The Mind Garden: A Brain Computer Interface Game
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ABSTRACT
With the development of medical research and Human Computer Interaction, Brain Computer Interface (BCI), which is an interesting intersection between these two fields, is becoming a more and more popular topic. Various researches and commercial products have been created to support the applications of Brain Computer Interface. In this paper, a BCI based games is introduced to help people training their concentration and meditation skills with a lot of fun. In this game, users can use their attention to control the growth of trees that they planted in the garden and the change of environments using meditation.

Keywords: Design Games, Brain Computer Interface, Human Computer Interaction.

INTRODUCTION
Recently, researchers in human-computer interaction have been exploring Brain Computer Interaction systems for academic, medical care and entertainment purposes. In the area of Brain Computer Interface game design, some of the challenges discovered so far are misusing BCI, not intuitive interactions, and difficulties in use. We attempt to develop a system that overcomes those challenges by learning from previous researches.

An Overview of BCI
Although the EEG is an imperfect, distorted indicator of brain activity, it remains nonetheless its direct consequence. Also, it is based on a much simpler technology and is characterized by much smaller time constants when compared to other non-invasive approaches such as MEG, PET, and fMRI. When it became possible to process digitized EEG signals on a computer, the temptation was great to use EEG as a direct communication channel from the brain to the real world. Early research programs in that direction were sponsored by defense agencies. One of ten cites the project headed by Dr.J.Vidal, director of the Brain-Computer Interface Laboratory at UCLA, as the first successful endeavor at building a BCI [24]. Some years later, several works confirmed that it was indeed possible to determine reasonably well what mental task (out of a specified small set of tasks) was performed by a subject on the basis of his EEG. In this reference, mental task discrimination used a feature compounding asymmetry between right and left hemispheres in all frequency bands and on all electrodes.

The last ten years have witnessed an explosion in the area of BCI research. A cornerstone was the first workshop on BCI technology that took place in 1999, in Albany, New York, where 22 research groups presented their work [1]. Among them were the Grazgroup [2], the Neil Squire foundation [3], the Wadsworth Center [4], the Tuebingen group [5], and the Beckman Institute [6]. A formal definition of the term BCI has been set forward: “A brain-computer interface is a communication system that does not depend on the brain’s normal output pathways of peripheral nerves and muscles.” The framework is now clearly defined, and the critical mass is reached.

RELATED WORKS
RaviDuel
RaviDuel [7] is an Internet game using Brain Computer Interface, it is developed by researchers from Hallym University. The BCI system translated real-time neuronal activities from prefrontal cortex (PFC), or hippocampus (CA1) of a rat into external device control commands and used them to drive a neuron based internet game.

BCI for virtual car control
Researchers from Shenzhen Institute of Advanced Technology in China develop a 3D interactive game as the visual feedback for an online MI EEG based BCI training [8], and the program is integrated into application module of BCI2000 system for other usage.

MindTactics: A BCI Game Platform
Researchers from Drexel University have developed a game environment called “MindTactics” [9] as a test platform for BCI devices to conceptualize experimental cognitive paradigms in ecologically valid environments as well as test BCI gameplay paradigms. MindTactics is capable of integrating data from multiple devices including the optical brain imaging based BCI and it records behavioral log files for further analysis.
SYSTEM DESCRIPTION
The Mind Garden introduces a Brain Computer Interface based Game. In this game, player need to wear a headset with sensors called Mindset which developed by company called Neurosky. This device can output two quantitative values: attention and meditation after processing the raw brain wave data. The connection between the device and computer is Bluetooth.

System Architecture
The system design and architecture is displayed in the Figure 1.

![System Architecture](image)

Figure 1: System Architecture

Neurosky Mindset
The MindSet is a market EEG headset which debuted in 2009. The device consists of earphone, a microphone, and a sensor arm. The headset’s reference and ground electrodes are on the ear phones and the EEG electrode is on the end of the sensor arm, sitting on the forehead above the eye. It can collect research-grade EEG data, and set of analyzed concentration and meditation data which can be communicate via Bluetooth between the device and computers.

![Mindset Manual](image)

Figure 3 Mindset manual

Other Development Environment
The development and testing were conducted in a standard PC laptop running Windows 7 Ultimate (Intel(R) Core(TM) Duo T6600 2.20 GHz, 2 GB RAM, 13” LCD at 1366x768 pixels). The software was built using Adobe Flex 4.1 and Adobe Flash Professional CS5 using ActionScript 3.0. The Flash player version was 10.1.102.64.

Interaction Techniques
Based on the research of current BCI related game design, BCI as the primary control method is proved to be difficult to create good user experience. Due to the unstable and nonlinear output, the BCI device is not very suitable for the type of game which requires precise control. In this game design, the primary control device is mouse.

Game Design
Concept and Rules
The basic concept of this game is a farm type of games. It is a game for people to practice the concentration and meditation skills. The whole rhythm of this game is relaxed. Player can decorate the garden by planting trees and add environment elements like sun, cloud and rainbow. Attention and meditation values are used respectively for tree planting and environment element generation.

Mindset Output Values
- Attention value
- Meditation value
- poor signal quality probe
- EEG band powers (delta, theta, alpha, beta, gamma)
- raw EEG wave samples (at 512Hz)
**Game User Interface**

![Game UI](image)

**Figure 4: Game UI**

1. **Plant slots**
   Player can pick up one kind of tree from here and drag and drop to the garden to plant it.

2. **Environment element slots**
   Player can pick up one environment element from here and put it to the garden to generate it.

3. **Mindset network connection indicator**
   It is an indicator to display the current connection status between the Mindset and computer.

4. **Attention/Meditation Energy bar**
   This bar shows the current attention/meditation energy value. The current value type is determined by which element is selected by player. Two colors: green and purple for meditation and attention.

5. **Upgrade button**
   When the energy bar is full, which mean players attention/meditation is strong enough, this upgrade button will appear. By clicking this button, user can upgrade the selected elements.

6. **The environment element**
   This is an environment element which is controlled by player’s meditation value. For each of the environment element, it contains a continuous animated transition from the beginning state to the final state. The transition is triggered by changing the value in the energy bar. Once the user’s meditation hit the maximum value, the upgrade button will appear. After upgraded, the element will keep the final state.

7. **The plant**
   This is a plant element which growth is controlled by player’s attention value. Each of the plant can be upgraded 5 times until it comes to the final state.

To upgrade it, user needs to keep concentrate on the plant to increase the attention value then use the upgrade button to improve the plant. The difficulty of upgrading the plant is increased time by time. It means user needs to concentrate more in order to upgrade in the later state.

**Game Play Walkthrough**

- **Initial screen:**
  User need to wear the headset to change the status from “disconnected” to “OK” (Figure 5).

- **Plant a tree to the garden**
  Drag the plant to the garden, mouse click to highlight the selection. Then concentrate on it and increase your attention power to upgrade your plant (Figure 6).

- **Add environment elements to the garden**

![Initial screen: empty garden](image)

**Figure 5: Initial screen: empty garden**

![Plant a tree](image)

**Figure 6: Plant a tree**
Drag an element from the environment bar and place it in the garden and use meditation to change the environment (Figure 7).

- Decorating the garden

By alternatively using your different "mind power", the player can create a fantastic garden (Figure 8).

**DISCUSSION**

In this section, we discuss the implications of the system.

**Limitations and Future work**

**Limitations**

- Different users may have different mind wave pattern, so the effect of game control can be an issue
- The way of pre-connection is very strict. In some cases, it is difficult to make connection immediately
- The ergonomics of the headset is not well designed, in some cases, the sensors cannot touch the skin on the ear due to various ear shapes of different people

**Future work**

- Users can customize their own plants and environment elements.
- Make the game accessible to multiple platforms
- Include some social elements which enables to invite friends and share their garden to the SNS
- Discover more interactions and objects to control
- Allow user to upload their items to the online item library

**CONCLUSION**

In this paper, a novel type of game is introduced based on Brain Computer Interface. The primary purpose of this game is to train people’s concentration and meditation skills. With the development of Brain Computer Interface, this system can be applied in different scenarios and widely used platforms.

**REFERENCES**


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