Decoding Action Intentions: Pedestrian Indoor Navigation in Natural Environments

Ann-Christin Täubert[1], Aurelia Ziegler[2], Tim Sieber[2], Bernd Ludwig[2], Gregor Volberg[1], Noah Meißner[2]
[1]Department of Psychology, University of Regensburg; [2]Department of Information Science, University of Regensburg

Introduction

Effective human-machine interaction in pedestrian indoor navigation is highly challenging. For productive interaction, the artificial agent, i.e. the navigation system, must infer and update a theory of the human's status of mind (e.g. perceived position, intentions) and hence predict timely and accurately when the human needs which information. For example, the artificial agent should recognise the human's intention to wrongly turn right, before they do so, and instruct the human to turn left instead. EEG and eye tracking data from humans following navigation could be an avenue to create and maintain such as model. In laboratory research, oscillatory EEG activity in the alpha and beta frequency range is consistently found over central areas (i.e. the motor cortex) and associated with motor planning (Volberg and Thomaschke, 2017), while eye tracking can reveal intentions for motor behaviour, such as object-related actions (Ambrosini et al., 2011, 2015). Can laboratory findings (i.e., central alpha and beta activity predictive of motor planning) be replicated in natural environments?

Study Design and Methods

Our current approach is therefore to collect data using a mobile 8-channel EEG system, a HoloLens for eye tracking and video data of the participant's visual field. Electrode positions were AFz, FCz, C3, C4, CPz, Pz, PO3 and PO4. For the reference track, participants are instructed to walk a planned route of approximately 200m through a university building, consisting of walking straight ahead, walking through doors and taking turns. This is repeated four times, e.g. forwards and backwards, as well as with open and closed doors (participant is instructed to open doors). The complex Track is longer and enters a busy area with natural human encounters. Position data was used to identify relevant time windows for events (stepping into a radius of 1.5m around doors or 3.5m around corners commenced the door or corner event, respectively).

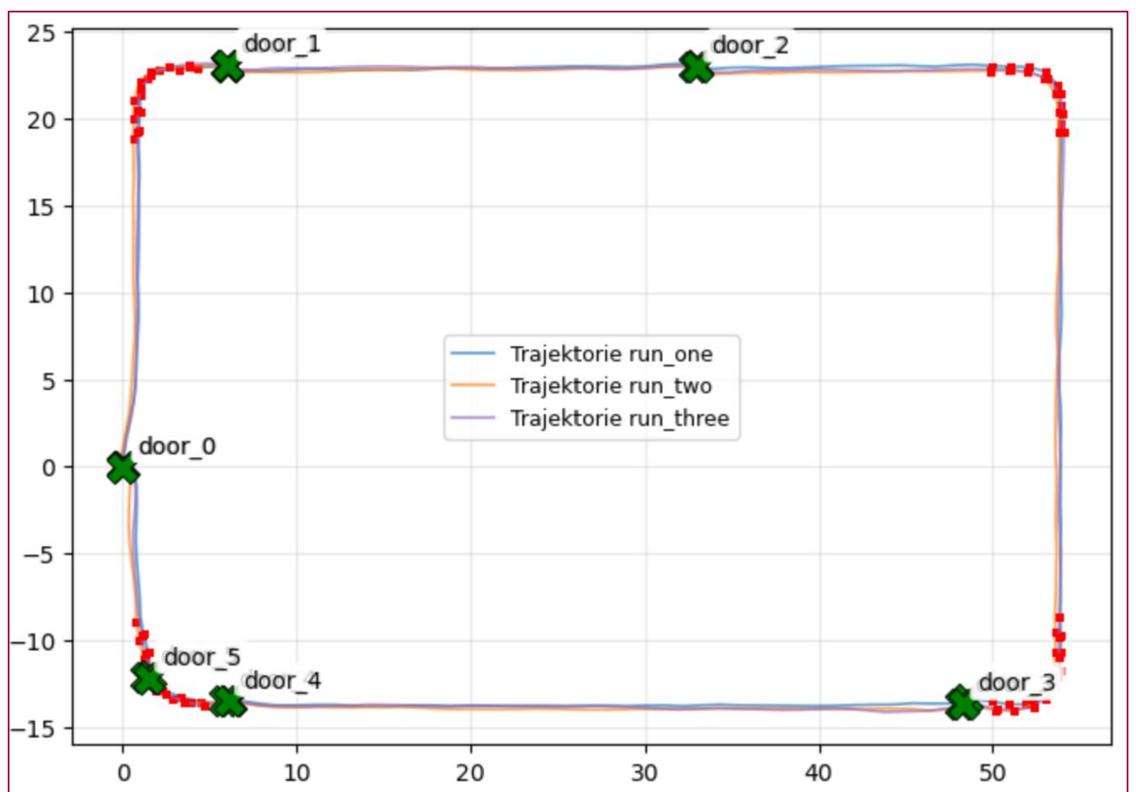

Fig. 1: Walking route with offline-generated landmarks.

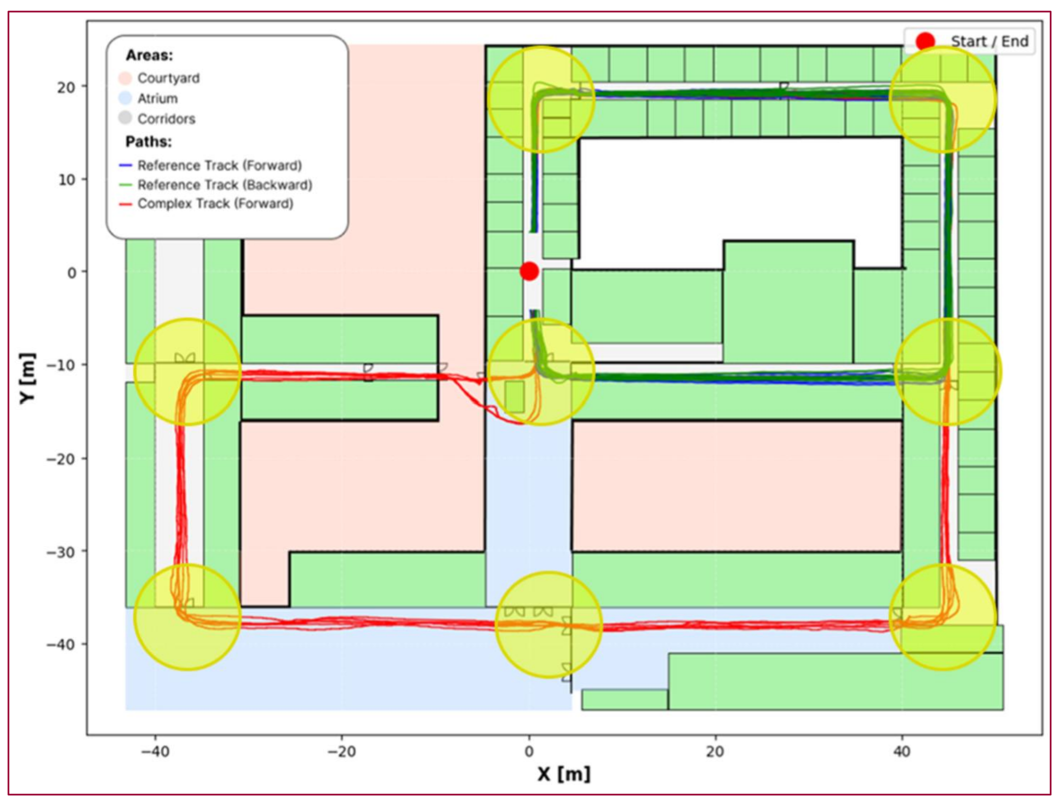

Fig. 2: Recorded trajectories.

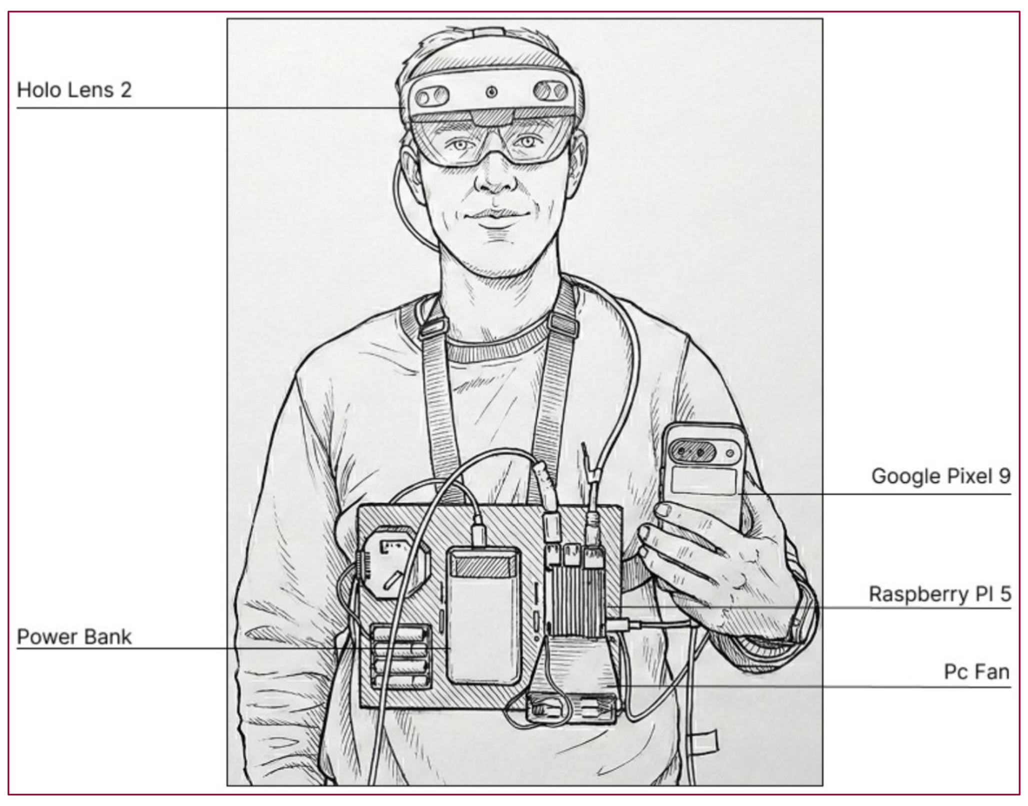

Fig. 3: Microsoft HoloLens 2 and Google Pixel 9 (EEG system not pictured).

Preliminary Results

Preliminary data analysis (n=1) indicates that high classification accuracy (60-80%) for door and corner events was present at 8-12Hz, i.e. alpha / mu rhythm (from -0.5s before onset to onset). The central electrode Cz showed peak accuracy (about 75%) for doors at 8-12Hz, while for corners, electrodes AFz, Fz (frontal electrodes) and C3 performed similarly in accuracy (about 70%). This indicates successful replication of previous laboratory findings in natural scenes.

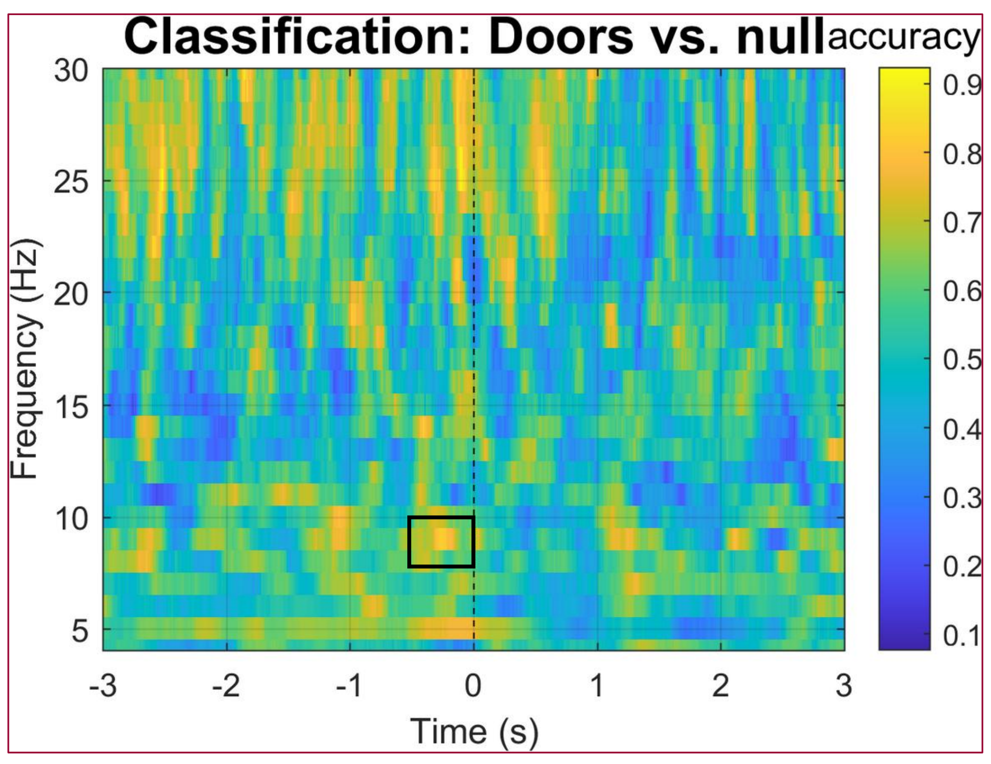

Fig. 4: Classification accuracy for 'doors' versus null events. The data was the change in power relative to a 3 to 3.6 s post-event baseline.

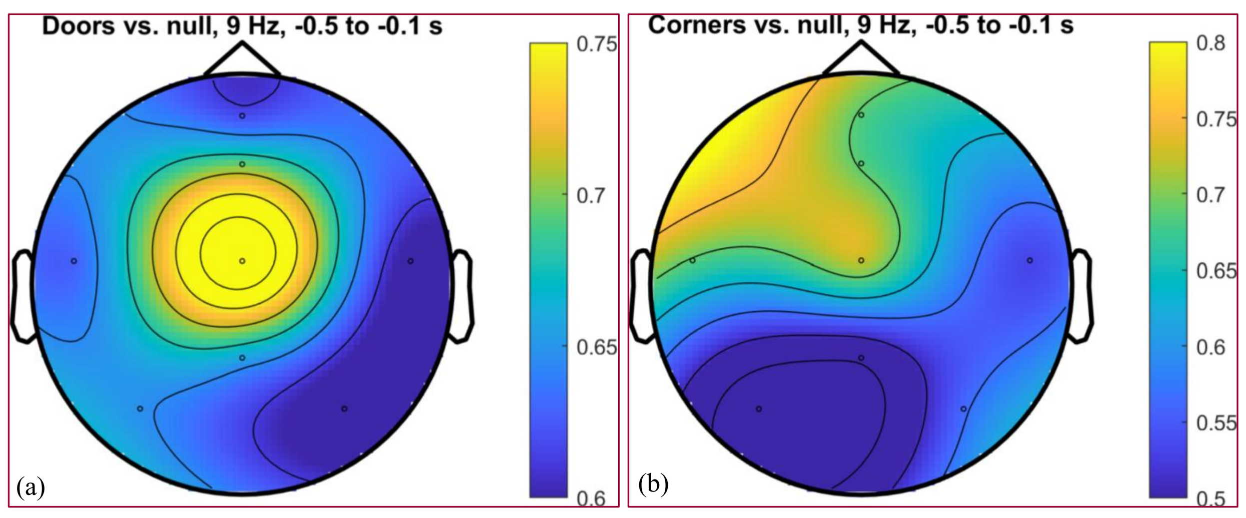

Fig. 5: (a) Topography for the 9 Hz pre-stimulus accuracy for classification of doors vs. null events; (b) Topography for the 9 Hz pre-stimulus accuracy for classification of corners vs. null events.

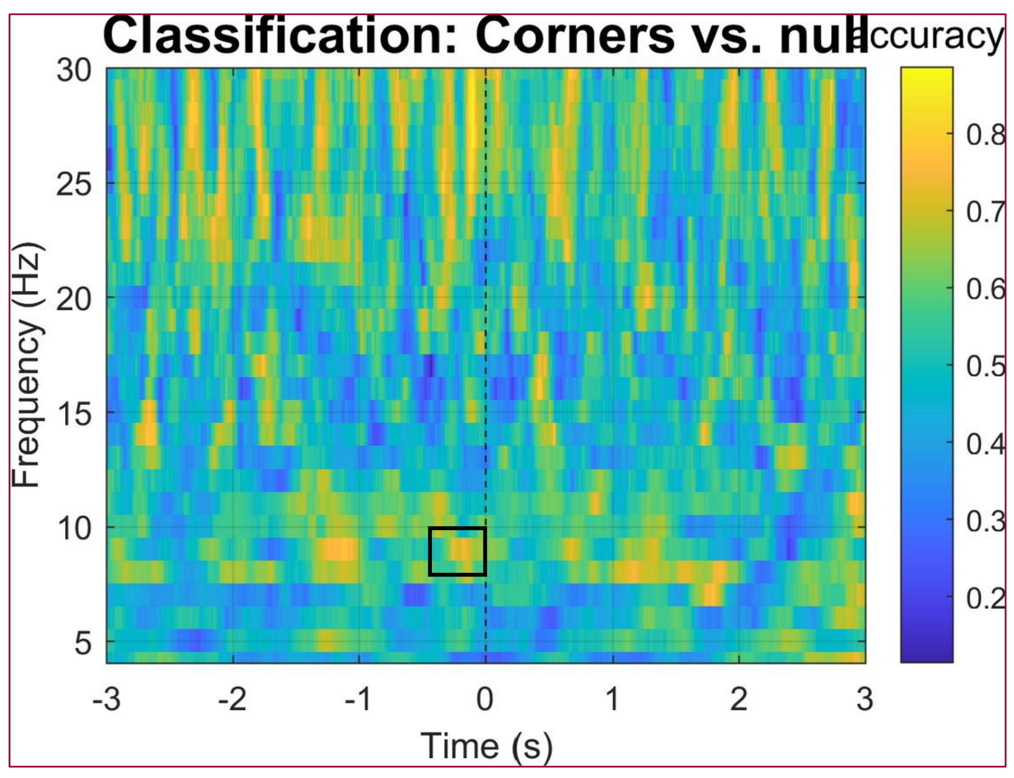

Fig. 6: Classification accuracy for 'corner' versus null events. The data was the change in power relative to a 3 to 3.6 s post-event baseline.

Next Steps

Our next steps are testing left versus right turn-taking, as well as testing more complex paths. With data from more participants and more conditions (forward/backward, reference/complex) we will repeat our established analysis.

References

Ambrosini, E., Costantini, M., & Sinigaglia, C. (2011). Grasping with the eyes. Journal of neurophysiology, 106(3), 1437-1442.
Ambrosini, E., Pezzulo, G., & Costantini, M. (2015). The eye in hand: Predicting others' behavior by integrating multiple sources of information. Journal of neurophysiology, 113(7), 2271-2279.
Volberg, G., & Thomaschke, R. (2017). Time-based expectations entail preparatory motor activity. Cortex, 92, 261-270.