Monitoring and Interpreting Human Motion to Support Clinical Applications of a Smart Walker

Paschalis Panteleris*, Antonis Argyros*

*Foundation for Research and Technology – Hellas (FORTH), Greece, {padeler,argyros}@ics.forth.gr

We present two proof-of-concept applications of human motion perception technologies for automating clinical tests performed by the FriWalk smart walker. FriWalk is a robotic walker currently being developed in the context of the EU H2020 project ACANTO that is designed to operate in a "personal" or a "clinical" mode. The goal of the clinical FriWalk is to support/automate clinical tests and rehabilitation of patients with mobility problems. The two applications under consideration are the following:

(A) **The "short physical performance battery" (SPPB) test:** SPPB is a standardized method used by geriatricians to measure the functional status and physical performance of older adults. The test measures lower extremity function using tasks that mimic daily activities. One of these tasks is the "sit-stand" test. To pass the test the patient sits on a standard chair and has to perform five sit to stand transitions as quickly as possible and without using his/her hands. FriWalk automates the execution of this test by monitoring and interpreting the motion/activities of the user. To start the test, the user signals the walker to move to the proper position with a gesture. The walker autonomously moves at a proper distance from the user and asks him/her to start the test. Instructions and feedback are displayed on the walker's touch screen called "FriTab". At any point, the user may stop the test and signal the walker back using the "cancel" and "return" gestures, respectively. The walker monitors the execution of the test and, upon completion, provides feedback to the user.

(B) **Gait analysis** is used to detect early symptoms of frailty and reduction in the mobility of older adults. The state of the art in clinical gait analysis is to deploy a carpet-like structure instrumented with pressure sensors. However, such methods can only provide information regarding the pressure points and do not capture the articulation of the human skeleton during the act of walking. FriWalk automates this process by monitoring a 3D skeletal model of the user. To start the application the user has to move in front of the walker and perform a predefined gesture. He/she then turns around and starts walking while FriWalk follows him/her autonomously in a follow-the-user scenario. At the same time, FriWalk tracks and records a 3D skeletal model of the user which is then made available to the physician for further analysis.

Both applications are based on three vision-based modules that run in real time on board the FriWalk:

3D human body tracking [1]: Provides articulation information from markerless visual observations obtained by a depth sensor mounted in the front of the walker. The method can detect automatically the user and estimate the 3D pose of either the full or the upper part of his/her body (up to 4 meters away).

Simultaneous localization, mapping and moving object tracking (SLAMMOT) [3]: The RGB-D sensor information is used to create a map of the environment and segment the static background from the moving objects in the foreground. The method leverages on the fact that the majority of the motion in a sequence of frames can be attributed to the egomotion of the camera. Areas in the FoV that do not follow the predicted motion pattern but can be clustered together due to uniform motion are identified as foreground moving obstacles.

Gesture recognition [2,4]: Using the skeleton information from the body tracker, this module interprets hand/arm gestures performed by a user. This enables vision-based human-walker interaction that is particularly useful for the implementation of the aforementioned clinical applications.

Note: The vision components that are employed in the above described scenarios can be demonstrated lively during the Workshop.

Acknowledgements: This work was partially funded by the H2020 project ACANTO http://www.ict-acanto.eu/

References

[1] Michel D and Argyros A, APPARATUSES, METHODS AND SYSTEMS FOR RECOVERING A 3-DIMENSIONAL SKELETAL MODEL OF THE HUMAN BODY, U.S. patent application No. 62/053,667, 22/09/2015.

[2] Michel D, Papoutsakis P and Argyros A, GESTURE RECOGNITION APPARATUSES, METHODS AND SYSTEMS FOR HUMAN-MACHINE INTERACTION, U.S. provisional patent application No. 62/051,271, 16/09/2015.

[3] Panteleris P and Argyros A, "Vision-Based SLAM and Moving Objects Tracking for the Perceptual Support of a Smart Walker Platform", In European Conference on Computer Vision Workshops (HAU3D 2014 - ECCVW 2014), Springer, pp. 407-423, Zurich, Switzerland, January 2014.

[4] Michel D, Papoutsakis KE and Argyros A, "Gesture Recognition Supporting the Interaction of Humans with Socially Assistive Robots", In Advances in Visual Computing (ISVC 2014), Springer, pp. 793-804, Las Vegas, Nevada, USA, December 2014.