# Measuring feet trajectories: challenges and applications

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*GAIMS* is a *non-intrusive* system, developed at the University of Liège, that measures feet trajectories. In this context, non-intrusive means that the observed person does not need to wear anything, such as sensors, markers, *etc.* Measuring feet trajectories is needed to derive interesting information about the gait of the observed person, which can be used in many different high level applications such as the biometric identification, the follow-up of patients with some neurological diseases, *etc.* *GAIMS* is reliable (precise, accurate, insensitive to clothes and lighting conditions, *etc*). Moreover, it can be used to acquire long trajectories, for two reasons. Firstly, the feet are followed both in the swing and in the stance phase, which is an advantage in comparison to electronic walkways. Secondly, *GAIMS* can capture feet trajectories in large areas (about $10\,m$), and thus provides data related to multiple gait cycles.

*GAIMS* is in fact a high-level measuring instrument combining multiple low-level measurements. *GAIMS* uses several range laser scanners, covering a common horizontal plane located a few centimeters above the floor. The distance measures taken by a sensor can be converted in a point cloud, and the clouds merged into a global point cloud. The positions and orientations of the sensors can be determined by calibration. Using several sensors allows to cover a larger area, reduce (self-)occlusions, and enhance the global point cloud density.

The current version of *GAIMS* relies on 4 range laser scanners (BEA LZR-i100). Note that synchronizing them is impossible. It follows from an analysis of the various sources of noise that the point cloud perceived may be highly distorted. When the person is walking very fast, the asynchronism cannot be neglected, and the perceived point cloud is highly deformed (either compacted or elongated depending on the motion direction). Other origins of imperfect clouds include the limited field of view, the (self-)occlusions, and the flying pixels (outliers).

A classical processing approach starts with the segmentation of the scene into its components (the walls, the objects, the legs, *etc*). Afterwards, the location of each component is defined (usually by its centroid), and tracking coupled to data association techniques are used to estimate the trajectory of each component. Even if this processing flow is often encountered in the literature, it is inappropriate to measure the feet trajectories for many reasons, some of them related to the noisy point clouds.

In this work, we propose a new processing pipeline. We localize the two feet directly from the global point cloud without clustering. To this end, we have designed an algorithm based on the machine learning techniques. Then, an optimization approach based on multiple combined criteria is used to identify the feet with the labels “left” and “right”. Finally, we interpolate between the successive feet coordinates with the same labels. Our new processing pipeline has been used successfully for the analysis of the gait of patients with multiple sclerosis.

The feet trajectories measured and labeled by *GAIMS* can be used to derive many significant gait descriptors.