Biomarkers based on activity traces from connected objects of daily life to monitor and predict the early risk of falls in the elderly.

Falls of the elderly are a major socio-economic burden. For example, the estimated cost for fall-related care in the United States in 2015 was US $ 30 billion [1]. Falls are indeed relatively frequent beyond 65 years (1/3 of people over 65 fall at least once a year [2]) and their resulting injuries and psychological consequences (fear of falling, depression) are dramatic for this population. Indeed, beyond their intrinsic gravity, they tend to limit the mobility of people and thus to increase the risk of falling again. It would therefore be crucial to be able to detect as early as possible the appearance of a high risk of falling in non-pathological elderly people who have not yet fallen. Such a predictive indicator would make it possible to take care of these people before the onset of the fall phenomenon, and thus before entering the vicious cycle of fall-loss of mobility-more falls... For this, a promising avenue is to evaluate the evolution of physiological markers (biomarkers) associated with the risk of falling. The spatio-temporal characteristics of walking, and in particular their variability, are among the most predictive biomarkers [3]. It would therefore be interesting to be able to measure these characteristics in a non-invasive and robust way, and with a known and controlled margin of error.

This measurement is currently possible using dedicated sensors, such as inertial units or instrumented insoles embedded on the shoes [4,5]. These solutions, however, are limited when it comes to scaling up to regular monitoring of a large portion of the population (the targeted population is not pathological). To face this scaling up challenge, it would be much more efficient to use all the data already measured by embedded sensors in the various connected objects we use (connected watches, smart phones, etc.). This would allow less intrusive, much larger and more regular monitoring. Some solutions, including commercial ones, already make it possible to estimate some walking characteristics (step duration, walking speed). However, their accuracy and reliability are relatively low [6] and they are therefore not satisfactory for our case study.

Thus, this thesis aims at implementing a method for estimating walking characteristics, and their variability, using low-cost, non-dedicated sensors embedded in connected objects of daily life. These walking features will be used to compute biomarkers to monitor and predict the early risk of fall in the elderly. Special care will be taken in evaluating the accuracy and robustness of the method. The candidate will be required to: 1) review existing methods and data; 2) define the needs in terms of accuracy of measurement and estimation of walking characteristics so that the resulting biomarkers are sufficiently predictive of the risk of falling; 3) set up and carry out an experiment combining walking in ecological environment and reference measurement in order to constitute a labelled database for the learning and evaluation of the method; 4) propose a solution for estimating the walking characteristics and correctly characterize the estimation uncertainties.

This thesis will be co-supervised by the Laboratory of Biomechanics and Impact Mechanics for its expertise in human walking and the Geoloc laboratory for its know-how on the exploitation of traces of activities, these two laboratories having already recently collaborated on similar themes [7]. This

project is part of the Ifsttar's projet fédérateur Mobilités et Transitions Numériques (http://mobtransnum.ifsttar.fr/).

The candidate must have a master's degree (or equivalent degree) in applied mathematics, signal processing or bioengineering and should have an interest in human movement. The candidate will have solid bases in programming and good writing skills in English. Applications should be send **before March 27th** by email to thomas.robert@ifsttar.fr, including a CV, a motivation letter, and an account (even temporary) of the grades obtained during the master.

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