Emotional Machines: Synthesis and Expression of Emotions in Interactive Installations

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Abstract

How to make art installations capable of emotional interaction? Through research on robotics and cognitive psychology, we proposed a mechanism for emotion perception, synthesis, and expression in interactive art. This mechanism utilized deep neural networks as the unit of perception, psychological models as method for emotion synthesis to drive motions generated in real time based on signal processing. Based on this architecture, we created several interactive installations as our study of how emotional factors affect interaction.

Keywords

emotional interaction, robotics, cognitive psychology, perception, expression, synthetic motion, animation.

Introduction

When Wassily Kandinsky moved his brush to push pigment molecules of different colors, bringing them together into specific distribution patterns, he experienced an emotional interaction in this process. Today, with the development of artificial intelligence, especially affective computing, machines can partially simulate emotions. As artists, we strive to create machines that elicit emotional experiences. Does a machine that can provide emotional interaction require genuinely experiencing emotions? While a machine having subjective feelings would imply consciousness, the issue itself is fraught with controversy [1]. The presence of emotions in a machine, however, from the artist's standpoint, is not of paramount importance; rather, the emphasis lies on the machine's capacity to demonstrate emotional capabilities. Based on the study of the paradigm of robotics, there is an ambition to devise a mechanism consisting of perception, deliberation, and expression, conceptualizing a machine equipped with such attributes as an integral element within the realm of human-art interaction.

Perception

Perceptual ability, delineating the processing of abstract external signals, involves the compression of high-dimensional redundant signals into low-dimensional feature vectors. When scrutinizing the mechanics of perceptrons and neural networks linking these vectors, artists discern distinct elements such as competition, suppression, passion, and calmness. The process of backpropagation training appears akin to a form of introspection into internal cogitations.

Contemporary artists conceiving art as a mental experience, find a direction for exploration through cognitive psychology. Computational psychology offers an avenue for synthesizing personalities within the realm of artistic creation. The shared psychological model between humans and machines opens avenues for mutual emotional experiences. In the wearable robot Iris, A convolutional neural network is utilized to detect facial expressions [2]. Through interlinking with human body and capturing biological signals like heart rate and skin conductivity, the creation of an artificial organ with a semblance of self-personality becomes plausible, albeit with potential expressions of a split personality. This resonance or separation of emotions becomes distinctly evident in interactive scenarios.

Figure 1. Iris, a wearable robot has a heart rate sensor connect to the wearer to share feelings with the wearer.

Emotion synthesizing

If we consider that the essence of art lies in psychological experiences, then psychology may indeed offer insights for artistic creation. For instance, in the realm of emotional understanding and synthesis, the PAD model has been applied to simulate human responses to emotional stimulus [3]. This model maps emotions onto a three-dimensional vector space, thereby providing a mathematical framework for defining emotions. Once quantified, machines can simulate and synthesize novel emotional states. Furthermore, artificial intelligence pioneer Marvin Minsky contends that emotional activity is not a singular data mapping; rather, it arises from the activation of some regions within the brain while others are inhibited [4]. Inspired by his insights, we employ perceptrons to simulate this process. Each perceptron presents an emotional vector, and when multiple perceptrons are interconnected, emotions are synthesized based on adjustments to their respective weights.

Expression

Once emotions are synthesized, how does the machine express them? Inspiration can be drawn from Disney animations. Leveraging insights from signal processing and systems theory, we utilize simple signal generators and filters to synthesize motion. For instance, employing a spring-mass-damper system to filter motion allows for the real-time generation of complex movements through parameter adjustments. Furthermore, insights from cognitive psychology regarding motor skills offer guidance. For instance, Pew proposed a three-tiered framework for describing the organization and control of motor skills: inner-loop control, higher-order control, and voluntary movement [5]. From an artistic standpoint, this framework can be interpreted as keyframe animation, algorithmic animation, and neural network based (RNN) motion generation, which can be applied to practical work.

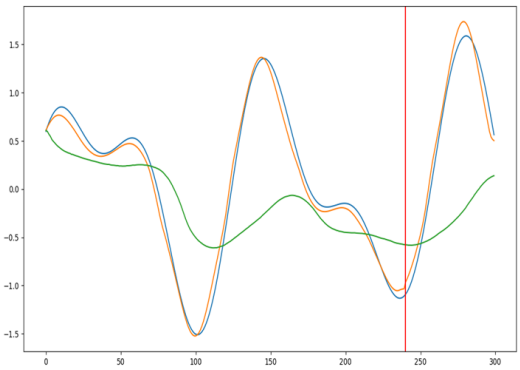

Figure 2. Two animations (Red and Green) are generated by neural networks deviating from the target curve (Blue). Blue line: Original animation with different parameters.

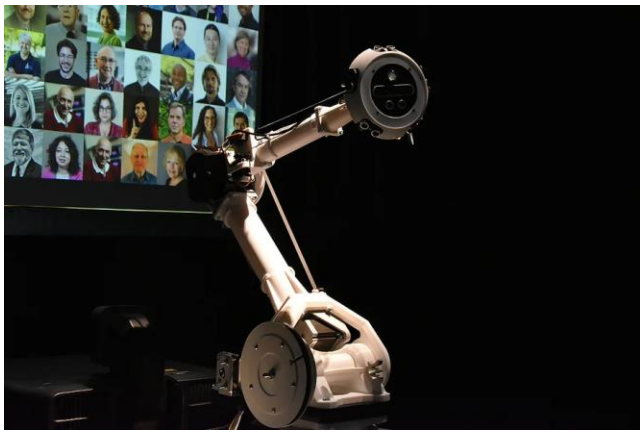

Figure 3. Connection, an AI robot has 5 motors controlled by motion synthesizer to perform smooth motions with emotional expression.

Conclusion

As an example of applying the above theory, Robot Connections provides a platform. Driven by affective computing, it autonomously seeks out faces in a crowd according to its own preferences. Once it identifies a face that meets its criteria, the robot captures a photograph and compares it with faces in its database, revealing and displaying the most similar face. This database consists of 375 images of pioneers in the field of computer graphics from the ACM SIGGRAPH history database. It houses a deep neural network for facial tracking, analysis, and comparison, as well as simulations of emotions and synthesizes of motions based on study of psychology, influencing the robot's psychological state and behaviors.

Artificial intelligence determines its own expression through its perception and understanding of the audience. This process encapsulates the mutual understanding and interaction between the audience and the machine. Therefore, here, "Connections" is more than a pre-programmed mechanical arm or an art sculpture. It serves as a conduit across time and space, extracting biological features to compare and associate viewers with key historical figures. The AI-driven decisions, such as selection or omission, enthusiasm or indifference, often evoke subtle emotional experiences and may even alter the audience's behavior. This, perhaps, is the way we are embracing the future of AI.

References

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Bibliography

Yamin Xu is an artist and electronics geek, working in the edge that blurs animation, artificial intelligence, and robotics with an emphasis on the exploration of computational perception as an inseparable part of art expression. Because of his interdisciplinary background, he strives to create and define new things, which have not been clearly perceived as art. This motivation is sustained by his rigorous art/engineering practice, which is informed by the convergence of divergent spheres of study: religion and science, privacy, and surveillance, robotic and organic. The result is in innovation, feedback to affect and expand his understanding and definition of art. His artwork has been exhibited internationally, such as ACM SIGGRAPH, TEI and CAA. Currently, Yamin Xu is an Assistant Professor at Bowling Green State University Digital Arts program.