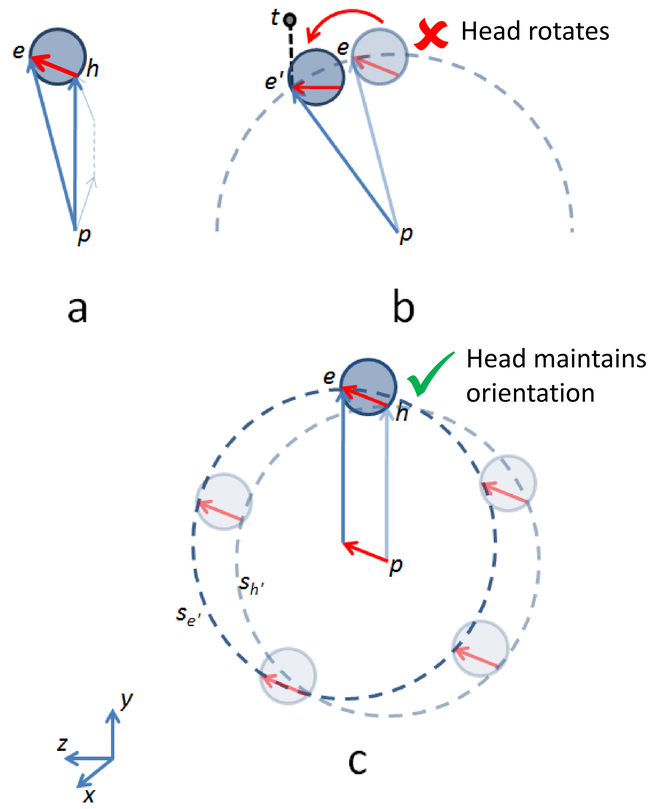
Integrating Head and Full-Body Tracking for Embodiment in Virtual Characters

David Borland, Universitat de Barcelona and RENCI, UNC Chapel Hill



Pivot-and-Project

In this method we project *t* vertically along the *y*-axis to a new position *e',* such that *e* can be placed at *e'* by rotating around *p*, thus matching the head-tracker position in *x* and *z*.

Figure:

a) Simplified avatar upper-body bone structure. Typically a number of bones between *p* and *h* form the "spine".
b) Rotating *p* such that *e* matches *e'* also rotates *h* to no longer match the head tracker orientation.
c) Pivot-and-project method. Two spheres offset by $\overrightarrow{he}$ enable correct handling of the head rotation by projecting *t* onto sphere $s_{e'}$.

Pros:

- Minimal avatar manipulation—a single bone rotation.
- Uses head-tracker position data for the *xz* plane, where most head motion occurs (looking side-to-side, walking)

Cons:

- Does not use all head tracker data—vertical position determined from avatar geometry

The Problem

In virtual embodiment scenarios the participant in a virtual environment is presented with a first-person view of a virtual body, providing the illusion that the body is, to some extent, their own. This body-ownership illusion can be strengthened by animating the virtual body using *body tracking* of the participant. Poor head-tracking quality from a full-body tracker, especially when wearing an HMD, increases the possibility of inducing *simulator sickness,* so a *separate higher-quality head-tracking system* is used. We outline principles for *combining the head- and body-tracking data* to generate appropriate first-person views that *maintain the user's body-ownership illusion without inducing simulator sickness*, and describe two related methods based on these principles.

Principles and Constraints

Two objects to match

- Viewpoint (virtual camera)
- Representation (avatar bone positions and rotations)

Assumption: Head tracker more accurate

Principles

- Use head-tracking data whenever possible for virtual camera
- Modify body-tracking data as little as possible to match head-tracking data

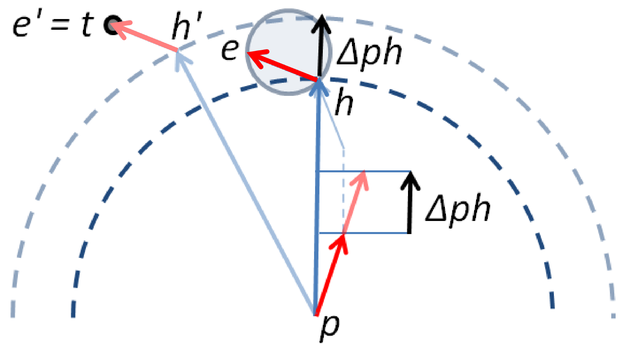
Constraints

- Match avatar eye midpoint and look-at direction exactly with virtual camera
- Introduce no additional foot motion (sliding)

Terminology

- *t*: head tracker position (transformed to eye midpoint of participant)
- *e*: avatar eye midpoint (from body tracker)
- *h*: avatar head position (from body tracker)
- $\overrightarrow{he}$: vector between avatar head position and eye midpoint (direction determined by head tracker rotation)
- p: pivot bone (base of avatar torso/spine)
- *e'*: desired avatar eye midpoint, derived from *t*

Objective: Match *e* as closely as possible to *t*, given the principles and constraints above



Pivot-and-Stretch

In this method we allow the length of the bone anchored at *p* to stretch or shrink as well as rotate, enabling *e* to match *t* exactly.

Figure:
Adjusting the length of *p* by *Δph* enables the placement of *h* at *h'* and *e* at *e' = t* while maintaining the head rotation from the head tracker.

Pros:

- Uses all head-tracker data
- No increase in possibility of inducing simulator sickness

Cons:

- Additional manipulation of avatar geometry

UNIVERSITAT DE BARCELONA
renci RESEARCH ENGAGEMENT INNOVATION
VERE TRAVERSE *iCrea INSTITUCIÓ CATALANA DE RECERCA I ESTUDIS AVANÇATS
eventLAB Neuroscience & Technology