Comparison of accelerometric with cinematographic data in simulated fall movements

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Introduction
Approximately one out of three people, living at home at the age 65 or older, fall at least one’s a year (Prudham et al., 1981; Tinetti et al., 1988). The incidence of falls increases with age. A study of the nineties reported the following increase in incidence of falls: from 47 per 100 persons/year for age category 70-74 years to 121 per 100 persons/year for the age category 80 years and older. Obviously, there is need for a reliable falling detection system. This could be possible by the implementation of kinematic criteria (limits of direction and amplitude of the velocity in a fixed reference frame) (Ge Wu, 2000). With these kinematic criteria it is possible to distinguish fall movements (tripping, forward and backward fall) , about 300 - 400 ms before the impact with the ground, from a normal daily activity (object picking, sitting down, down stairs, in/out tub, lying down, walking). The first purpose of the present study is to explore the usefulness of accelerometric techniques for recording kinematic data in fall movements, comparing accelerometric with cinematographic data. The second purpose is to develop kinematic criteria based on accelerometric recording to distinguish a fall movement from normal daily activities and to implement these criteria in a reliable fall detection system.

Methods
Four fall movements (forward, backward, sideward, tripping) and eight normal daily activities (object picking, walking, running, up stairs walking, down stairs walking, sitting down, standing up, lying down) have been simulated by 5 subjects, with 3 trials each. A VHS camera was used for 2D cinematographic movement recording and an accelerometer was placed on the sternum to measure accelerations. The purpose was to validate the accelerometer by comparing the accelerometric with the cinematographic data. Further, the accelerometric measurements were used to set up kinematic criteria to distinguish a fall movement from a normal daily activity. These criteria were based on an algorithm, programmed in Visual Basic, that was able to detect critical amplitudes within a fixed time window of the derivative of the accelerometric signal. In this way, the system will not react to slow movements, but only to impact movements. When these conditions were met, the original accelerometric signal was averaged over two distinct time intervals, occuring .5 sec before and after impact. When the difference between these two averages exceeds a threshold value, an alarm is triggered (fig1,2).

Fig 1. Accelerometric signal of a sideward fall along the x-axis
Results

Results in figure 3 proved (fig. 3, a) the accelerometer to be a useful instrument for recording kinematic data. The graphs, presented below, show also the transformation from a fixed reference frame to a local reference frame linked to the falling body (fig. 3, b).
After developing the kinematic criteria based on accelerations, the algorithm was able to distinguish correctly fall movements from normal daily activities. Consequently, it is possible to implement these kinematic criteria in a reliable falling detection system. The first simulation tests proved to be successful. Further field tests and refinements of the algorithm are needed to devise a reliable fall detection system.

References

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