Using Body-Worn Sensors and Computer Vision to Inform Data-Driven Home Modifications for Falls Prevention in Older Adults

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Background

- Falls are the leading cause of injury-related death and disability among people >75 years old in the UK[1]
- They are associated with healthcare costs of ~£2.3 billion/year [2], and can lead to reduced mobility, increased anxiety and depression in fallers[2]
- With over 80% of falls happening at home [3], the overall goals of our project are to:

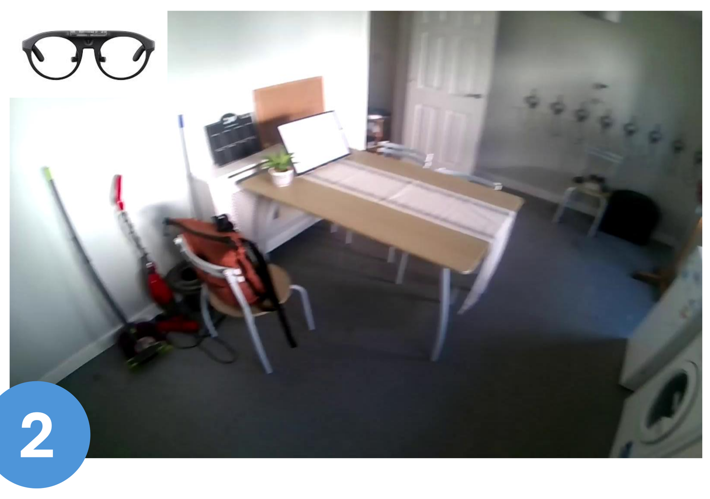
1) Identify characteristics of living environments associated with increased fall risks and/or suboptimal movement patterns through **context-driven biomechanical assessment**
2) Implement home-based modifications that inform both post-occupancy and pre-occupancy evaluations

Aims and objectives

- To enable **context-driven assessment** of fall-risks, it is critical to develop 3D environments and localise the individual in the 3D environment
- In this study we present out novel methodology for 3D environment reconstruction and mapping using video captured through eye-tracking glasses (Pupil Neon) and iPad LiDAR sensor:
  - ❖ In three houses reflecting architectural styles from different time periods (1920, 1970 and 2010)
  - ❖ And at a self-selected walking speed mimicking routine behaviour

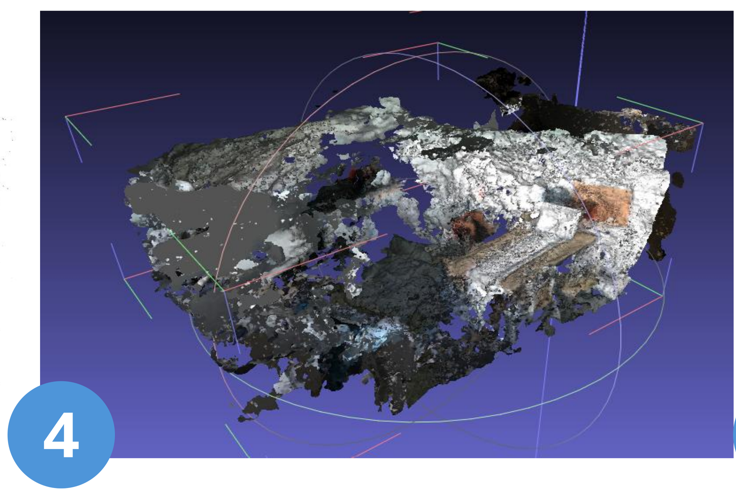
Methods

1 Create a LiDAR scan of the house using an iPAD

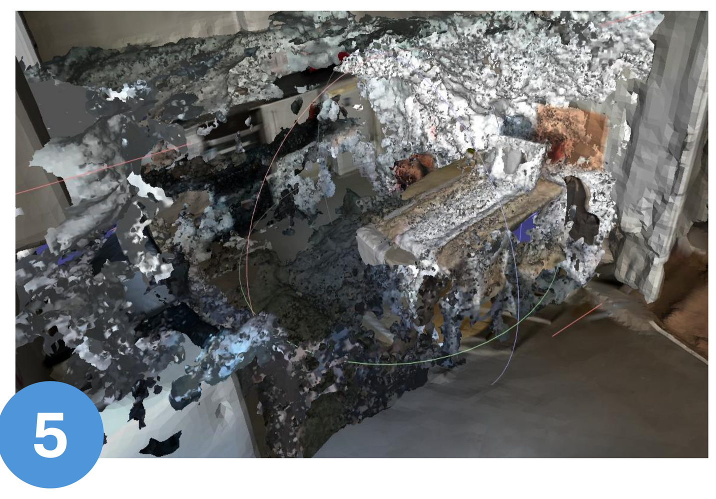


2 Acquire frames from the scene camera on Pupil Neon

3 Determine the location of the camera in 3D using SfM (COLMAP); scale is arbitrary



4 Create a mesh of a single object/room using neural radiance fields



5 Register the mesh to the LiDAR scan to convert camera poses to metric scale

Results

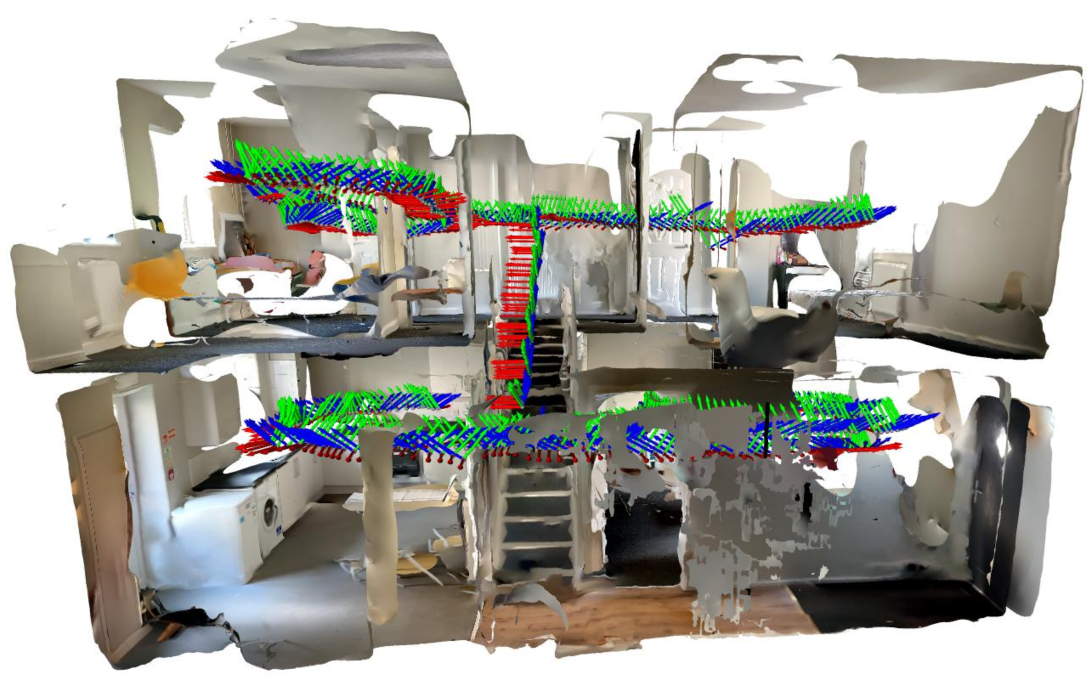


Fig. A (1920)

Fig. B (1970)

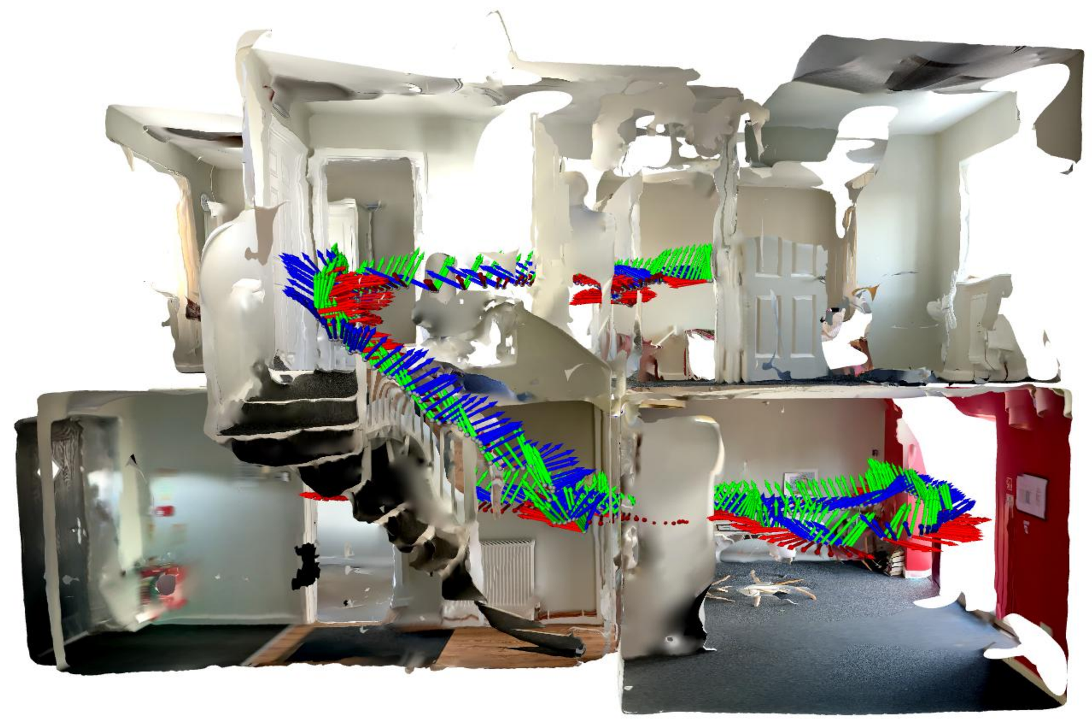


Fig. C (2010)

- The trajectory and 3D environment could be mapped accurately in the three houses (*Figs A–C*) using only the video data captured by Pupil Neon and LiDAR data
- We can calculate the walking trajectory, head pose and gaze of individuals moving through the mapped environments
- We have identified factors that may limit the accuracy of our measurements (e.g. fast walking speed, illumination levels)

Conclusion and next steps

- **We have developed methodology to accurately map older adults' home environments and how they move through it using eye tracking technology and an iPAD**
- **We will combine this with biomechanical data, gaze-mapping and environmental feature detection (using AI) to provide a holistic overview of the environmental and individual behavioural factors that may contribute to falls risk in the homes of older adults, and allow targeted interventions/home modifications to reduce falls risk**

1. Lockhart, T. E. *et al.* Prediction of fall risk among community-dwelling older adults using a wearable system. *Sci Rep* 11, 20976 (2021); **2.** Mulliner, E., O'Brien, T. D., Maliene, V., Maganaris, C. N. & Mason, R. Older Adults' and Professionals' Attitudes Towards Stair-Fall Prevention Interventions. *Healthcare* 13, 1324 (2025); **3.** RoSPA- The Royal Society for the Prevention of Accidents. *RoSPA* https://www.rospa.com/.

AI, Artificial Intelligence; LiDAR, light detection and ranging; SfM, structure from Motion.

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