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Titel
Plantare Druckpunktmessung bei intelligenten Orthesen mit großzügig und optimal angeordneten Drucksensoren

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Zusammenfassung

Einleitung
The elderly frequently present with difficulties controlling their balance and, where clinically appropriate, may be prescribed an orthosis to help. However current monitoring of the patients involves visits to clinic. Remote monitoring of the patients could reduce the number of unnecessary visits to the clinic and help targeting the right patients. Smart orthoses attempt to address this issue with embedded sensors, which can collect objective data. Centre-of-pressure (CoP) trajectory and velocity have been linked with balance ability and the risk of falling [1]. An orthosis able to measure CoP data could provide useful information regarding its efficacy and measure the impact of the orthotic intervention. This work aims at finding strategic locations for a sparse distribution of sensors to be placed on the plantar surface of an orthosis. Such system aims at providing accurate estimation of CoP, whilst minimising financial costs and battery drainage.

Methodik
A pressure mat was used to record plantar pressure and calculate CoP data from five active, able-bodied subjects walking at pre-defined slow, normal and fast walking speeds. Subsequently, the CoP was estimated based on data extracted from that measured plantar pressure, at isolated, strategically-selected, locations, which simulated a sparse distribution of individual ‘sensors’. The locations of the ‘sensors’ were selected using a pseudo-global optimisation, which aimed to minimise the difference between measured trajectory of the CoP from the pressure mat data and that estimated by the sparse ‘sensor’ distribution. Initially, the
data from a single subject’s (S1) normal speed steps was used to identify optimal number of sensors, and their locations. Subsequently, artificial weightings were added to each ‘sensor’ location and a second optimisation algorithm was applied to further refine the CoP estimations for the intra-subject comparison over different walking speeds.

**Ergebnisse**
The initial optimisation procedure revealed that eight-sensor-distribution achieved target RMSE-s in x- and y-directions (4mm) for steps of all investigated speeds. The eight-sensor-distribution was applied to the four other subjects and the mean RMSE between the measured CoP trajectory from the pressure mat and the estimated one from the optimally-distributed sparse sensors, was defined. Those RMSE values were deemed acceptable for three of the four subjects. Upon the application of weighting for walking speed, RMSE values were improved, compared to a non-weighting strategy and were deemed acceptable for four of the five subjects. The figure shows the temporal centre-of-pressure (CoP) trajectories, as measured by the pressure mat (blue solid line/circles) and estimated by the sparse ‘sensor’ distribution (red dotted line/red halved circles). The circles represent the CoP location at every 20% of the step. The ‘sensor’ locations (green triangles) are positioned proportionately, relative to each subject’s footprint.

**Schlußfolgerung**
This work suggests that CoP trajectory could be adequately monitored by eight force sensors, embedded into a smart orthosis, located at specific positions on the plantar surface. The weightings could be applied to improve CoP trajectory prediction to account for different walking speeds. The inclusion of optimal pressure sensor distribution into smart orthoses could provide a cost-effective and portable method of real-time data collection in clinics. Furthermore this system could provide means for remote collection of clinically-meaningful data to the orthotist. The technique shows good inter-subject performance, albeit not universally. Future refinement of the algorithms, as well as expansion of the subject cohort to patients with lower limb disabilities, may further improve the inter-subject transferability.
Literaturreferenzen

Image: LAR figure_2167.png