MSc Thesis Proposal – Navigation control of a multipurpose assistive robot vehicle

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Background

In industrialized countries, regional disparities in healthcare and welfare services, increased medical expense caused by aging societies and shortages of medical staff have become serious problems. In Sweden, it is expected that about 25% of Swedes population will be older than 65 years old by 2060 [1]. For this purpose, robot technology (RT) is expected to be an important key to find solutions to these problems. In particular, different walking-aid robots have been proposed during the last decades. In particular, the walking-aid robots can be classified in two main groups according to the mobility factor [2]: active-type walkers (driven by a servo motor) and passive-type walkers (driven by a servo brake). However, the physical support is provided by means of a fixed length and stiffness aluminum stick and cannot be customized depending on the needs of the specific user and environmental conditions. From those researches, a special focus has done in terms to increase the level of multimodal interaction, sensing and control to facilitate the perception of the environment for a better guidance and provide a static physical support to avoid falling down. However, dynamic physical support, the adaptability to the user/task needs and the multipurpose design concept has scarcely studied.

For this purpose, at Karlstad University, a multipurpose human-friendly robot for assisting elderly persons (e.g. walking-support) as well as assisting care givers (e.g. carrying-medical tools) is under development. Due to the complexity of the proposed research, two assistive robots vehicles are under development at Karlstad University: an intelligent carrying-medical tools robot vehicle (*iCAR*) [3] and a human-friendly assistive robot vehicle for supporting physically elderly (*hWALK*) [4]. A mobile robot vehicle with on board sensors, and two-actuated and four-passive wheels composes the iCAR. A simplified fuzzy logic controller has been implemented for the navigation control. The iCAR was able to correct its posture in order to follow the subject after a transitional period of time. On the other hand, a time-delay neural network was designed and implemented for the 3D gesture recognition. A successful gesture recognition percentage of 91% was obtained. A two- wheeled inverted pendulum mobile robot, a 3-DOFs desktop haptic interface, a mobile computer and a wireless module for communication purposes, composes the hWALK. A PID controller was implemented for the stability control and preliminary experiments were presented to verify the stability of the two-wheeled inverted pendulum. As a result, under static condition the *hWALK* was stabilized in about 16 seconds on a surface with carpet padding and 30 seconds on a surface with parquet. In order to improve the velocity control of the two-wheeled inverted pendulum of the *hWALK*, the LQR was implemented as a compensator for the wheel angular velocity to the existent PID controller [5]. More recently, both the *iCAR* and *hWALK* have been integrated into a multipurpose human-friendly assistive robot vehicle (*KFriend*) for providing assisting caregivers and supporting physically elderly. In particular, due to the fact the 3D gesture recognition system implemented into the *iCAR* has designed for a statically stable mobile platform, a denoising the human motion data of the 3D gesture recognition system for a dynamically stable mobile platform has been proposed and implemented. From the experimental results, a 95.20% of success ratio was obtained [6].

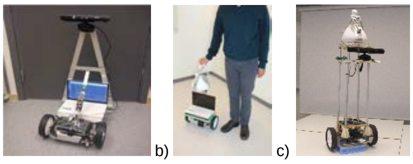
a) b) c)

Figure 1. Assistive robot vehicles developed at Karlstad University: a) iCAR and b) hWALK c) KFriend

Objectives:

The objective are:

- Integrate the 3D gesture recognition to the navigation control of the mobile robot;
- Determine suitable control techniques for improving the accuracy of the navigation control of the mobile robot and implement them into the proposed system.

Tasks and tools

The thesis work should comprise the following tasks:

- Literature study on mobile robots, signal processing and control techniques
- Design the proposed control strategy
- Implement the algorithm in an ARM processor for real-time applications
- Verify the implemented algorithm in a real environment
- Write thesis report describing the work and results

Requirements

One student in MCs programs in Electrical Engineering, Mechanical Engineering, and Physics Engineering or similar is suited for this job. The master thesis work will take 20 full working weeks (30 hp). Candidate should have a basic background in control, modelling and signal processing. Good programming skills is desired. It is also important that the applicant have good writing and communication skills. Please attach a list of courses with marks and a CV in your application.

References

[1] Wilén, A., Ljungberg, A. (2009). The future population of Sweden 2009–2060, Statistics Sweden, Forecasting Institute, pp. 20.

[2] Fukuda, T., Huang, J., D., Pei, Sekiyama, K. (2015) "Motion control and fall detection of intelligent cane robot, Intelligent Assistive Robots, Springer Tracts in Advanced Robotics, vol. 106, pp. 317-337.

[3] Solis, J. et al. (2014). Development of a human friendly robot vehicle for carrying-medical tools: Embodying perceptual capabilities, 14th Mechatronics Forum Int. Conf. Mechatronics, pp. 370-376

[4] Solis, J., De la Rosa, J.P. (2015). Development of a human-friendly walking assist robot vehicle: System Integration and Preliminary Stability Tests, 14th World Congress in Mechanism and Machine Science.

[5] Solis, J., Sansanayuth, T., Shojaei, E. (2016). Velocity control improvement for the Human-Friendly Assist Robot Vehicle, 2016 IEEE/SICE International Symposium on System Integration, pp. 331-336.

[6] Solis, J., Amaral, F. (2017). Denoising of human motion data for a 3D gesture recognition system for a two-wheeled inverted pendulum robot, IEEE International Conference on Advanced Intelligent Mechatronics, pp. 43-44

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