Human balancing in VR under the influence of optical flow

TECHNISCHE UNIVERSITÄT DARMSTADT
Sensorimotor Control & Learning
Centre for Cognitive Science

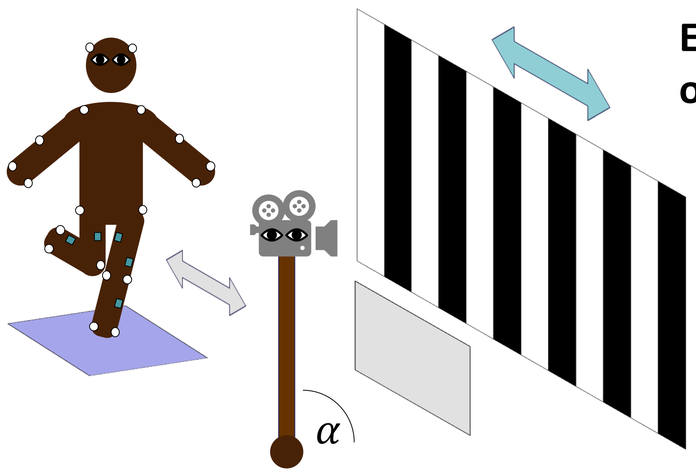
Kai Streiling, Maximilian Stasica, Alsou Bellmann, André Seyfarth and Loes C. J. van Dam

Motivation and questions

We assume that the Feeling of **Agency** over a change in the environment plays a role **discriminating self-generated from external optical flow**.

- How are **visual** and **proprioceptive** cues integrated for stable balancing?
- How are **external perturbations** in one domain **detected** and **countered**?

The moving room illusion VR environment



Experimental conditions on the background

- pattern: *striped/ grey*
- lateral motion: *linear/ sinusoidal, fast/ slow*
- *static phase 10 s movement 10 s static phase 10 s*

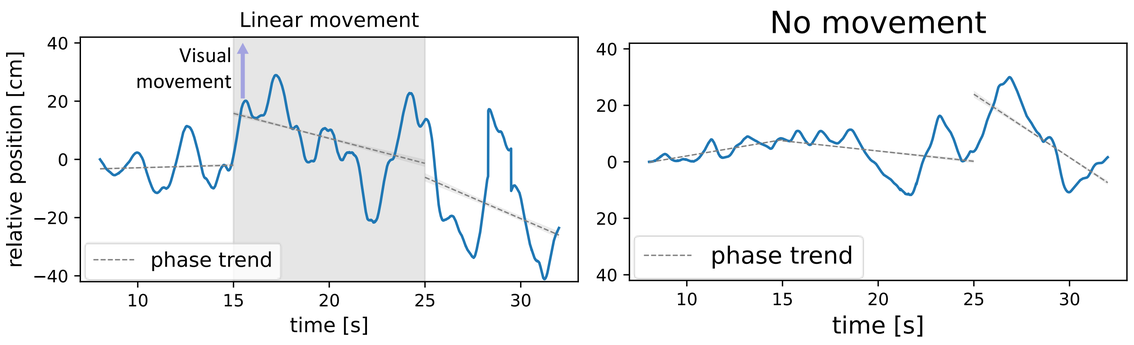
Captured human data
- ○ Motion capture
- n = 7 participants

LQG model
- Visual angle and angular velocity
- α Proprioceptive angle and velocity

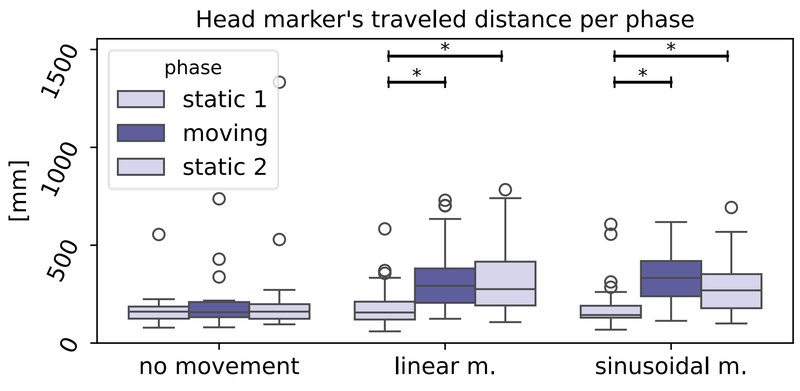
Initial experimental results

1. Average balancing dynamics

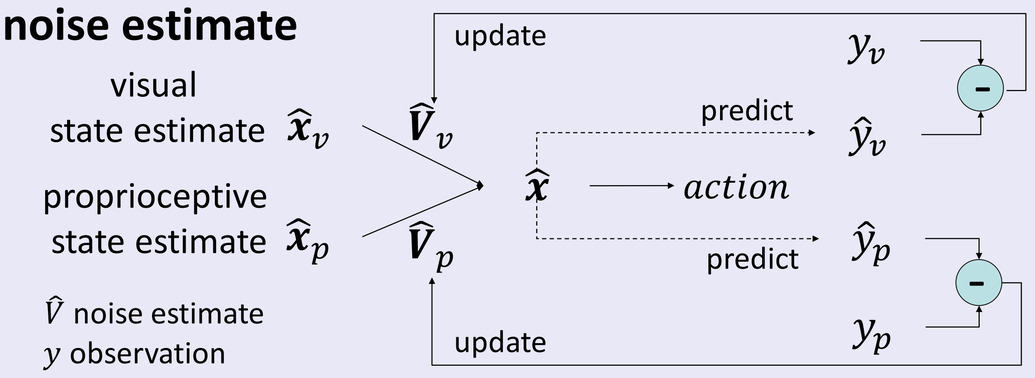
Average relative head position over time



2. Validation: Optical flow influences human balancing
   - Less stable standing during and after visual movement



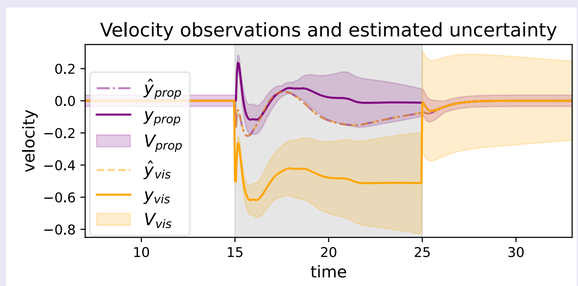
LQG model: multisensory estimate with adaptive noise estimate

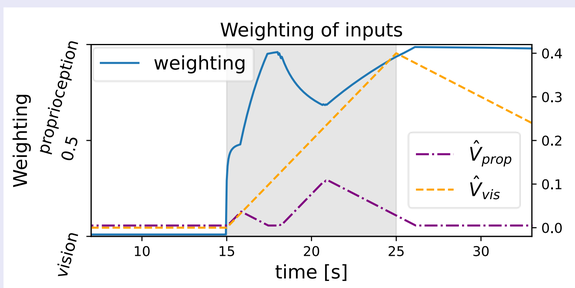


The weighting mechanism in simulation

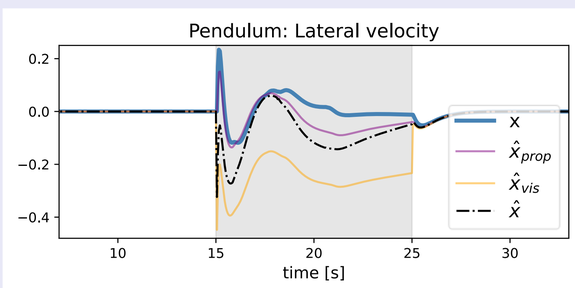
2. The sensory weighting mechanism based on the comparator model for Agency

Velocity observations → Estimated noises and weighting





Resulting velocity estimates

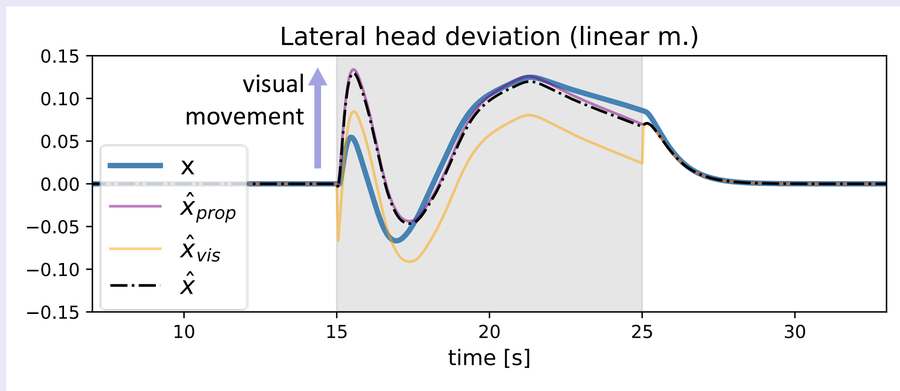


Ext. visual disturbance → No Agency about perceived optical flow

Increased visual noise estimate → Decreases weight on visual input

Initial model results

1. Qualitative fits of predicted average pendulum head position



Further initial model predictions

- Increasing motor noise disturbs the weighting mechanism and leads to increased susceptibility (for linear movements).
- Smooth acceleration delays the perturbation detection.

Conclusion

- The proposed model provides a mechanism for reweighing cues in a manner consistent with Agency
- Promising initial model predictions

Limitations

- Small sample size
- Only initial model parameters
- Model cannot explain after-effects

Outlook

- Additional data collection
- Fit parameters to collected data
- Compare alternative modelling approaches

References
- Engel D., Schütz A., Krala M. et al. (2020). Inter-trial phase coherence of visually evoked postural responses in virtual reality. Exp Brain Res 238, 1177–1189. https://doi.org/10.1007/s00221-020-05782-2
- Leonards U., Fennell J.G., Oliva G., Drake A., Redmill D.W. (2015). Treacherous Pavements: Paving Slab Patterns Modify Intended Walking Directions. PLOS ONE 10(6): e0130034. https://doi.org/10.1371/journal.pone.0130034

The adaptive Mind

SCL research group

Contact:
kai.streiling@tu-darmstadt.de