Phone Based Motion Control Travel Technique in VR

Bachelor Thesis Presentation

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Outline

- Overview
- Phone based motion control
  - Phone tracking
  - Travel techniques
  - Graphical User Interface
- Evaluation Results
- Future Work
- Conclusion

Overview

- Virtual environment and Immersive virtual environment-IVE-
- Navigation in virtual environment
  - Standard devices
    - Mouse and keyboard
  - Multimodal devices
    - Gloves , handled device, and PDA
- Walking In Place technique
- More degree of freedoms or less
- Focus on Travel Techniques

Phone based motion control

- Android Operating System
- Connectivity
- Phone tracking
- Travel techniques
- Graphical User Interface

Phone based motion control

Phone Tracking

- Magnetic field sensor
- Orientation sensor
- Calculating heading value
  - Using orientation and magnetic field sensors
  - Results were inaccurate and unstable
- Orientation sensor is used to track the mobile in all direction
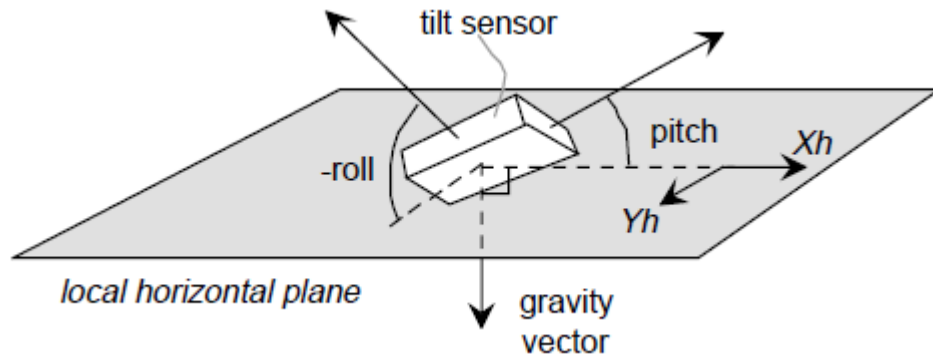
Tilt sensor angles referenced to the local horizontal plane

$$Heading = arcTan\ (Yh/Xh) \qquad (1)$$

$$roll\ (\theta)\ and\ pitch\ (\phi)$$

$$Xh = X*cos(\phi) + Y*sin(\theta)*sin(\phi) - Z*cos(\theta)*sin(\phi)$$
$$Yh = Y*cos(\theta) + Z*sin(\theta) \qquad (2)$$

$$
\begin{aligned}
Heading\ for\ (Xh < 0) \quad &= 180 - arcTan(Yh/Xh) \\
for\ (Xh > 0, Yh < 0) \quad &= -arcTan(Yh/Xh) \\
for\ (Xh > 0, Yh > 0) \quad &= 360 - arcTan(Yh/Xh) \\
for\ (Xh = 0, Yh < 0) \quad &= 90 \\
for\ (Xh = 0, Yh > 0) \quad &= 270
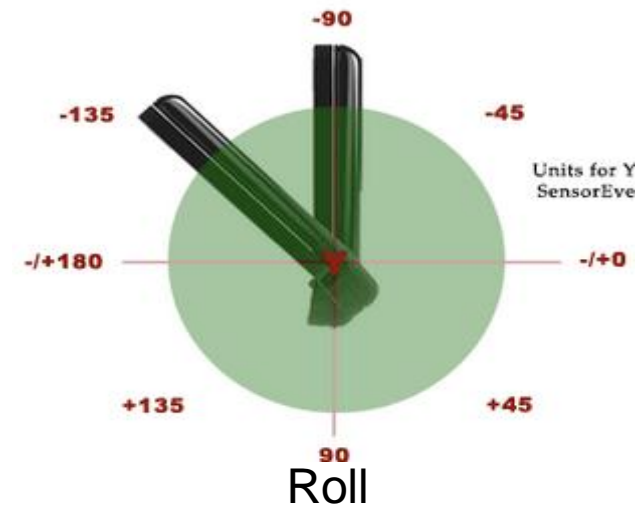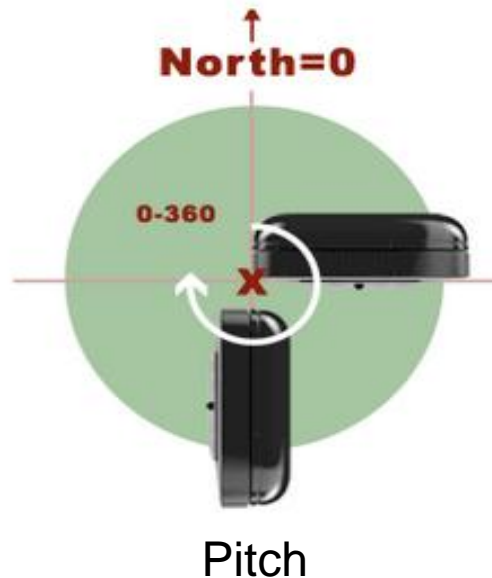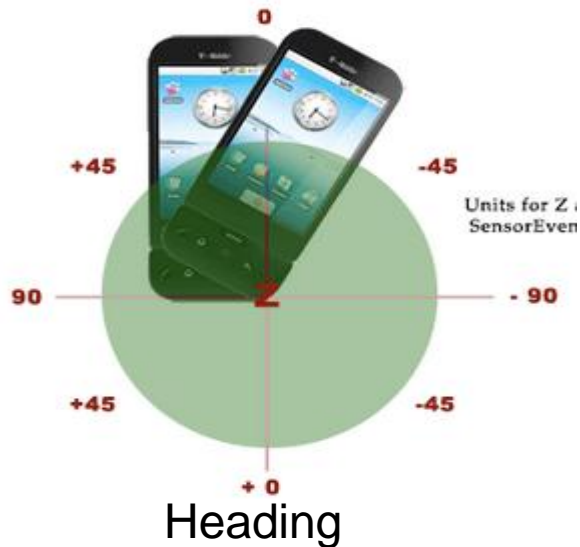\end{aligned} \qquad (3)
$$

Equations to calculate the heading using orientation and magnetic field sensors

Phone Orientation Sensor

- Provides mobile orientation
- Rotation
  - Azimuth = Heading = around Z axis
  - Pitch = around X axis
 - Roll = around Y axis

Heading   Pitch   Roll

Travel Techniques

- Focus on Three criteria
  - Start and end motion
  - Alternate movement speed
  - Indicate movement direction
- Touch based motion control
- Acceleration techniques
- Steering based motion control

Touch based Motion Control

- Translation
  - Simulating a locomotion technique
  - Translation gesture detection
  - Mobile orientation indicates movement direction
  - Send data to the IVE
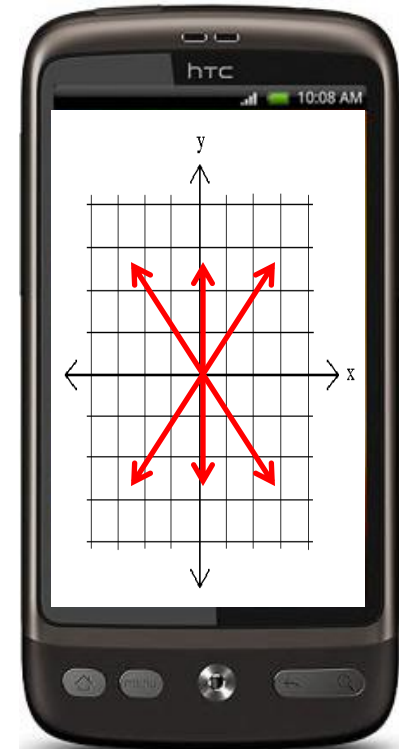
Translation

Acceleration techniques

- **Manual Speed**
  - Freedom of choice
  - Constant speed to travel with
- **Gas Pedal**
  - Simulates Cars gas pedal
  - Quadratic function
- **Finger Speed**
  - Movement speed : displacement over time
- **Height Rate**
  - Increasing linearly
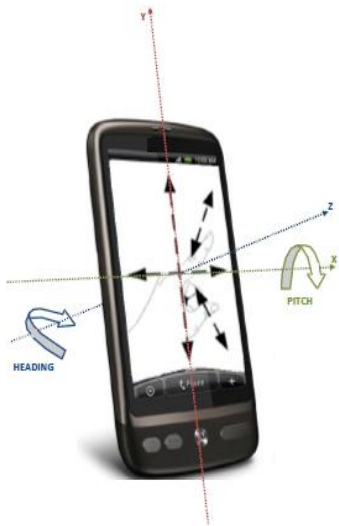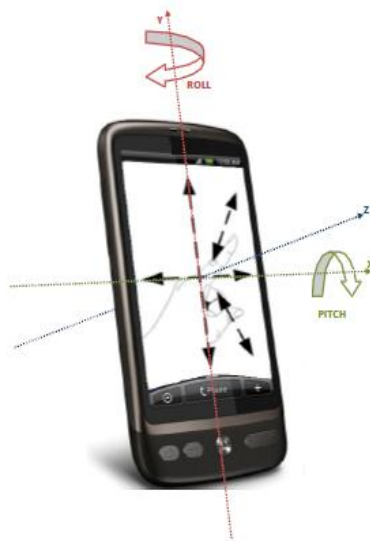
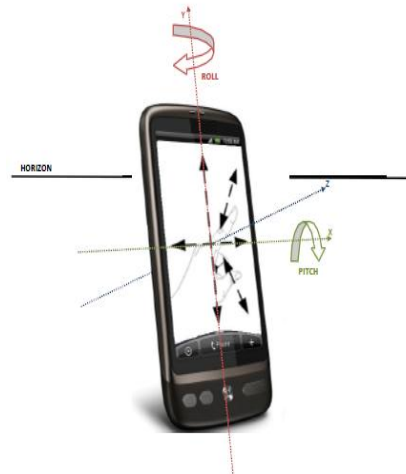Manual Speed   Other techniques

Steering based Motion Control
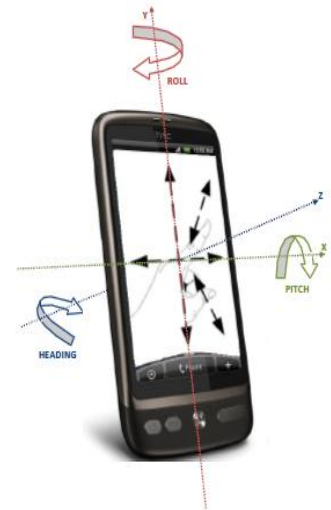
Rotate By Heading
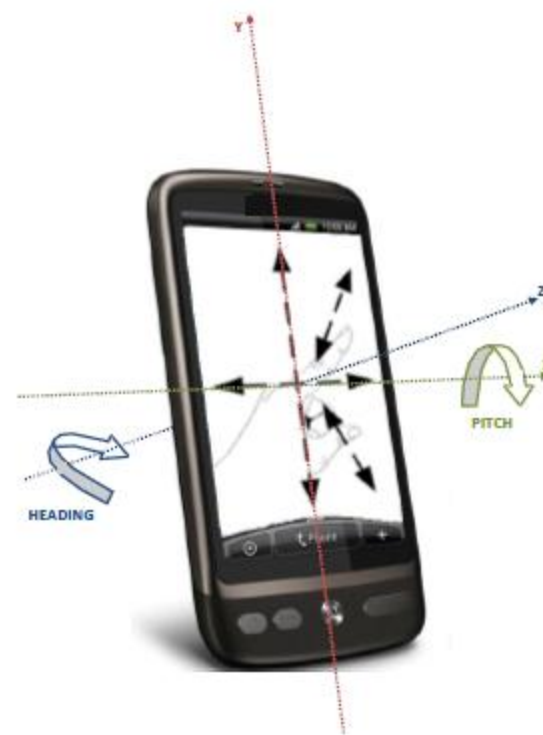
Rotate By Roll

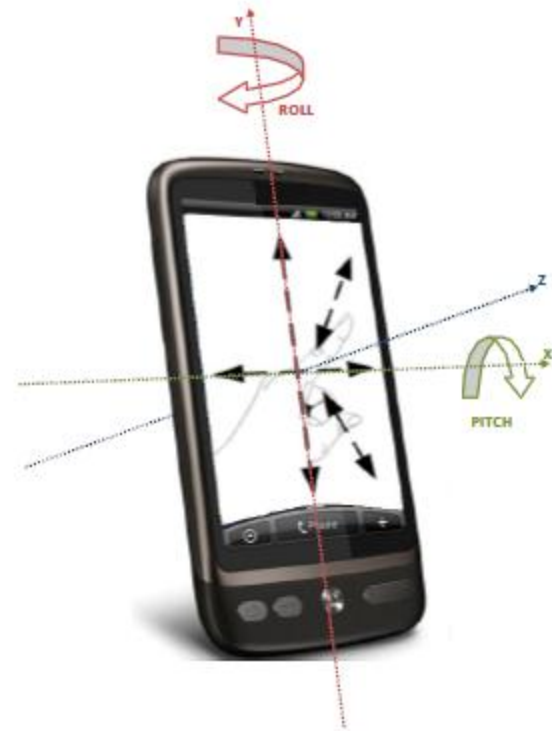Rotate By Roll
with fixed horizon

Merged Rotation

Rotate By Heading

- Phone azimuth mapped to IVE heading
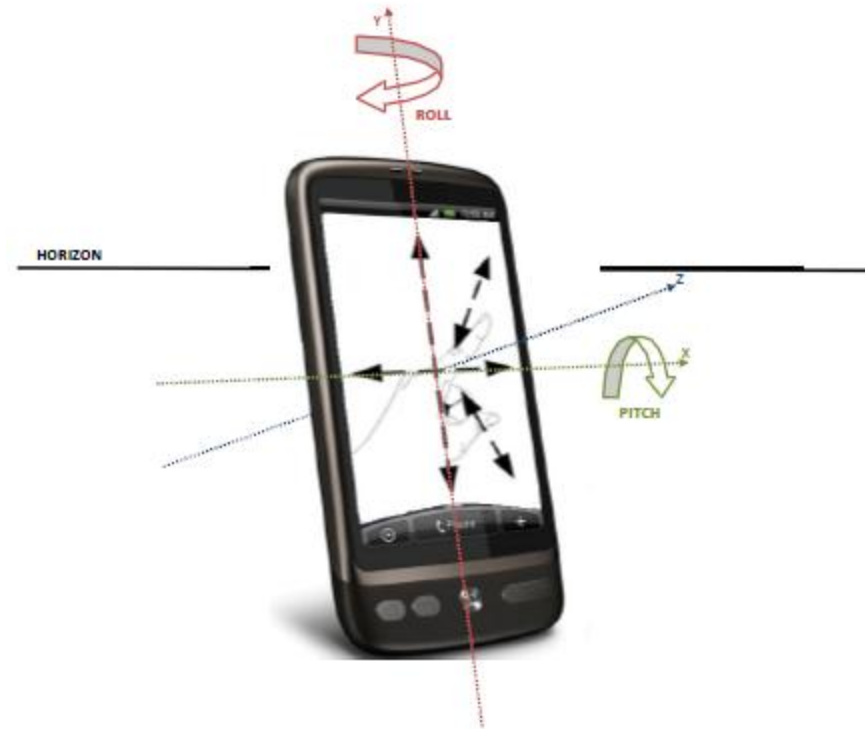- Phone pitch mapped to IVE pitch

Rotate By Roll

- Phone roll mapped to IVE heading
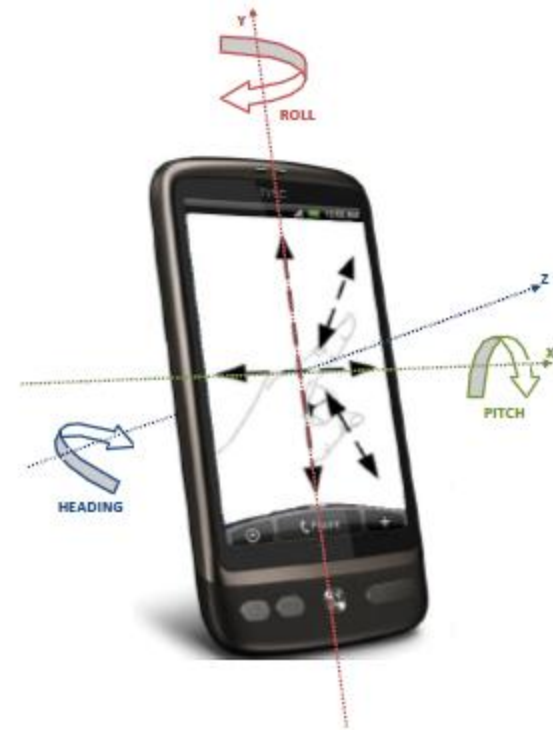- Phone pitch mapped to IVE pitch
- Horizon changes

Rotate By Roll with fixed horizon

- Phone roll mapped to IVE heading
- Phone pitch mapped to IVE pitch
- Fixed horizon
- Suitable for in building navigation

Merged Rotation
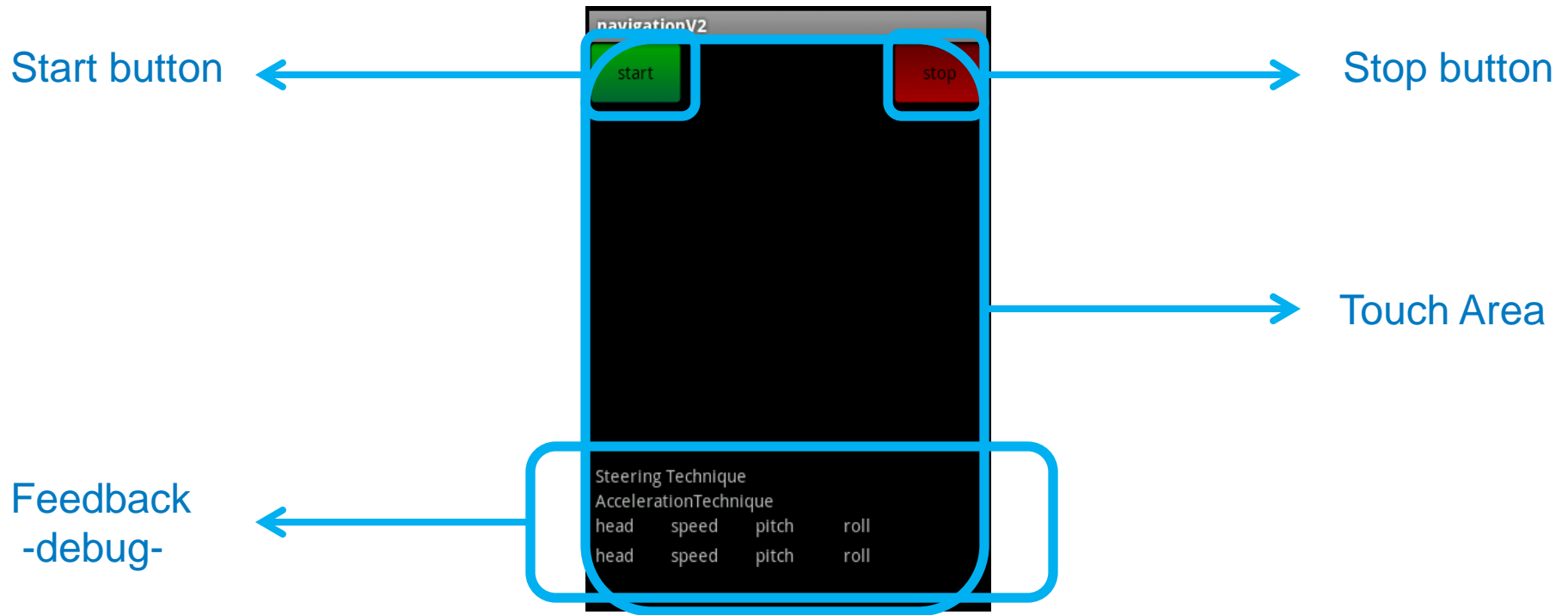
- Combine rotate by roll and heading
- More degree of freedoms
- Phone azimuth and roll mapped to IVE heading
- Phone pitch mapped to IVE pitch

Graphical User Interface

Start button

Stop button

Touch Area

Feedback
-debug-

navigationV2

start

stop

Steering Technique
AccelerationTechnique
head   speed   pitch   roll
head   speed   pitch   roll

Menu
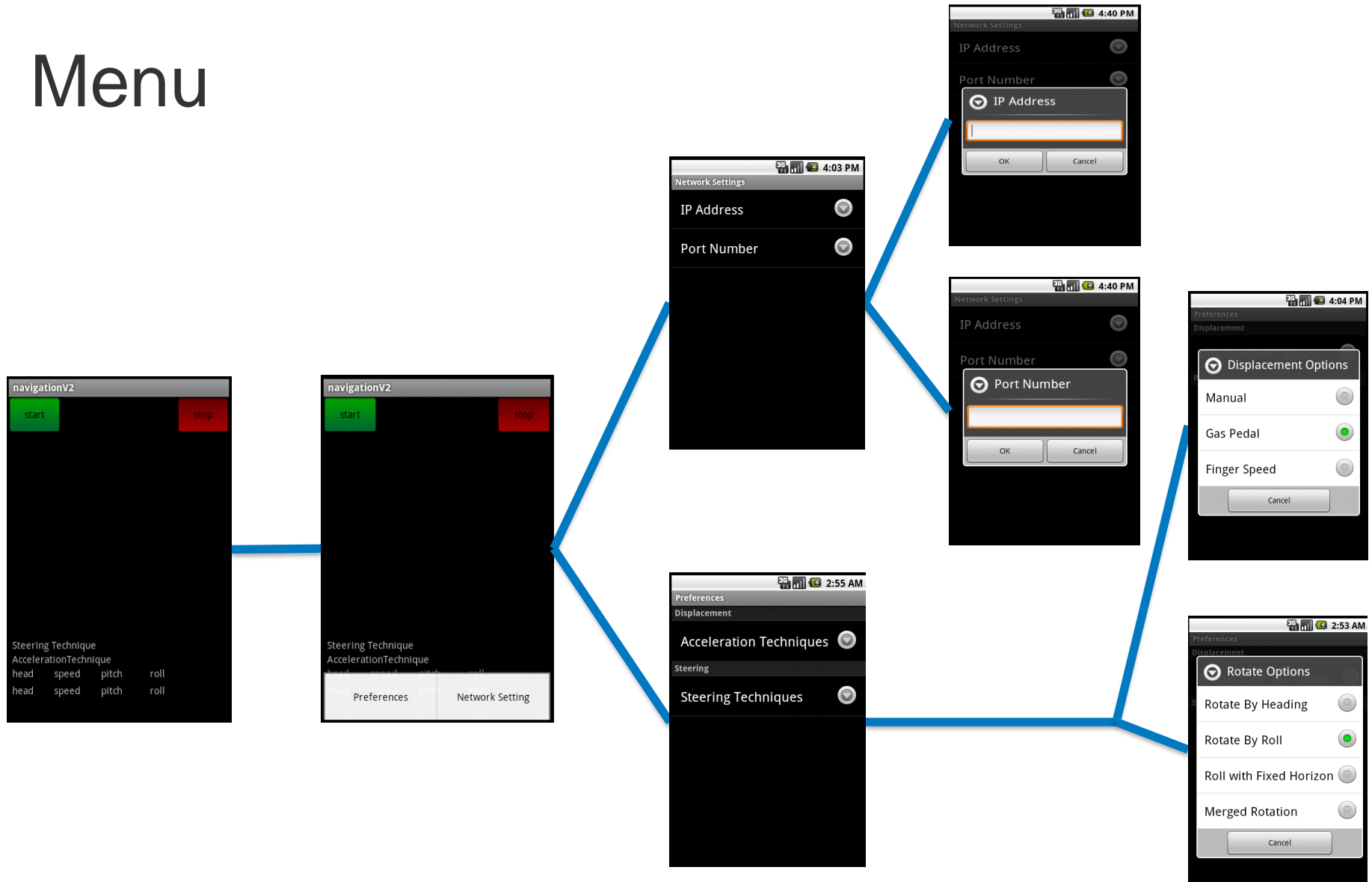
Navigation steps
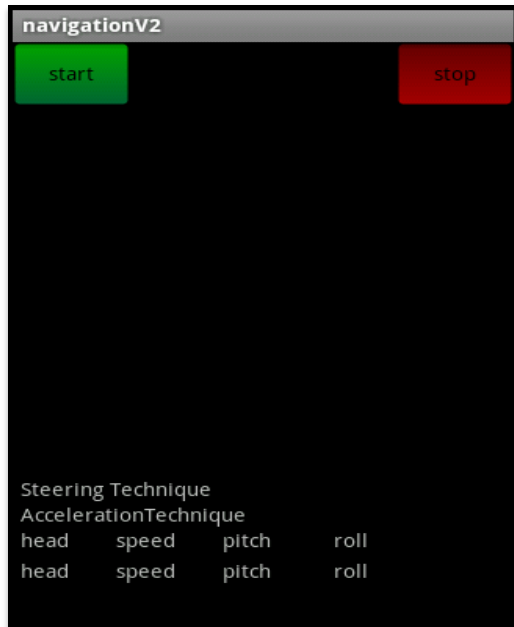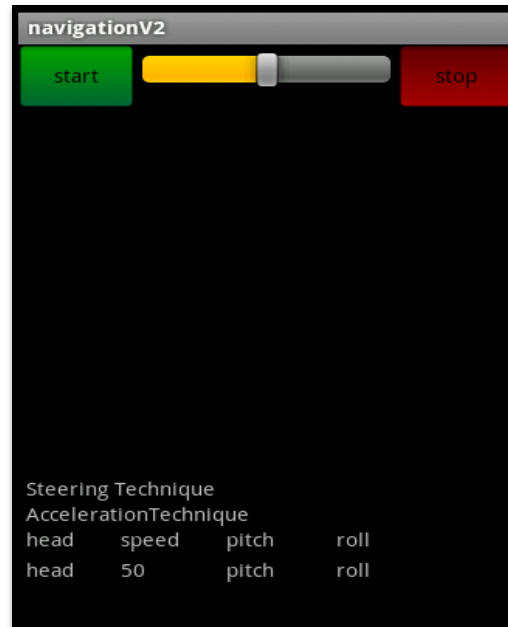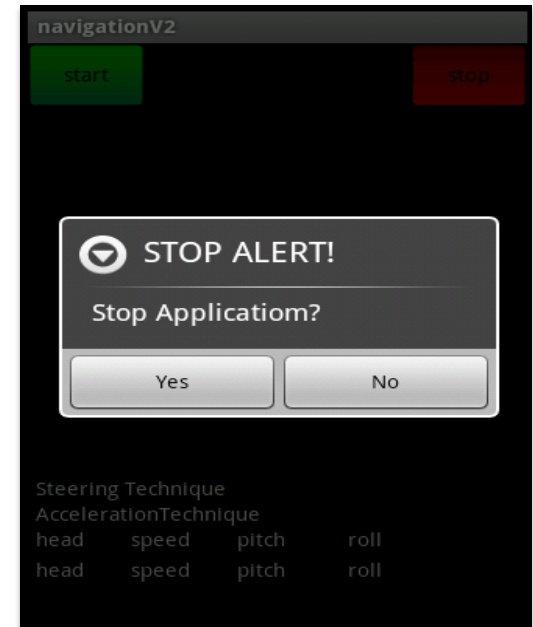
| START | NAVIGATE | STOP |

Evaluation Environment

- Terrain 3D on 3D TV

- Steering Techniques

- Acceleration Techniques

- Attrakdiff

- SUS - The System Usability
  Scale -

Steering Techniques

- Follow the tunnel

- Trying to be within the tunnel

- Comparison

  - Accuracy

  - Standard deviation

  - Time

- Users Feedback

  - Improve the sensor readings

  - Lagging in the heading reaction

  - Rotate by roll is the favorite for 5 users out of 8

Average distance from center
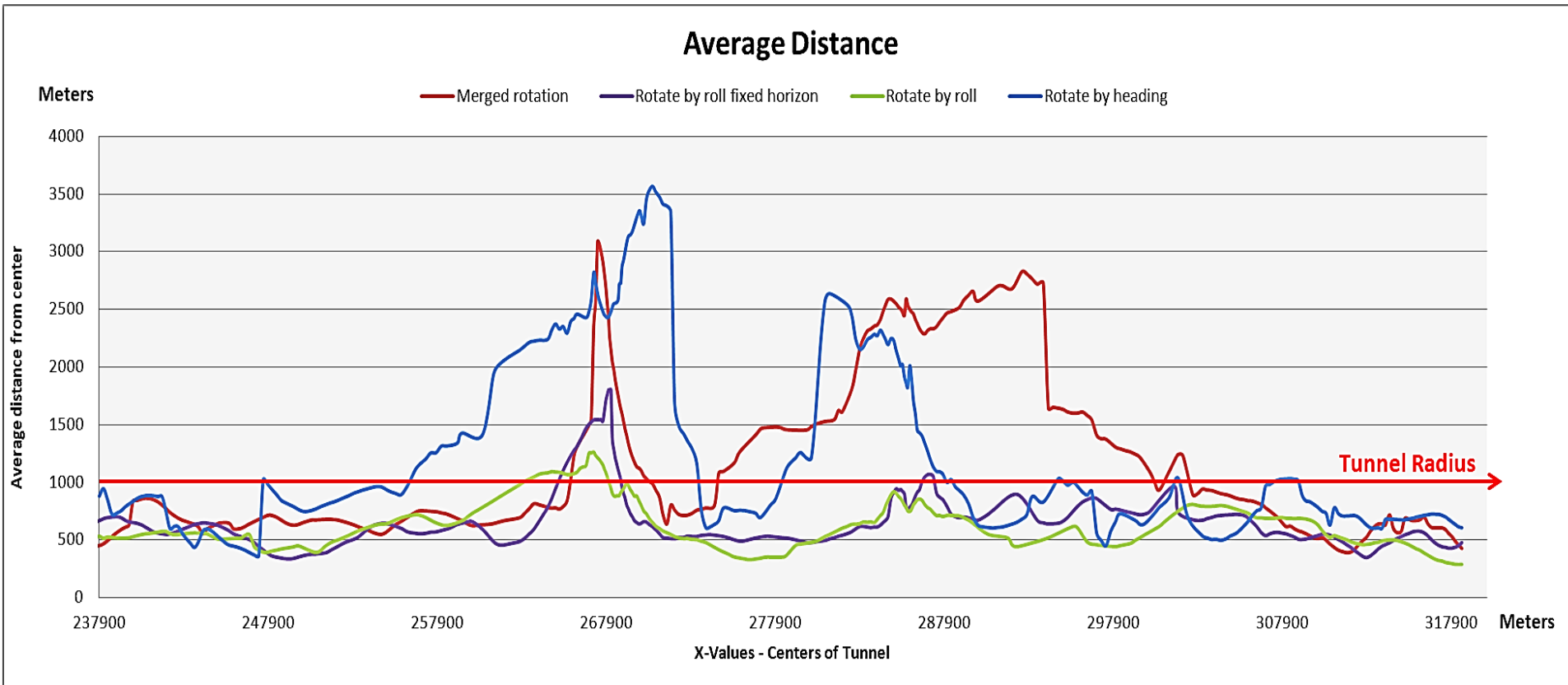
Standard Deviation

Standard deviation for all users

Legend:
- Heading Standard deviation
- Roll Standard deviation
- Fixed Horizon Standard deviation
- Merged Standard deviation
- **Tunnel radius**
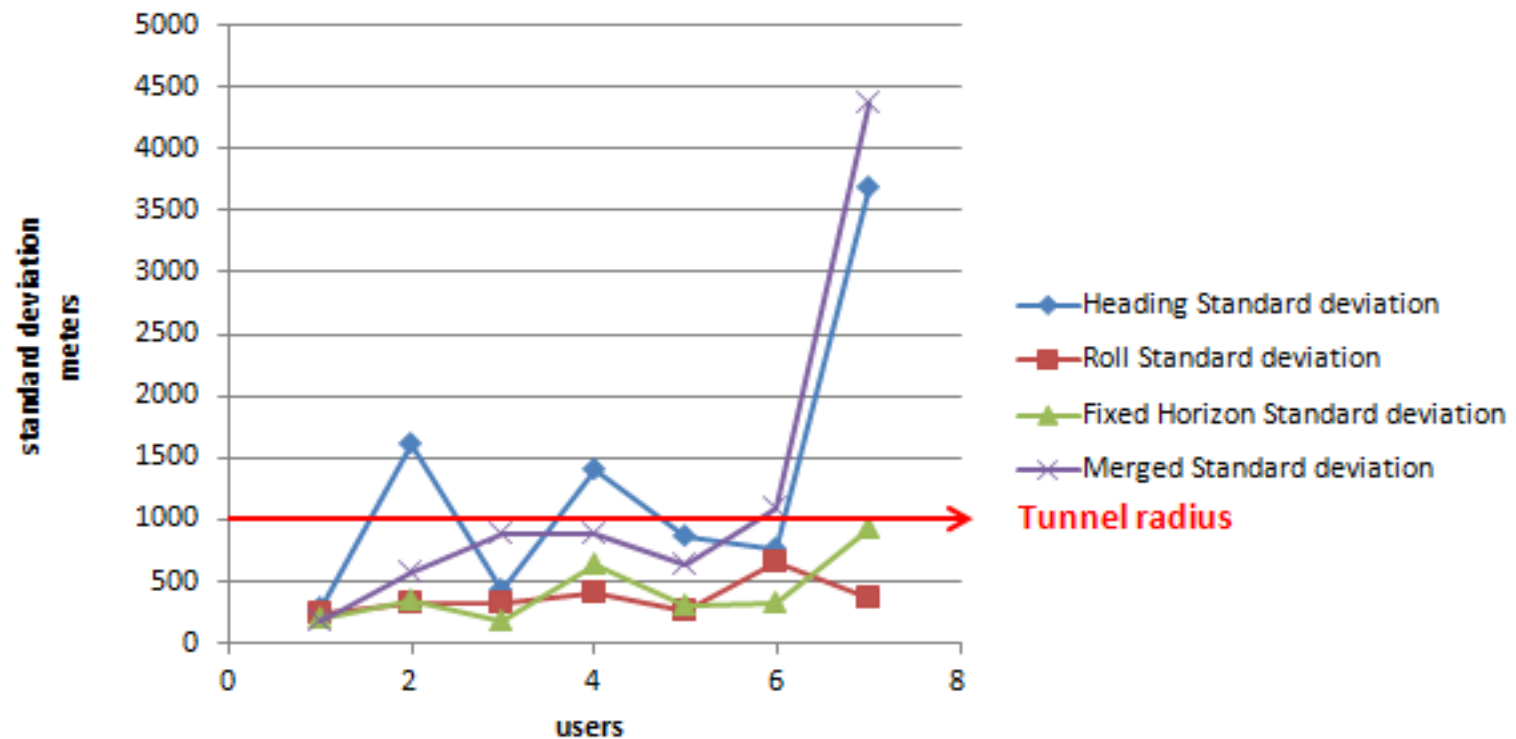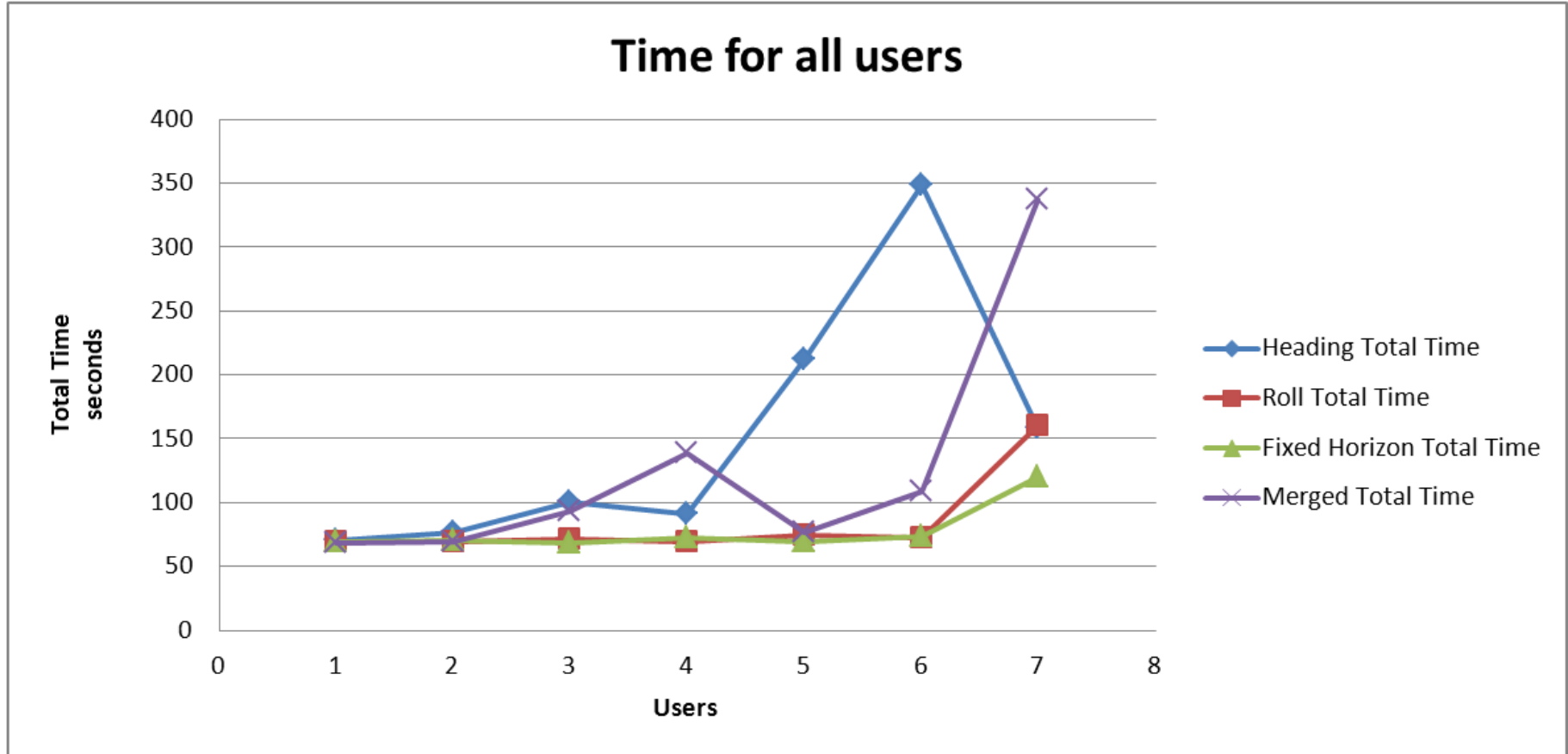
Total Time

Average Calculations

Standard deviation

Total Time

Mean Standard Deviation

	Rotate By Heading	Rotate By Roll	Rotate By Roll with fixed horizon	Merged Rotation
Mean Standard Deviation	1248.487044	470.9887025	433.5490241	1401.549051

Tunnel radius

Mean Time

	Rotate By Heading	Rotate By Roll	Rotate By Roll with fixed horizon	Merged Rotation
Mean Time	157.2802555	102.1860039	99.63975363	132.2902553
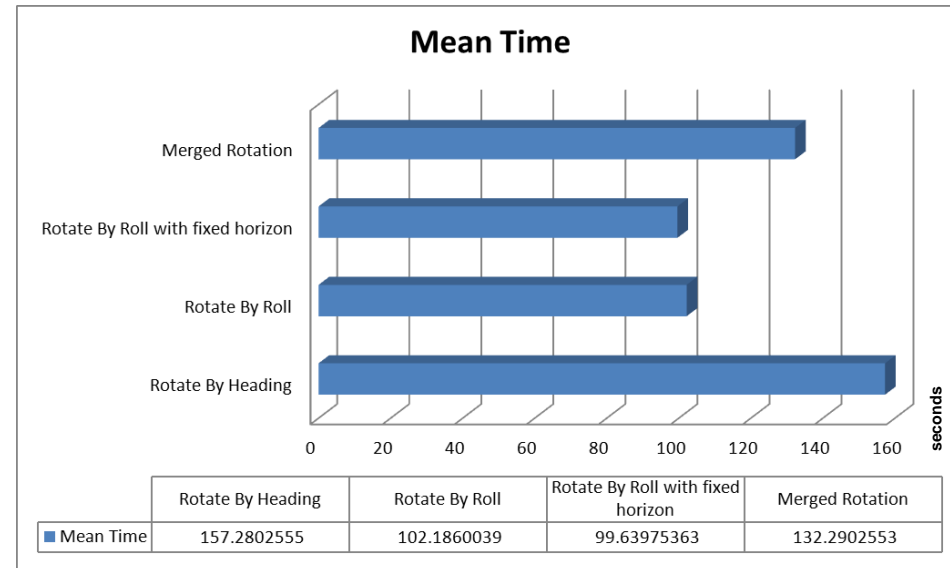
Accuracy

- Percentage of time within the tunnel to the total time

Accuracy for all users
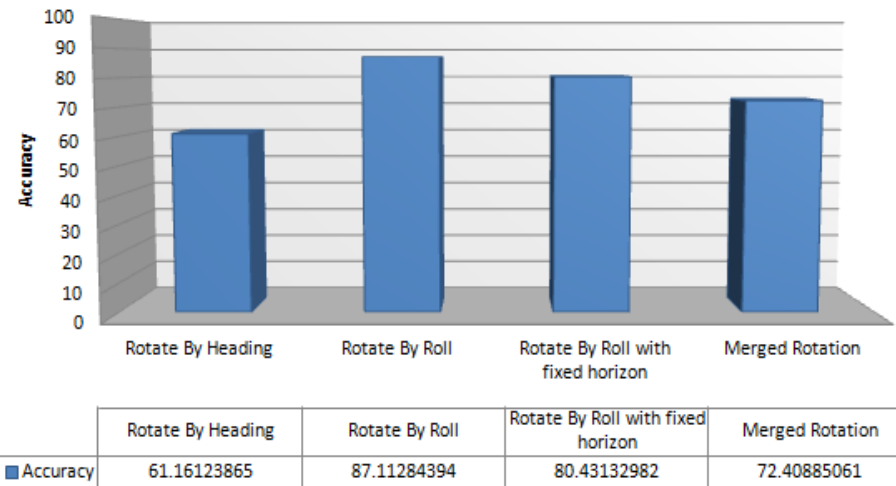
Legend:
- Heading Accuracy
- Roll Accuracy
- Fixed horizon Accuracy
- Merged Accuracy

Average Accuracy

	Rotate By Heading	Rotate By Roll	Rotate By Roll with fixed horizon	Merged Rotation
Accuracy	61.16123865	87.11284394	80.43132982	72.40885061

	Rotate By Heading	Rotate By Roll	Rotate By Roll with fixed horizon	Merged Rotation
Mean time out	53.95000186	12.99885757	17.46786	34.71942971

Acceleration Techniques
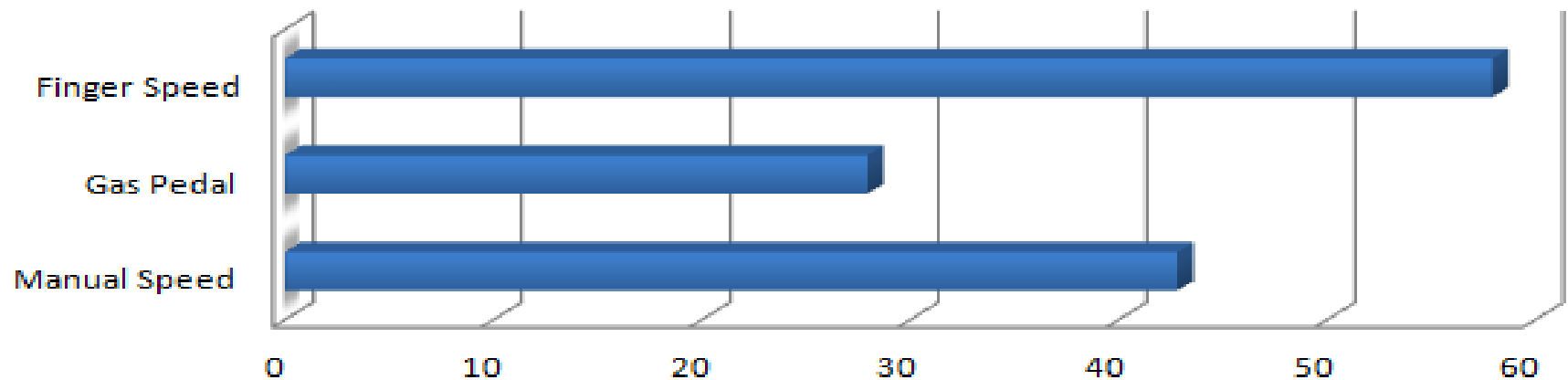
- Go from point to another

- Score the minimum time

- Comparison

  - Time

- Users Feedback

  - Gas pedal is the best for 6 users out of 8

  - Investigate more on gas pedal implementation

  - In manual speed user lose the advantage to move faster

  - Finger speed is expected to keep rolling when finger is up

Total time
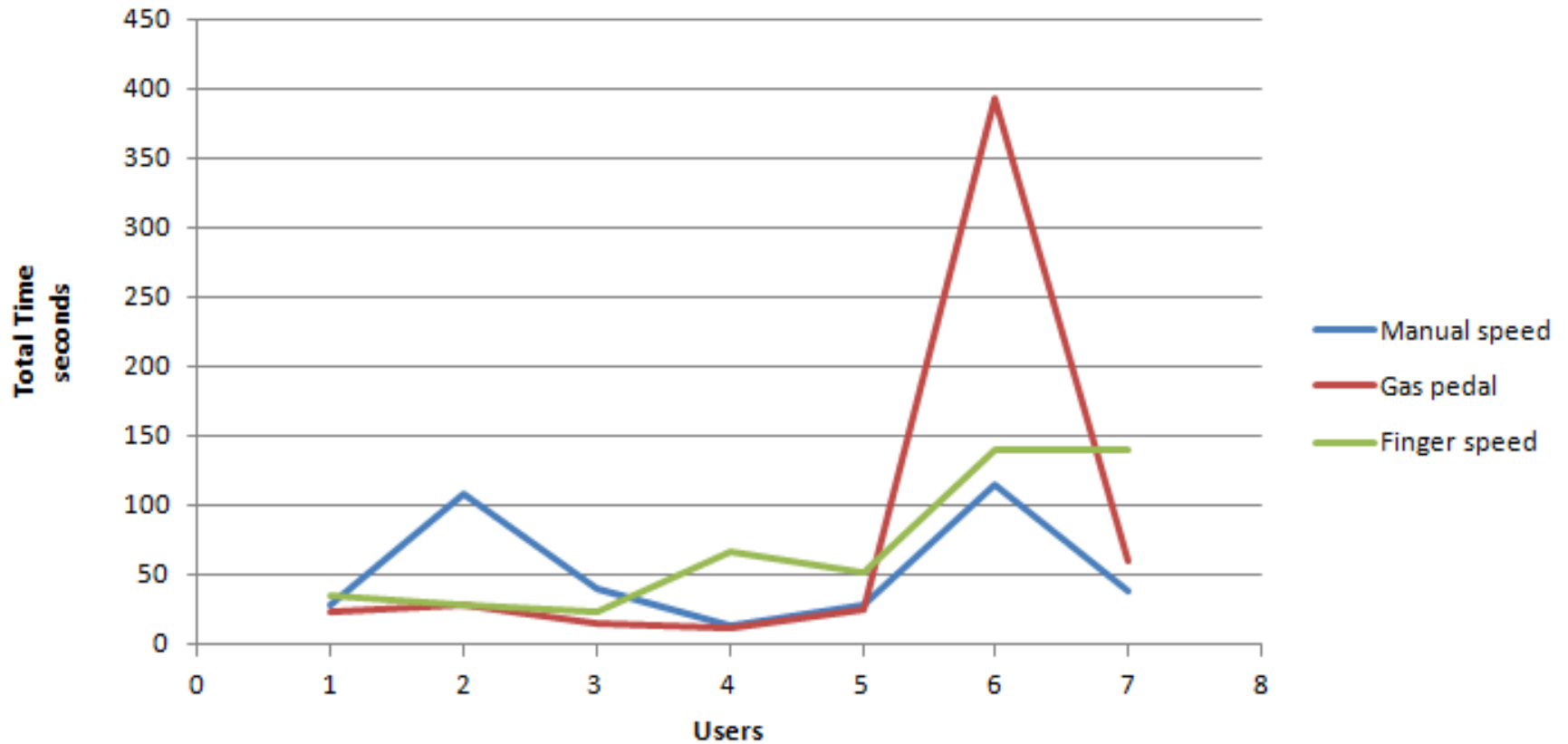
Average time

Average Time

	Manual Speed	Gas Pedal	Finger Speed
Average Time	42.81366867	27.94050133	57.937836

**Total Time**
seconds

Attrakdiff

- Test users evaluate the whole system
  - Qualitative evaluation questionnaire is not relevant for the travel interaction in virtual environment
- Pragmatic quality
- Hedonic quality – stimulation
- Hedonic quality – identity
- Attractiveness
- Overall product is very attractive
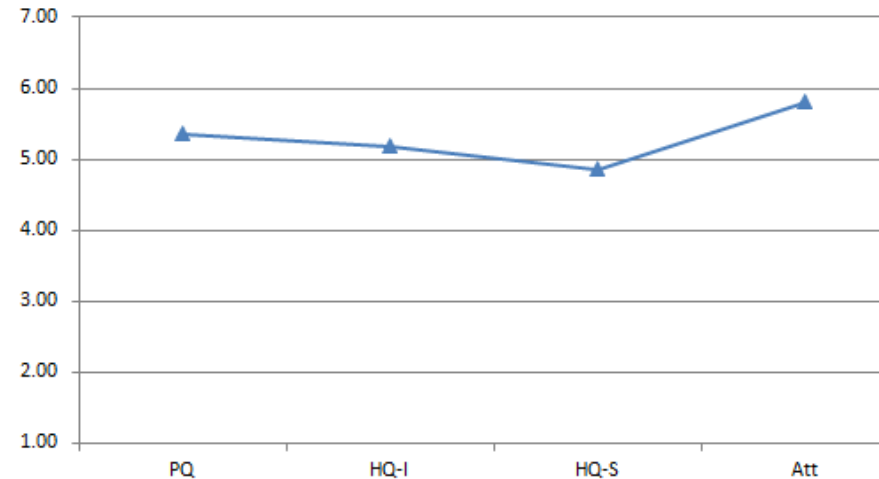
Attrakdiff graph

SUS - The System Usability Scale

- Results range from 40 to 87.5
- Test users evaluate the whole system
 - Again questionnaire is not relevant for interaction in a virtual environment
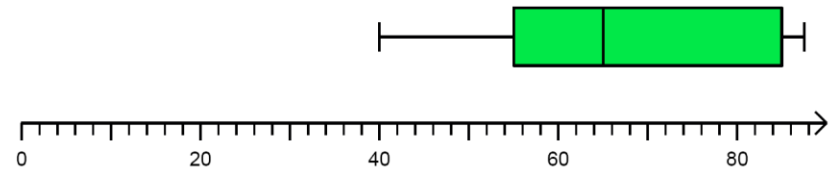
SUS diagram

Future work

- Focus more on:
  - Steering technique : Rotate by roll
  - Acceleration technique : gas pedal
- Investigate other hardware
  - external sensor could be used
- Tracking the handled device
- Investigate translation in the X axis direction
- Adding audio, haptic, or visual feedback on both the IVE and handled device
- Investigate a new methodology to evaluate
- The navigation technique could be merged with Google Earth 3D Environment

Conclusion

- Phone based motion control system
- Travel techniques
    - Acceleration techniques
    - Steering techniques
- Evaluation
    - Steering techniques
        - Rotate by roll and Rotate by roll with fixed horizon
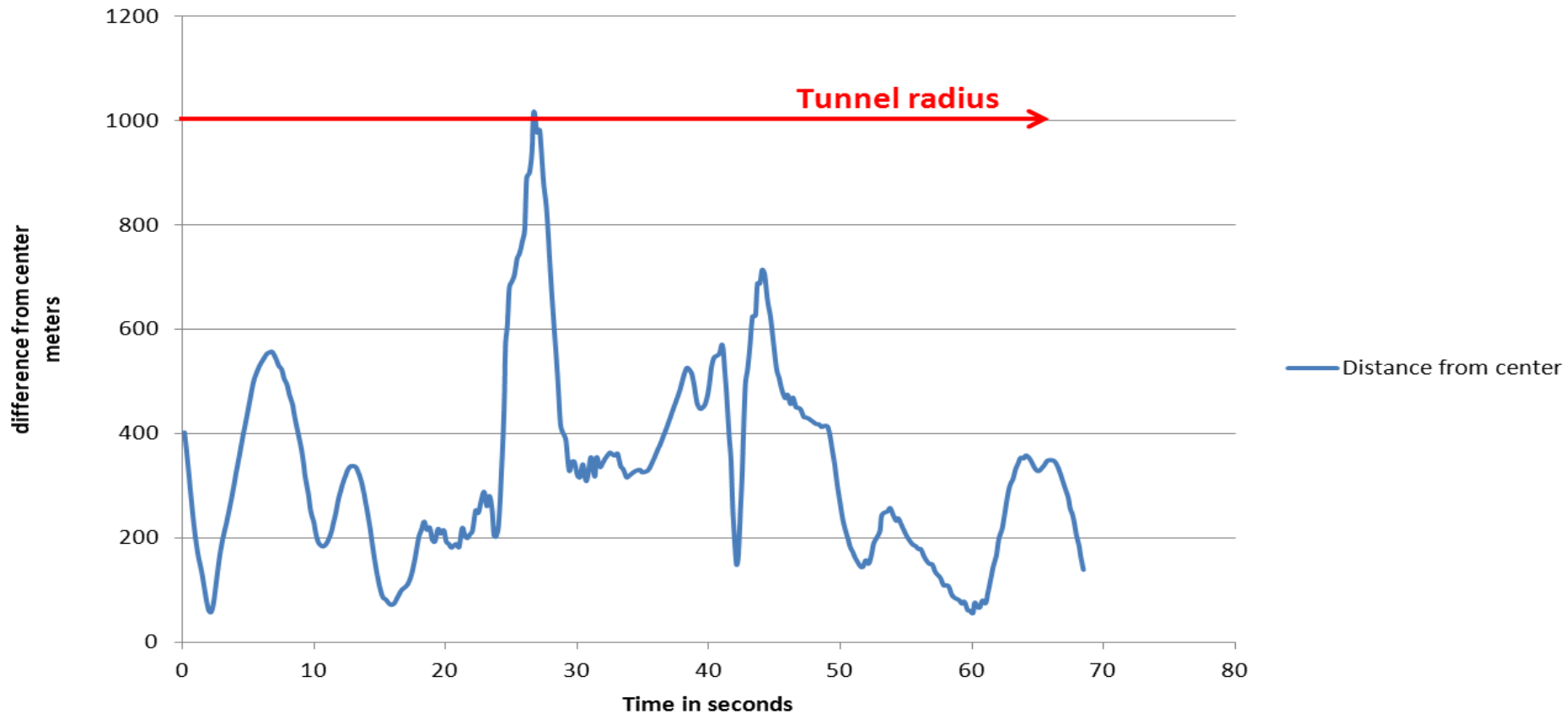
Total Time	Total Time in Tunnel	Total Time out	Accuracy
68.471003	68.223003	0.248	99.63780288

Conclusion

- Phone based motion control system
- Travel techniques
  - Acceleration techniques
  - Steering techniques
- Evaluation
  - Steering techniques
    - Rotate by roll and Rotate by roll with fixed horizon
  - Acceleration techniques
    - Gas pedal technique
  - Attrakdiff and SUS
- Future work

Discussion

Thanks for your attention

"Happiness is the interval between periods of unhappiness"

Don Marquis