Understanding and Leveraging Head Movement as Input for Interaction

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Introduction

Advantages of Head Movement as Input:

- **Simple & Powerful**: intuitive, precise, and offers a wide input range.
- **Built-in & Cost-Effective**: inherently available in HMDs, easy to track without extra hardware.

Interaction Benefits:

- **Hands-free**: supports accessibility, and enables interaction when hands are occupied.
- **Complementary for other modalities**: enhances hand- and gaze-based interaction for performance and multi-tasking, or just for more enjoyment in gaming.

Research Aims:

This PhD research aims to establish a deeper understanding of how to effectively leverage head movement as input in interactive systems. This includes:

- **Systematic Literature Review**
  Synthesizing existing research on head-based interaction.
- **Design of Interaction Interfaces in HMDs**
  Optimizing head-input systems with multimodal coordination.
- **Generalization of Design Principles**
  Applying HMD design insights to diverse interactive systems.

Research Progress

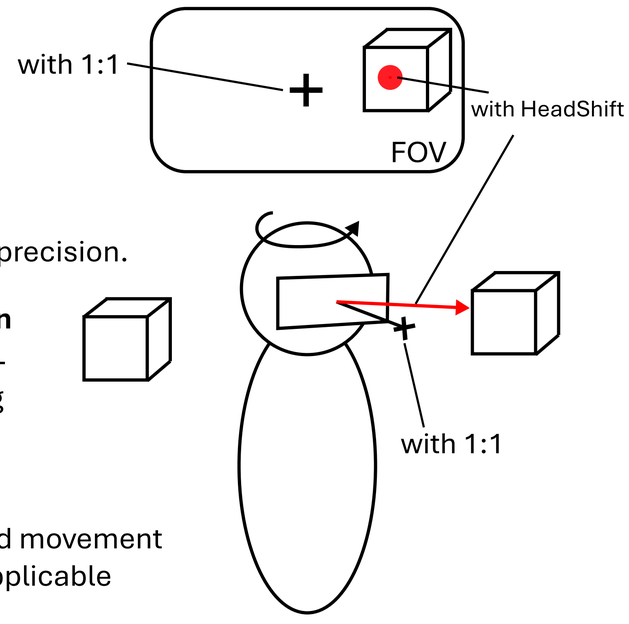
Completed Work: HeadShift

The current head pointing fixes the cursor to the head vector i.e. centre of the field-of-view (FOV), which has limitations in:

- **Limited Precision** for small targets.
- **Exaggerated Head Movement** for large amplitude of target distances.

Key features of HeadShift:

- **Pointer Acceleration**
  Requires less effort with higher precision.
- **Natural Eye-head Coordination**
  Better ergonomics, pointing performed in a comfortable viewing angle.
- **Head Input Only**
  Target-agnoistic, only takẹs head movement properties as input, generally applicable across devices.



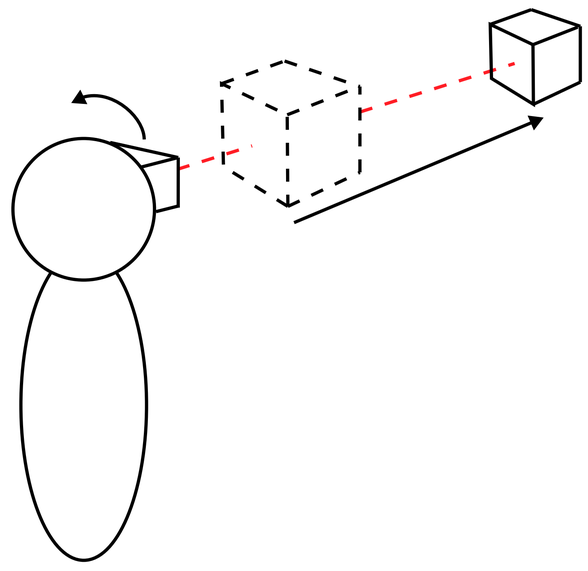
HeadShift reduces the amount of head movement required for moving the cursor (red dot) and makes targets selectable within a comfortable gaze range around the head vector.

Work-in-Progress: HeadReview

We're conducting a systematic literature review on head-based interaction techniques with the PRISMA protocol.

Current Progress: included 155 papers published before 2024, extracting data and plan to include 2024 papers as well.

Work-in-Progress: HeadDepth



Tilting head up to move an object into depth along the gaze direction (red dotted line).

Moving an object by just looking with your eyes and tilting your head!

Gaze for Direction + Head for Depth

But this is not straight forward:

- **Unintentional Control**
  Head movements can be unintentionally driven by gaze shifts, triggering unintended control.
- **Visual Constraints**
  When gaze is fixating, head movement is constrained by the fixation point, limiting control range.

Preliminary Takeaways

Eye Gaze is NOT the same as Head Vector

Head Vector approximates eye gaze but is not identical. They are coupled and can interfere. Head-based interactive systems should consider eye-head coordination, even without gaze input.

Keep Head Pointer in a Comfortable Viewing Range

Head pointing interfaces should keep the pointer within a comfortable eye-in-head range to optimize head control and user experience.

Gaze Fixations Constraints Head Rotation

When using gaze as an input vector or requiring constant visual feedback during large amplitude of head control, mapping functions should account for visual constraints on head input range.

Future Plan

Improving Hand Interaction with Head Input:

- Using eye and head input to enhance hand performance in rotation-scaling-translation tasks.
- Researching how head input can best fit in the multimodal technique design.

Extending Findings beyond HMDs:

- Integrate our findings with HMDs into general interfaces such as desktops, IoT systems, or smartphones.

Contributions

A Systematic Literature Review on Head-based Interactive Systems
Contribute to the field an overview and systematic analysis of works on head-based interactive systems.

Novel Head-based Interaction Techniques for HMDs
Design and evaluate 3D interaction techniques that improve interaction efficiency and user experience for HMD interfaces and beyond.

Design Principles on Head-based Unimodal and Multimodal Interfaces
Head-based interactive systems need to consider eye-in-head coordination in the design. More to be discovered in the future.

Supervisor: Hans Gellersen