

[GCT565] Augmented Humans - Final Presentation

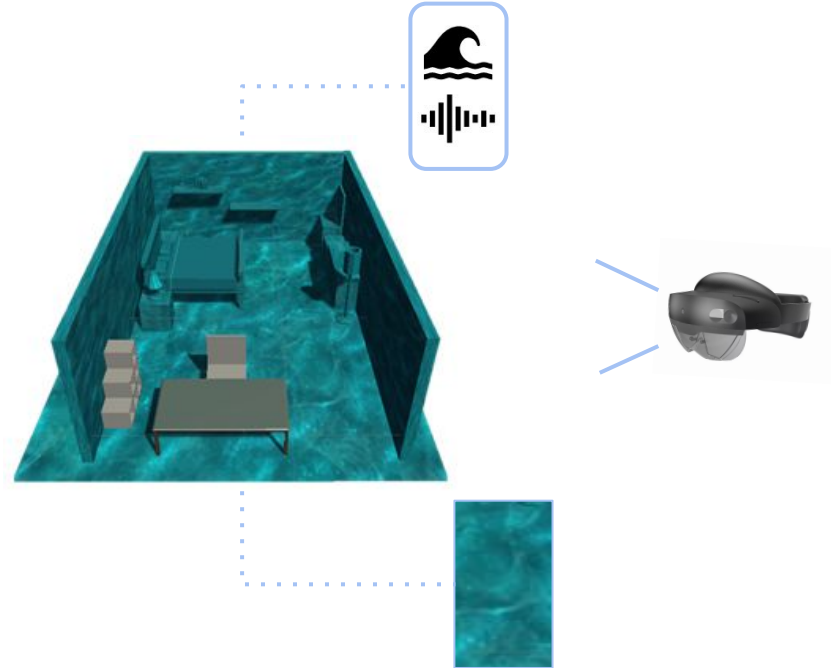
Immersive Multimodal MR Environment for Relieve stress

Team 6

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Research Objective

1. **Want to lower user's stress level**
2. **Make Immersive Mixed Reality Environment**
 - a. Spatial Mapping
 - b. Background Sound
3. **In Task Scenario, Measure User's stress**
 - a. Qualitative evaluation : EEG
 - b. Quantitative evaluation : Questionnaire + Interview



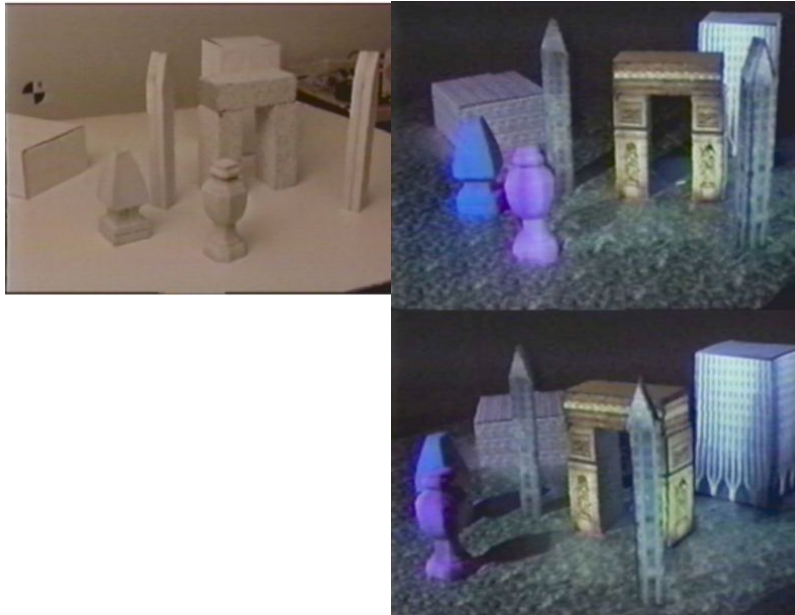
Contributions

1. A Novel approach to the **MR environment in spatial units** rather than object units.
2. A Novel approach that **leveled the Immersive MR environment** with **auditory and spatial mapping**.
3. A Novel approach using the **MR environment as a means of relieving stress** in daily life.

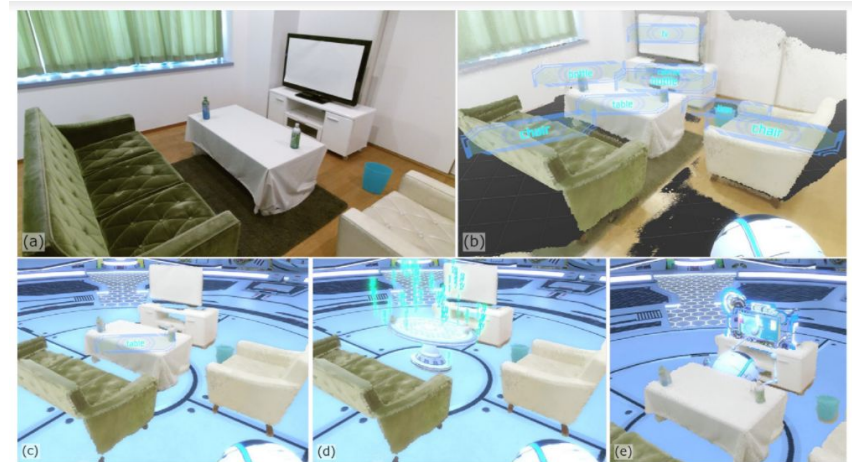
Literature Review

MR Environment in Spatial Units

[1]



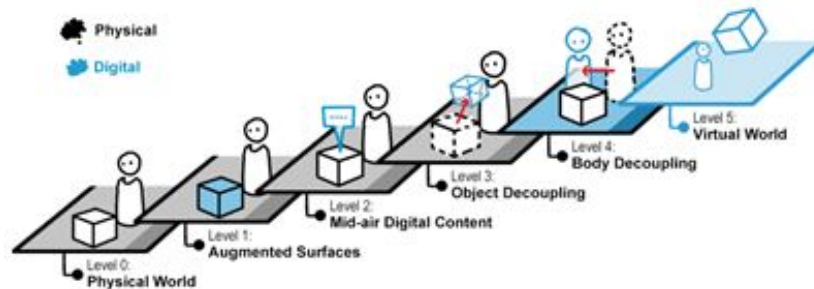
[2]



Literature Review

Levelled the Immersive MR environment

- Augmented Level (O)
- Immersive MR Environment (X)



[3]



Literature Review

Levelled the Immersive MR environment

- Augmented Level (X)
- Immersive MR Environment (O)

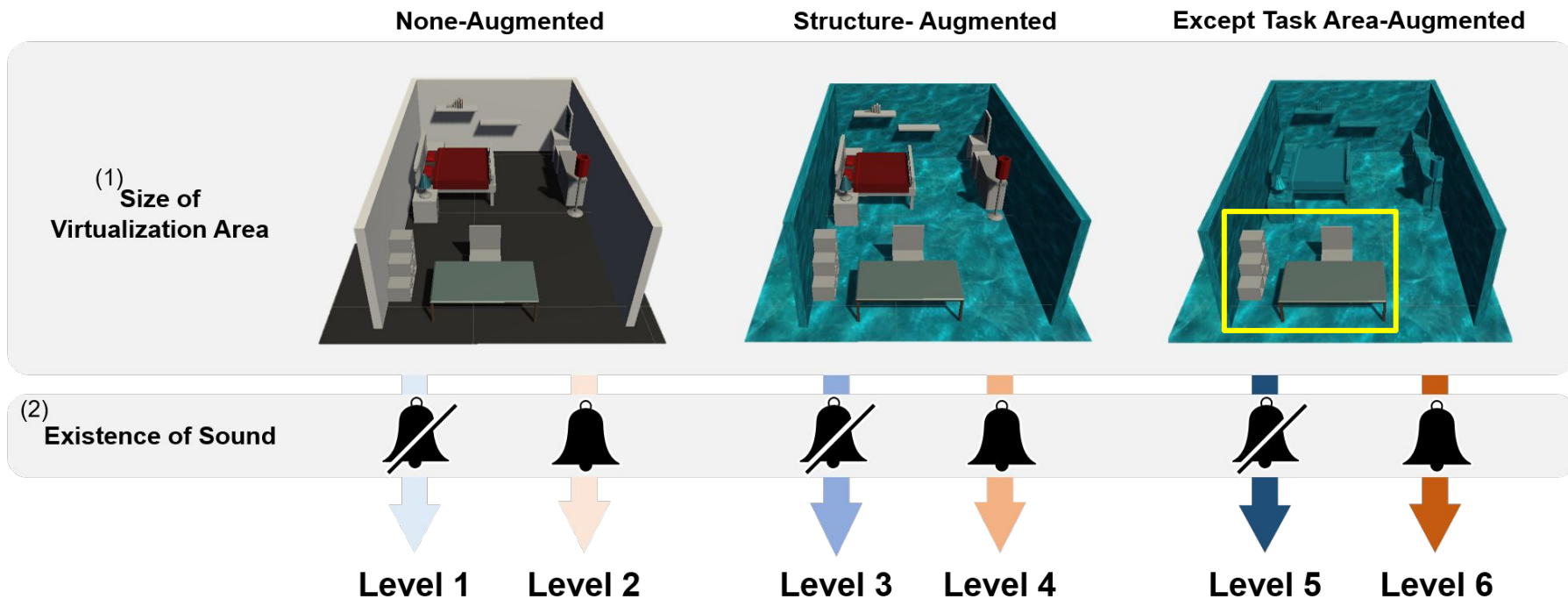
[5]



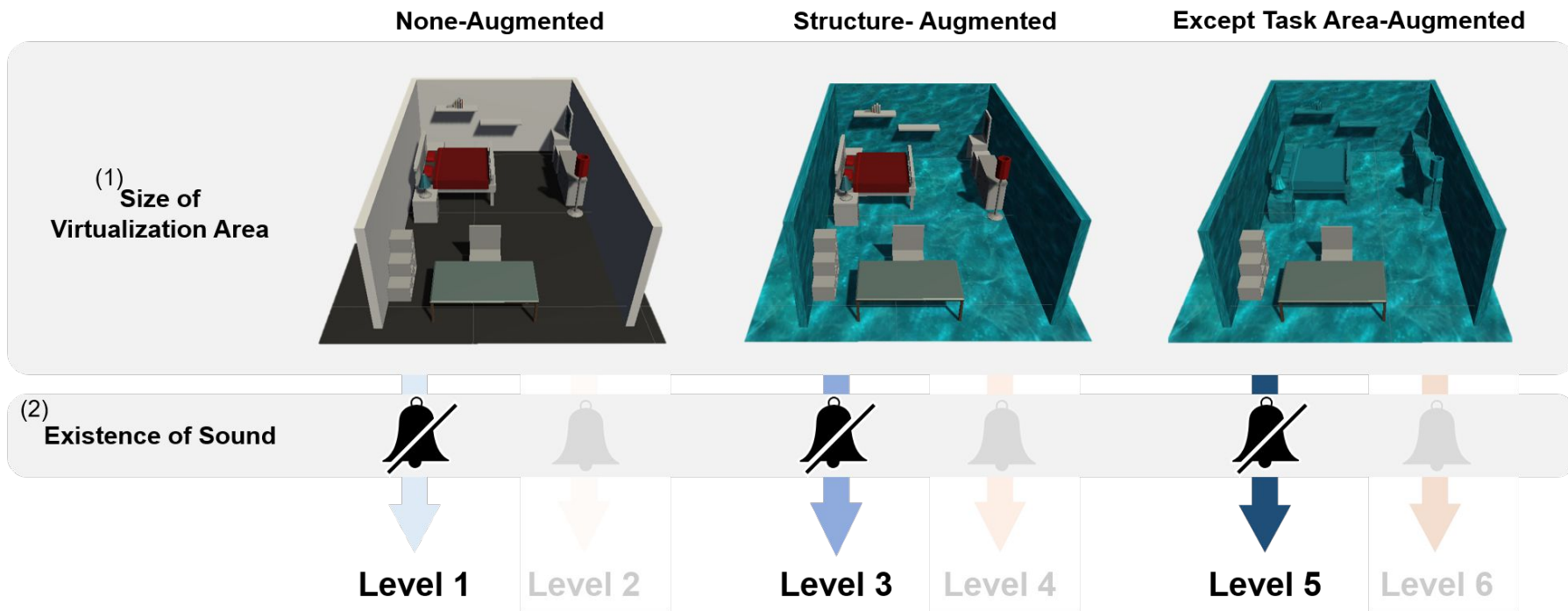
MR environment as a means of relieving stress in daily life

- Most studies so far have been studied targeting specific industrial fields or situation scenarios
 1. *Education : Used for healthcare or science education* [6, 7, 8, 9, 10,11, 12]
 2. *Training : Used to be skillful in real situations through repeated learning* [13, 14, 15, 16]
 3. *Industry : Used to simulate or learn industry mechanisms* [17, 18, 19]
 4. *Contents : Alice in Wonderland* [20]
 5. *Treatment : Psychological treatment to lower user's anxiety* [21, 22, 23, 24]
- There have been no studies on stress relief
 1. *Specific Arrangement of desk Scenario* [25]

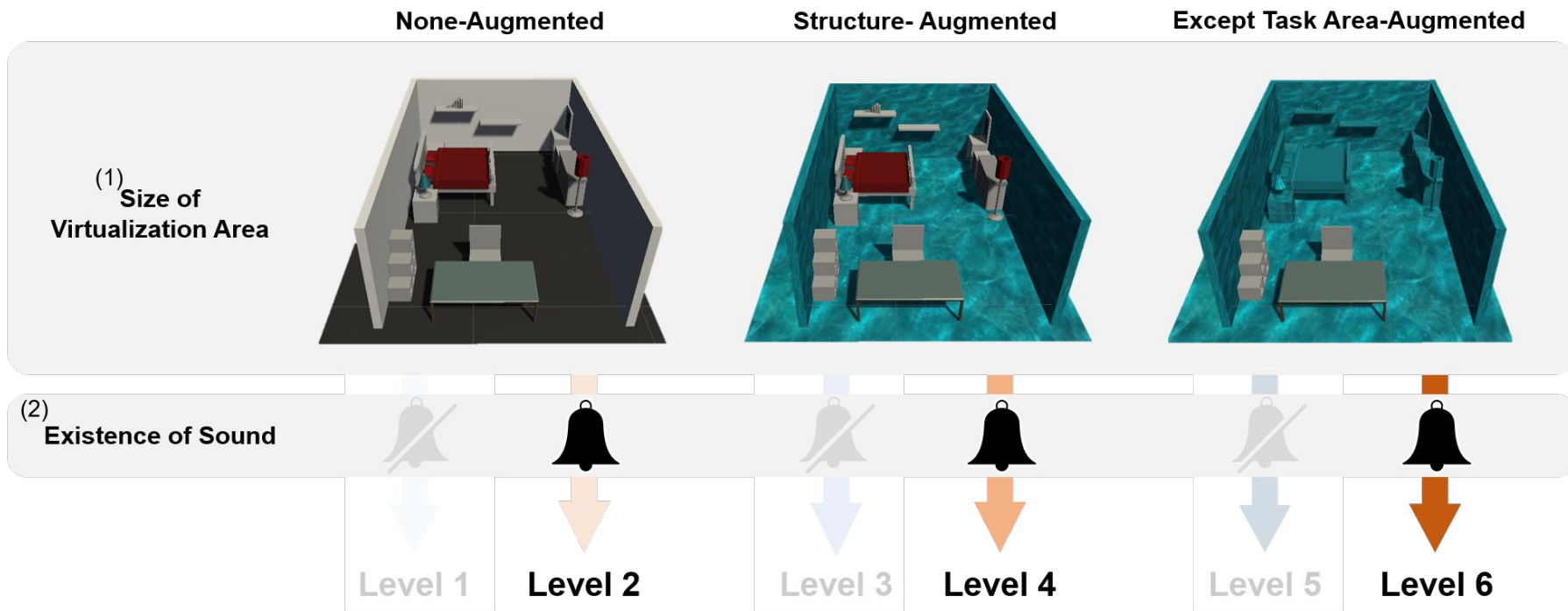
Approach



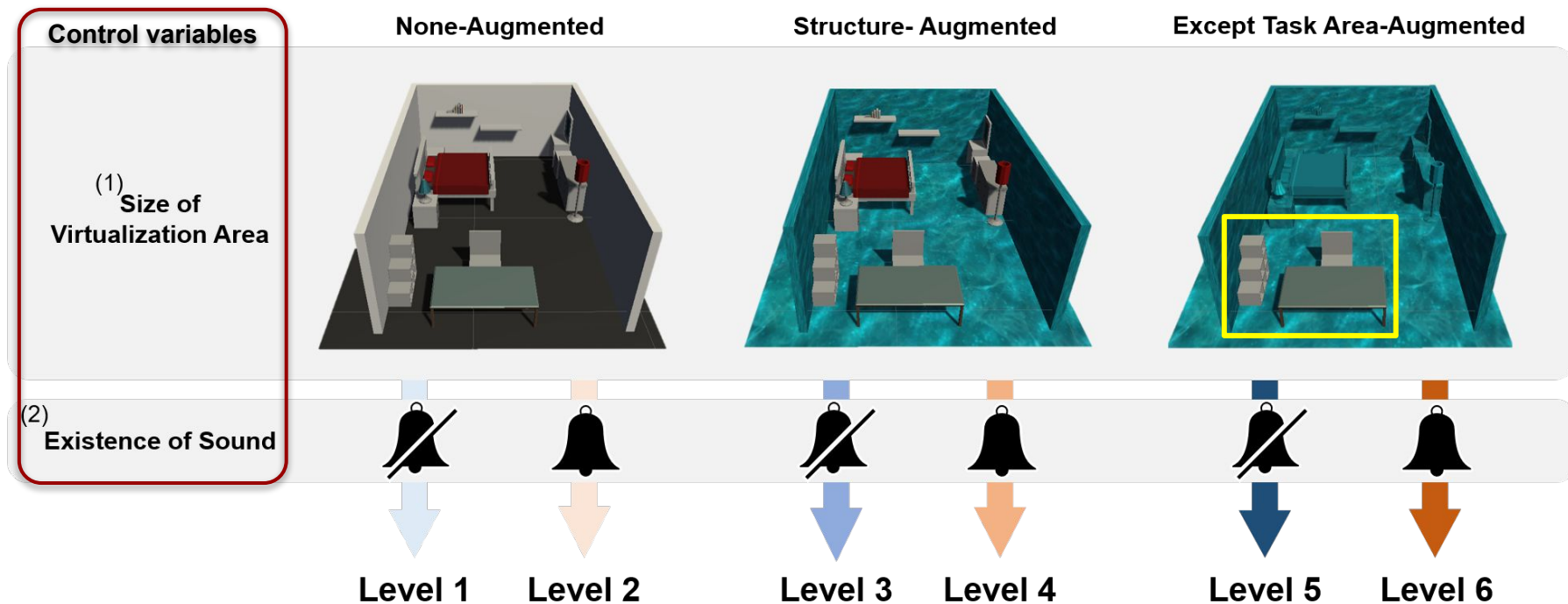
Approach



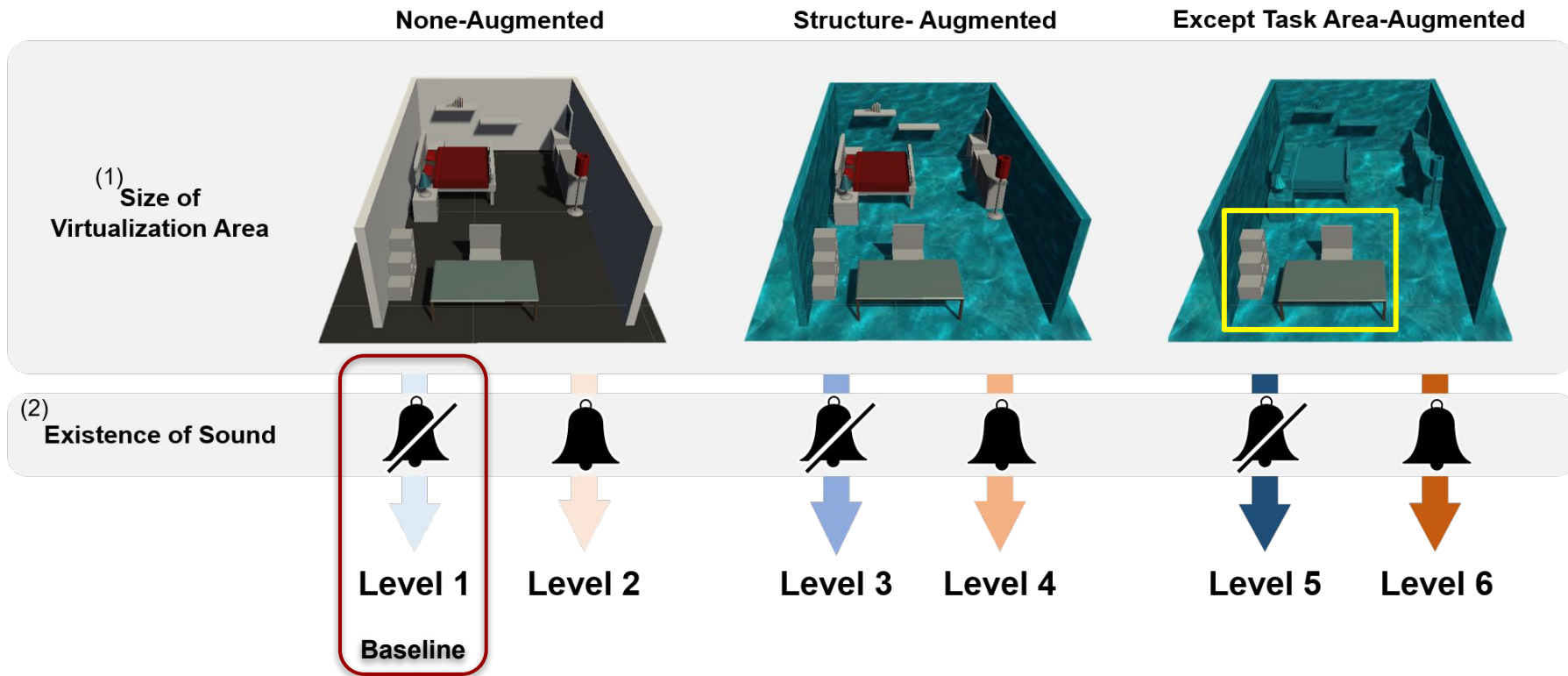
Approach



Approach



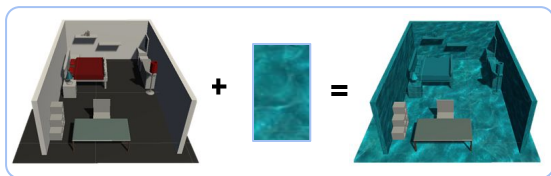
Approach



Implementation detail

Change Augmented Level

1. Spatial Mapping



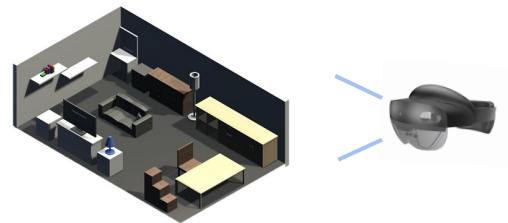
1. Scene Segmentation



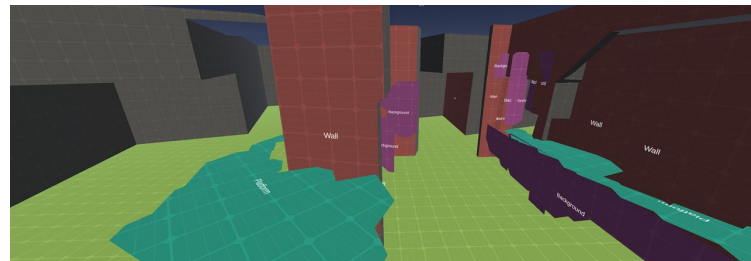
2. Select Mapping Area



3. Mapping 2D image



Scene Understanding SDK

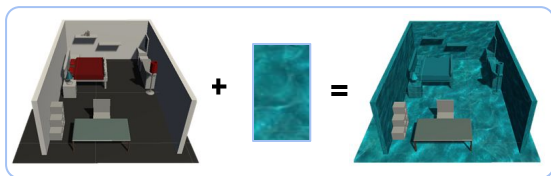


[26]

Implementation detail

Change Augmented Level

1. Spatial Mapping



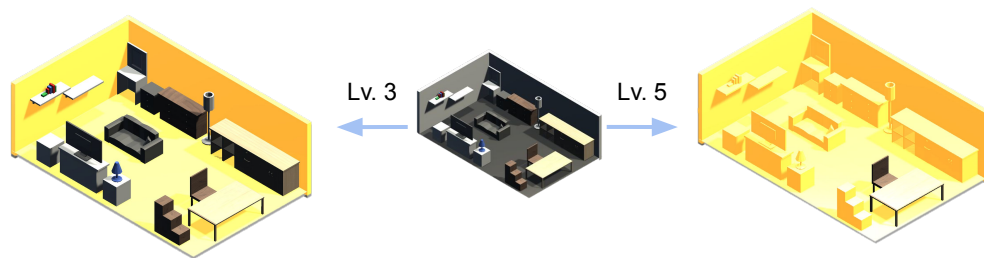
1. Scene Segmentation



2. Select Mapping Area



3. Mapping 2D image

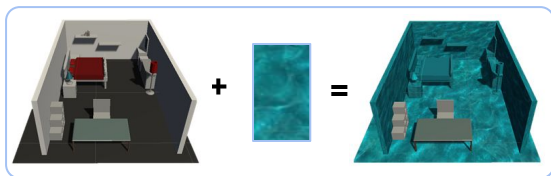


Level	Description	Virtualized Tag
1, 2	Full real-world state without any virtualization	Nothing
3, 4	Virtualized spatial structures	Wall, Floor, Ceiling
5, 6	All objects except for the task scene are virtualized	All (Except Task Area)

Implementation detail

Change Augmented Level

1. Spatial Mapping



1. Scene Segmentation



2. Select Mapping Area



3. Mapping 2D image



Space



Forest



Snow



Underwater



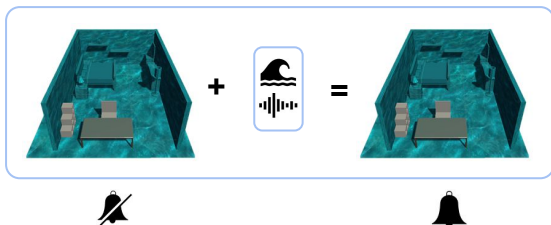
5 Themes

- Sky
- Space
- Forest
- Snow
- Underwater

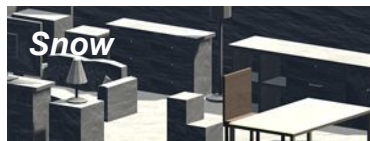
Implementation detail

Change Augmented Level

2. Background Sound



- a. **With & Without Background Sound**
- b. Related to mapped scene's **Theme**



+

+

+

+

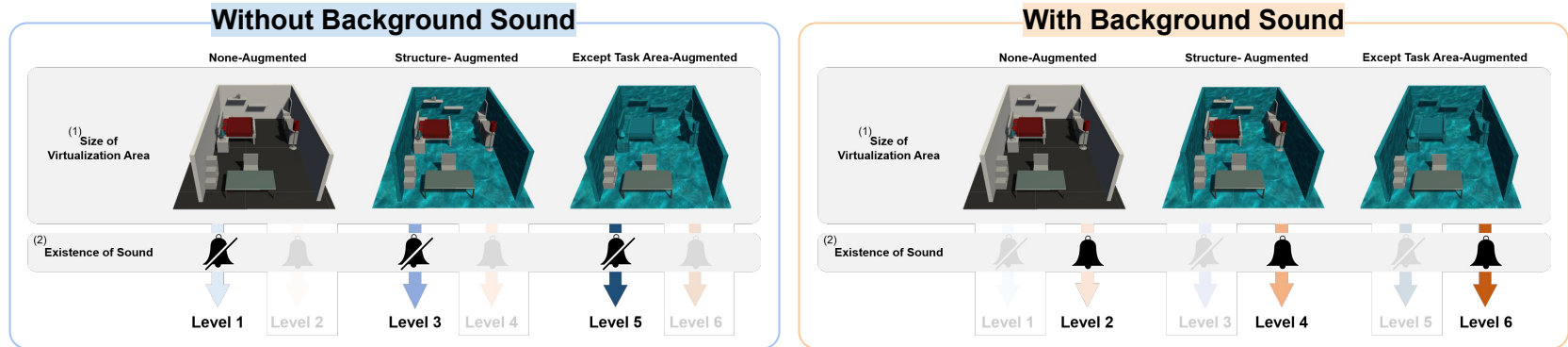
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User Study Plan

Main user study

- Recruitment of **30** participants
 - **15** participants : Execute task **without Background Sound**
 - **15** participants : Execute task **with Background Sound**



- Each participant conducts an experiment in **three environments**.
- Participants **select one theme** and proceed with the experiment.
- Experimenters **in both environments wear the device** and proceed with the experiment

User Study Plan

Study Scenario

Time (mins)	Order		Description	Note
10	Questionnaire before experiment		Gender, age, XR experience and etc	Google Survey
15	1	Preset	Time to get used to the environment	Provides missions to explore the space
	1	Task Practice	Time to understand and practice the task	Solve a set of preliminary task problems (No Time Limitation)
	5	Environment 1 Task Set 1	Do the first set of problems	Solve 30 questions as quickly as possible
	1	Break	Break time	
	5	Task Set 2	Do the second set of problems	Solve 30 questions as quickly as possible
	1	Break	Break time	
15	Environment 2	The whole process of <Environment 2> is the same as that of Environment 1.		
15	Environment 3	The whole process of <Environment 3> is the same as that of Environment 1.		

30 Participants * 3 different level of environments * 2 times of Tasks * 1 Themes = 180 data

(for each environment → 15 participants * 2 times of Tasks = 30 data)

User Study Plan

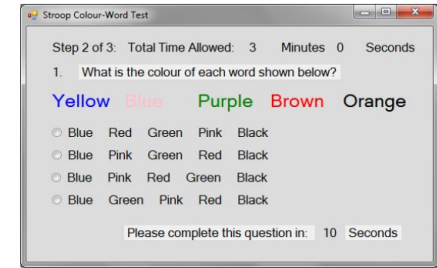
Task

The Task must meet the following conditions:

1. Give user enough mental load to make user stressful, but only enough to not give up.
2. Ensure that the user's knowledge level is not affected in performing tasks.

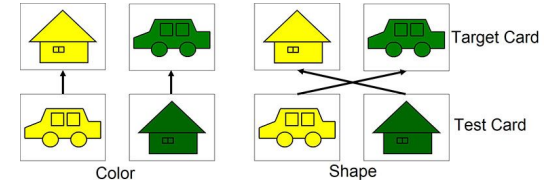
⇒ Choose **“Cognitive Flexibility Test”** with **limited time**

Sample Questions		Sample Answers
Q1	Pick 5 odd black cards	[♠A] [♣3] [♠7] [♠9] [♣A]
Q2	Find all number cards 4	[♥4] [♦4] [♠4] [♣4]
Q3	Find all queen cards	[♥Q] [♦Q] [♠Q] [♣Q]
Q4	Find 3 cards to fit the formula [] + [] = []	[♠A] + [♦2] = [♣3]
Q5	Find and place 4 cards according to the rules of [Clover][Heart][Clover][Heart]	[♣Q] [♥3] [♣2] [♥Q]



[28]

Figure 2: Stroop colour-word test.



[27]

Technical Evaluation

EEG

Classifier	Reference	Reported Accuracy%	Acquired Signals	Classes	n° Electrodes	n° Subjects
Artificial Neural Network (ANN)	[21]	76.0%	EEG,ECG,GSR	2 no-stress/stress	14 Wet	22
	[28]	79.2%	EEG,SCL,BVP,PPG	2 levels of stress	5 Wet	15
Cellular Neural Network (CNN)	[21]	92.0%	EEG,ECG,GSR	2 no-stress/stress	14 Wet	22
Decision Tree	[21]	84.0%	EEG,ECG,GSR	2 no-stress/stress	14 Wet	22
Fisher linear discriminant analysis (FLDA)	[22]	90.5%	EEG,EOG	2 alert and fatigue states	32 Wet	8
Gaussian Discriminant Analysis (GDA)	[7]	74.9%	EEG,GSR	2 high or low stress level	14 Wet	11
K-Nearest Neighbors (k-NN)	[7]	65.8%	EEG,GSR	2 high or low stress level	14 Wet	11
	[30]	76.7%	EEG	2 levels of stress	14 Wet	9
Linear discriminant analysis (LDA)	[29]	77.5%	EEG	3 low, medium, high mental fatigue	16 Wet	10
	[6]	86.0%	EEG,ECG,EMG,GSR	3 stress,relax,and neutral	4 Wet	10
Naive Bayes (NB)	[21]	77.0%	EEG,ECG,GSR	2 no-stress/stress	14 Wet	22
	[32]	69.7%	EEG,ECG,GSR	2 mental workload and stress	2 Wet	9
Random Forest (RF)	[33]	79.6%	EEG,EMG,ECG,GSR	4 cognitive states	8 Wet	12
	[27]	84.3%	EEG,ECG,BVP	3 mental stress states	14 Wet	17
Support vector machine (SVM)	[30]	75.2%	EEG	3 levels of stress	14 Wet	9
	[7]	80.3%	EEG, SCL	2 high or low stress level	14 Wet	11
	[34]	85.4%	EEG	2 positive or negative emotion	14 Wet	11
	[9]	87.5%	EEG,ECG,HRV	2 stress and rest	2 Wet	7
	[31]	88.0%	EEG	2 levels of stress	14 Wet	10
	[32]	90.1%	EEG,ECG,GSR	2 mental workload and stress	2 Wet	9

STATE-OF-THE-ART STRESS CLASSIFICATION [29]

Technical Evaluation

Devices for EEG data collection



AR Glasses [30]



EEG Data Collection Device [31]

Technical Evaluation

Devices for EEG data collection

Device maker



[32]



OPENBCI

[33]

EMOTIV

[34]

Elements

Input channels

Noise level

Usability

Technical Evaluation

Devices for EEG data collection [34]

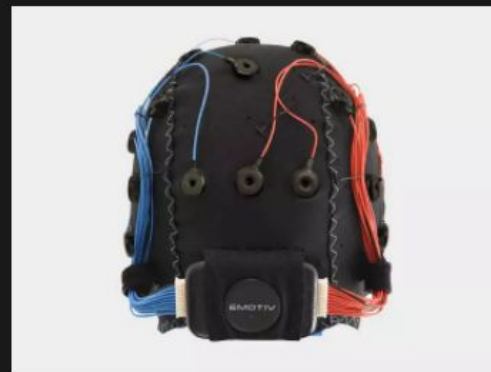
EMOTIV



EMOTIV | **INSIGHT**



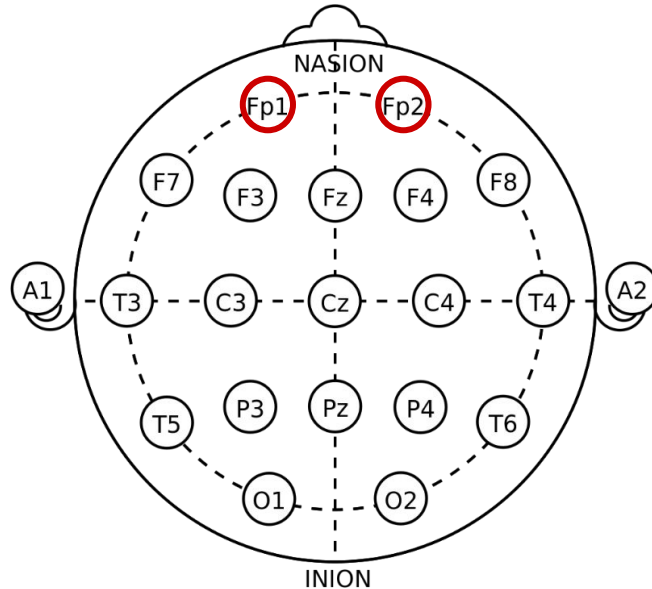
EMOTIV | **EPOC^x**



EMOTIV | **EPOC^{Flex}**

The stage of stress analysis using EEG data _ 1. Data Collection

B. The Method of measurement. (Position and selection of electrodes)



International 10-20 system [35]

“Mental workload vs. stress differentiation using single-channel EEG”

Fp1 and Fp2 single-channel

Meaningful for measuring stress.

[36, 37]

Devices for EEG data collection_Comparison

Name of model	Emotiv_ INSIGHT	Emotiv_EPOCx	Emotiv_EPOC flex
# of channels	5 channels : AF3, AF4, T7, T8, Pz	14 channels: AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4	Up to 32 channels (+ 2 references)
Sensor material	Hydrophilic semi-dry polymer	Saline soaked felt pads	Saline OR Ag/AgCl + Gel
Sampling rate	128 samples per second per channel	2048 internal downsampled to 128 SPS or 256 SPS (user configured)	1024 internal downsampled to 128 SPS
Frequency response	0.5-43Hz, digital notch filters at 50Hz and 60Hz	0.16 – 43Hz, digital notch filters at 50Hz and 60Hz	0.16 – 43Hz, digital notch filters at 50Hz and 60Hz
Filitering	Built in digital 5th order Sinc filter	Built in digital 5th order Sinc filter	Built in digital 5th order Sinc filter

[34]

Technical Evaluation

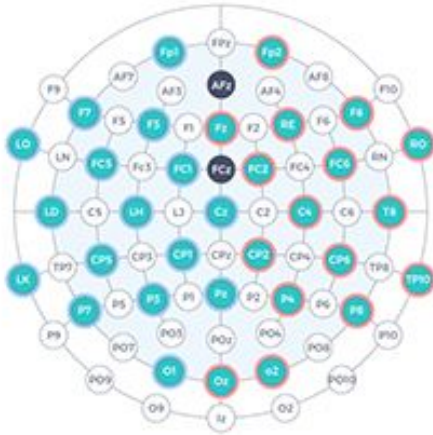
Devices for EEG data collection_Comparison

Name of model	Emotiv_INSIGHT	Emotiv_EPOCx	Emotiv_EPOC flex
Emotional States	Excitement	Excitement	Excitement
	Long term excitement	Long term excitement	Long term excitement
	Frustration	Frustration	Frustration
	Engagement	Engagement	Engagement
	Relaxation	Relaxation	Relaxation
	Interest/Affinity	Interest/Affinity	Interest/Affinity
	Focus	Focus	Focus

[34]

Technical Evaluation

Devices for EEG data collection_Comparison



[Emotiv_EPOC flex 's 32 channels]

Frequency response

Sampling rate

Sensor material

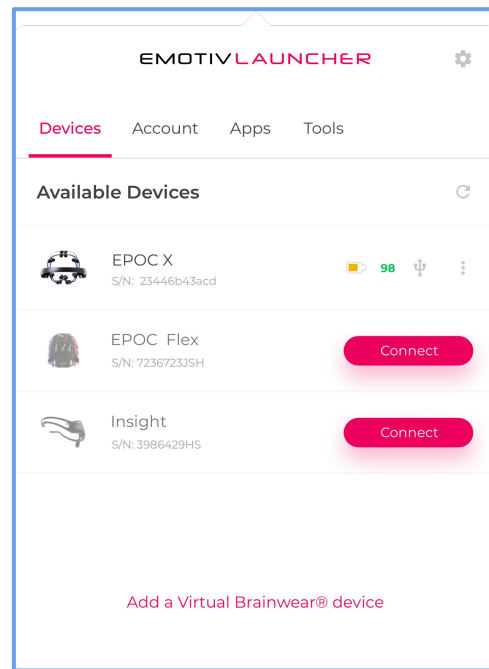
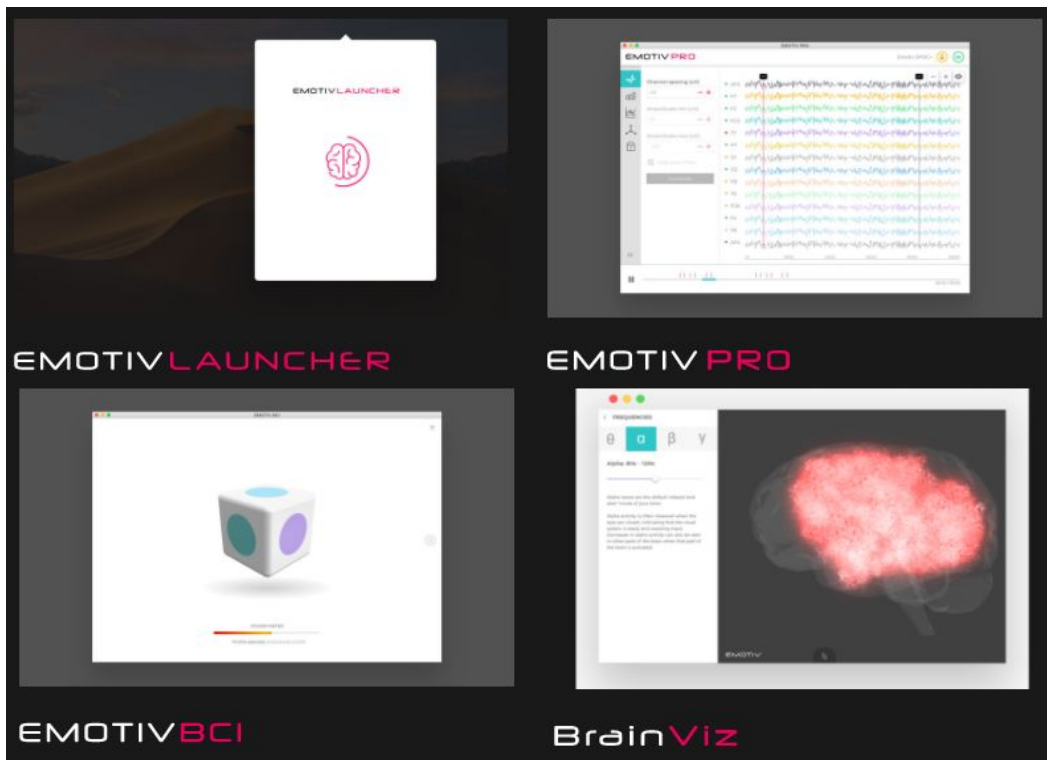
Accuracy

Usability

[34]

Technical Evaluation

Software for EEG data Analysis [34]



[EMOTIV LAUNCHER]

Software for EEG data Analysis _ Emotiv PRO

The stage of stress analysis using EEG data _ 1. Data Collection

- The Method of measurement. (Wet or Dry) [38, 39]

Wet

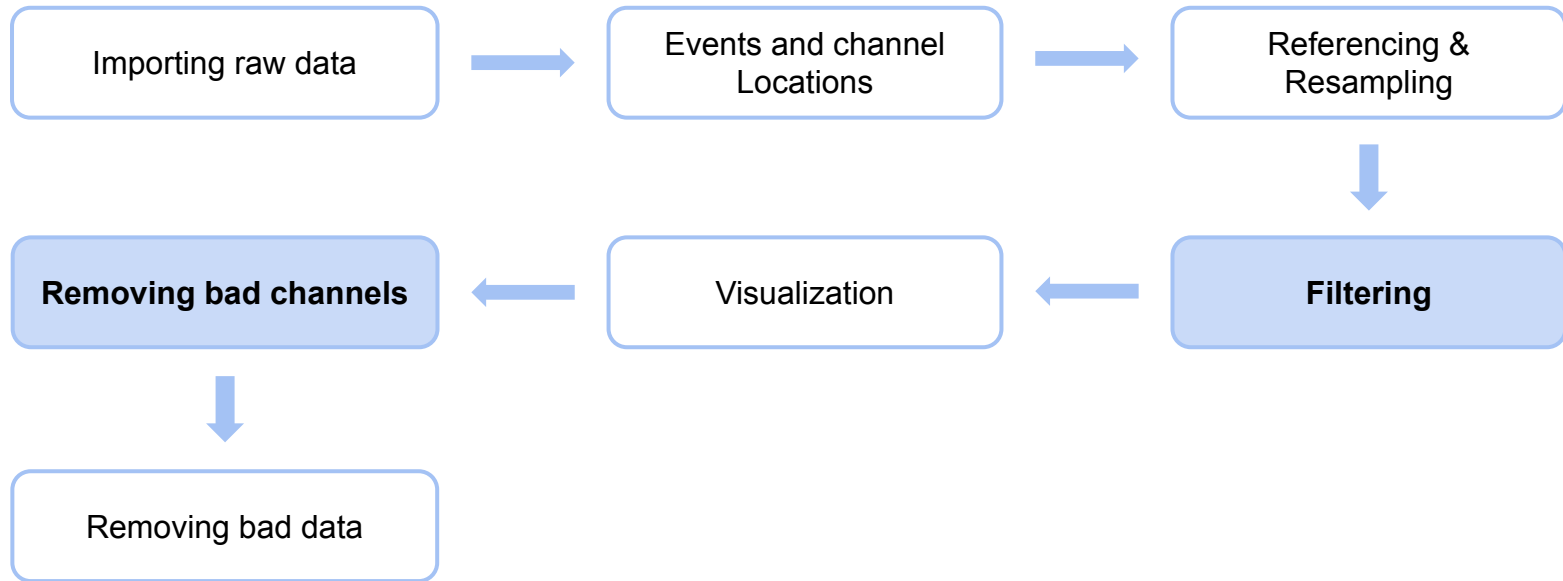
Dry

- The ease of application
- The ease of removal
- Similar to real-life conditions
- The quality of data

Technical Evaluation

▀ The stage of stress analysis using EEG data _ 2. Transformation (pre-processing)

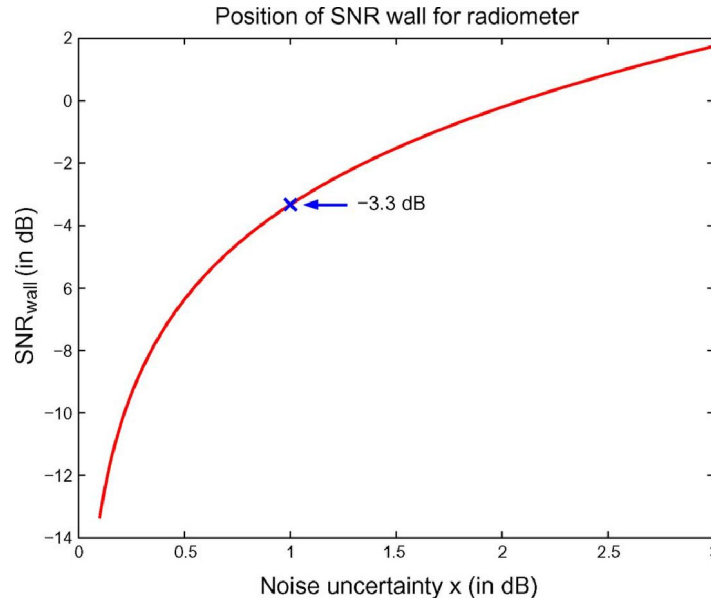
A. 7-stages to pre-processing



Technical Evaluation

The stage of stress analysis using EEG data _ 2. Transformation (pre-processing)

B. SNR(signal-to-noise ratio)

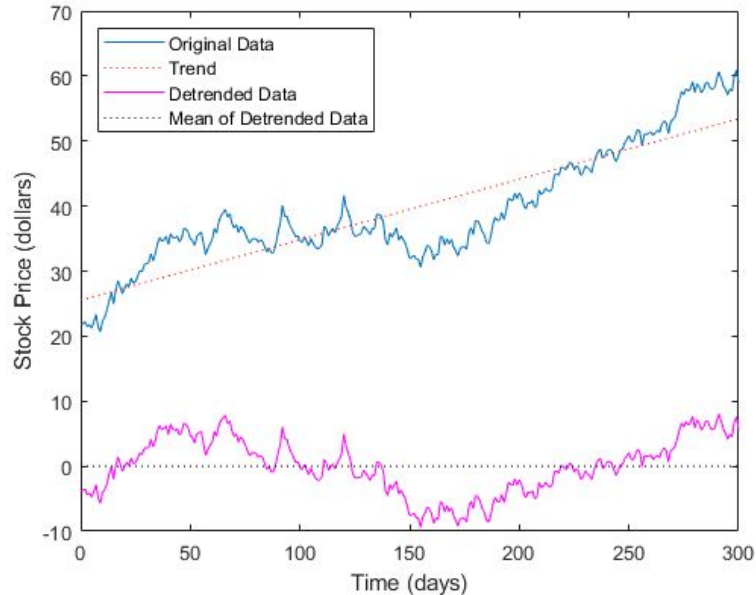


e.g. SNR when $x = 1$ [40]

Technical Evaluation

▀ The stage of stress analysis using EEG data _ 2. Transformation (pre-processing)

C. Detrending



[41]

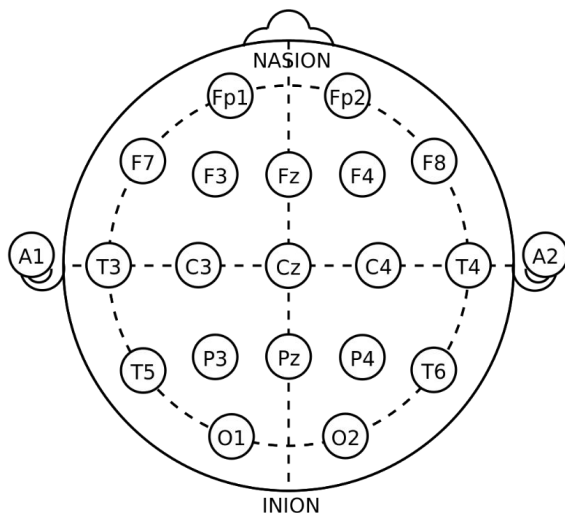
Trending (bias)



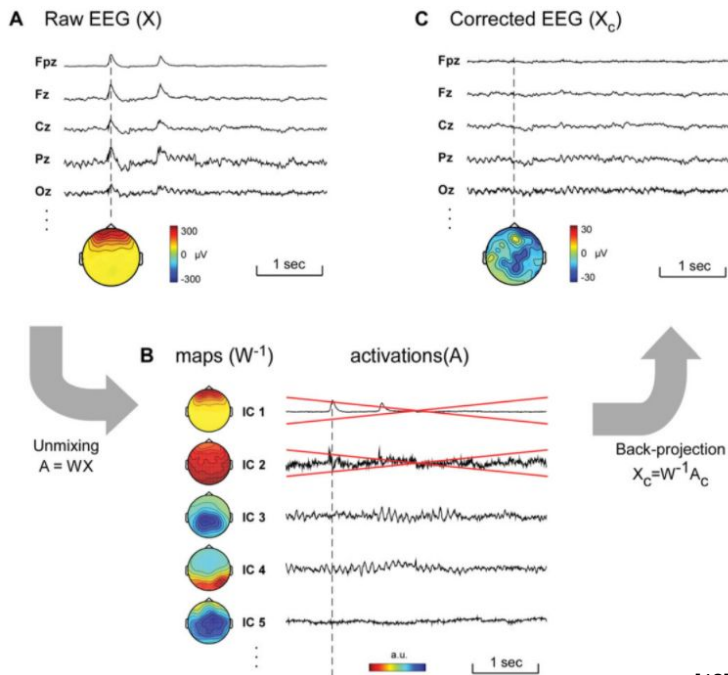
Detrending

The stage of stress analysis using EEG data _ 2. Transformation (pre-processing)

D. ICA(Independent Component Analysis)



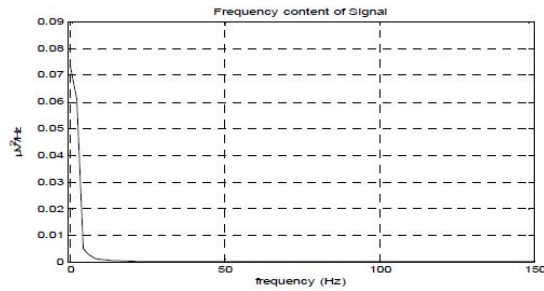
International 10-20 system [35]



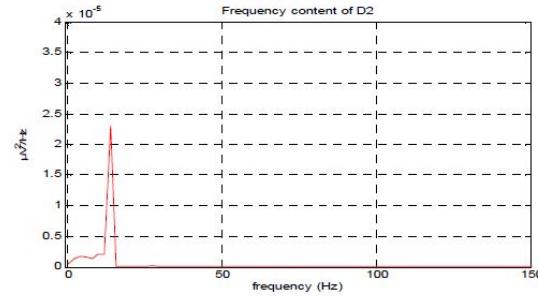
[42]

The stage of stress analysis using EEG data _ 2. Transformation (pre-processing)

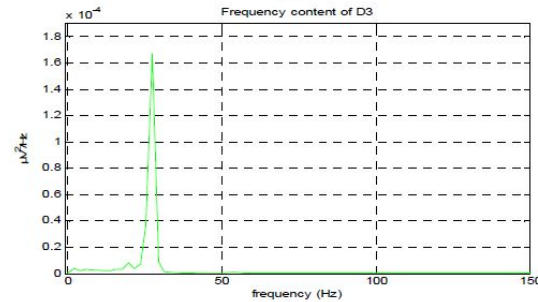
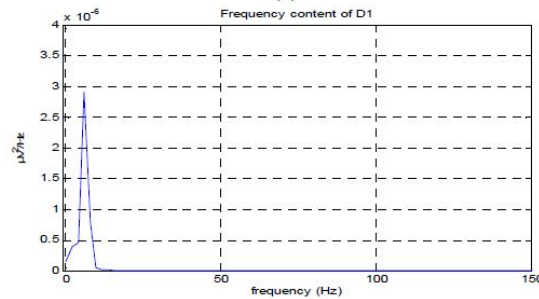
E. Fourier transform



(a)



(c)



(d)

Fourier transformation of each Frequency level of real data of normal person [43]

Technical Evaluation

▀ The stage of stress analysis using EEG data _ 3. Data Analysis

- Selection of classification algorithm.

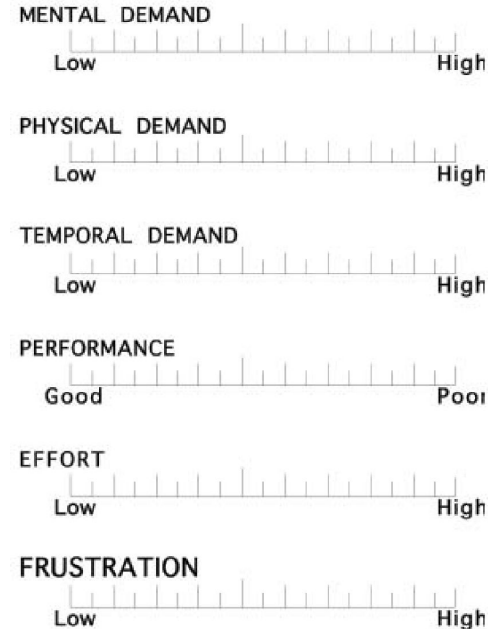
Modeling	F1-Score
SVM	$\frac{2 * Precision * Recall}{Precision + Recall}$
Random Forest	
KNN	
Decision Tree	
DNN	

User Study Plan

Questionnaire [44]

RATING SCALE DEFINITIONS		
Title	Endpoints	Descriptions
MENTAL DEMAND	Low/High	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	Low/High	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	Low/High	How much pressure or time constraint was felt? Was the pace of the task slow and leisurely or rapid and frantic?
EFFORT	Low/High	How hard did you have to work (mentally and physically) to accomplish your level of performance?
PERFORMANCE	Good/Poor	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
FRUSTRATION LEVEL	Low/High	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Category of NASA-TLX



Response form of NASA-TLX

Questionnaire sample

Please rate how far you would agree with the statements below.

SD = strongly disagree; **D** = disagree; **N** = neutral; **A** = agree; **SA** = strongly agree.

- I felt that I am fully immersed with the MR environment.
- I felt that I am fully concentrated with the Task.
- HMD was uncomfortable.
- I was able to carry out the task in a more fun.
- I am willing to continue to use this environment when performing my work in the future.
- When performing the task, I couldn't hear the surrounding sound well.
- I felt like I could concentrate better than when I performed it in a real environment.
- Task level was hard.
- It was difficult to control the device to perform tasks.

Potential Applications



[45]

Study, Reading books



[46]

Work



[47]

Take a rest

Potential Applications



[48]

Meditation



[49, 50]

Sports (Yoga, Climbing etc.)



[51]

Work out (in gym)

Thank you

References

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