

# Brain Painting: Action Paintings based on BCI-Input

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## Abstract

We introduce roboPix, a robot, which is able to paint action paintings from a user's thoughts using a Brain-Computer-Interface (BCI). The BCI provides signals, which encompass the user's recognized thoughts and the user's level of excitement. These signals command the movement of the robot's arm, which spreads the paint on the canvas. Our system combines explicit and implicit signals to personalize and affect the created painting. Furthermore, we implemented a feedback loop to engage the user in interacting with the system again after losing focus. This system creates a modern art representation of the user's excitement and thoughts at the moment of creation.

## 1 Introduction

This system extends the previous roboPix painting robot (Burkovski et al. 2011) by adding a Brain-Computer-Interface (BCI) to control the movement of the robot's arm. Hence, the system is able to create action paintings just by using a participant's thoughts and excitement as input rather than a mobile phone's acceleration sensor. The created paintings (see Figure 1) are inspired by the American artist Jackson Pollock (1912-1956) who splashed and dripped paint on a canvas. Our system is meant to be a tool to create action paintings in a unique way and to visualize a user's feelings and emotions in the way the paint is spread on the canvas.

Previous Brain Painting systems (e.g. Kübler et al. 2008) focused on using BCI-data to move a cursor within a grid in order to create digital paintings. By using a robot, paint, and a canvas, we introduce a physical representation of the user's thoughts and emotional state at the moment of interacting with the system. Our system combines explicit and implicit BCI-input (Sahami et al. 2012) for triggering and influencing the painting. The explicit input is used to control the movement of the robot's arm while the strength of the explicit input and the implicit excitement affect the intensity of the movement and rotation of the robot's arm. By using an explicit thought as a trigger for the movement, our system lets the user feels in control of the system.



Figure 1: A finished action painting drawn by the roboPix robot based on the BCI-input of a user.

## 2 System

Our roboPix system consists of four components, two hardware components (the BCI and the robot) and two separate software components (see Figure 2). The first component uses the Emotiv EPOC BCI to control the movement of the robot's arm. It uses the EPOC's Affective Suite to read the user's current emotional state. This information can be read without a user-specific training because it is detected similarly for each user. In addition, we use the Cognitive Suite, which can recognize previously recorded thoughts amongst other thoughts while wearing the BCI. Since every person's brain is folded differently, the raw-data read from the brain differs for each user. Therefore, each user has to record a neutral state and the thought of moving the robot's arm. Then, the Emotiv SDK can recognize that thought later and measure the thought's strength on a floating-point scale from 0.0 to 1.0.

The values coming from the BCI are read by the BCI-Receiver component. The BCI-Receiver component is a C++ application that uses the Emotive SDK to read the BCI-data, record a user-specific training, and send the data to other components via UDP.

The roboPix-Controller component is a C# application, which receives data from the BCI-Receiver component via UDP and calculates the movement of the robot's arm using the strength of a previously trained thought and the excitement value. The robot, which evolved from the TenSeconds project (Burkovski et al. 2011), has four degrees of freedom. The movement of each of the four axes is triggered by the recognition of a previously trained thought. The amplitude of the movement is dependent on the strength of the thought. The rotation speed is influenced by the excitement value, which causes paintings of more excited users to look more chaotic.

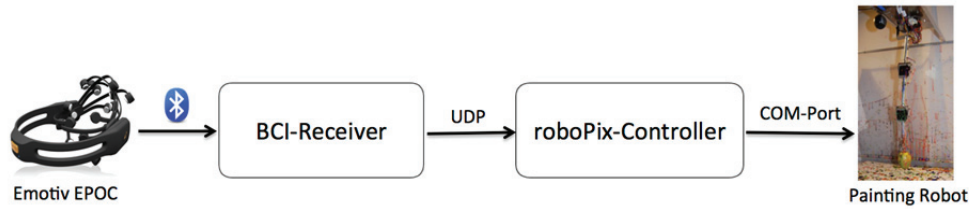


Figure 2: The architecture and interaction between the components of the system

From previous experience with the Emotiv EPOC, we learned that triggering a previously trained thought becomes more difficult the more time has elapsed since the training of the thought. Hence, we introduce a feedback-loop, which should remind the user of thinking the previously trained thought again. We argue that if the user is not able to trigger the movement of the robot anymore, the excitement value of the user will decrease. In order to remind the user of the trained thought (moving the robots arm), the robot automatically moves its arm slowly when the excitement falls below a threshold value of 0.2. Our hypothesis is that users are more likely to think of the movement again if there is some initial visual feedback.

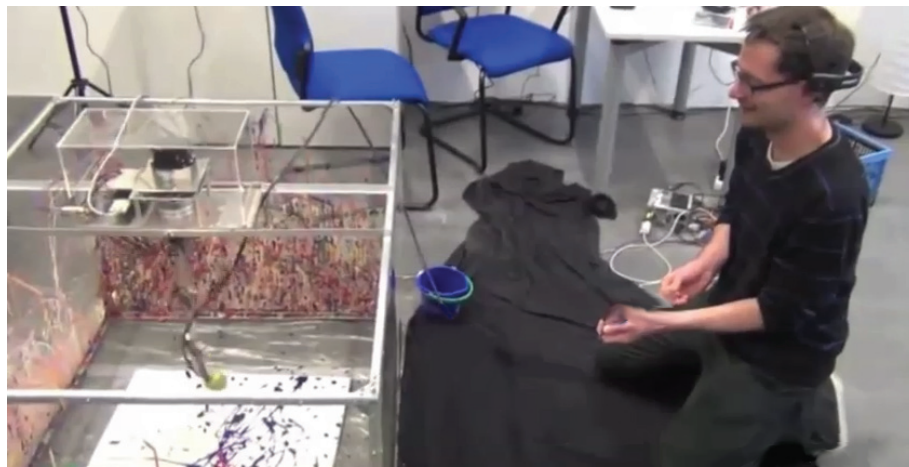


Figure 3: A participant using the roboPix painting robot

### 3 Demo Procedure

In the following the procedure of conducting a demo is described. At first, the robot is disconnected from the BCI's data stream to prevent unintended movement of the robot while the participant is being connected to the Emotive EPOC. We make sure that every sensor has a very good connectivity to the participant's skull. Once the headset is set up, the participant is asked to look at a wall and relax while the system is recording a neutral state. After that, the system needs to know how the participant is thinking about moving the robot's arm. The participant is asked to step in front of the robot and to hold the thought of moving the robot's arm from left to right and vice versa while the system records that thought. Once the thought

is recorded, the system is ready for painting a picture. An empty canvas is inserted into the drawing area of the robot. Then, the robot is connected to the data stream and the participant is asked to think about moving the robot's arm from left to right again (see Figure 3). The robot now moves its arm based on the data from the BCI. For now, the paint has to be inserted manually into the robot. As soon as the robot is connected to the BCI, the facilitator pushes the paint into the container, which is mounted at the bottom of the robot's arm.

## 4 Conclusion and Future Work

The presented roboPix painting robot is able to create action paintings based on a user's thoughts and emotional state. We introduced a feedback loop to help users to trigger a previously trained thought. In future work, we want to conduct a user study to evaluate the impact of the feedback loop towards the triggering of the robot's movement. This user study is planned to be a between-subjects study, where one group paints a picture using the feedback loop and another group paints without the feedback loop. Other challenges involve taking other implicit BCI-values (e.g. frustration and meditation) into account, representing them in the painting, and drawing inferences from the painting about the BCI-data that the picture is based on.

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