Remote Automatic Fall Detection and Activity Monitoring using Smart Wearables

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A timely alarm after a fall can save the faller's life and reduce the risk of debilitating injuries. In a connected world, wearable sensors offer a massive opportunity to accurately detect falls and send immediate alarms to family and healthcare providers. At CSEM, we have developed real-time embedded algorithms for unobtrusive fall detection focused on context and activity classification. These algorithms can detect falls more accurately while rejecting false positives. Our solutions target sensors embedded in non-stigmatizing widely available wearable devices.

Falls occur in more than 30% of older adults (≥ 65) worldwide and have dire consequences ranging from injuries and fractures to death. The inability to recover after a fall can result in long lying times leading to institutionalization. In recent years, wearable sensors have emerged as potential solutions to the problem of remote fall detection and risk assessment. As wearables get smarter, the field is moving towards full ecosystems such as shown in Figure 1, capable of:

- Detecting a fall using sensors onboard wearables
- Checking the health status of the user
- Sending an alarm to family members or healthcare providers.

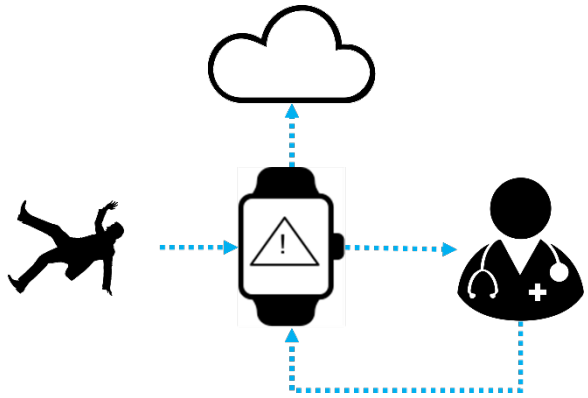

Figure 1: Fall detection ecosystem.

In the EU H2020 project ACTIVAGE, such an ecosystem was deployed with more than 450 users and caregivers as a technical feasibility proof of concept. The users received an alarm in the form of a gentle vibration on their smartwatch with the option to confirm or decline a fall. After one minute, if the alarm was unanswered by the user, communication via message or call was established with a family member or healthcare professional. The users also had the option to send an alarm themselves in case of an undetected fall. Furthermore, remote data collection was implemented through the cloud, enabling the retrieval of detected events for a refined analysis.

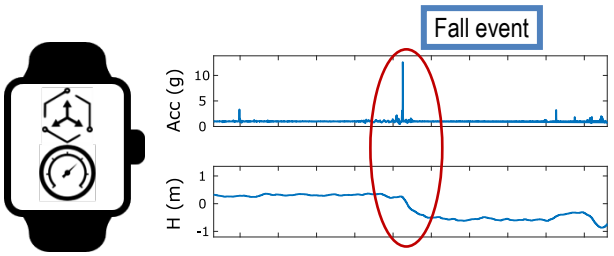

Figure 2: Smartwatch sensor signals during a fall. Acc: accelerometer. H: relative height derived from barometer.

We built the fall detection algorithm in this ecosystem based on two sensors commonly available in smartwatches, namely accelerometers and barometers. An example of a fall recorded with these sensors is shown in Figure 2.

The proposed algorithm is embedded and works in real time. It receives a continuous stream of data and outputs a fall flag whenever an event is detected. Activity classification runs in parallel to add context to the detection, eliminating a wide range of false positives. This strategy is presented in Figure 3.

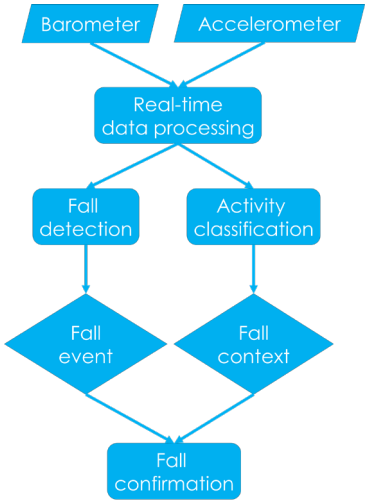

Figure 3: Algorithm structure.

We validated this approach on a dataset of simulated falls in 5 young, healthy participants. The dataset included falls from walking, standing, and during postural transitions. The algorithm achieved a sensitivity of 87% on a total of 90 fall signals, and 95% if very soft falls are excluded. Furthermore, the algorithm was tested with 7 young, healthy participants during daily life activities to check for misclassifications. On a total of 93 hours of measurement, the algorithm produced an average of three false positives per day.

These results are in line with the state of the art [1], and highlight the importance of using real world falls with at-risk persons for fine tuning fall detection algorithms and reducing false positive rate while maintaining a high sensitivity. This is especially true with wrist-worn sensors, since some movements performed during the day generate signal patterns that can resemble falls. The analysis of real-world fall events from at-risk persons is ongoing at CSEM to go beyond the state of the art in fall detection.

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[1] F. Bagalà, C. Becker, A. Cappello, L. Chiari, K. Aminian, J.-M. Hausdorff, J. Klenk (2012), Evaluation of accelerometer-based fall detection algorithms on real-world falls, PloS One, 7(5), e37062.