# Development of a Sensor-Based Fall Prevention System for Patients with Dementia

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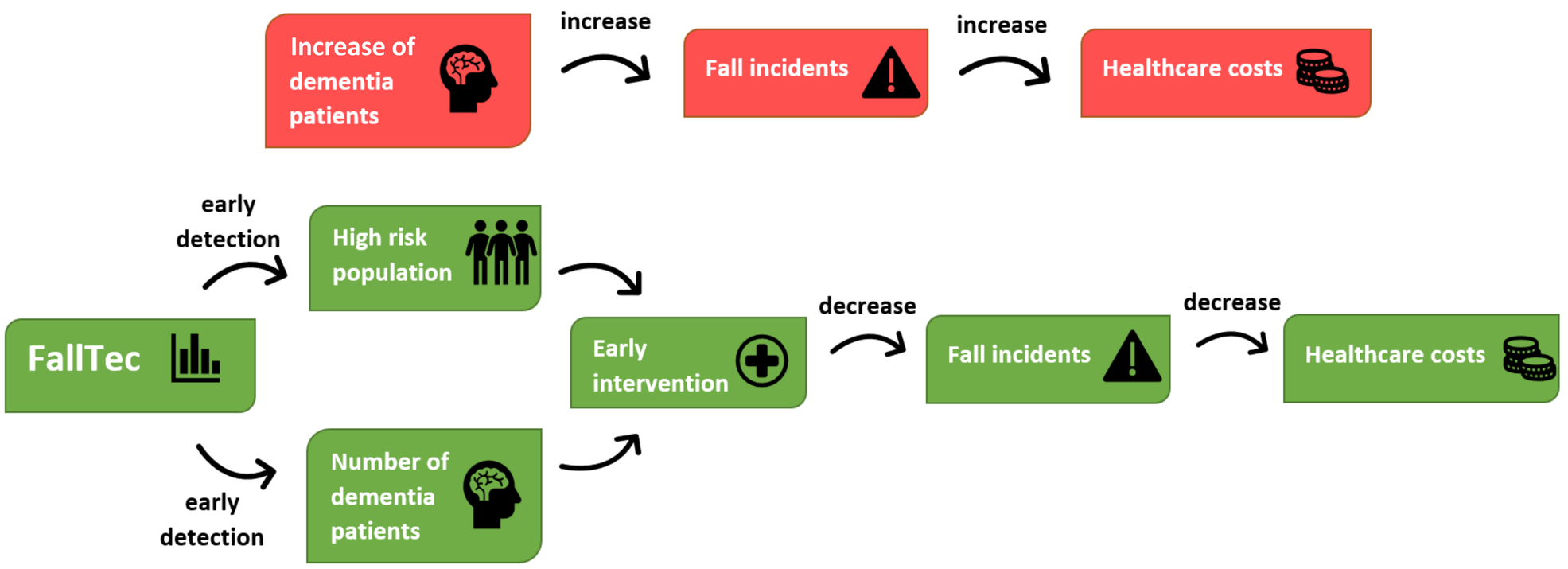


**FIGURE 1.** Schematic Explanation of the Project FallTec

## Background

Many older people suffer from the consequences of falls, which cost about 32 billion Euro per year in the European Union [1]. The consequences of a fall include reduced quality of life and premature death. The risk of falling is even 2-3 times higher in dementia patients [2]. Within this group, high risk patients can be identified using gait analysis. Studies show that gait parameters such as low cadence and increased step length variability not only indicate the risk of falling but can also indicate the onset of dementia [3]. Therefore, preventative interventions can be initiated early on [4] and long-term health care costs can be reduced.

## Development

In this project, a prototypical fall detection system based on a portable inertial measurement unit (IMU) was developed. The person suffering from dementia carries a belt with the device at the lower back. The collected data is transferred wirelessly to a server and then analyzed, evaluated and visualized in our web-based application. Thereby, our prototype helps with the identification of patients with high fall risk.

An acceleration-based algorithm for gait event detection was developed in consideration of the literature [5]. Its validity and reliability were evaluated in a master thesis.

## Validity and Reliability of the Prototype

The aim of the pilot-study was to assess the validity and reliability of the newly developed FallTec algorithm ($A_F$) and a state-of-the-art algorithm ($A_M$) [6] for temporal gait analysis with the prototype at a preferred and a slower gait speed. An Insole Pressure System (IPS) was used as a gold-standard-method. Four healthy young adults (two men and two women) participated and conducted four walking tests of 26 steps at two gait velocities. The step durations, cadence and step duration coefficient of variation (CoV) were evaluated with single-measurement (SM) and multi-measurement (MM, averaged) evaluation.



**FIGURE 2.** IMU-based prototype (left) and IPS (right)

At preferred gait velocity, all step durations were detected correctly by both algorithms. At a slow walking velocity, the relative event detection failure increased to 30% with $A_F$ and to 6% with $A_M$.

The validity of the cadence estimation by $A_F$ and $A_M$ was excellent ($RMSE_{rel}$ 0-1%). The validity of step duration estimation by $A_F$ and $A_M$ was good to excellent ($RMSE_{rel}$ 3-6%), the validity of gait variability estimation by $A_F$ and $A_M$ was poor ($RMSE_{rel}$ 74-239% of CoV of step durations).

The test-retest reliability of step duration estimation by $A_F$ was poor (ICC 0.33-0.42) and by $A_M$ poor to moderate (ICC 0.26-0.68) in SM evaluation. With MM evaluation the test-retest reliability changed to moderate to good by $A_F$ (ICC 0.66-0.76) and to good by $A_M$ (ICC 0.80-0.82).

The results of this pilot-study are promising, but further algorithm adaptions and research need to be performed before using the evaluated methods in clinical practice.

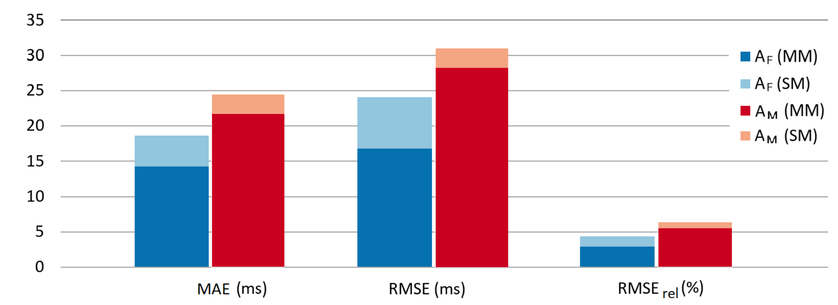


**FIGURE 3.** Comparative validity of the step durations estimated by $A_F$ and $A_M$ at preferred walking speed

## References


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