associated with an increased risk of falling in elderly people. Kinematics of this task is usually extracted by using markers applied on the body surface, and *ad hoc* hardware and software. In clinical practice, the qualitative information obtained by visual inspection is commonly accepted as a cheap, quick, and easy to use way of determining subjects' motor skills. In the present contribution, markerless analysis of video sequences captured with a low-cost video camera is performed to extract performance kinematic parameters, and test if they were able to predict scores coming from the Short Physical Performance Battery (SPPB) test [1].

METHODS: 41 healthy elderly subjects (70±9 yrs) were administered the whole SPPB test, and scores from the tests were calculated. Then, they were asked to repeat the STS task 3 times at a self-selected comfortable speed. A digital camera was used to capture the videos (1.4 Mpixel, 25 fps). Translations and rotations of relevant points at the shoulder, waist, knee, and ankle level were estimated by means of a maximum likelihood approach carried out by transforming the video frames in the Gauss-Laguerre domain [2]. Then, a 2D kinematic body model was built to estimate the angle trajectories, namely trunk and leg flexion (i.e. $\alpha(t)$ and $\gamma(t)$) [3]). The duration of each STS phase, minimum values of both $\alpha(t)$ and $\gamma(t)$, and maximum velocities were then calculated from these trajectories. To verify if the extracted parameters were able to predict SPPB scores, regression was done both separately for each parameter and by using a multivariate approach, with SPPB scores as dependent variables.

RESULTS: The analysis of $\alpha(t)$ and $\gamma(t)$ and their maximum velocities shows limited leg mobility and high trunk oscillations (α_{min}=48.5±10.9 deg; γ_{min}=70.9±6.1 deg; $V\alpha_{max}$=76.6±25.9 deg/s; $V\gamma_{max}$=30.4±11.9 deg/s): subjects present a "fully forward" strategy in accordance with published studies on elderly population. No parameter was able alone to reliably predict SPPB scores, whereas multivariate statistics obtained by using all the parameters yielded fair results (residual variance 2.3 SPPB points).

CONCLUSIONS: Parameters extracted from STS manoeuvre kinematics, as estimated by the Gauss-Laguerre markerless approach allowed identifying the different strategies in movement execution in a repeatable yet patient-comfortable way. At the same time, the results obtained in terms of their ability to predict the overall scores from the SPPB test were just fair, thus outlining the need to objectively monitor not only STS, but also the other SPPB motor tasks (i.e. balance and gait).

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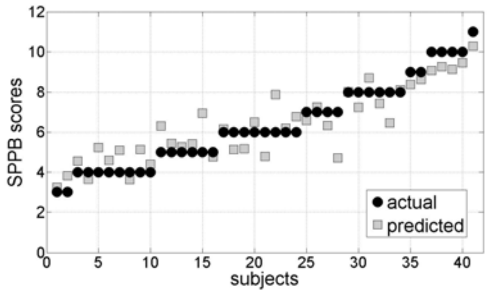

Fig. 1. SPPB scores as fitted by multivariate statistics (actual scores in black circles)

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O.10

3D gait analysis using wearable 6D IMU on shoe

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INTRODUCTION: Recently, a number of studies have shown that miniature body-worn inertial sensors can be used for temporal and spatial gait analysis. 2D Gait analysis by means of inertial sensors was introduced on lower limbs [1] and then on foot [2]. Use of 3D sensors was introduced in [3] for drop-foot stimulation. The aim of this study was to provide a wearable inertial system attached to the shoe providing accurately spatio-temporal gait parameters and the 3D trajectory of the foot during unconstraint walking involving different pathways.

METHODS: A 6D Inertial Measuring Unit (IMU) including tri-axial accelerometer and tri-axial gyroscope was attached on the rear part of the shoe. Key temporal events of each gait cycle were detected using 6D signals. Static period before gait initiation was used to know initial orientation, and then 3D orientation quaternion was incrementally computed with gyroscope signals and re-aligned at each static period through accelerometers. Therefore, IMU was virtually aligned to compute 3D accelerations in fixed frame. 3D velocities and displacements were computed by integration of accelerations and by considering some biomechanical constraints to avoid error accumulation. More than 90 gait cycles with various velocities were recorded using a motion capture system as reference, including 7 VICON cameras and 3 markers attached to the 6D IMU. Different walking trajectories including turning were tested.

RESULTS: Results are given for overall gait cycles including transition steps and turns. 3D Orientation was determined with 2.4° RMS error. Accuracy±Precision obtained for step length, foot clearance and stride velocity were respectively 1.6±4.9cm, 0.3±0.8cm and 1.3±4.2cm/s. Figure 1 Compares the foot trajectory based on 6D IMU system with the reference system.

CONCLUSIONS: The results obtained so far showed that the 6D IMU attached on foot were more precise than previous technique using 2D gait analysis. The proposed method has a great potential in clinical evaluation of gait. Moreover it doesn't require any per-subject calibration and works automatically with any gait path. Main contributions are new parameters, such as 3D spatial trajectory and orientation. The system will be used in the framework of SMILING project aiming at counteracting falls in the elderly by challenging the patient to solve new motor problems in real time.

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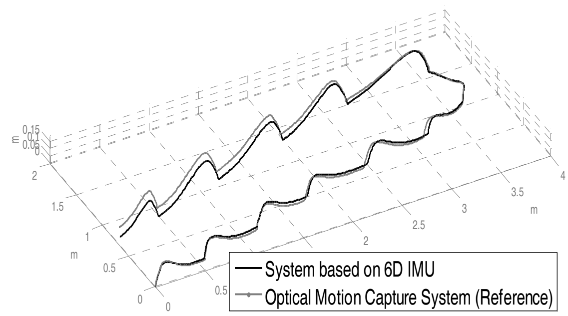

Fig.1 3D Foot trajectory during gait initiation, steady state walking and turning.

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O.11

Automated biofeedback assistance for freezing of gait in patients with Parkinson's disease

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INTRODUCTION: Freezing of gait (FOG) is a disabling gait disturbance commonly seen in patients with advanced Parkinson's disease (PD). It has been suggested that external cuing provided in a timely fashion may help the patient to negotiate the FOG episode and to resume functional walking. In recent years, the use of context aware wearable devices for medical purposes has been gradually spreading. We tested the idea that a wearable device that recognizes, in real-time, the occurrence of a FOG episode and provides auditory cueing may be used to "break" the freezing and reduce its impact on the mobility of patients with PD.

METHODS: 10 PD patients (66.5±4.8 y; H&Y in "ON";2.7±0.6) with a history of FOG were studied. 8 patients were examined in the "OFF" state (>12h from last medication uptake) and 2 patients who experience FOG also during the "ON" medication cycle were examined in the "ON" state. Patients wore a miniature 3D accelerometer (27x 4x15 mm^3, 25 grams) attached to one of their ankles. Time series of acceleration were transmitted (64Hz) wirelessly to a wearable device (132x82x30 mm^3, 231 grams) placed on the trunk for real-time identification of FOG (using an algorithm based on a set of frequency content criteria). Earphones placed around the subject's neck and connected to the wearable device produced a 1 Hz ticking sound whenever an episode was identified and lasted 3 s after the subject resumed walking. The subjects walked twice for about 10 min in paths representative of normal daily walking (straight line, turning, and moving around rooms) with and without the earphones connected. Real time annotation and simultaneous video taping were used to determine the number of FOG episodes. Self-report of patient satisfaction also determined using a standardized form.

RESULTS: 8 patients exhibited FOG in the lab. 96.2% of the identified FOG episodes (n=237) were detected online by the wearable device and in all of these cases the auditory cuing started to operate. The 'technological' sensitivity and specificity of the device were 73.1% sensitivity and 81.6%, respectively (based on 0.5 sec moving window). Post-hoc optimization analysis suggested that these figures could have been 88.6% and 92.8%, respectively; if the device would have been