

# An Emotionally Intelligent User Interface: Modelling Emotion for User Engagement.

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## ABSTRACT

This paper presents a model for simulating emotion and personality in interactive systems. This paper argues that by introducing simulated emotional responses and state dynamics to future systems, they will provide a more life-like, engaging and interactive experience to their users, and provide a more effective and efficient user interaction. Further, by simulating Emotional Intelligence in a system, a developer may be able to provide a more tailored user experience, and be provided with more control over the outcome of a user's interaction with their system. Emotion theory and expression are explored, and a model is presented based upon emotional states. Implementation of this model is then presented as an intelligent back end process that utilises dynamic video stream analysis that feeds into an interactive display. The proposed system, and its hardware implementation is presented, followed by a discussion of future areas of research.

## Categories and Subject Descriptors

H.5.2 [User Interfaces]: User Centered Design.

## General Terms

Design, Experimentation, Human Factors, Theory.

## Keywords

Human-Computer Interaction, Interaction Design, Engagement, Vision System.

## 1. INTRODUCTION

Research into intelligent machines aims to produce hardware and software that can support humans in their everyday tasks, and provide a user experience that is both adaptive and transparent in its execution. Providing machines with simulated emotional intelligence and human-like mannerisms requires a paradigm shift in human's perception of software and computers in general. If technology and electronic devices are to be designed to become an integral part of human life, then many factors need to be considered before their role can become transparent. Introducing human expression and simulated emotional intelligence into system design can have a positive impact on the user experience, and the effectiveness of its use.

## 2. BACKGROUND

### 2.1 Emotion Theory

The current literature on emotion theory lacks a clear definition

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OzCHI 2007 Proceedings, ISBN 978-1-59593-872-5

of what constitutes an "Emotion", with over a hundred different definitions proposed [1]. However, for the purposes of the topic of this paper, the term "Emotion" will be used to describe the reactive processes that occur as a result of the phenomenon loosely labelled as an "Emotion", and the result of the

experience given by such reactions. Russell (2004) describes such an understanding of an Emotion as "Emotion Concepts", where even though we are unable to provide a solid definition for the phenomenon labelled as an Emotion, we can gain an appreciation of the term through our general understanding of it. This is generally achieved by the experience of the reaction, or as termed by Russell (2004), the "Event" that occurs as a result of experiencing an emotion. These reactions that result from an emotional experience are generally categorised into two fields of study on the subject. It is argued that: 1) Emotions are Cognitive (The mental aspect), and 2) Emotions are Physical (The bodily aspect) [2]. Damasio (1994) argues that there are primary and secondary emotions. Primary emotions are those emotions that are stimulated through environmental factors. They occur automatically as a reaction to the stimulus, and are followed by an induced cognitive state. Secondary emotions are those that are learned reactions occurring from a recognised correlation between a primary emotion and the environmental factor that induces it. For example, attributing feelings of grief and sadness at the death of pet, or exhilaration at your favourite team scoring the winning goal in a game of robot soccer. It is the ties between the thought and corresponding physical reactions associated with that thought that can have an impact on a humans experience while involved in a specific event. Harnessing this power will allow designers to influence the emotional response and promote an engaging experience for their audiences.

### 2.2 Giving Emotional Intelligence to Computers

Why is it beneficial to give computers the ability to recognise and/or express an emotional reaction? Emotions play an important role in human intelligence, the decision making process, social interactions, perception, memory, learning, creativity and more [2]. Damasio (1994) in his studies involving patients suffering from prefrontal cortical damage describes how these patients are unable to express or feel emotion, severely inhibiting their ability to manage and make decisions. Although some of these patients are able to recognise when they should have an emotional reaction to an event, they are unable to have the emotion, and therefore act irrationally when presented with basic decisions. For example, one patient was described as being unable to decide what time they would be free for an appointment. The patient was seen to enter into a never-ending search for the best possible outcome, and tried to consider every possible outcome in order to come up with an answer. The patient was not affected by embarrassment at the

amount of time it was taking to make the decision, nor did they display an ability to rely on what is often termed as “gut instinct”. Therefore an inability to react emotionally to a given situation can result in a seemingly unintelligent response. Picard (2000) argues that researchers involved in the creation of intelligent machines “have focused on problem solving, reasoning, learning, perception, language and other cognitive tasks considered central to intelligence”. It is often complex neural networks, algorithmic and logic structures used to in ‘intelligence simulation’ with emotion ignored as being a critical and influencing factor as seen in human beings.

### 3. SIMULATING AN EMOTIONAL REACTION

#### 3.1 Displaying an Emotional Reaction

As previously described, emotional reaction occurs in two categories: Physical and Cognitive. Cognitive reactions are often the hardest to measure, and consist of the affect of emotion on decision-making, mood, and the social nature of emotional display. For example, it is unlikely that the same extent of emotional display would be evident in ones workplace, as would be apparent in their home.

The physical aspect of emotional reaction consists of changes in physiology and physical expression as a result of feeling a particular emotion. These can be described in terms of how “easily perceived” they are by other people [2]. For example, facial expression, body language, vocal intonation etc can be easily observed relative to respiration, blood pressure, temperature, pulse, respiration and perspiration [2].

#### 3.2 Emotional Machines

Why give emotions to Machines? This paper proposes that simulating emotional reactions in interactive systems would result in a better user experience, supported by a more effective use of the software. By introducing simulated emotional responses and personality dynamics to interactive systems, the systems can become more ‘aware’ of their operating environment (interactions with the user) and adapt accordingly. Providing this intelligence in the interface is integral to the future development of user-centric systems, geared toward providing a more complete user experience. Additionally, simulating emotional intelligence may have a positive impact on consumer’s perception of technology, and technology branding. This paper proposes that the simulation of emotional reaction will increase the likeability of the interface, and help facilitate social identification between the product and the user. It has been shown that such an emotional attraction to a product promotes brand loyalty on both a cognitive [3] and a behavioural [4, 7] level. To facilitate this development, social cues such as emotional reaction should be simulated in the products aimed at consumers.

Humans have been shown to elicit fundamentally social reactions to computers when provided with very little in the way of visual cues [5]. By simulating emotional intelligence in machines, developers can tailor the user experience for their users, and provide a more efficient, effective user interface that relies on the pre-developed cognitive models of their users [6].

### 4. THE EMOTION STATE MACHINE

To effectively simulate emotion in a number for contexts, this paper presents the use of an ‘Emotion State Machine’ to guide the emotional reactions presented by a machine.

The Emotion State Machine consists of a number of transitional states that a machine can be in at any one time, that has an effect on its behaviour across the two categories of emotional expression (Physical and Cognitive). For the simulated emotional expression to appear more natural and lifelike, the emotional state may only transition through neighbouring states. For example, this prevents a machine that was once ‘ecstatic’ to suddenly become ‘enraged’. It must transition from ‘ecstatic’, to ‘happy’, ‘angry’, and then finally to ‘enraged’ as a response to external stimuli. The current emotional state would then have an effect on the reaction given for a specific event that is appropriate to the situation.

Each state also determines the acceptable emotional response to a given external stimulus. This works much the same way as humans utilise social rules in a given situation. For example, much the same way as a human would not contort their face in disgust during a business meeting; a machine would not show disgust during a tutoring session with a student. For the Emotion State Machine to be effective, it must also consider the cognitive nature of the interaction between emotion and reaction. It is not enough that it simply simulates a physical reaction to an event, but that the emotional state has an effect on other elements such as task completion, decision-making and environmental interactions. The Emotion State Machine’s Example Values are presented below in Figure 1:

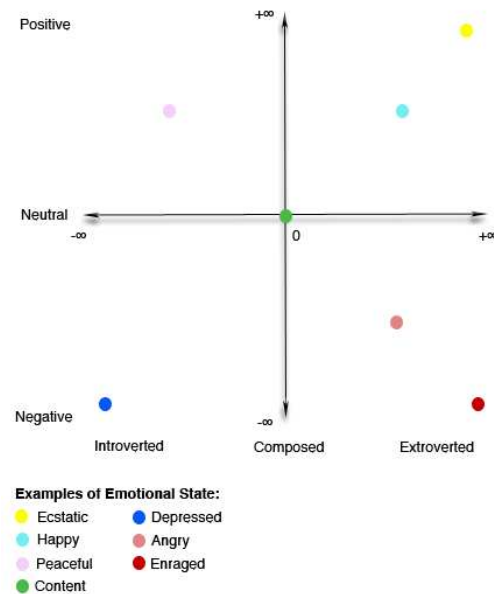


Figure 1. Emotion State Machine Example Values. Points with axis demonstrate potential emotional states based upon assigned x and y values.

#### 4.1 Emotional State Transition

Moving between emotional states relies on external environmental factors. These factors are given weights to determine their emotional impact. In order for one emotional state to transition to another, the weights of the environmental stimuli are considered. This is the basis for the Emotional State Machine. To most effectively simulate the emotional state transitions of human beings, adjustment of the state must occur in increments along the x and y axis. Perceived environmental factors by the machine can result in these changes to state that

in turn can effect the emotional reaction displayed by the machine. For example, it is considered to be unnatural for a machine that was once displaying an ecstatic emotional reaction, to ‘over-react’ and suddenly start to display an enraged emotional reaction, given little in the way of emotional stimulus. In order to smooth the transition between states, the weights are considered for accurate representation of emotional impact. Environmental factors hold weights for both the x and y axis, shown as a set EF. Therefore Emotional State ES is equal to the current state value CSV plus the perceived environmental factors weights.

$$ES = CSV + EF(x, y) . \quad (1)$$

Once the current emotional state value is determined, this value can be used to impact on the physical and cognitive emotional responses of the machine. For example, the emotional state may determine the interactive properties of the machine with its user, including vocal intonation, its demeanor; even its task efficiency and completion.

## 4.2 Simulation of Physical Response

Using a number of user interface elements, and an animated intelligent agent, a number of interactive elements are available for displaying physical responses based on emotional state.

Colour plays an important role in emotion. Using colour, it is possible to induce particular emotions in individuals, and affect the ways in which certain objects are perceived on an emotional level [8, 9, 10].

By changing the colour palettes used in an application, different cues can be presented the user to simulate emotional state. By changing the colour of each of the interface elements in response to the current Emotional State, the systems basic emotions can be conveyed to the user in a simple and effective manner, for example red conveying an anger state, while green conveying an envious state.

Previous studies have shown that humans rely on facial expression, and body language the most to determine another human beings emotional state [12]. It is therefore important that accurate representation of this emotional state is presented using an animated agent.

Complementary to Facial Expression, body language is another communicative channel used to convey emotional state [12]. Providing ‘body language’ to systems could be achieved by using an animated interface, utilising such things as screen transitions and menu selection options.

Finally, Sound can have also have an impact on the perception of, and the ability to induce an emotional state [11]. System sounds, volume and intensity all have an impact on the perception of this physical response.

## 4.3 Simulation of Cognitive Factors

In order for consistency and the physical display of an emotional reaction to correspond with user input, this paper proposes the use of a ‘Shared Universal Emotive Set’ to be used within the system. This shared emotive set keeps a record of current emotional state, and keeps track of attributes that may affect this emotional state. Data pertaining to the current emotional state can be shared among applications, or other devices. A sample of such variables may consist of the following:

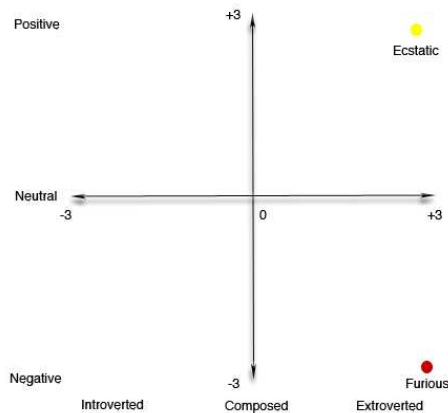
**Table 1. Sample of Variables used to provide Emotional Intelligence.**

Global Variables	Individual (Immediate) Variables
Global Emotional State (Mood)	Sub-Emotional State
Current Task	ESM x and y values
Amount of Interaction Explained	Last Reaction

These variables give the ability for the system to react to given interaction events in real time. For example, by providing a ‘Global Emotional State’ to a system, the underlying mood may be developed, that would have an impact on the short term emotional reactions displayed by the machine. The ‘Sub-Emotional State’ may be used by the system to produce a simulation of immediate emotional response given particular stimuli. This information combined with the users perceived emotional state may be used to determine the appropriate given response to a user request. It is simulations of emotional responses such as these that form the basis for a transparent and believable simulated human-like interaction.

## 4.4 Simulating Believable Emotional State Transition

To most effectively simulate this level of emotional reaction, the changes between a computers state should be considered. For example, a machine displaying an emotional state of ‘ecstatic’ (presumably due to an events such as a consistent praise in its efforts) should not suddenly change to ‘furious’ or ‘desperate’ should the computer receive a criticism for its last decision. Therefore, implementation of the emotional state machine in a system environment should also include the ability to provide weights of the emotional influences in the environment, as provided by the Emotional State Machine. Firstly a range is set along the x and y axis of the Emotional State Machine, giving the ability to alter the sensitivity of the system during an interaction. For example if a range of 3 is provided to each axis, and x and y weights of (0, -2) are used if the computer receives praise, it would take the user providing three criticisms of the computers performance in a row to change the systems emotional state from ‘Ecstatic’ to ‘Furious’ in the provided model:



**Figure 2. Emotion State Machine. State transition for 3 criticisms recieved. Criticism Weight = (0, -2)**

## 5. IMPLEMENTATION

### 5.1 Overview

In order to test the effects of the Emotional State Machine, it is to be incorporated into an Interactive Display, situated in a high traffic area for maximum exposure. The display will remain idle until a user is being detected as initiating an interaction, at which time the system displays small visual cues suggesting emotion based upon input collected from the user. The application itself can be used in conjunction with any number of software applications that result in a high level of feedback to the user. Simulation of the Emotional Response will occur in the two areas described earlier: Physical Response, and Cognitive effects. By simulating emotions in this context, the concept of emotional intelligence may be introduced. The systems behaviour may dynamically change to accommodate the user interaction. It is suggested that simulating the emotional response will engage audiences more than if the capabilities were not introduced, and provide the ability to have an impact on the perception of the system based upon the experience of the user.

### 5.2 System Operating Environment

The system is to be implemented using Apple hardware and a commercially available touch screen display. The system will be placed in a university school foyer. This is considered to be a high traffic area, and it is expected that it will result in the highest possible exposure to potential users of the system. As the users will mostly come from users of the building, it is expected that they will have a high level of familiarity with the Apple OSX interface, as this is the most common personal computer in use in this school. The users will interact with the system through a touch screen interface, with data capture occurring through the use of a digital video camera, and a microphone connected to the system. User interaction will be tested through the use of an animated software agent, and engagement tested through a familiar help application.

### 5.3 System Components

The system is made up of the following hardware components: Apple Intel Mac Pro, running OSX 10.4 Server, Apple iSight camera, 46" Touch Screen Display, Omnidirectional USB Microphone. The system will be developed using a 13inch 2.16ghz Intel Macbook, with the built in microphone and iSight camera. Software development is achieved using the XCode 2.0 development environment, the Objective C and Cocoa development tools. This environment provides a powerful and easy to use set of tools for developing this type of application.

## 6. FUTURE WORK

Future work for the emotional state machine will be to implement the system in the environment described, and test its impact on user engagement with familiar software applications. Further to this, the Emotional State Machine will be refined to accommodate other environmental influences on the machine. The collection of data associated with this level of interactivity with users could have a large impact on the development of user-centric systems in the future. The implementation of software such as the Emotional State Machine, could impact on software systems in that they will be able to deal with the human interaction on a more personal level. This not only promotes loyalty by the consumer for specific products, but also gives developers the ability to design systems that are sensitive to human emotion and mood, sensitive of certain issues, and

capable of adapting to environmental influences. Future work for this project will be to attempt to incorporate some of these features into an existing software system based upon results gathered.

## 7. ACKNOWLEDGMENTS

The Author would like to acknowledge the support of family and friends for their support in my undertaking this research.

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