Emotion Simulation for a Virtual Human: Implementing the "As-If" Body-Loop in a Cognitive Architecture

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Introduction

Background

Implementation

Summary
Bielefeld University
I. Introduction
The Virtual Human “Max” ..
  a) .. as a guide in a computer museum.
  b) .. as an opponent in a cards game.

II. Psychological background of emotion simulation
  a) Structural theories
  b) Dimensional theories
  c) Neurobiological background

III. Implementation
  a) Emotion Dynamics Simulation
  b) Non-Conscious & Conscious Appraisal

IV. Summary
I. Introduction

The Virtual Human “Max” ..

.. as a guide in a computer museum (Germany, 2004).
→ A cooperative scenario!

.. as an opponent in a cards game (Tokyo, 2005).
→ A competitive scenario!
I. a) Smalltalk with Max

Virtual guide scenario since 01/2004:

- Emotion dynamics system driven by:
  - perception (video camera)
  - interpretation (keyboard input)
  - dialog manager (BDI-based reasoning)

- Feeds back to:
  - dialog manager (cognitive)
  - behavior generation (non-cognitive)
I. a) Smalltalk with Max - Video
I. b) Competing with Max

- Playing the cards game “Skip-Bo” against Max:
  - Competitive game with contrary goals for two players
- Emotion recognition using biometrical sensors (Skin Conductivity & EMG, data recorded)
- Empirical study conducted at NII, Japan, 2005
  - 32 subjects, average age 30, one non-Japanese
  - Interactions recorded on digital video
- In cooperation with Prof. Helmut Prendinger during a three month stay as a pre-doctoral JSPS-fellow
I. b) “Skip-Bo” Setup

Laptop 1: Emotion Recognition

Laptop 2: Rendering and Game Engine

Network connection

50” Plasma Display with Loudspeakers

Mirror

SC sensor

EMG sensor

Mouse

DV-Camera

EMG sensor

SC sensor
I. b) Max plays SkipBo - Video
The Virtual Human Max.. is a testbed for studying human-like behavior in natural face-to-face interactions.

Multimodal interaction in our three-sided cave-like installation using:

- data-gloves
- infrared cameras
- 3D-vision interface
Part II

Emotion Simulation for Max

or

How do we improve our agent’s acceptance as a social partner?
II. Psychological background

a) Cognitive emotion theories
   • Affect & Proto-Affect (Ortony et al., 2005)
   • Component Process Model (Scherer, 2006)

b) Dimensional emotion theories
   • “Gefühlsverlauf” (Wundt, 1922)
   • Conscious vs. non-conscious appraisal (Scherer, 2006)

c) Neurobiological background
   • Primary and Secondary Emotions (Damasio, 1994)
   • The “as-if” body loop of emotions
II. a) Affect & Proto-Affect (Ortony et al., ‘05)

• Three levels of information processing:
  1. Reactive:
     - limited to processing simple stimuli and initiating approach and avoidance behaviors.
       → proto-affect
  2. Routine:
     - locus of unconscious, uninterpreted expectations and automatized activity.
       → primitive and unconscious emotions
  3. Reflective:
     - home of higher-order cognitive functions, including metacognition, consciousness, and self-reflection
       → full-fledged, cognitively elaborated emotions
II. a) Affect & Proto-Affect (Ortony et al., '05)

- information flow and interrupts
- sensory inputs
- motor outputs

→ Secondary?

- cognitively elaborated emotions
- primitive emotions
- proto-affect

→ emotional impulses

The world

Reflective

Routine

Reactive
II. a) Component Process Model (Scherer ’06)

**Intrinsic Pleasantness** & Expectation

**Goal conduciveness** & Expectation

**Dominance**

**Timing!!!**
II. b) Dimensional theories of emotion

Describing the “diffuse feeling state”? (Scherer 1988)

Mostly three dimensions:
1. Pleasure (Lust – Unlust)
2. Arousal (Erregung – Beruhigung)
3. Dominance (Spannung – Lösung) (Wundt 1863/1922)

- What is the difference between emotions and feelings?
- How many emotions/feelings?

(Wundt 1863/1922)

“Gefühlsverlauf”

(Scherer 1988)
II. b) Conscious vs. non-conscious

The verbalization problem:

• Most processes believed to remain unconscious (A)
• Even not all conscious representations can be verbalized (B)

→ Zone of valid self-report measurement lies on top! (C)

(Scherer 2006)
II c) Primary emotions (Damasio ‘94)


“[..] we are wired to respond with an emotion, in preorganized fashion, when certain features of stimuli in the world or in our bodies are perceived, alone or in combination. Examples [..] include size (as in large animals); large span (as in flying eagles); types of motion (as in reptiles); certain sounds (such as growling); certain configurations of body state (as in the pain during a heart attack).” (p. 131)

- Stimulus activates amygdala (A)
- Various responses ensue:
  - Internal responses (IR)
  - Muscular responses
  - Visceral responses
  - Responses to neurotransmitter nuclei and hypothalamus (H)
  - Hypothalamus gives rise to endocrine & other chemical responses

![Diagram of amygdala responses]

- IR (Internal responses)
- H (Hypothalamus)
- A (Amygdala)
- Endocrine & other chemical responses
II c) Secondary emotions (Damasio ’94)

Book: “Descartes' Error, Emotion Reason and the Human Brain.”

“[..] I believe that in terms of an individual’s development [primary emotions] are followed by secondary emotions, which occur once we begin experiencing feelings and forming systematic connections between categories of objects and situations, on the one hand, and primary emotions, on the other.” (p. 134)

- Stimulus activates amygdala (A)
- Stimulus is analyzed in the thought process
- Secondary emotions utilize the machinery of primary emotions

→ The “as-if” body loop of emotions might be applied!

![Diagram showing the interaction between different brain regions and bodily responses](image-url)
III. Implementation

a) Emotion dynamics simulation (Becker et al., 2004)
   • Implementing the “subjective feeling state” grounded in the Physis of the virtual human.

b) Non-conscious and conscious appraisal (Becker et al. 2006)
   • Non-conscious appraisal based on “intrinsic pleasantness” (Scherer 2001) & proto-affect (Ortony et al. 2005)
     → Primary emotions
   • Conscious appraisal based on BDI-based reasoning about “goal-conduciveness” (Scherer 2001)
     → Secondary emotions

“Gefühlsverlauf”
(Wundt 1863/1922)
(Scherer 1988)

“Secondary emotions”
(Damasio 1994)
III. a) Emotion dynamics simulation

- Valence of emotion coupled with valence of mood
- Concept of boredom added to increase believability of the virtual human
- Simulation of two spiral springs to implement dynamics of emotions
- Aspects of personality traits can be modeled in emotion dynamics parameters

→ Assuring mood-congruency of emotions
III. a) PAD-space

**secondary emotions**

- happy
  - (P=50 A=0 D=±100)
- surprised
  - (10, 80, +/-100)
- angry
  - (-80, 80, 100)
- annoyed
  - sad
  - (P=-80 A=80 D=100)
- fearful
  - (-80, 80, -100)

**primary emotions**

- relief
  - concentration
  - (0, -80, 100)
- frustrated
  - (0, 0, +/-100)
- depressed
  - (0, -80, -100)
III. b) Non-conscious & conscious appraisal

Cognition layer

- conscious appraisal
  - goal-conduciveness

- non-conscious appraisal
  - intrinsic pleasantness

Physis layer

- emotional impulses

memory
  - autobiography
  - expectations

dominance
  - reappraisal
  - coping

PAD-space
  - Pleasure
  - Arousal

Emotion dynamics:
  - mood
  - emotion

aware emotions
primary emotions
involuntary behavior
III. b) PAD-space (in detail)

- **happy**  
  \((P=50, A=0, D=\pm100)\)

- **bored**  
  \((0, -80, 100)\)

- **concentrated**  
  \((0, 0, +/−100)\)

- **depressed**  
  \((0, -80, -100)\)

- **frustration**
  \((P=-80, A=80, D=100)\)
  \((P=-50, A=0, D=100)\)

- **relief**
  \((P=-50, A=0, D=\pm100)\)

- **angry**  
  \((80, 80, +/−100)\)

- **annoyed**  
  \((80, -80, +/−100)\)

- **surprised**  
  \((10, 80, +/−100)\)

- **sad**  
  \((-80, 80, -100)\)

- **fearful**  
  \((-80, 80, -100)\)

**Awareness likelihood**  
\[= (0.3 \times, 0.2 \times, 0.6 \times)\]
IV. Summary

Modeling Primary and Secondary Emotions, HowTo:

• Primary emotions as reactive responses to stimuli:
  • No memory, no expectations, no higher-order cognition involved
  • “Intrinsic pleasantness” (Scherer) leads to “Proto-affect” (Ortony)
    → emotional impulse for emotion dynamics system
  • Direct elicitation of primary emotions
    → PAD-space (Wundt)

• Secondary emotions are “cognitively elaborated” (Ortony)
  • Conscious (re)appraisal based on memory & expectations (Scherer)
    → BDI-based reasoning also for coping
  • They “utilize the machinery of primary emotions” (Damasio)
    → PAD-space as “awareness filter”
    → Facial expression of “relief” triggered by primary emotion “happy”
IV. The future?

Repliee-Q2 (University of Osaka) (Repliee-Q1expo, 2005 in Aichi)

The making of the robot “Sonny” (“I, Robot”, 2004)