Non-verbal communication (NVC) and Emotions in Virtual Worlds
Part 1: Fundamentals, limits, and an architecture for NVC
Part 2: Defining and parameterizing emotion

2013, April 1st
One context, two short talks

0. Who, where, and what

1. Fundamentals, limits, and an architecture for non-verbal communication

2. Defining and parameterizing emotion

Short introduction about the university

Context → need → potential architecture

Potential model → results
One context, two short talks

0. Who, where, and what

1. Fundamentals, limits, and an architecture for non-verbal communication

2. Defining and parameterizing emotion

"HES"
Applied sciences universities

0.1 Who

0.2 Where?

0.3 What?
One context, two short talks

0. Who, where, and what

1. Fundamentals, limits, and an architecture for NVC

2. Defining and parameterizing emotion

1.1 Fundamentals & limitations

1.2 An event-based architecture
0. Who, where, and what

1. Fundamentals, limits, and an architecture for non-verbal communication

2. Defining and parameterizing emotion

2.1 What is emotion and how it has been represented?

2.2 Emotional Expressions: Notions of emoFace and emoMotions

2.3 An emotional model and some results
o. Who, where, what?

- A four languages country
- Acronyms
- Universities of applied sciences
- Building location
- Student percentage
- Activities
Introduction

Who?

Four language regions

People speaking:

- German
- French
- Italian
- Romanche

![Language Map](image)

- German 65%
- French 25%
- Italian 9%
- Romanche 1%
Introduction
Who?

Acronyms

“HES”
→ applied / engineer universities

“HES-SO”
→ language, G,F,I,R

“HE-Arc”
→ specific region

“ISIC”
→ Specific lab

HES

HES-SO

HE-Arc → school

ISIC → lab

HE-Arc: 500 students

HES-SO: 18k students
Introduction

Where?

Universities of applied science in Switzerland

HES-SO
Introduction
Where?

Locations
HES-SO and HE-Arc

Haute Ecole Arc

HES-SO
Introduction
Where?

Haute Ecole Arc « HE-Arc »

Two sites for me

1. Neuchâtel: teaching

2. St-Imier: « ISIC » lab
Introduction

What?

Industry

99%

Professional A-level

90%

Academic A-level

90%

Ph.D.

HES-SO, M.Sc.
1.5 years

Classic University B.Sc. and M.Sc
successive
3 + 1.5 years

HES-SO, B.Sc.
3 years

Entrance, 1 year

Engineer universities

75%

99%

75%
Introduction
What?

Activities

- Microtechnologies

→ *e.g.* watches

ISIC – St Imier
Introduction
What?

Activities
• Microtechnologies

→ *e.g.* satellites

ISIC – St Imier
Introduction

What?

Activities

• Image processing

• Computer graphics

• Augmented reality

ISIC – St Imier
1. Fundamentals, limits, and an architecture for NVC

1.1 Fundamental concepts & limitations

- A relatively complex subject
- Virtual world, Realities, and Paradigms
- Virtual communities
- Virtual humans and social actors, user and avatars
- Interpersonal communication
- Non-verbal communication (NVC)
- Contextual limitations and constraints
1.1 Fundamental concepts & limitations

Changing paradigm... a relatively abstract topic

Virtual Reality
3D Social Forum
Avatar, agent, and autonomous VHs

Social networks...

3D environments

Sharing information
1.1 Fundamental concepts & limitations

Virtual worlds

⇒ Not the “real” world

⇒ The real challenge is to define what is the reality

“A place where I can do things that I cannot do in the real worlds”…?

She’s in a VW

She’s in the reality
1.1 Fundamental concepts & limitations

Realities
⇒ From reality to virtually
1.1 Fundamental concepts & limitations

Paradigms
⇒ Non trivial conceptualization
- This is not “home”
- Can it become “home”?  
- Humans => social communities

Paradigm shift

Heaven or hell?
1.1 Fundamental concepts & limitations

Virtual community ➔ VE + VHs

Important concepts
1. virtual actors
2. interpersonal com.
3. “communication”
4. real-time constraint

Virtual environment (VE)
Virtual human (VH)
Virtual community
1.1 Fundamental concepts & limitations

Virtual humans

- Avatar
- Agent
- Autonomous agent
1.1 Fundamental concepts & limitations

Social actors

No more simple «users» but active «social actors»

=> individuals attempt to grips with the changing world around them

=> interact with other individuals and social groups

=> Subtle behavior must be managed

Human communication

⇒ Emotionally consistent context

Poor NVC context

Strong NVC context
1.1 Fundamental concepts & limitations

From user to avatar

Real World
- Natural Conversation
- Human reality
- Non-users
- Users

Virtual World
- VR Clients
- VR Server
  1. Event Manager
  2. Emotion Handler
  3. Scene Controller

Virtual human reality
- Avatars
- Agents

Conversation in VR
1.1 Fundamental concepts & limitations

Interpersonal communication

Important studies
- Analyzing subjects with their involved Virtual Environment
- New activities developed during interaction in VR

=> Challenging model: relationship between subject & context

Definition: « a process by which a group of social actors in a given situation negotiates the meaning of the various situation which arise between them »
1.1 Fundamental concepts & limitations

What is «communication»?

Communication as a - natural medium
- VR medium

Non-verbal communication (NVC)

Nowadays virtual world conversation, i.e. text + graphics only

http://www.simplybodylanguage.com/what-is-body-language.html
1.1 Fundamental concepts & limitations

Contextual limitations

To achieve a rendering for NVC

→ limited resources

→ real-time constraints
1. Fundamentals, limits, and an architecture for NVC

1.2 NVC Architecture

- The issue to solve
- VR platform enriched with NVC
- Task to achieve
- From a dialogue to its CG interpretation
- Graphical metaphor of emotion
- General principle
- NVC trigged by emotions
- Message protocol & event management
- First results
1.2 NVC architecture

The issue to solve

On the one hand...
NVC
→ physical events
→ context

...on the other hand
Context events
→ emotional events
→ NVC
1.2 NVC architecture

The issue to solve

- Context
  - Influenced by: Physical events
  - Enriched by: Emotional events

- NVC
1.2 NVC architecture

VR platform enriched with NVC

Orange arrow
- Connection with user sensorimotor channels

Blue arrow
- Control of large numbers of parameters
1.2 NVC architecture

VR platform enriched with NVC

- User/computer control
- Feedback

In a VE, users only live a projection of the virtual reality

=> Impossible full control

Feedback:
- Graphics enriched with NVC
- Representation of another avatar
- Representation of potential agent

User's representation: first person view

Control parameters

User
1.2 NVC architecture

Tasks to achieve

- To design such an architecture => identifying and managing the root parameters
- To ensure the consistency of the model => effort on the heart of this architecture: the emotional model

**Task #1** Designing architecture

=> identify & manage “root” parameters

**Macro PofV. architecture**

**Task #2** “Ensure” consistency

=> effort on the emotional model, dynamics & classifiers

**Micro PofV. heart**
1.2 NVC architecture

From a dialogue to its CG interpretation

Dialogue:
- A: “Hello”
- B: “Hi chick!”
- A: “What? 😞”
- B: “sorry…”
- A: “It’s ok 😊”
1.2 NVC architecture

From a dialogue to its CG interpretation

Dialogue

A: “Hello”
B: “Hi chick!”
A: “What? 😞”
B: “sorry…”
A: “It’s ok 😊”

Associated dialogue: ➡
Emotional correlation: ➡
Emotional computation: ➡
One sentence → one \{v,a,d\} emotion

→ Dynamic emotional model: formal approach

→ Emotional cues parameters: Classifiers

1.2 NVC architecture

Graphical metaphor of emotion

Dialogue

A: “Hello”
B: “Hi chick!”
A: “What? 😞”
B: “sorry…”
A: “It’s ok 😊”

CG animations
- Facial and body emotional interpretations
1.2 NVC architecture

Graphical metaphor of emotion

VR-server/clients

- Emotional model
  - \{v, a, d\}
  - Target
  - Polarity

- Dynamic event manager
  - Multi user
  - Free interaction

- VH emotional mind
  - 3D emo. model \{v, a, d\}
  - Memory based on history of dialogs

Classifiers
- “SuperClassifier”
- “ANEW”

Dialogue

A: “Hello”

B: “Hi chick!”

A: “What? 😞”

B: “sorry…”

A: “It’s ok 😊”

CG animations
- Facial and body emotional interpretations

Psychological lab: experimental guidance
1.2 NVC architecture

General principle

Real world

Users → GUI ← VR-Client(s)

Virtual Environment

Emotional model

VR-Server

CONTEXT

Users: Conversations in VR

Virtual world

VR Server:
1. Event Manager
2. Emotion Handler
3. Scene Controller

Virtual human reality

GUI
1.2 NVC architecture

Our proposal
1.2 NVC architecture

NVC triggered by emotions

One event generates multiple non-verbal events

Each non-verbal event => CG interpretations

Notice that
- Mainly facial expression involved
- Hand and posture play a major role too

1. Event occurs and is noticed
2. Event identified
3. Emotion increases
4. Peek of emotion
5. Potential threat is gone
6. Emotion change from neg. to pos. valence
7. Event now considered as funny
8. Peek of the opposite emotion
1.2 NVC architecture

Event management

- Requested events
- Certified events and induced NVC events
- Server message frame encoder
- Event sorting and event action managers
- Event management
- Server message frame decoder
- Server
- Event management
- Certified events...
- ... sent to all VHs viewing VH:
  - VH change of facial emotion
  - VH full body emotional expression
  - VH change of orientation
  - VH standing still animation
  - VH collision animation
  - VH move forward
  - End simulation
- ... sent to a unique VH:
  - Meet new VH
  - Can see a VH
  - Cannot see a VH
- ... sent to all VHs in VH range
- Client
- User interaction
- GUI
- Rendering management
- Animation management
- Client message frame encoder
- Client event requests
  - Text utterance
  - Move forward
  - Stop moving
  - Rotate
  - Change emotion direct user interaction
- Certificates events and induced NVC events
1.2 NVC architecture

Event management

Server & clients
Main parallel processes
- Communication
- Event management

Server
- Event sorting
- Event action
- Emotional engine

Clients
- User <=> GUI
1.2 NVC architecture

Event management

Server & clients
- Coders / decoders
- Universal & local clocks

Server

Clients
- GUI =>
- Graphics engine

Diagram:
- Process 1 communication
  - User
  - Decoder
  - 3D graphics engine
  - Graphical user interface

- Process 2 event manager
  - 1. event sorting
  - 2. event action
  - 3. emotional engine

- Encoder
- Local clock
- Universal clock
1.2 NVC architecture

Event management

**Server**
- Dynamics event history data set
- Classifiers
- Emotional dynamics
  $\rightarrow \{v,a,d\}$

**Clients**
- Animations
  $\rightarrow$ Bubble
  $\rightarrow$ Lips/talking
  $\rightarrow$ Breathing
  $\rightarrow$ Facial
  $\rightarrow$ Body
- Crowd or self concerned events
Results: potential virtual community
1.2 NVC architecture

Results: NVC and emotion in virtual environment
End of part 1
Questions and short break

Next, part 2:
Defining and parameterizing emotion
2.1 What is emotion and how it has been represented?

- Not to mixed with
“Parameterizing emotion”, an impossible mission?

//\ Not to mix with associating users emotion to their avatar

Realtime Performance-Based Facial Animation
What is « emotion »?

“An emotion is the complex psychophysiological experience of an individual's state of mind...”

“Emotions are very complex experiences...”

Solution
→ Psychological estimations
→ Linguist statistics
(1) Set of emotion

- Try to extract clues for a set of emotion

Models of Emotion
Strategies

Simple set of emotion

- Joy
- Surprise
- Sadness
- Anger
- Fear
- Disgust
(2) Correlated set of emotions

⇒ Main issue: limitation of classification

Correlated set of emotions
(3) Dimensional model

- Offer a seamless emotion from three dimensional emotion space: V. A. D.

- Intuitive interface

Axis range: [-1.0, 1.0]

References

From text and user... ...to emotion

Data mining
- Large text database
- Language classifiers
- Lexical classifiers

*emoFaces*
- VAD to facial expressions

*emoMotions*
- VAD to body motion

Text message → Data Mining → V, A, D values

User input → GUI

Formal emotional model

emoFaces

emoMotions
2.2 Emotional Expressions: *emoFaces* and *emoMotions*

- 27 emoWords and emoFaces
- 27 emoMotions
- 3 animated examples
- From one emotion to another
27 emoWords and emoFaces

Internal emoWords survey
11 subjects from 25 to 43 years old
Derived 27 emotional terms potentially corresponding to the 3D emotional space (VAD)

Designed 27 emoFaces for each emoWord
Use interpolation for real-time use in VAD space
Captured 27 emoMotions for each emoWord

Divide 27 emoMotion area in the VAD space
Captured 27 *emoMotions* for each *emoWord*

Divide 27 *emoMotion* area in the VAD space
Three examples

- Sad/Bored
  - Emotional Motions
  - Neutral valence
  - Low arousal
  - Low dominance

- Sleepy
  - Emotional Motions
  - Neutral valence
  - Low arousal
  - Moderate dominance

- Furious
  - Emotional Motions
  - Negative valence
  - High arousal
  - High dominance
Emotional Expressions in VAD

Changing Valence

Emo-Faces

Furious

Excited

Emo-Motions
Emotional Expressions in VAD

Changing Arousal

Emo-Faces

Bored / Sad

Surprised / Afraid

Emo-Motions
Emotional Expressions in VAD

Changing Dominance

Emo-Faces

Peacefull

Vicious / Suspicious

Emo-Motions
2.3 An Emotional Model

- Making VH More Alive
- Emotional model principle
- Types and flow of Emotion
- Results and discussion
Making VH More Alive

- Breathing simulation
- Lip movement and speech
- Turning head and gaze
- Body movement

Emotional Model

Turning head and gaze

Lip movement

Breathing simulation

Body movements -- especially hands
Emotional model principle

Emotional wave

Distance from center of the emotional cube to any current \{v,a,d\} emotional coordinate

- Dynamic threshold for potential change of facial expression
- Dynamic threshold for potential full-body emoMotion

Facial expressions occur
- “▲”: change of facial expression becomes possible
- “▼”: full-body emoMotion becomes possible

VR-server interruption time step (e.g. hundreds of milliseconds)
- “●”: VR-server calls potential facial expression
- “●”: VR-server calls full-body emoMotion
Types of Emotion

STE: Short Term Emotions
LTE: Long Term Emotions
IPE: Inter-Personal Emotions

Let’s the valence, arousal, and dominance \textbf{flows} be $F_v, F_a,$ and $F_d$

Three fields ($h$)

$h_{ii\pm}$: self field
$h_{ij\pm}$: discussion field
$h_{i\pm}$: personal field

\[
F_v(v_i, h) = (\alpha h_{ij+} + (1 - \alpha)h_{ij-})(b_0 \text{sign}(v_i) - b_3 v_i^3) + \beta_v(h_{iiv} - v_i)
\]
\[
F_a(a_i, h) = ((1 - \mu)h_{ij} + \mu h_i)(d_0 - d_1 a_i) + \beta_a(h_{ii\alpha} - a_i)
\]
\[
F_d(d_i, h) = g_+ h_{i+} - g_- h_{i-} + \beta_d(h_{ii\alpha} - d_i)
\]

Results from the European CYBEREMOTIONS grant 7th framework program, main contribution from the ETHZ WP
Results

Control discussion and personal fields
Thanks! 😊
Questions / discussion
Thanks! 😊

Questions?

Main references:

- An Event-based Architecture to Manage Virtual Human NVC in a 3D Chatting Environment
  Stéphane Gobron¹² & Junghyun Ahn¹
  David Garcia³, Quentin Silvestre¹, Daniel Thalmann¹⁴, Ronan Boulie¹

- An NVC Emotional Model for Conversational Virtual Humans in a 3D Chatting Environment
  Junghyun Ahn¹ & Stéphane Gobron¹²
  David Garcia³, Quentin Silvestre¹, Daniel Thalmann¹⁴, Ronan Boulie¹

Original works presented at:
AMDO 2012, 11~13 July, Spain