Emotion Overflow: An Interactive System to Represent Emotion in Fluid Dynamics

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Abstract : Emotion plays a fundamental yet challenging role in social communication. We envision a world where individuals can effortlessly and elegantly express their emotions, encouraging them to share their feelings and enhancing social interactions. The objective is to utilize language to convey the intended nuances that are not readily apparent. With the advent of artificial intelligence, numerous research endeavors have been undertaken to elucidate emotional traits from facial expressions, verbal communication, and natural language, thereby facilitating the acquisition of emotional intelligence. However, the expressive method of emotion remains largely unexamined. Recent work has culminated in the presentation of measured information in words, color, or emojis, which is straightforward.We are focusing on creating an alternative way of emotional expression, inspired by fluid dynamics. We propose that emotion is expressed in the metaphor of fluid.Emotional attributes, valence, and arousal are converted to viscosity and divergence of emotion.Throughout visual representation with touch interaction, users can represent their emotion in a more abstract and artistic way. This works suggests that de-verbalized and abstract emotional expressions can become a channel for emotional exchange that has not previously existed.

1. Introduction

Emotion plays a fundamental yet challenging role in social communication, profoundly influencing how individuals convey and interpret messages in interpersonal interactions [1], [4]. Effective emotional expression enhances social bonds, facilitates mutual understanding, and contributes to the overall quality of social interactions. Despite its paramount importance, expressing emotions in a nuanced and dynamic manner remains a complex endeavor.

With the advent of artificial intelligence, numerous research endeavors have been undertaken to elucidate emotional traits from facial expressions, verbal communication, and natural language [3], [7], [8]. These advancements have significantly contributed to the acquisition of emotional intelligence in machines, enabling more empathetic and responsive interactions between humans and technology. However, while emotion recognition has advanced, the methods for expressive emotional communication have been largely unexamined.

Recent work in emotional expression often culminates in the use of words, colors, or emojis to represent emotions [5], [9], [10]. While these methods are straightforward and widely adopted, they offer limited depth and abstraction, failing to capture the dynamic and multifaceted nature of human emotions [2], [6]. Emotions are inherently fluid and constantly evolving, a characteristic that traditional expressive methods struggle to represent effectively.

In this paper, we focus on creating an alternative method of emotional expression inspired by fluid dynamics. We propose that emotions can be metaphorically expressed through fluid characteristics, providing a more abstract and artistic medium for emotional communication. By converting key emotional attributes—valence and arousal [2]—into fluid properties such as viscosity and divergence, our system allows users to represent their emotions in a visually dynamic and interactive manner. Through touch-based interaction, users can manipulate and explore fluid representations of their emotional states,
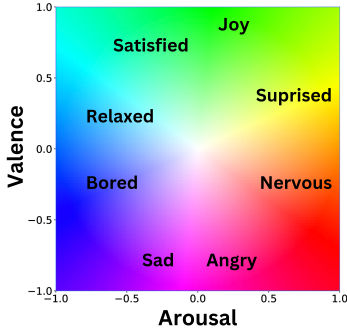
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Figure 1 2D Color Map of Valence and Arousal in our research. The fluid moves more quickly and dramatically as the Arousal increases, while a higher Valence causes the fluid to dissipate more rapidly.

facilitating a new channel for emotional exchange that transcends verbal and static symbolic methods.

Our contribution lies in the development of *Emotion Overflow*, an interactive system that leverages fluid dynamics to represent emotions. This approach not only aligns with human linguistic and cultural perceptions of emotion but also offers a novel interface for exploring and communicating complex emotional states in a more intuitive and engaging way. By bridging the gap between emotional recognition and expression, Emotion Overflow provides a unique platform for enhancing emotional intelligence and fostering deeper social interactions.

2. IMPLEMENTATION

Our approach utilizes a GPT model to translate emotion attributes into fluid characteristics for visualization. The process consists of two main stages: emotion attribute extraction and fluid characteristic generation. We focus on two key emotion attributes: First is valence, defined as the value associated with a stimulus, expressed on a continuum from pleasant to unpleasant or from attractive to aversive. The second is arousal, which is characterized as a state of excitement or energy expenditure linked to an emotion[2].

The GPT model analyzes the input text to determine values for these attributes based on the emotional content expressed. The emotion attributes extracted are subsequently mapped onto specific fluid characteristics to create a visual representation of the emotional state.

The color of the fluid is determined by a combination of both valence and arousal values as shown as Figure 2, with the color scheme designed to reflect the pleasantness and intensity of the emotion [6]. Variance over time, primarily influenced by the valence attribute, represents the fluid's stability or volatility. This characteristic cor-
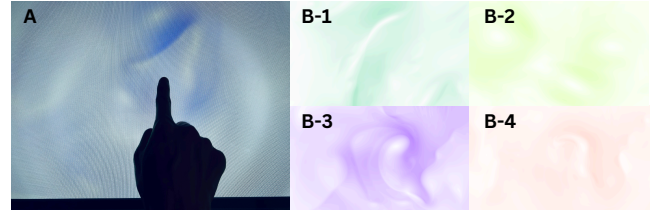
Figure 2 Overview of Emotion Overflow. A) Users are touching screen to interact with fluid. B) The representation of users emotion in fluid form. B-1 is satisfied, B-2 is joy, B-3 is sad, B-4 is nervous.

responds to the steadiness or fluctuation of the emotional state, providing a visual cue for the emotion's constancy or variability. Lastly, fluid responsiveness is derived from the arousal attribute. This characteristic governs how quickly and dramatically the fluid reacts to user interactions, effectively mirroring the energy level associated with the emotion. Through this mapping process, the complex nuances of emotional states are translated into an interactive and visually dynamic fluid medium, allowing for an intuitive representation of the input emotion.

The Fluid in this experiment is coded using three.js, a JavaScript library for generating and presenting animated computer graphics within a web browser via WebGL. The implementation was inspired by the "fluid-three" GitHub repository, which implements Stable Fluids **?**, a method that provides a foundation for simulating various kinds of fluids electronically.

3. DEMO APPLICATION

Emotion Overflow provides users with the ability to visualize their emotions through fluid simulations and interact with these visualizations, offering a novel means of self-expression. The system integrates a text analysis module that interprets the emotional content of user inputs and a fluid dynamics engine that generates corresponding visual representations. Users engage with Emotion Overflow via a multi-touch screen interface, allowing for intuitive manipulation of the emotion-driven fluid simulations.

3.1 Direct Emotion Visualization

In the first demonstration, Emotion Overflow showcases its core functionality. Users begin by entering a brief description of their current emotional state into a text box. The system analyzes this input to identify the predominant emotion. Based on this analysis, a unique fluid simulation is generated instantly on the multi-touch screen. Users can then interact with the fluid using various touch gestures. The fluid responds dynamically to each interac-

Figure 3 Users sharing their emotions through fluid simulations

tion, providing a tangible and engaging representation of the user's emotions. This direct visualization helps users to better understand and articulate their emotional states through visual feedback.

3.2 Emotion Guessing Game

The second demonstration transforms Emotion Overflow into an interactive game that challenges users to interpret emotional expressions conveyed through fluid dynamics. In this demonstration, the system generates a fluid visualization based on a previous user's emotional text input. New participants observe the fluid's behavior and attempt to identify the emotion it represents. They can interact with the fluid on the multi-touch screen to explore its characteristics further. After making their guesses, the original emotional input is revealed, prompting a group discussion. Participants assess the accuracy of their interpretations, evaluate how effectively the fluid conveyed the intended emotions, and discuss the balance between abstraction and clarity in emotional expression through fluid dynamics. This interactive game not only enhances users' emotional literacy but also fosters a deeper understanding of how emotions can be visually represented.

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