A data-driven classification solution for the timed-up and go test in risk falling assessment

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***Abstract*— This study presents a new version of the TUG test used to diagnose the falling risk in elderly persons. Patients are equipped with wearable inertial sensors and a classification algorithm is implemented to predict the risk.**

***Clinical Relevance*— This new test would allow clinicians to improve the diagnostic efficiency of the TUG test while preserving its simplicity of application.**

I. INTRODUCTION

The present study addresses the issue of automated classification methods of healthy and risky subjects based on the Timed-Up and Go test. This test was introduced in 1991 by Podsiadlo and Richardson [1] and since many other studies have proposed to improve its diagnostic performances. However, Barry *et al.* have shown in 2014 the poor performances of the current test [2] with a sensitivity of only 32%. In this study, our goal is to keep the simplicity of the test while improving its sensitivity performances by analyzing signals recorded during the tests by inertial wearable sensors.

II. METHODS

An age simulation suit was used by four different subjects who performed the TUG test in triplicate with and without the simulation suit. Each subject was equipped with five wearable inertial sensors at five specific positions: neck, belt, right wrist, left and right foot. The inertial sensors used for the test were MetaMotionR sensors developed by Mbientlab Inc. This technology is composed of a BMI160 6-axis Accelerometer + Gyroscope, a BMM150 3-axis Magnetometer, a BOSCH 9-axis Sensor Fusion, a 8MB Flash Memory and a lithium-ion rechargeable battery. 9 signals (accelerometry, gyrometry and magnetometry) were measured during each run.

The implemented method is decomposed as follows: time synchronization, axis recovery, pitch and roll estimation by a Kalman filter, followed by the yaw angle reconstruction, the probabilistic estimation of two statistics: direction and motion, the motion decomposition into four phases, feature extraction (duration, vertical accelerometry magnitude and frequency) for each motion phase, and finally motion classification. The latter step was based on a logistic regression model using 12 motion features as discrimination variables. A total of 24 runs were carried out using a full factorial design of experiments.

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III. RESULTS

For four different positions of the sensor, the logistic model was able to discriminate positive and negative runs with 100% of sensitivity and specificity, except for the use on the wrist. That position was not able to provide informative signals for the TUG test. The logistic model was only composed of two motion features: duration of the turn round and duration of the return phase.

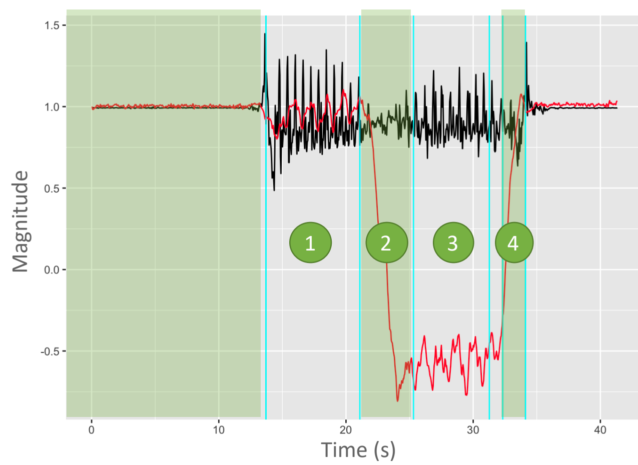

Figure 1. Automatic TUG Motion Segmentation. 4 phases of the TUG test during a pilot trial. Black: vertical accelerometry. Red: yaw angle

IV. DISCUSSION & CONCLUSION

This pilot study has shown the proof of concept of an improved TUG test using inertial wearable sensors associated with a sensor fusion method and a logistic regression model. An automatic TUG motion segmentation was successfully tested and two discriminant motion features were identified. New experiments are ongoing on real patients to confirm the performances obtained with the age simulation suit.

REFERENCES

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