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Evaluate Voice or Foot-based Interaction Techniques for Navigating 2D Radiological Images in the Virtual Reality Operation Theatre

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**Experimental Design**

Problem statement and motivation

The usual way of interacting with the radiology images in OT(Operation Theatre) is either via mouse or keyboard. Due to sterility surgeons need an assistant to show them the exact images. However, communication with the substitute might be complicated, if the operator and surgeon do not have an equal level of professional skill, which consume time and might interrupt the workflow. Under these circumstances, it is necessary to provide a comfortable, precise and sterile interaction technique to enable surgeon to interact with computing devices independently. Our aim is to develop a system where a surgeon can access valuable information seamlessly without touching monitor or without any help of assistant. During surgery the foot, and voice of the surgeon is considered as non-sterile. This area can be considered to design an interactive device to extract information from computer.

We have designed a Virtual Reality Operation Theatre in perspective of Bangladesh. In this environment, innovative interaction tools can be preliminary evaluated to determine how much usable and efficient the tools for real operation theater, without incorporating new tools into the real operation theatre.

The case study will be conducted to evaluate the performance of voice command against interactive shoe[[1]](#footnote-0).

Executive Summary

The research study is designed to evaluate the foot based interaction(interactive shoe) against voice command. Those devices will be examine by the researches of computer science engineer /surgeons and/or the medical students of Anwar Khan Medical College and Hospital or XYZ.The performance of the researchers/ surgeon and/or medical students will be evaluated and their valuable opinion will be taken into account for possible range of future direction.

At the beginning of the test performance all participants, will get a consent and questionnaires in order to collect personal data and get an overview of the participants’ background. To determine the subject’s dominant foot the subject needs to kick a ball. The experiment will be conducted in within subject, where subjects will evaluate all prototypes.

During the experiment the subject will be ask to sit in a chair infront of a table. In a VR Environment an image will be show to them. The task is to find the exact image from the stack of slices of the CT scan images using voice command and interactive-shoe.

While the subject is performing the interaction the feet movement and voice commands will be record. After the evaluation, the footage will be analyzed. In order to get the same camera angle for all of the subject’s feet they will be asked to stand on a mark on the ground. After the experiment they will get questionnaires to evaluate their experience during the test.

Hypothesis

Prediction of outcome:

foot based interaction technique is more efficient compare to voice command or vice versa.

Null hypothesis:

foot based interaction technique is as efficient as the voice command.

Independent Variable (Within subjects)

an interactive shoe

voice command

Dependent Variables

duration of interaction

Controlled Variables

camera focussing on subject

tasks

mark on ground

Instructor Script

* Welcome the participant
* let sign consent
  + mention lower limb and voice will be recorded
* let kick the ball
  + to determine the dominant foot
* let fill out pre-task questionnaires
* lead to the VR environment
* explain general experiment
  + to scroll the radiology images
* give the task sheet
  + wait until the participant read it
  + ask for questions
  + tell to stand on the mark on the ground
* for each condition practice session will be executed first
* when the participant feel confident then he will start the task
* for each condition three different CT scan images will be arranged and corresponding radiology images will be adjust accordingly.
* Task completion time will be measure
* after the completion of each condition, the subject will attend post task questionnaire
* at the end of the experiment, thank the participant for sharing their valuable time and opinion.

**Task Script**

You are going to perform two tasks using two different methods.

A dummy box consists of different material of balls, is placed on top of the table and its surrounding is covered with piece of green clothes as shown in Figure 1.

A set of 2D CT scan images will be display in the VR environment, screenshot of 2D image shown in Figure 2.

Method 1(Interactive-shoe):

Task: You will stand/sit in front of the table wearing Interactive-shoe. Your task is to *fetch* *the small ball which is hidden in one of the big balls* from the stack of 2D CT scan images. For this, please see all or few of the 2D CT scan images in the computer screen by scrolling up or down to detect the hidden small ball.

*To activate the scrolling command: press the push-button side of the interactive-shoe*

*For scrolling up: drag your foot forward*

*For scrolling down: drag your foot backward*

*To freeze the screen: press the push-button side of the interactive-shoe*

You will repeat the same task three times with different set of CT scan images.

Method 2(voice command):

Task: You will stand/sit in front of the table. Your task is to *fetch* *the small ball which is hidden in one of the big balls* from the stack of 2D CT scan images using voice command. For this, please see all or few of the 2D CT scan images in the computer screen by scrolling up or down to detect the hidden small ball.

*For scrolling up: please say “UP/ FORWARD”*

*For scroll down: please say “DOWN/ BACKWARD”*

You will repeat the same task three times with different set of CT scan images.

After the completion of each task you suppose to attend post-test and post-task questionnaire

| Consent to Participate in a Research Study |
| --- |
| Video release and Information about the Participation in a Research Experiment |
| Please read the following information carefully.  Study: Evaluate Voice or Foot-based Interaction Techniques for Navigating 2D Radiological Images in the Virtual Reality Operation Theatre  Conductors: Kanij Fatema and Anup Roy  Organization: Stamford University, Bangladesh  Group leader: Ambreen Zaman  Contact: ambreenbremen@gmail.com, khushikanij@gmail.com, engr.aroy@gmail.com  **Description:** You are invited to participate in a research study that analysis and evaluate the performance of the voice and foot-based interaction and investigate different approaches in VR environment.  In this study, you will be asked to scroll 2D radiology images with two different methods. One is using voice command and another is interactive shoe (foot based interaction). The exact procedure will be explained to you at the beginning of the experiment.  Your participation in this research is voluntary. You may choose to participate or to withdraw your participation at any time without any penalty. You have the right to refuse to answer particular questions. Your individual data will be kept private. Please do not hesitate to let the conductor know if you have any questions, or would like to take a break at any time.  **Risks and Benefits**: Aside from slight foot fatigue and might be digital eye strain for VR glass , there are no known risks involved in this procedure. However, your participation does benefit in our research to evaluate voice-based, and foot-based interaction which could result in an interaction development based on the users’ performance.  **Duration:** Your participation will take approximately 30 minutes.  **Video recordings:** Separately from your consent to participate in the study, you may optionally provide us with your consent to use these recordings for scientific analysis and also separately for use in publications. *We sincerely appreciate your involvement and valuable feedback, and we thank you for your participation.*  Signature: *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*  ***Please sign the attached form on “Consent for Participation in a Research* Experiment” to indicate your agreement to these terms and conditions.** |

| Consent to Participate in a Research Study |
| --- |
| With my signature below, I certify that I have read the attached document *“Information about the Participation in a Research Experiment”* and I am well informed about the motivation and procedure of this research experiment on *“Evaluate Voice or Foot-based Interaction Techniques for Navigating 2D Radiological Images”*.  I am aware that my participation in this study is voluntary and that I may withdraw from participation at any time without explicit reason and with no further consequences.  I agree that the data resulting from my participation in this experiment will be subject to anonymous scientific analysis and publication.  *Please tick the boxes if you agree:*  **[ ] I agree to participate in this research experiment under the conditions described above and in the attached document.**  **[ ] I agree to being recorded on photos / film for the purpose of anonymized analysis.**  **[ ] I agree to the publication of portions of the photo / film materials.**  First and last name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Place and Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| For internal use only (do not fill):  **P\_\_\_\_** | **G \_\_\_\_** | Conductor: \_\_\_\_\_\_\_\_\_\_\_ | T \_\_\_\_ | Comment: \_\_\_\_\_\_\_\_\_\_\_\_ |

| Study: Evaluate Voice or Foot-based Interaction Techniques for Navigating 2D Radiological Images in the Virtual Reality OperationTheatre  Conductors: Kanij Fatema, Anup Roy, and Ambreen Zaman  Organization: Stamford University, Bangladesh  Contact: ambreenbremen@gmail.com, khushikanij@gmail.com, engr.aroy@gmail.com |
| --- |
| ***Participant ID:\_\_\_\_\_\_\_Date:\_\_\_/\_\_\_/\_\_\_ Location:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_***  What is your Profession? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What is our specialization? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Year of Experiences of your career? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Age? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_    Gender? Female Male Neutral  Dominate foot? Left foot Right foot  Do you have any physical disability or disorder?  If any other, please mention: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Is your leg of foot movements constrained in any special way? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  How do you interact with Computing devices in *Private*?  mouse  touch pad  other pointer/ click devices, please mention:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Do you use your feet for delicate control purposes in regular activities during common procedures?  Car driving  Piano/ organ playing  others, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Do you have any experience of using Virtual Reality? \_\_\_\_\_\_\_\_ if yes,  Please mention: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  What is your primary computing device?  Computer Laptop Tablet or Smartphone  Thank you for your valuable time. We are looking forward for your kind cooperation and support in this research experiment. Please give me the following detail to make contact with you in future.  Email:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Contact Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

| Appendix G – Post-Test Questionnaire | | |
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| ***System Usability Scale (SUS)***  ©Digital Equipment Corporation, 1986  ***Participant ID:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Task:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_/\_\_\_\_\_/\_\_\_\_\_\_***  **Think about the experience you had with the *interactive-shoe* , in how far do you agree or disagree with the following statements:** (*Please* ***tick (√) mark one*** *box that best describes your reactions* ) | | |
|  | |  |
|  |  | Strongly Strongly  disagree Agree |
| 1. | I think that I would like to use this system frequently | 1 2 3 4 5 |
| 2. | I found the system unnecessarily complex | 1 2 3 4 5 |
| 3. | I thought the system was easy to use | 1 2 3 4 5 |
| 4. | I think that I would need the support of a technical person to be able to use this system | 1 2 3 4 5 |
| 5. | I found the various functions in this system were well integrated | 1 2 3 4 5 |
| 6. | I thought there was too much inconsistency in this system | 1 2 3 4 5 |
| 7. | I would imagine that most people would learn to use this system very quickly | 1 2 3 4 5 |
| 8. | I found the system very cumbersome to use | 1 2 3 4 5 |
| 9. | I felt very confident using the system | 1 2 3 4 5 |
| 10. | I needed to learn a lot of things before I could get going with this system | 1 2 3 4 5 |

| Post-test Questionnaire |
| --- |
| ***NASA Task Load Index (TLX)***  ***Participant ID:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Task:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_/\_\_\_\_\_/\_\_\_\_\_\_***  **Think about the experience you had with the *interactive-shoe*. In how far do you agree or disagree with the following statements:** (*Please* ***tick (√) mark one*** *box that best describes your reactions* )   * Mental Demand: How mentally demanding was the task?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | |  * Physical Demand: How physically demanding was the task?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | |  * Temporal Demand: How hurried or rushed was the pace of the task?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | |  * Performance: How successful were you in accomplishing what you are asked to do?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Perfect Failure | | | | | | | | | | | | | | | | | | | |  * Effort: How hard did you have to work to accomplish your level of performance?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | |  * Frustration: How insecure, discouraged, irritated, stressed, and annoyed were you?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | | |

| Post-Task Questionnaire |
| --- |
| * I think the interactive shoe..…   Strongly Strongly  Disagree Agree   * is fun to use:   1 2 3 4 5   * is comfortable to use:   1 2 3 4 5   * provide high accuracy:   1 2 3 4 5   * is accessible:   1 2 3 4 5   * causes thigh fatigue:   1 2 3 4 5   * causes calf fatigue:   1 2 3 4 5   * causes foot fatigue:   1 2 3 4 5 |

* Can you name the three aspects that you like about the interactive-shoe?

1.

2.

3.

* Can you name the three aspects that you dislike about the interactive-shoe?

1.

2.

3.

| Appendix G – Post-Test Questionnaire |
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| ***System Usability Scale (SUS)***  ©Digital Equipment Corporation, 1986  ***Participant ID:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Task:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_/\_\_\_\_\_/\_\_\_\_\_\_***  **Think about the experience you had with *voice command* , in how far do you agree or disagree with the following statements:** (*Please* ***tick (√) mark one*** *box that best describes your reactions* ) |

|  |  | Strongly Strongly  disagree Agree |
| --- | --- | --- |
| 1. | I think that I would like to use this system frequently | 1 2 3 4 5 |
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| Post-test Questionnaire |
| --- |
| ***NASA Task Load Index (TLX)***  ***Participant ID:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Task:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_/\_\_\_\_\_/\_\_\_\_\_\_***  **Think about the experience you had with *voice command*. In how far do you agree or disagree with the following statements:** (*Please* ***tick (√) mark one*** *box that best describes your reactions* )   * Mental Demand: How mentally demanding was the task?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | |  * Physical Demand: How physically demanding was the task?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | |  * Temporal Demand: How hurried or rushed was the pace of the task?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | |  * Performance: How successful were you in accomplishing what you are asked to do?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Perfect Failure | | | | | | | | | | | | | | | | | | | |  * Effort: How hard did you have to work to accomplish your level of performance?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | |  * Frustration: How insecure, discouraged, irritated, stressed, and annoyed were you?  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | Very low Very High | | | | | | | | | | | | | | | | | | | | |

| Post-Task Questionnaire |
| --- |
| * I think the ***voice command***..…   Strongly Strongly  Disagree Agree   * is fun to use:   1 2 3 4 5   * is comfortable to use:   1 2 3 4 5   * provide high accuracy:   1 2 3 4 5   * is accessible:   1 2 3 4 5   * causes throat discomfort/fatigue:   1 2 3 4 5   * increase vocal effort:   1 2 3 4 5   * decrease ability to sustain pitch:   1 2 3 4 5   * loss of endurance:   1 2 3 4 5 |

<https://www.youtube.com/watch?v=nfNxZOEMjj0>

* Can you name the three aspects that you like about the ***voice command-***based interaction?

1.

2.

3.

* Can you name the three aspects that you dislike about the ***voice command***-based interaction?

1.

2.

3.

* Do you have any further suggestion regarding the foot-based interaction?
* Do you have any further suggestion regarding the voice-based interaction?
* Do you have any further suggestion regarding the experimental setup for two conditions?
* Of the two interaction styles for the 2D images I found …
  + most comfortable : ⃝ Interactive-shoe ⃝ voice command
  + most precise: ⃝ Interactive-shoe ⃝ voice command
  + most efficient: ⃝ Interactive-shoe ⃝ voice command
* Which interaction technique do you like the most and why?
* Which interaction technique do you dislike and why?

1. Zaman, A., Reisig, L., Reinschluessel, A. V., Bektas, H., Weyhe, D., Herrlich, M., ... & Malaka, R. (2018, April). An Interactive-Shoe For Surgeons: Hand-Free Interaction With Medical 2D Data. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems* (p. LBW633). ACM. [↑](#footnote-ref-0)