Devices for Assisted Living

# DALi c-Walker on the move

## Interview with Daniele Fontanelli

### What did you investigate as part of the DALi project?

The main expected outcome of the DALi project is to deliver an intelligent cart conceived to help senior people in crowded and potentially stressful environments. To achieve this ambitious goal, the cart intelligence builds upon three components:
***A) sensor architecture.***
***B) cognitive engine.***
***C) rendering of information and mechanical guidance.***
During the DALi project, I have jointly worked with Prof. Luigi Palopoli on three topics, each belonging to one of the three components previously reported.

For the sensor architecture, we have collaborated with Prof. David Macii of University of Trento on the design of the walker localization algorithms. ***The main goal of localization is to keep track of the position of the cart, and hence of the senior using it, when it moves inside the indoor environment.***
To this end, we have conceived a sensor fusion algorithm that coherently fuses the information available from the walker (mechanical and visual odometry, tachometers) and coming from the environment (radio frequency ID tags, visual markers and environmental visual maps) in an efficient way. The algorithm shows to be robust to partial failures of sensors, which is a key feature for a reliable application of the proposed solution in a real environment. A related problem that has been investigated is the deployment of the environmental sensors: how many sensors are needed to guarantee the desired tracking accuracy? Based on the characterization of the sensors available in the current version of the DALi c-Walker, we have designed an algorithm able to optimally derive the deployment of the sensors in the environment given the maximum tolerable uncertainty. In these days, we are carrying out several on-the-field experimental trials to test the effectiveness of the localization algorithm as an enabling technology for the other platform components.

The cognitive engine is the “brain” of the c-Walker: it implements the ability to understand the emotional situation of the user and to interpret the user surroundings to the purpose of planning the correct course of action and hence achieve the desired location in the environment. Our involvement for this component was to design the cognitive engine that discriminates, understands and predicts the motion of the human beings in the c-Wlaker surroundings. Based on this information, the local planner, i.e., ***the planner that determines local deviations in the motion of the user to avoid collisions and unsafe situations, is able to produce alternatives according to the user needs.***
The baseline of this thread of research is the set of motion templates that govern the user movements in shared spaces, which are part of the project findings. This is a work that is still in progress, since it is sequential to the other outcomes of the project.

Finally, I have participated in the design of the mechanical guidance with the partners from the University of Siena. We have conceived a system that is able to steer the human inside the environment according to the trajectory generated by the global/local planners. The mechanical guidance is based on the walker brakes: the idea is to modulate the braking forces on the rear wheels in order to guide the user to the desired trajectory. The guidance is very gentle in order to minimize the user feelings of being “controlled” and, hence, maximize user acceptance. Moreover, the control becomes more and more authoritative whenever the departure of the user from the planned trajectory increases. Nevertheless, ***the senior has always the possibility to override the controls and so remains in charge of the decisions during the path execution.*** As a back-up system and to increase the guidance authority for safety reasons, we have added a simpler and more natural guidance system that is obtained by changing the angle of the front steering wheels of the c-Walker.

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### Impact of the research in the field

While the localization algorithms represents solutions to the particular system at hand, the optimal solution to the environmental sensor deployment represents a new point-of-view of the general problem of optimal sensor placement known in robotics. We are still working on this subject, trying to analytically solve the sensor deployment in its most general formulation.
For what concerns the motion templates, we think that this is a valuable work that tries to rigorously define and estimate the human behaviours in shared environments, a subject that is still roughly defined in the field of service robotics.

Finally, the mechanical guidance does not represent a novelty per se, since solutions for other service robotic applications already exist. However, we are confident that the experiments with the seniors will validate our solution as “comfortable” and, consequently, we think that this paradigm as the potential to be widely applied in similar service robots.

### Selected publications


Payam Nazemzadeh, Daniele Fontanelli, David Macii, Luigi Palopoli, “Indoor Positioning of Wheeled Devices for Ambient Assisted Living: a Case Study”, IEEE International Instrumentation and Measurement Technology Conference (I2MTC), 2014

Alessio Colombo and Daniele Fontanelli and David Macii and Luigi Palopoli, “Flexible Indoor Localization and Tracking based on a Wearable Platform and Sensor Data Fusion,” IEEE Trans. on Instrumentation and Measurements, 2013

Payam Nazemzadeh and Daniele Fontanelli and David Macii and Tizar Rizano and Luigi Palopoli, “Design and Performance Analysis of an Indoor Position Tracking Technique for Smart Rollators,” Indoor Positioning and Indoor Navigation (IPIN), 2013

Alessio Colombo and Daniele Fontanelli and Dhaval Gandhi and Antonella De Angeli and Luigi Palopoli and Sean Sedwards and Axel Legay, “Behavioural Templates Improve Robot Motion Planning with Social Force Model in Human Environments,” Proc. IEEE Int. Conf. on Emerging Technologies & Factory Automation (ETFA), 2013

Alessio Colombo and Daniele Fontanelli and Axel Legay and Luigi Palopoli and Sean Sedwards, “Motion Planning in Crowds using Statistical Model Checking to Enhance the Social Force Model,” Proc. IEEE Int. Conf. on Decision and Control, 2013

Daniele Fontanelli and Antonio Giannitrapani and Luigi Palopoli and Domenico Prattichizzo, “Unicycle Steering by Brakes: a Passive Guidance Support for an Assistive Cart,” Proc. IEEE Int. Conf. on Decision and Control, 2013


### About Daniele Fontanelli

Daniele Fontanelli received the M.S. degree in Information Engineering in 2001, and the Ph.D. degree in Automation, Robotics and Bioengineering in 2006, both from the University of Pisa, Pisa, Italy. He was a Visiting Scientist with the Vision Lab of the University of California at Los Angeles, Los Angeles, US, from 2006 to 2007. From 2007 to 2008, he has been an Associate Researcher with the Interdepartment Research Center ``E. Piaggio", University of Pisa. From 2008 to 2013 he joined as an Associate Researcher the Department of Information Engineering and Computer Science and from 2014 the Department of Industrial Engineering, both at the University of Trento, Trento, Italy. His research interests include real-time control and estimation, resource aware control, mobile robotics and visual servoing, localization algorithms and human robot interaction.