CS243 Software Engineering
Course Project

Team No. 3
Project No. 4
Immersive Virtual Tour

Empirical Testing Report

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Introduction

Purpose

The empirical tests covered here serve to evaluate user performance in the Immersive Virtual Tour application.

Research Questions

Conventional system (S1):

The current system has the feature to move forward (one step) in the direction the user is facing when his angle of inclination with the horizon is less than -15 degrees. Similarly, when the user turns more than 15 degrees, the character begins to turn in the same direction. The user has to look towards an object, then press and hold a button for few seconds to interact with it.

Designed system (S2):

In the system to be tested, to move in a direction user has to move his head in that direction, and character will make a turn only when user will turn his head in real life. To interact with an object user needs to just has to press a button once when looking at it.

Q. Is the number of head turns and movements required to complete the task lesser in S2 than in S1?
Q. Is the time taken required to complete each representative task lesser in S2 than in S1?
Q. Is the number of button presses required to complete the task lesser in S2 than in S1?

Representative Tasks

1. Go to the front of the main staircase of the CSE Department.
2. Go to the door of Professor Chandan Karfa's room on the ground floor.
3. Look towards Professor Chandan Karfa's room on the ground floor, while standing in front of the seminar room (indicated by a yellow arrow).
4. Go to the entrance of the second year B.Tech Laboratory on the second floor.

Research Design

To get the answers of the research questions the users were given the prototype and asked to perform the representative tasks.
As the user performed the tasks, we collect dependent variable data and analysed various parameters.

Dependent variables

1. Task completion time(sec):
   Measure of time taken to complete the task, starting from fresh start of the app each time.

2. Movement rate(nos/min):
   Rate of Steps taken(Head movements) to complete the task.

3. Turning rate(nos/min):
   Rate of head rotations taken to complete the task.

4. Button press rate(nos/min):
   Rate of button presses made to complete the task.

Independent Variables

1. Head mounted device size
   Levels of the variable:
   - Large(L)
   - Small(S)

2. Motion sensitivity of the device
   Levels of the variable:
   - High(H)
   - Medium(M)
   - Default(L)

Procedure of data collection

1. First the participants were put through some practice trials for familiarization.
2. The task under each test condition was presented to each participant on a Head mounted device.
3. Between subject testing technique is employed to test each user only at one configuration of independent variables.
4. Task completion time was calculated by using an internal clock in the prototype, which was started on initiation of the tour, and stopped when the participant completed the task. If the task was not completed, the corresponding entry in the data table was marked as ‘Did Not Finish (DNF)’.
5. The rate of head turns and head movements was also calculated by monitoring the gyroscope readings within the prototype.
6. Ratio of each data point was taken to see by what percent S2 is better than S1.

Participant details

Participant Number	Age Group	User Type	Visited CSE department	Prior VR experience
1	14-18	School Student	NO	NO
2	14-18	School Student	NO	NO
3	17-22	College Student	YES	NO
4	17-22	College Student	YES	YES
5	14-18	School Student	NO	YES
6	25-30	Professor	NO	NO
7	14-18	School Student	YES	YES
8	17-22	College Student	NO	YES
9	25-30	Professor	YES	NO
10	17-22	College Student	NO	NO
11	14-18	School Student	YES	NO
12	14-18	School Student	NO	NO

Results

Data Analysis

After the completion of the representative tasks, the collected data is analyzed and different design techniques are compared and contrasted. Here, we will be using the **Analysis of Variance** (ANOVA) technique.

As the group sizes are equal (2) we can ignore last two requirements of ANOVA. In all cases, the following conditions for ANOVA are satisfied:

- Normal distribution of data
- Variance in each experimental condition is fairly similar

Movement rate (number of steps / minute)

Participant No.	**Screen Size**	**Sensitivity**	**Value in S1**	**Value in S2**
1 , 7	L	L	82	48
2 , 8	S	L	64	37
3 , 9	S	H	52	38
4 , 10	L	H	63	25
5 , 11	L	M	72	30
6 , 12	S	M	70	31

ANOVA Analysis

Step 1:

	In S1	**In S2**
Mean	67.16	34.84
Standard Deviation	10.08	8.03
Variance	101.76	64.56

Grand Mean = 51
Grand Standard Deviation = 18.99
Grand Variance = 360.72
Total sum of squares (SS_T) = $\sum(x_i - \text{mean\_grand})^2$
(where x_i is the error rate value of the i-th participant)

SS_T for Movement Rate = 3968

Degree of freedom(DoF) = Number of group means - 1

DoF for SS_T = 12 - 1 = 11

Step 2:
Model sum of square(**SS_M**).

- Calculate $(\text{mean\_group}_i - \text{mean\_grand})^2$ for the i-th group
- Multiply by n_i, the number of participants in the i-th group
- Sum for all groups
  SS_M = 1044.58
  Dof of SS_M = number of group means – 1
  Dof of SS_M = 2 - 1 = 1

Step 3:

Residual sum of squares(**SS_R**)

SS_R = SS_T – SS_M

DoF (SS_R) = DoF (SS_T) – DoF (SS_M)

SS_R = 3968 - 1044.58 = 2923.42

Dof(SS_R) = 11 - 1 = 10

Step 4:

Calculate two average sum of squares or mean squares (MS)

Model MS (MS_M) = SS_M/DoF(SS_M)

Residue MS (MS_R) = SS_R/DOF(SS_R)

MS_M = 1044.58 / 1 = 1044.58

MS_R = 2923.42 / 10 = 292.342

Step 5:

Calculate F-ratio

F = MS_M / MS_R

Dof(F) = (Dof(SS_M) , Dof(SS_R))

F = 3.57

Dof(F) = (1 , 10)

Step 6:

Critical value for (1 , 10) = 4.96 ($p < .05$)

The proposed system (S2) has no significant effect on reducing errors as compared to existing system (S1)

$F(1 , 10) > 3.57$

Task Completion Time (seconds)

Participant No.	Screen Size	Sensitivity	Value in S1	Value in S2
1 , 7	L	L	180	85
2 , 8	S	L	157	52
3 , 9	S	H	130	60
4 , 10	L	H	210	105
5 , 11	L	M	173	72
6 , 12	S	M	175	78

ANOVA Analysis

Step 1:

	In S1	In S2
Mean	170.84	75.34
Standard Deviation	26.45	18.82
Variance	699.76	354.26

Grand Mean = 123.09

Total sum of squares (SS_T) = $\sum(x_i - \text{mean\_grand})^2$

(where x_i is the error rate value of the i-th participant)

SS_T for Task Completion Time = 32630.9

Degree of freedom (DoF) = Number of group means- 1

Dof for SS_T = 12 - 1 = 11

Step 2:

Model sum of square(**SS_M**).

- Calculate $(\text{mean\_group}_i - \text{mean\_grand})^2$ for the i-th group
- Multiply by n_i, the number of participants in the i-th group
- Sum for all groups.

SS_M = 9120.25
Dof of SS_M = number of group means – 1
Dof of SS_M = 2 - 1 = 1

Step 3:

Residual sum of squares(**SS_R**)

SS_R = SS_T – SS_M
DoF (SS_R) = DoF (SS_T) – DoF (SS_M)
SS_R = 32630.9 - 9120.25 = 23510.65
Dof(SS_R) = 11 - 1 = 10

Step 4:

Calculate two average sum of squares or mean squares (MS)

Model MS (MS_M) = SS_M/DoF(SS_M)
Residue MS (MS_R) = SS_R/DOF(SS_R)
MS_M = 9120.25 / 1 = 9120.25
MS_R = 23510.65 / 10 = 2351.065

Step 5:

Calculate F-ratio

F = MS_M / MS_R
DoF(F) = (DoF(SS_M) , DoF(SS_R))
F = 3.87
DoF(F) = (1 , 10)

6. Step 6:

Critical value for (1 , 10) = 4.96 ($p < .05$)

The proposed system (S2) has no significant effect on reducing errors as compared to existing system (S1)

$F(1, 10) > 3.87$

Turning Rate (number of turns / minute)

Participant No.	Screen Size	Sensitivity	Value in S1	Value in S2
1 , 7	L	L	87	53
2 , 8	S	L	70	40
3 , 9	S	H	60	35
4 , 10	L	H	67	28
5 , 11	L	M	68	30
6 , 12	S	M	70	31

ANOVA analysis of data:

Step 1:

	In S1	In S2
Mean	70.34	36.16
Standard Deviation	8.95	9.28
Variance	80.26	86.16

Grand Mean = 53.25

Total sum of squares (SS_T) = $\sum(x_i - \text{mean\_grand})^2$

(where x_i is the error rate value of the i-th participant)

SS_T for Turning Rate = 4334.25

Degree of freedom (DoF) = Number of group means - 1

DoF for SS_T = 12 - 1 = 11

Step 2:

Model sum of square(**SS_M**).

- Calculate $(\text{mean\_group}_i - \text{mean\_grand})^2$ for the i-th group
- Multiply by n_i, the number of participants in the i-th group
- Sum for all groups

SS_M = 1168.27
DoF of SS_M = number of group means – 1
DoF of SS_M = 2 - 1 = 1

Step 3:

Residual sum of squares(**SS_R**)

SS_R = SS_T – SS_M
DoF (SS_R) = DoF (SS_T) – DoF (SS_M)
SS_R = 4334.25 - 1168.27 = 3165.98
Dof(SS_R) = 11 - 1 = 10

Step 4:

Calculate two average sum of squares or mean squares (**MS**)

Model MS (**MS_M**) = SS_M/DoF(SS_M)
Residue MS (**MS_R**) = SS_R/DOF(SS_R)
MS_M = 1168.27 / 1 = 1168.27
MS_R = 3165.98 / 10 = 316.598

Step 5:

Calculate F-ratio

F = MS_M / MS_R
DoF(F) = (DoF(SS_M) , DoF(SS_R))
F = 3.69
DoF(F) = (1 , 10)

Step 6:

Critical value for (1 , 10) = 4.96 ($p < .05$)

The proposed system(S2) has no significant effect on reducing errors as compared to existing system (S1)

$$F(1 , 10) > 3.69$$

Button Press Rate (number of presses / minute):

Participant No.	Screen Size	Sensitivity	Value in S1	Value in S2
1 , 7	L	L	20	7
2 , 8	S	L	24	9
3 , 9	S	H	42	16
4 , 10	L	H	31	10
5 , 11	L	M	27	5
6 , 12	S	M	28	19

ANOVA analysis of data:

Step 1:

	In S1	In S2
Mean	28.67	11
Standard Deviation	7.52	5.40
Variance	56.67	29.2

Grand Mean = 19.835

Total sum of squares (SS_T) = $\sum(x_i - \text{mean\_grand})^2$

(where x_i is the error rate value of the i-th participant)

SS_T for Movement Rate = 1365.67

Degree of freedom(DoF) = Number of group means- 1

DoF for SS_T = 12 - 1 = 11

Step 2:

Model sum of squares (**SS_M**).

- Calculate $(\text{mean\_group}_i - \text{mean\_grand})^2$ for the i-th group
- Multiply by n_i, the number of participants in the i-th group
- Sum for all groups

SS_M = 312.229
DoF of SS_M = number of group means – 1
DoF of SS_M = 2 - 1 = 1

Step 3:

Residual sum of squares(**SS_R**)

SS_R = SS_T – SS_M
DoF (SS_R) = DoF (SS_T) – DoF (SS_M)
SS_R = 1365.67 - 312.229 = 1053.441
Dof(SS_R) = 11 - 1 = 10

Step 4:

Calculate two average sum of squares or mean squares (**MS**)

Model MS (**MS_M**) = SS_M/DoF(SS_M)
Residue MS (**MS_R**) = SS_R/DOF(SS_R)
MS_M = 312.229 / 1 = 312.229
MS_R = 1053.441 / 10 = 105.3441

Step 5:

F-ratio (**F**)

F = MS_M / MS_R
DoF(F) = (Dof(SS_M) , Dof(SS_R))
F = 2.963
DoF(F) = (1 , 10)

Step 6:

Critical value for (1 , 10) = 4.96 (p < .05)

The proposed system(S2) has no significant effect on reducing errors as compared to existing system (S1)

$$F(1 , 10) > 2.963$$

Conclusion

By doing empirical testing we found out that even though the proposed S2 design appears better statistically, it is not.

There is no significant advantage in choosing the S2 design technique as the observed difference between S1 and S2 data is less.

The Analysis of Variance technique indicates that it will not be worth to spend time and money into development of a S2-like system.