Extended LazyNav: Virtual 3D Ground Navigation for Large Displays and Head-Mounted Displays

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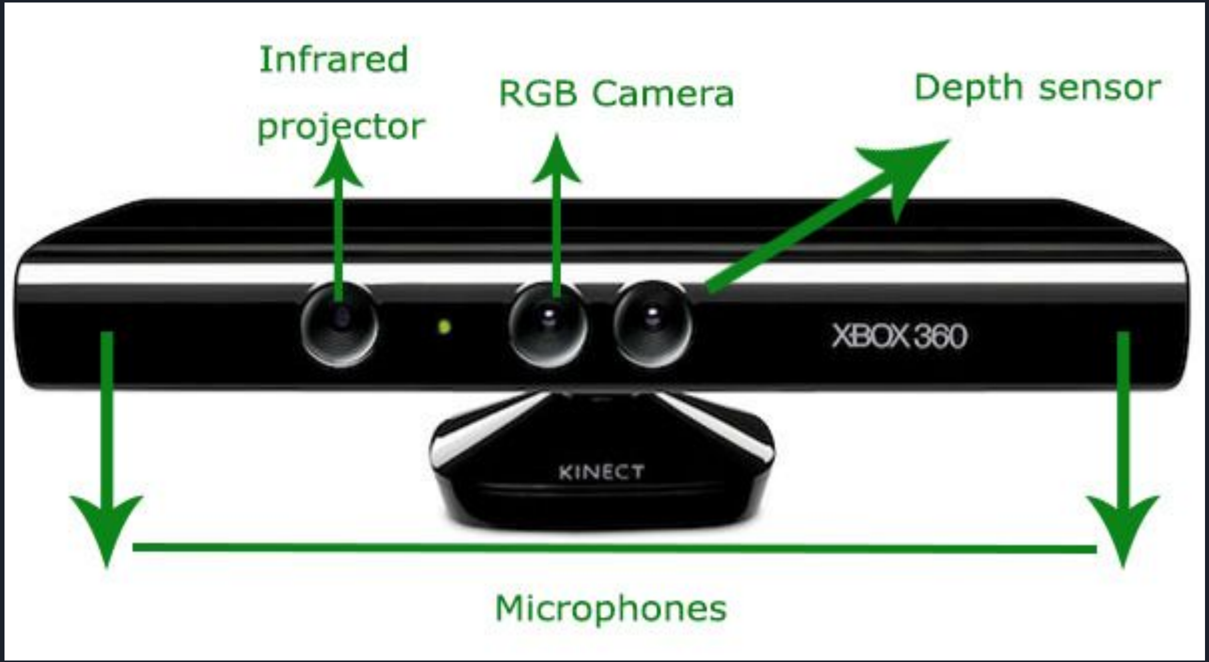
Kinect: RGB-D Sensor



Introduction

- ➔ This paper presents the extended work on LazyNav, a head-free, eyes-free and hands-free mid-air ground navigation control model presented at the IEEE 3D User Interfaces (3DUI) 2015, in particular with a new application to the head-mounted display (HMD).
- ➔ The **Mid-Air** interaction metaphor makes use of only a single pair of the tracked body elements to tailor the navigation.
- ➔ Therefore, the user can navigate in the scene while still being able to perform other interactions with the hands and head, e.g., carrying a bag, grasping a cup of coffee, or observing the content by moving her eyes and locally rotating her head.

Mid-Air Interaction

- Mid-air techniques are useful in public spaces to interact with immersive 3D contents.
- For instance, in the context of large-format public displays, users do not have to connect, touch or wear any specific devices and can instantaneously interact with the system from a distance.

LazyNav ?

- A ground navigation control mechanism, which balances general requirements (i.e., intuitive, fast, and accurate navigation) with a “L***azy***” concept that is crucial for public space applications.
- A “Lazy Interface” is designed to meet the following requirements:
    - Comfortable to use,
    - Secondary action doable, and
    - Socially acceptable.
- To achieve this goal, ***non-tiring motions*** with ***non-critical body parts*** are applied.

Walking-In-Place Techniques

- The most straightforward solution for ground navigation might be to have a one-to-one mapping between the user gestures and the virtual motions
- Example: An omnidirectional Treadmill which allows user to walk in VE as they do in real world. -- Frissen et al
- These techniques try to mimic as much as possible the user locomotion. This certainly gives a better immersive feeling, however, it also results in more tiring and sub-efficient interactions

Omnidirectional Treadmill

LazyNav on Large Display

Figure taken from web and paper

Design

- Body Motions should be selected based on 2 principle criteria:

1. The user should not need to use the critical body parts such as hand, eyes nor head rotation to navigate.
2. The motions should be easy to perform, to understand and not tiring.

- Seven such motions can be selected.

Seven Positions

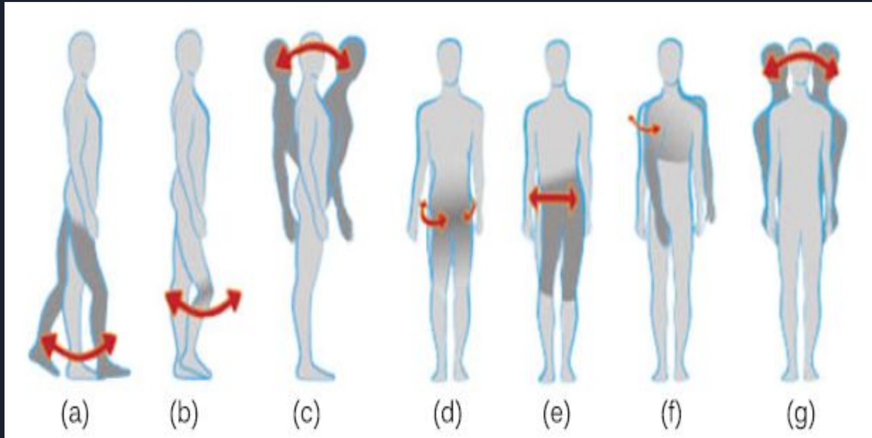


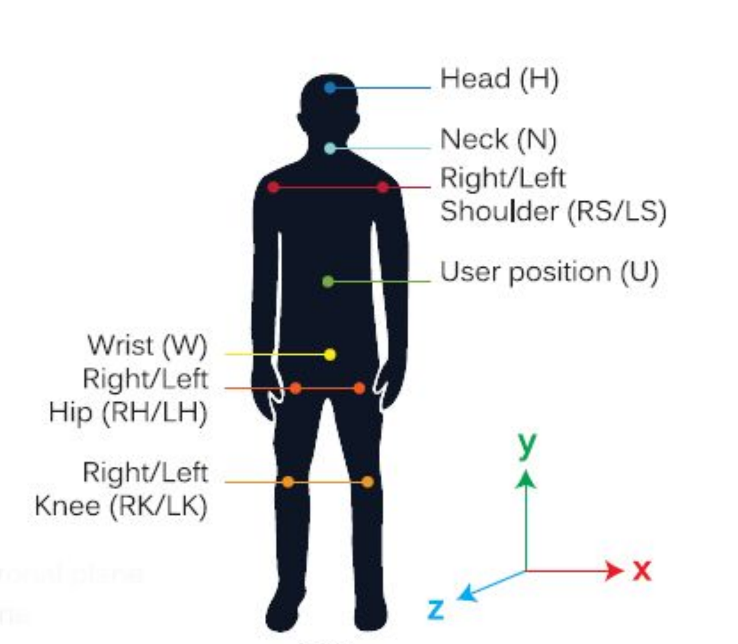
Fig. 2. Designed user motions: (a) step (the user just puts one foot forward or backward), (b) bend knees, (c) bend bust, (d) rotate hips, (e) bend hips, (f) rotate shoulders and (g) lean bust.

Figure taken from paper

- A, B, C work in the Sagittal Plane i.e. to move forward/ backward
- D, E, F, G work in the Coronal Plane i.e. to change direction/ rotation.

Computation

- All the motions are computed by measuring the angle between different user positions by capturing a set of tracked body points at each time-step using RGB-D sensor i.e. Kinect.. w.r.t. a reference pose captured at the beginning in 3D i.e. X(width), Y(height), Z(depth).
- For example: for bend bust, the vector goes from the user position U to the user head H, and we compute the angle in the z-axis. For the [bend hips], the angle from the user position U to the left hip LH is compared with the one from the user position U to the right hip RH in the x-axis.



(b)

Transfer Function

$$f(x) = \begin{cases} 0 & \text{if} \quad x \in [0, \alpha] \\ \left(\frac{x-\alpha}{1-\alpha}\right)^{\beta} & \text{if} \quad x \in [\alpha, 1], \end{cases}$$

- ➔ Transfer function is calculated based on the value of motion receptor angle “x” calculated by computing angles between the 3D points captured of the reference and current poses, it’s output ranges from 0 to 1 after normalizing.
- ➔ It is applied to user interaction to map it with virtual camera motion to move forward/ backward and rotate.
- ➔ α controls beginning of the motion effect,
- ➔ B controls the slope of the function.

Assumptions

To make Ground Navigation easy to use:

1. Uncorrelated Body Parts
2. Correlation between Virtual and Real Motions
3. Secondary Action
4. Lazy Navigation

Final Set of Motions

1. Based on the assumptions, a pair of interactions can be decided to view(V) and walk(W).
2. Thus, based on 7 motions explained, total 49 pairs can be used for walking and viewing, out of which the pairs that include the same body part for both can be eliminated and thus only 49-13= 36 pairs can be used.

not tested | not finished | finished

View	bend bust	lean bust	rotate shoulders	rotate hips	bend hips	bend knees	do a step
bend bust	–	–	100%	82.5%	100%	100%	100%
lean bust	–	–	100%	100%	70.4%	100%	100%
rotate shoulders	100%	100%	–	11.2%	100%	100%	100%
rotate hips	100%	100%	10.5%	--	–	100%	100%
bend hips	100%	40.3%	100%	--	–	100%	100%
bend knees	100%	100%	100%	100%	100%	--	--
do a step	100%	100%	100%	100%	100%	--	--

Figure taken from paper

User Study

- Participants could not complete the task when too correlated body parts were used to view and walk and were able to better synchronize when two motions were thinly correlated.
- Also, motions having similar correlation between real and virtual movements appeared easier opposed to having opposite correlation i.e. motion in sagittal plane to rotate the view, and a motion in the coronal plane to walk.

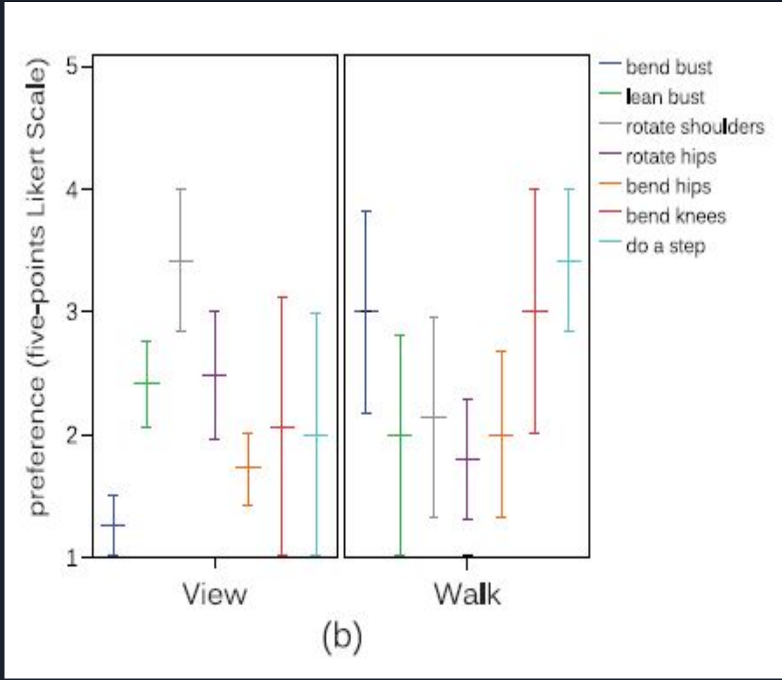


Figure taken from paper

Best Set of Motions

The three favorite motions to turn the view ([rotate shoulders], [rotate hips], and [lean bust]) and the three favorite motions to walk ([bend bust], [bend knee], and [step]).

Pairing these 6 motions into 9 pairs results to:

A. [V: rotate shoulders - W: bend bust]
B. [V: rotate shoulders - W: bend knees]
C. [V: rotate shoulders - W: step]
D. [V: rotate hips - W: bend bust]
E. [V: rotate hips - W: bend knees]
F. [V: rotate hips - W: step]
G. [V: lean bust - W: bend bust]
H. [V: lean bust - W: bend knees]
I. [V: lean bust - W: step]

Continue

The 9 pairs are rated based on the categories and a score of >5 is preferable.

Thus, the motion pairs: d([V: rotate hips - W: bend bust]), f([V: rotate hips - W: step]) and i([V: lean bust - W: step]) are suitable for Large Display setting.

And, out of the [rotate hips] and [lean bust] motion, [lean bust] is more suitable for viewing along with [step] for walking as, [rotate hips] is more correlated to [step].

	a	b	c	d	e	f	g	h	i
understandable	6.6	6.5	6.5	6.5	6.2	6.6	6.8	6.6	6.8
comfortable	4.5	5.0	5.1	4.8	5.5	5.3	5.6	4.8	5.6
ease-of-use	5.2	4.7	5.1	5.2	4.7	5.1	5.6	4.8	5.6
not tiring	4.3	4.9	4.8	5.2	4.9	5.4	4.7	4.8	5.0
accurate	5.3	4.6	4.7	5.7	4.4	5.3	5.5	4.8	5.0
2nd action doable	5.9	5.9	5.6	6.3	6.1	6.5	6.1	5.9	6.2
motion sync	4.0	4.1	4.1	5.2	4.3	4.6	4.7	4.8	5.8
error prone	4.9	4.4	5.0	6.0	4.5	5.2	5.2	5.1	5.2

LD

Figure taken from the paper

Conclusion

This is a complete system for interactive mid-air ground navigation which is suitable for a large collection of applications in both LD and HMD settings and can use several alternative body motions to control the virtual walk-through and allows critical body parts (hands, arms, head and eyes) free to perform other tasks.

https://youtu.be/Y6zgFUl01Mo

References

- Extended LazyNav: Virtual 3D Ground Navigation for Large Displays and Head-Mounted Displays by Parinya Punpongsanon, Student Member, IEEE, Emilie Guy, Student Member, IEEE, Daisuke Iwai, Member, IEEE, Kosuke Sato, Member, IEEE, and Tamy Boubekeur, Member, IEEE

Our Implementation

- ➔ We will implement most of the paper except for the part showing green and red lines when users is following the path or walks out of the way while travelling in the virtual world.
- ➔ Also, we are not sure about which map to use for the application, so maybe we will design a game where user can pick up objects by travelling in the virtual world by moving using the set of motions discussed in the paper, or put up a simple map with a maze where user needs to perform the set of motions to go from one end to the other.

Questions?