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# First-person Vision-based Assessment of Fall Risks in The Wild, Towards Fall Prevention in Older Adults

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## Abstract

Falls in older adults is one of the most important public health problems world-wide. In our previous works, we showed that first-person vision (FPV) data acquired by chest- and waist-mounted cameras have the potential to be utilized to (A) develop novel markerless deep models to estimate spatiotemporal gait parameters over time (e.g., step width) by localizing feet in 2D coordinate system of RGB frames (using optical flow and RGB streams) and (B) automatically identify environmental hazards (e.g., curbs, stairs, different terrains) that may lead to falling. In this paper, a summary of our recent FPV-based approaches for fall risk assessment in the wild are being discussed. These approaches aimed to eventually inform clinical decisions on the most appropriate prevention interventions to reduce fall incidence in older populations.

## 1 Introduction

It is estimated that one in three older adults (OA, >65yrs) falls at least once each year, which leads to physical and psychological consequences. By conducting fall risk assessment (FRA), clinicians aim to understand what factors put each senior at a high risk of falling to inform the selection and timing of interventions (e.g., strengthening program). These risk factors are generally categorized as intrinsic (e.g., muscle weakness, gait and balance disorders, mental status alterations) and extrinsic or environmental (e.g., irregular, cracked, or slippery surfaces). Although the recent explosion of wearable inertial measurement units (IMUs), have facilitated the emergence of new ambulatory FRAs to monitor gait and balance control in the wild, these systems capture little or no information about the environmental conditions. This leads to general assumptions about gait performance in the wild and human-environment interactions. For instance, a high step time variability detected by IMU signals may be interpreted as an increased risk of falls, or may reflect locomotor adjustments to avoid collisions on a crowded sidewalk. First-person vision (FPV) data offer the potential to reconstruct events more readily than IMU-based data alone by capturing visual information on the properties of the environment that influence mobility behaviour (discussed in section 2.1). Moreover, FPV can be used to develop novel markerless models to extract spatiotemporal gait parameters (e.g., step width) to complement existing IMU-based methods (section 2.2). The findings of this research will facilitate novel strategies in fall prevention and interventions (e.g., strengthening program, balance re-training).

## 2 Methods

**2.1. Detecting environmental fall-related hazards with egocentric cameras.** To the best of our knowledge, our research on FPV-based detection of environmental fall risk hazards was the first to develop an automated method. Employing a chest-mounted camera, a ConvNet [1] was trained using a new binary feature extraction method (Gabor Barcodes) [2] to automatically detect environmental fall related hazards, including slope changes (e.g., stairs, curbs, ramps) and surfaces (e.g., gravel, grass, concrete). The ConvNet and Gabor Barcodes achieved 92% (for 12 classes) and 88.5% (for 17 classes) accuracies, respectively.

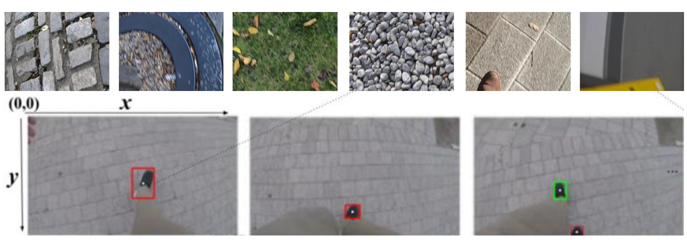


*Fig. 1:* Machine learning methods have been developed by our team to (A) identify different surfaces captured in indoor and outdoor environment (upper panel) and (B) estimate pixel-wise spatiotemporal gait parameters by localizing feet in 2D coordinate system of the frames captured by a belt-mounted camera (lower panel).

**2.2) FootChaser model for egocentric gait assessment in the wild.** FPV data may outperform IMUs for the purpose of estimating spatial parameters of gait. In [3] we proposed deep models to localize feet in 2D coordinate system of video frames captured by a waist-mounted camera (pointed down and ahead) (see Fig. 1-lower panel). We hypothesized that a waist-mounted camera view, compared to head- and chest-mounted camera views, would offer the best view as waist-level FPV offers a consistent view of the legs and feet even when turning and it affords greater resolution of the feet and the patterns/texture of the terrain than views higher on the body. The FPV data captured by participants while they were walking in different indoor (tiles, carpet) and outdoor (bricks, grass/muddy) environments and in different natural lighting conditions (e.g., shadows). The hybrid FootChaser model consists of: 1) FootRegionProposer, a ConvNet that proposes regions (i.e., bounding boxes) with high probability of containing feet in RGB frames (global appearance of feet), and 2) LocomoNet, a fine-tuned ResNet sensitive to periodic gait patterns, which examines the optical flow content corresponding to the proposed boxes and filters out the false positives. FootChaser was successful in extracting x and y trajectories of feet centers over time (pixel-wise error $\leq 10\%$ in x direction) and detection of gait abnormalities and CBRs (e.g., spikes in foot center trajectories).

## 3 Ongoing work

Although the aforementioned methods were promising, there are some limitations that should be taken into account: 1. the data were collected from young adults, and 2. the collected data did not include home environments. The collection of sufficiently large physiological datasets, especially from OA, is one of the primary challenges for the development of deep models. As there are no publicly available free-living FPV datasets from OA targeting fall prevention, we have been preparing a unique dataset, i.e., *Multimodal Gait and Fall Risk Assessment (MAGFRA)* dataset, with in the wild (MAGFRA-W) and in-clinic (MAGFRA-C) versions. OA fallers and non-fallers with diverse neurological conditions were recruited in this study and they were asked to wear IMU(s) and a GoPro camera on their waist 1. in the gait laboratory and 2. in the public environments of the Institute and in their home environments. The project has received ethics clearance, reference number 17589/Northumbria University. Considering state-of-the-art deep learning approaches, we expect to increase the efficiency and generalizability of the environmental hazard detection pipeline and validate our FootChaser Model on a larger dataset.

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## References

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