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AN EVOLVING BUILT ENVIRONMENT PROTOTYPE

A responsive built environment adapts to emotional state captured with openBCI and supervised machine learning method

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Abstract. In this paper, A new method of design by constructing direct connectionbetween the device and human with machine learning and brain-computerinterfaces techniques is explored. A prototype of an interactive box that can learnto adjust its lightning environment according to people's emotional feedback with python is built.

With the development of machine learning and the brain-computer interfaces (BCI), the accuracy of emotion recognition utilizing electroencephalography (EEG) reaches a practical level. And training model make the algorithm pointing out the state of the subject in real time possible.

In this paper, we canvas issues in training a model that a built environment learning from people's emotional feedback, which indicates that the interaction is based on the subject itself rather than between the designer and the subject. The aim of the experiment is to try to keep the subject excited or sleepy after the stimuli from the built environment's intelligent decision, which is generated from the interaction between the subject's EEG and the change of the illumination.

An open source, affordable, wireless bio-sensing headset-openBCI, is adopted, for the EEG detection, with the PYspace-a machine learning toolkit distinguishing the current state of the brain. The subject is required to stay in an interactive box with the headset on and watch a video containing one simple color. While the installation focusing on the response and influence of built environment toward people is limited, the motion and affection state of the subject is labeled. And with a random change to the luminance, the color temperature and the saturation of the video frame and supervise the machine to give the response to reach the preset state. After a long time collecting the data, the model figures out the sequence of events adjusted to people's general affection. We change the simple color into

a mixed condition and add some texture in the picture and repeat the learning process. After a series of space operation like scaling, zooming, flashing, alternating, moving and rotating, the subject shows different feedback in mind.

Where after, the algorithm recombines the structure of the time series of the video to test the change of the subject's mind. One subject should conduct the test repeatedly until an effective model is acquired for this person, and then subject could be change and the new model trained. The box finally earns the model to analyze the pattern of emotion fluctuation and the event series to reach the aimed emotion. After learning the method to interact, the box is upgraded physically for a better adjustment. This represents the design of the space is based on time series and the human emotion which also suggests the architects don't have to design the space directly based on the indescribable professional experience but the machine learning can decide the elements of design in a concrete sense.

The interactive box shows a potential to skip over the will of designer, construct a bridge between the device and the human and seize the advantage of solving the complex case which needs oversize dataset and comprehensive operation. The aesthetic training for the human race is always criticized for the non-standard voice and the extensive and consistent feedback of space reduces the users decision-making power. But using just their mind to shape the space they use, participants receive the return of the power. Using machine learning in the physiological condition especially the emotion can be fairly demanding for the artificial architecture.

And what need to be further assessed is the reliability and validity. Some standard questionnaire should be a decent implement in test of this aspect, before a more precise conclusion could be drawn.

Below is the Code recording the state, please note that the current Color(H,S,V), should be recorded with Mapped Alpha Value together. And for the optimized experience, all value should be mapped around [0,1].

```
public override List<float> CollectState()
    {
    List<float> state = new List<float>();
    state.Add (Hue);
    state.Add (Sat);
    state.Add (Val);
    state.Add (alphaValue/100f);
    return state;
    }
```

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