**MotionAvatar: an ungrounded haptic device to show the self-motion of the vehicle for the automation operating system**

Hypotheses:

1. Users can accurately perceive the movement status information of the virtual vehicle, including direction, speed, and angle, through the MotionAvatar.

2. Enhancing the connection between users and the manipulated object by sensing the movement status information of the vehicle, and users will still generate a subjective consciousness of autonomous control in the controlled mode, such as AI driving scenarios.

Two experiments:

1. test the effectiveness of haptic feedback of MotionAvatar

2. experiment about whether haptic of MotionAvatar can enhance the user's sense of driving agency

Experimental equipment:

Motionavatar

Laptop

Screen

**Experiment 1:**

(Purpose: haptic can create the ...)

Test the user in the different senses whether can tell different info

No vistual reference sense

Forward Back TurnLeft TurnRight

Experiment 1

Purpose MotionAvatar can pass the motion status of the vehicle to the users,motion status including DIRECTION ROTATION SPEED etc information without the visual info

Compare the vistuail effect and haptic effect and vis-haptic effect

Test the haptic effect is more accurer than vistual

Participant

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Stimuli and Apparatus

Only-visual

Only-haptic

Procedure:

Frequency and Duration two elements

Experiment Description:

This experiment aims to investigate the user's perception of the device in terms of force touch and verify whether it can accurately transmit physical hit of the motion state to the user, including the direction, angle and speed.

Experimental procedure:

After explaining the usage to the users,

one hand controls the direction while the other hand holds the device.

After three minutes of free experience,

fill in the questionnaire.

Basic info

Survey Questionnaire 1 haptic performance

Basic Information:

1. Do you have any experience with racing games or real driving?

2. Do you have any experience with automated devices?

3. Which hand did you use?

4. Which direction did you choose?

5. Did you choose vertical gripping?

Force impact degree (0 ~ 3):

(Make it clear in each question)

Can you tell the current direction of the car by my device ?

Forward or Back

Can you tell the current rotation of the car by my device ?

(Speed acceleration Forward or Back)

1. The strength of the device force feedback, you clearly received the tactile information.

(1) Direction Vector

No(0) (1) (2) Yes(3)

1. Rotation vector

No(0) (1) (2) Yes(3)

2. The clarity of the device force feedback, you clearly know the meaning of the current force feedback.

(1) Displacement vector

No(0) (1) (2) Yes(3)

(2) Rotation vector

No(0) (1) (2) Yes(3)

1. The strength you used when gripping the device.

No(0) (1) (2) Yes(3)

1. Whether your behavior is influenced by the device force feedback.

No(0) (1) (2) Yes(3)

1. Whether your thinking is influenced by the device force feedback.

No(0) (1) (2) Yes(3)

1. Whether the use of the device gave you any discomfort.

No(0) (1) (2) Yes(3)

Open questions:

7. What do you think is the impact of the device on your palm area? Please depict the affected area and your subjective impact size with a pencil.

8. Your relationship with the device system during use (greater than, less than, equal to), and why?

**Experiment 2:**

Experiment Description: This experiment mainly focuses on whether it is possible to generate a subjective sense of driving agency when using this device under the manipulated scenario. This experiment includes two sets of experiments according to within or without device. Each set of experiments includes two scenarios, active sense and passive sense, in the active scenario, users can freely manipulate the virtual vehicle, while in the passive scenario, the movement of the virtual vehicle is manipulated by a simulated AI. Note that in this simulation, another user will substitute as the AI. And there will be four experiments in total, each lasting for three minutes. After each experiment, users need to fill in a questionnaire.

Experimental Procedure:

First group without equipment (baseline test)

Passive Sensory Experience

The participant watches the screen and experiences the simulated AI driving.

Active Sensory Experience

While watching the screen, the participant actively controls the car.

Second group with equipment

Passive Sensory Experience

The participant watches the screen, holds the device in hand, and experiences the simulated AI driving at the same time.

Active Sensory Experience

While watching the screen and holding the device, the participant actively controls the car's behavior.

Survey Questionnaire 2 (-3 ~ 3)

1. I can fully control the movement of the car.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. The movement of the car is out of my free will.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. The behavior of the car is a non-will effect.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. The car is automatic, my body just makes them move.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. My participation during the entire driving process.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. I am willing to take responsibility for the possible results of the driving behavior.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. I feel the car has become a part of me.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. I feel manipulated when I am in action.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. The system is very valuable.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. The system is very helpful to me.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. I am immersed in it.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. I can easily concentrate during the experience.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. Operating the system is very simple for me.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. I am very proficient with this system.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. I feel very happy.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)

1. I am willing to try this system again.

Disagree(-3) (-2) (-1) Not sure(0) (1) (2) Agree(3)