Slicing the 3D space into planes for the fast interpretation of human motion

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Range Laser Scanners: a suitable technology for markerless human motion analysis

- Single-row *range laser scanners* measure the distance between themselves and the closest element, in a set of predefined directions that are usually located in a plane. Therefore, they can be used to analyse the geometry of a thin slice of the observed scene.
- They derive the distance measures from the *time-of-flight* of an infrared signal (e.g. a pulse). A large number of precise distance measures can be taken at high frequency (e.g. *274 directions scanned at 60Hz*, or 16440 measures per second, in the case of the sensor BEA LZR-U901).
- The suitability of range laser scanners depends on the speed of the observed elements, and is in general high for human motion [1].

Figure 1: BEA LZR (real size)

The wide variety of potential applications for human motion analysis with range laser scanners

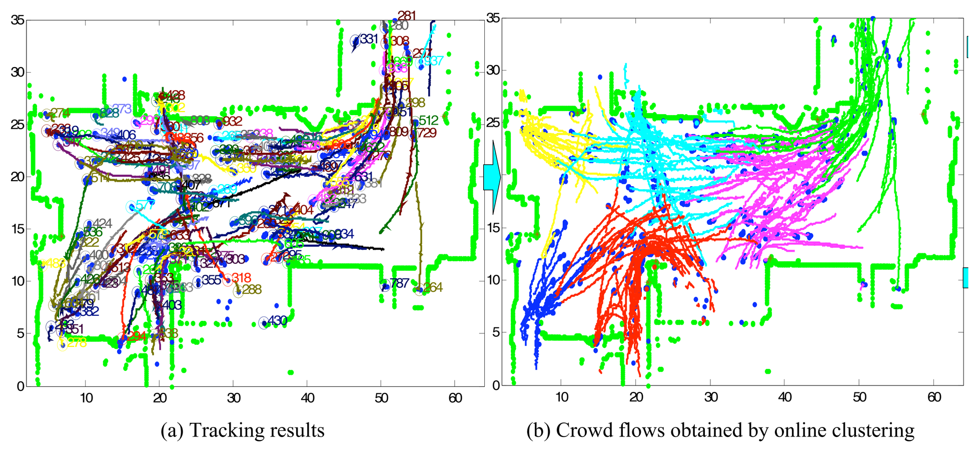

Figure 2: By analysing a thin horizontal slice of the scene, it is for example possible to track more than 150 people simultaneously with a few sensors, and to analyse crowd flows in public places [2].

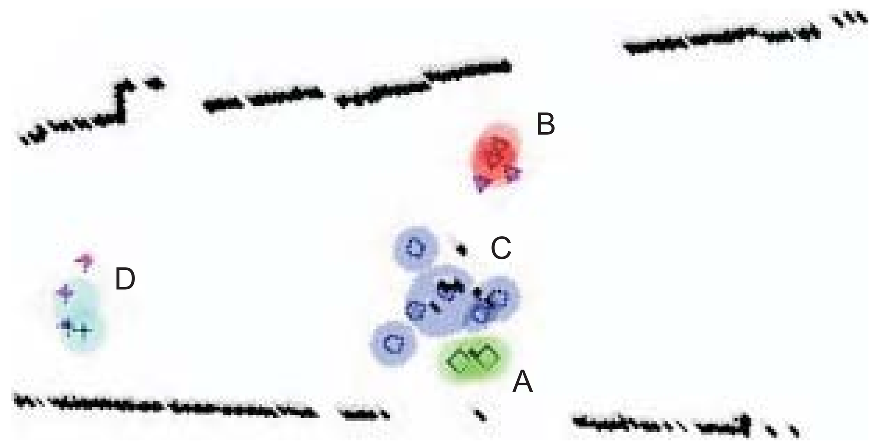

Figure 3: Analysing the behaviour of people and their interactions is also possible, as range laser scanners can be used to find the temporally coherent groups of people and to track these groups globally [3].

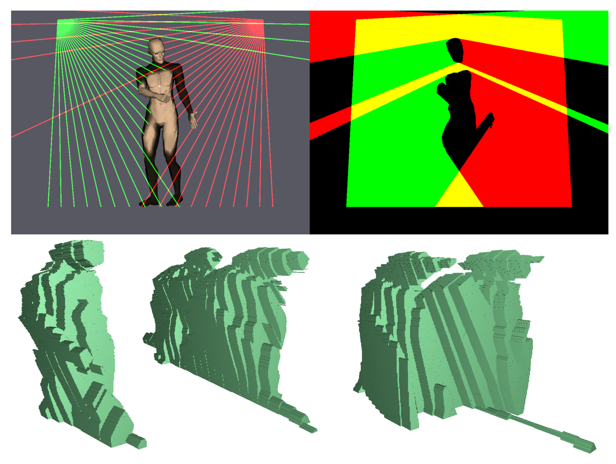

Figure 4: When a vertical slice of the scene is observed with range laser scanners in a doorframe, machine learning techniques can recognize piggybacking and tailgating scenarios [4]

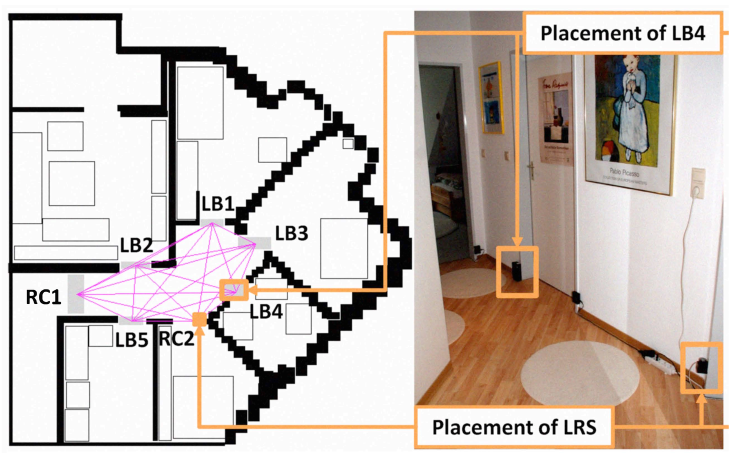

Figure 5: Human motion analysis with range laser scanners is also a cornerstone for some medical assessments. As mobility plays an important role in geriatrics, measuring the walking speed of elderly people with a range laser scanner placed in their flats has been proposed [5].

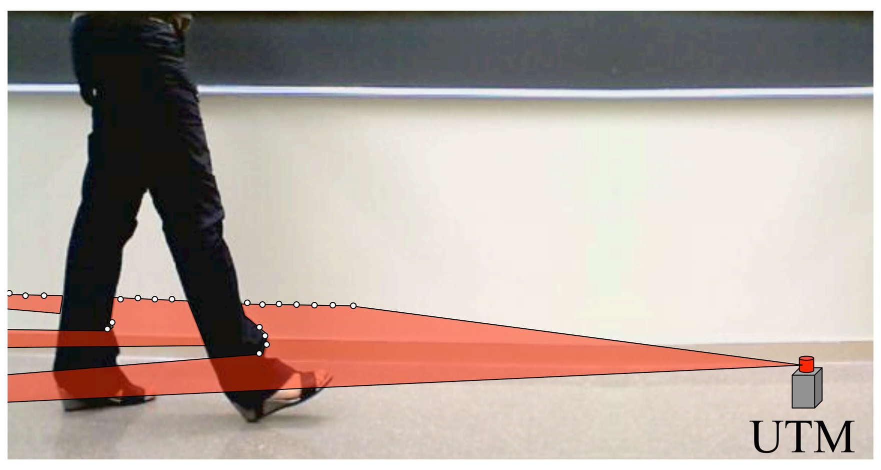

Figure 6: The gait characterization is also important in neurology, and measuring various gait characteristics with a range laser scanner has also been proposed [6].

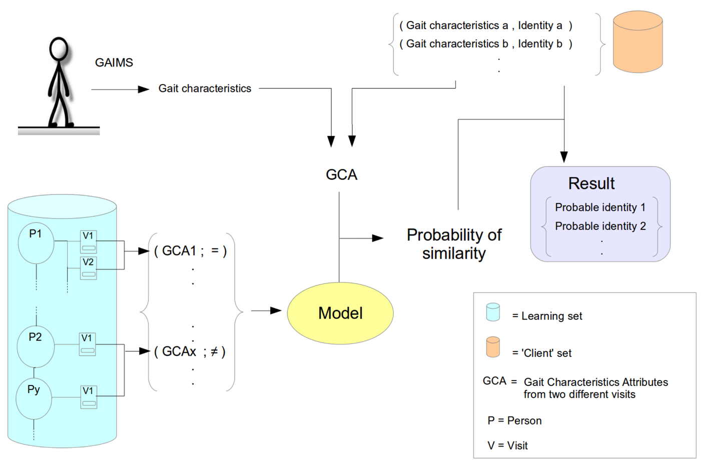

Figure 7: Some preliminary results suggest that range laser scanners could also be used to recognize people, with machine learning techniques, based on their gait [7], which has potential applications in intelligent houses, as well as in security.

Going further in the analysis and interpretation: the project *GAIMS* (gait analysis in multiple sclerosis)

In 2011, we started a multidisciplinary project, named GAIMS, to *analyse and interpret the gait of people with multiple sclerosis* (MS). Measuring their gait is important because most of them have walking impairments since the early stages of the disease, and perceive it as the most disabling symptom [8]. Thus, gait plays an important role *for showing there is no evidence of disease activity [9], as well as for demonstrating the efficacy of therapies*.

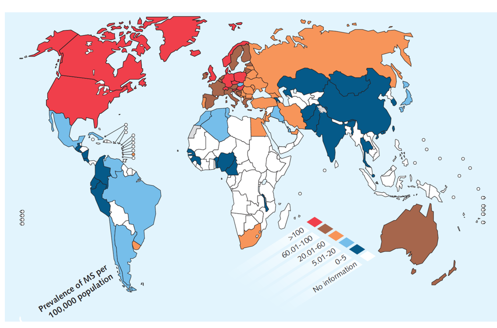

Figure 8: There are 2,500,000 people with MS in the world.

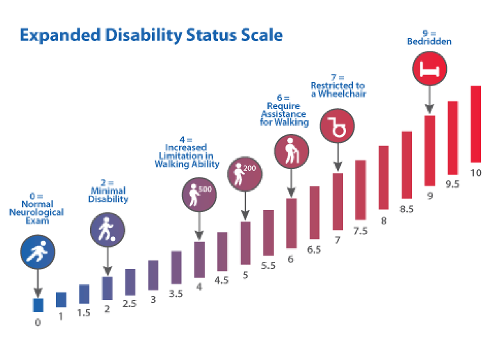

Figure 9: The disease course of MS and the EDSS score.

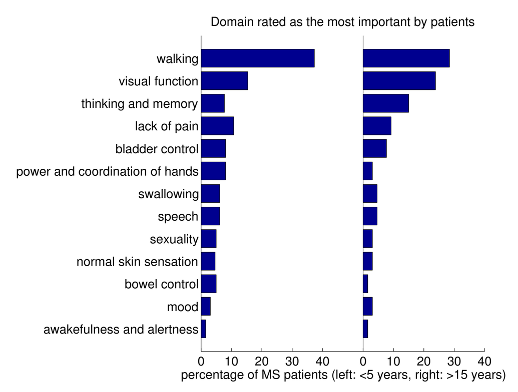

Figure 10: Gait is the most important domain for MS.

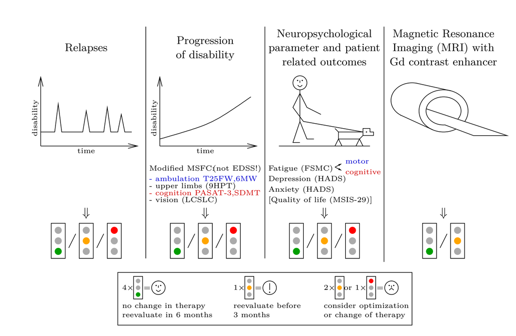

Figure 11: Gait helps to show the absence of disease activity

GAIMS measures the *trajectories of the lower limbs extremities* and derives many gait characteristics from them [1]. The system GAIMS is non-intrusive, in the sense that it is *contactless* and that its usage does not impact on the gait characteristics. The system is well suited for the clinical routine because there is no need to equip the observed person with sensors or markers. *It avoids the use of a treadmill, allows to analyse the gait both during straight lines and turns, and to analyze long walking tests, therefore allowing for an analysis of the motor fatigability* [10].

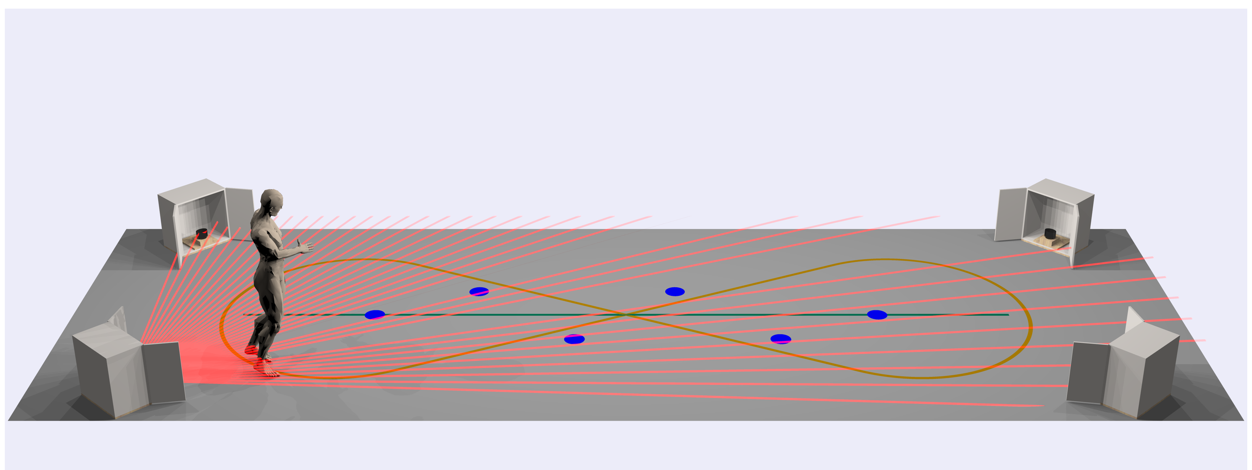

Figure 12: *GAIMS* measures feet trajectories with range laser scanners and derives many gait characteristics.

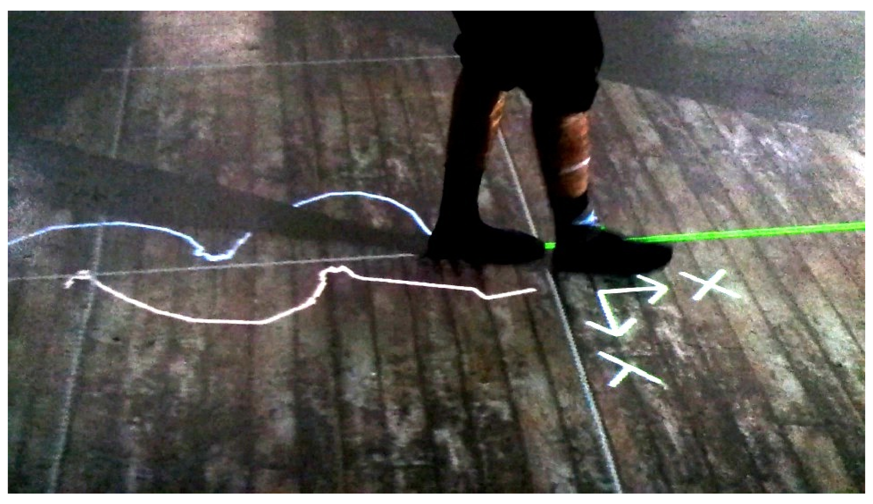

Figure 13: *I-see-3D* can project on the floor, in realtime, the feet trajectories observed with *GAIMS*.

Measuring the trajectories of the lower limbs extremities is sufficient, as we demonstrated that *GAIMS measures an important quantity of information about the state of the patient, which is done with an adequate accuracy*. In particular, GAIMS is able, with the help of machine learning techniques, to better detect ataxia than gait disorder specialists [11], and to detect when ataxia is increased between two successive visits of the same patient [12]. Moreover, it is possible to derive scores based on objective and quantitative measures of the gait that are well correlated with the subjective score used by neurologists [13]. Finally, GAIMS has been able to detect significant differences between healthy people, and different disability levels groups of people with MS [14].

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