participants in front of MAKS room and is present during the social part without further interaction,
- 3rd day: the robot welcomes the participants and reads the horoscope to the participants,
- 4th day: the robot welcomes the participants and reads the horoscope, then it reads the latest news from the newspaper,
- 5th day: the robot welcomes the participants, reads the horoscope and the latest news from the newspaper, then it reads a Christmas story at the end of the social part of the therapy.

Practical everyday activities such as preparing snacks or handicrafts complete the therapy. The exercises are prepared and carried out by a specially trained therapist and an assistant.

After every day reactions of participants and therapists are being recorded with a 360° camera in order to be evaluated (shown in Figure 2).

This is important for making minor adjustments like the speed and volume of the robot's speech but mainly to evaluate the interest and degree of participation of the elderly people. The baseline recording on the 1st day was done to compare it with the other days in order to analyze whether the robot is a distracting element or not. Furthermore, therapists are required to fill out anonymous questionnaires with the personal assessment about how the robot affects participants and whether the use of robots has created added value to the therapy. The advantage of this everyday procedure gives the possibility to individually approach every patient. Different reactions of different persons can be compared with each other and connections between the individual days can be establish. The new scenarios and ideas can be created together and this may even avoid the undesirable scenarios and developments of the therapy.

IV. RESULTS

As the therapy is currently being tested, it is not yet possible to speak about the final results. Nevertheless there are expected results and first comments about the presence of the assistance robot during the therapy. First opinions about acceptance in the questionnaires for therapists are mostly positive. The robot is seen as support and it gives relief to the therapists by reading and talking to the patients. There is a small problem with a monotonous language of the robot and it has to be improved. The patients also had a positive reaction to Anna's visits: „She made it very well.", „She was much better understandable compared to yesterday." These are one of the first comments on the therapy, pointing out that there is some improvement on Anna's performance.

Based on the previous studies [8,9] of the Erlangen project group it is expected that the use of an assistance robot in MAKS therapy will have preventive, stabilizing and therapeutic function on residents of a nursing home. The patients will be able to maintain their motor and cognitive skills for a longer period of time and their well being will be much improved. Their relatives and nursing staff would feel relieved and could benefit from the better health of a patient. Relatives could simply spend more time with the patient because he/she is more mobile and integrated. In case of the nursing staff, additional time could be used to apply more intense care for other patients in need. The presence of the assistance robot should enrich the therapeutic environment, but it will not be a substitute for a human therapists. The nursing staff should not be replaced by a robot, but supported in their work.

If the final results of the social activation will turn positive, the assistance robots will be used in the context of cognitive activation.

Besides the use of known cognitive training games, a sound controlled collaborative game is in development. The aim of this game is, that all therapy participants are working together to achieve a common goal by making sounds according to their abilities (shouting, drum sticks, clapping). The robot takes the role as game master in explaining the rules. The playing field is projected by the robot onto the floor, while the patients are forming a circle around that area.

Furthermore, the robots functionality is already extended with the possibility of a karaoke function. This function provides the opportunity for the therapists to activate the patients memory by asking questions about the artist or the song text. Accompanied by the following singing, this is both a cognitive and a social exercise.

The handling of the therapy will be modified and adjusted to integrate additional wishes of patients. Additionally the Wizard-of-Oz is now controlled by therapist with tablet instead of an external observer outside the room, so that the therapist could adjust the speed and time of interaction and will no longer be dependent on an external person (shown in Figure 4).

While the wellbeing of the patients will be in good hands, there also will be an improvement to the innovative application of Ambient Assisted Living (AAL). The project partners will have scientific exchange of experience, where they expand their expertise. It will hopefully lead to methodological and technical requirements for follow-up projects and it may be even possible that the project will gain new partners for the follow-ups. As it was mentioned in Section II.B, technical assistance systems will be integrated in form of a pilot system into the health care system in Saxony and there are even some further solutions for integration in the form of digital services, integration into support networks or adaptation to individual needs.

In addition to the successful integration of the therapy concept it is also important to integrate the mobile robot platform in the daily life of the nursing home. Like stated earlier, the robot offers a wide variety of opportunities. One of them is the realization of a robotic night shift companion - RoNiSCo [10]. Its purpose is to navigate through the hallways at night time and look for persons, that are potentially in risk of falling. The main goal here is to bind the person in risk by simply talking to them (Down-Talk). The robot is meant as a distraction from their
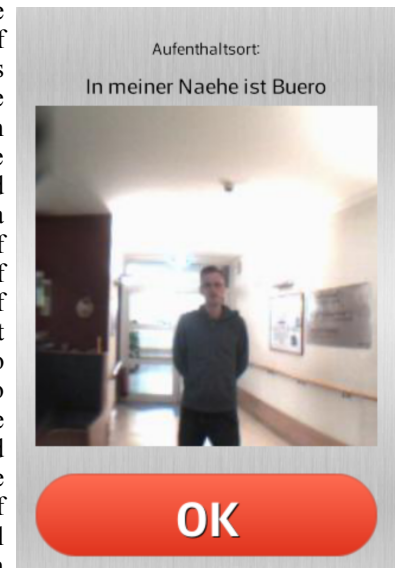

Figure 5: A screenshot of an incident notification on the staff's mobile device. Only the section of the image in which the person is visible, is sent to the staff.

previous goal as long as it takes the staff to arrive and solve the situation by escorting the elderly person back to their room. This is accomplished by the notification of the staff by a mobile device. It will sound a notification alarm and display an image of the detected person (shown in Fig. 5). In that moment the staff is able to discard the alarm, if the person is not known to have risks of falling or come to aid. Navigating in a dynamic environment is a big field of research on its own. Besides path planning and motion control it is imperative to find ways to model that dynamic behavior of the robot's surroundings [11,12,13,14,15,16]. The aggregation of all those algorithms, enables the robot to navigate safely over long periods of time, from the robot's point of view. The human perception of that navigation behavior is often in contrast. Multiple methods has been proposed towards a more socially acceptable navigation behavior [17, 18].

V. CONCLUSIONS

Care4All-Initial is currently working on a solution with a great potential of an expand including added value to the health-care and economy. The robot assistants are ideally suited for integrating additional functions in the form of digital services. This will allow them to be integrated into further support networks and be individually tailored to the needs of dementia patients, so that they even could be used at home.

With all this technological improvement and the added value to the therapy, the attractiveness of the care facilities will increase. The increased attractiveness for potentially interested parties will enable the Cultus gGmbH to at least temporarily develop an unique selling proposition, present itself as an innovative pioneer and establish further methods developed for human-technology interaction. The participating scientific partners aim to improve and expand their methodological competence related to the real-world scenarios for the target group in the new application scenarios.

Assistance systems offer enormous market potential for the Saxon health industry. The project team at HTW Dresden and the other partners involved in Care4All-Initial have been trying to make a progress with developing and establishing innovative AAL applications.

Due to the demographic development in Germany, there will be more nursing homes and more specialist will be needed. The assistance robot fits perfectly into the gap between new vacancies and the quality time during therapy. The nursing staff will be put up to great challenges with a bigger number of patients in the future and the assistance robot could be a great help to solve those challenges.

REFERENCES

[1] Elmar Graessel, Renate Stemmer, Birgit Eichenseer, Sabine Pickel, Carolin Donath, Johannes Kornhuber and Katharina Luttenberger: Non-pharmacological, multicomponent group therapy in patients with degenerative dementia: a 12-month randomized, controlled trial. BMC Medicine 2011, 9:129

[2] Birgit Eichenseer, Elmar Gräßel: Aktivierungstherapie für Menschen mit Demenz - motorisch - alltagspraktisch - kognitiv - spirituell (2015). Elsevier Urban & Fischer

[3] Patrick Fissler, Olivia Küster, Winfried Schlee, Iris-Tatjana Kolassa: Novelty Interventions to Enhance Broad Cognitive Abilities and Prevent Dementia: Synergistic Approaches for the Facilitation of Positive Plastic Change. Progress in Brain Research 207 (2013). pp. 403-434, http://dx.doi.org/10.1016/B978-0-444-63327-9.00017-5

[4] Fonfara, Johannes, Hellbach, Sven & Böhme, Hans-Joachim : Attention Please: Modeling User Interest in a Conversation with a Tour Guide Robot. Proceedings of the Workshop - Techniques Towards Companion Technologies in conjuction with the 13th Intelligent Virtual Agents conference (IVA 2013), 2013

[5] Poschmann et al: Wizard of Oz revisited: Researching on a tour guide robot while being faced with the public. RO-MAN 2012

[6] Marc Donner, Marian Himstedt, Sven Hellbach & Hans-Joachim Böhme: Awakening history: Preparing a museum tour guide robot for augmenting exhibits. Proceedings of the European Conference on Mobile Robots (ECMR), 2013

[7] Marc Donner, Peter Poschmann, Mathias Klingner, Frank Bahrmann, Sven Hellbach & Hans-Joachim Böhme: Obstacle detection for robust local navigation through dynamic real-world environments. Workshop on Color-Depth Camera Fusion in Robotics at the IEEE/RJS International Conference on Intelligent Robot Systems (IROS), 2012

[8] Luttenberger K, Donath C, Uter W, Graessel E (2012). Effects of multimodal nondrug therapy on dementia symptoms and need for care in nursing home residents with degenerative dementia: a randomized-controlled study with 6-month follow-up. Journal of the American Geriatrics Society 60: 830-840.

[9] Luttenberger K, Hofner B, Graessel E (2012). Are the effects of a non-drug multimodal activation therapy of dementia sustainable? Follow-up study 10 months after completion of a randomised controlled trial. BMC Neurology 12: 151

[10] F. Lischke, F. Bahrmann, S. Hellbach and H.-J. Böhme. RoNiSCo: Robotic Night Shift Companion. In Machine Learning Reports 03/2017, pages 26-35, 2017.

[11] Bahrmann, Frank, Hellbach, Sven. Böhme, Hans-Joachim (2016), Telehealth and Assistive Technology / 847: Intelligent Systems and Robotics, ACTA Press

[12] Bahrmann, Frank, Sven Hellbach, and Hans-Joachim Böhme. "Please tell me where I am: A fundament for a semantic labeling approach." Poster and Demo Track of KI (2012): 120-124.

[13] Hellbach, Sven, et al. "Learning is hard work: Detecting dynamic obstacles in occupancy grid maps." Workshop New Challenges in Neural Computation 2014. 2014.

[14] Bahrmann, Frank, et al. "Understanding Dynamic Environments with Fuzzy Perception." International Conference on Neural Information Processing. Springer, Cham, 2014.

[15] Einhorn, Erik, and Horst-Michael Gross. "Generic NDT mapping in dynamic environments and its application for lifelong SLAM." Robotics and Autonomous Systems 69 (2015): 28-39.

[16] Saarinen, Jari, Henrik Andreasson, and Achim J. Lilienthal. "Independent markov chain occupancy grid maps for representation of dynamic environment." Intelligent Robots and Systems (IROS), 2012 IEEE/RSJ International Conference on. IEEE, 2012.

[17] Kirby, Rachel, Reid Simmons, and Jodi Forlizzi. "Companion: A constraint-optimizing method for person-acceptable navigation." Robot and Human Interactive Communication, 2009. RO-MAN 2009. The 18th IEEE International Symposium on. IEEE, 2009.

[18] Shiomi, Masahiro, et al. "Towards a socially acceptable collision avoidance for a mobile robot navigating among pedestrians using a pedestrian model." International Journal of Social Robotics 6.3 (2014): 443-455.