Sensor Based Augmented Reality

Affective Interaction: Event Driven Sensors Applicability And Integration in Real, Virtual And Augmented Reality Scenarios.

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Overview

- Introduction to the research theme
- Related work relevant for this stage of work
- Scientific contributions
- Proposed achievements and current results
- Deviations and work plan updates
Introduction: AR and Sensors

Augmented Reality (AR): Represents a variation of Virtual Reality

- It “Enhances” real-world experience, and uses digital illusions.
- **Used in several areas**: Medicine, Architecture, Etc.

Virtual Reality (VR): Completely immerse a user inside a synthetic environment.

**Sensors:**

- Are **Devices** that detects and responds to some type of input from the physical environment.
- **Measure a physical quantity** and converts it into a signal which can be read by observer or instrument.
- There are several types of sensors: **orientation** (eg: accelerometer), **location** (eg. GPS), **biosensors** (eg. ECG), etc.

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2015-06-19
AR already uses Sensors such as:

- Cameras.
- Accelerometers.
- Gyroscope.
- Proximity.
- GPS, etc...

New Sensors becomes available:

- Less intrusive.
- Less expensive.
- Allows measurements of physiological signals more naturally.
- Allows automatic extraction of emotional states indicators from users signals.

THE CURRENT NEEDS:

- Adapt in a more coupled and natural way the AR environment to users:
  - Using signals and emotional status [1-2].

- Extend the concept of adaptive interface into AR
  - Examples applied to:
    - Therapy Exposures [3-5].
    - Game Development [7,20].
Introduction

Objective

WHAT?
Based on the current needs and opportunities, we will:

- **Extend** the already existent concept of adaptive AR interfaces, using emotional state indicators extracted automatically from physiological signals.
- **Develop a System** capable of controlling problem and propose actions based on events:
  - Events are controlled by parameters.
  - Evaluation measured based on successive baselines evolution.
- **Map** Events of Sensors in events of AR.
- **Build a System** which will allow:
  - User Friendly interface.
  - Generic and extensible modules.
  - Easy access to Config parameters.
  - Visualization of evaluation results.

THERE ARE OTHERS WITH SIMILAR IDEAS BUT STILL UNIMPLEMENTED...
Erick [8], Bradly [9] and Simona [22] already support this kind of integration, but in a unstructured and fixed way, with single script session and with a single emotional state.

Example:
- AR Applied to Exposure Therapy In Anxiety Disorders and Phobias Treatments.
Introduction

WHY?

**Therapy Exposure Scenario:** Conduct Study with patients suffering of Phobia diseases.

- The Patient is subject to **test in a controlled environment**.
- A **Baseline session parameters are defined**, with patient current health or emotional status. The parameters can be of: **Session Time and Elapsed, Object Location and Height, Distance, etc.**
- The **actions protocols** can take in consideration: Introduce more models, more speed, more height, more sound, more images, etc.
- The **Patient starts a predefined session**.
- The **sessions are controlled and monitored by therapists**, based on ranged values called thresholds.
- The **Patient Emotional States are increased or reduced based on triggered events**.
- The **Events depends on data coming from Physiological Sensors**.
- At the end, the **statistics will determine the Patient overall emotional and mental status** in terms of health progression.
- **Next session is started with values adjusted on previous sessions and therapy progressions.**

**Game Development Scenario:** Conduct Study with Game Development Area

- Access overall **performance for game integration and interaction** when using Physiological Sensors.
- **Extra capabilities when developing immersing reality applications.**

**Examples:**

- During therapy, **increase or decrease spiders** according to patients emotional status (**relaxed** or **stressed**).
- During game, **increase or decrease enemy's** according to player emotional status (**coward** or **hero**).
Introduction

Objective

**IMPLICATIONS?**

**Interface:**
Making an interface more adaptive, imply creating rules to relate **INPUTS** from users and **OUTPUTS** from applications [6].

**AR:**
Applied to AR, It is more complex because of various realities and dimensions involved, such as: Real, Virtual, Augmented, and Sensorial [6].

**SESSION SCRIPTS (PROTOCOLS in therapy):**
Allow different treatments and different outcomes [Table 1] in VRET [10].

![Fig.5 – Typical AR System Framework](image)
## Introduction

### Objective

The Exposure Treatments follows some protocols and outcomes to control therapy sessions.

### Outcomes [10]:

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Clinical sample</th>
<th>Design</th>
<th>Condition (N)</th>
<th>No. sessions</th>
<th>Primary outcome measure</th>
<th>Post assessment</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emmelkamp et al.</td>
<td>10</td>
<td>Acrophobia</td>
<td>Within-subjects design</td>
<td>VRET (N = 10)</td>
<td>2</td>
<td>AQ</td>
<td>VRET = In Vivo</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In Vivo Exposure (N = 10)</td>
<td>2</td>
<td>ATHQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emmelkamp et al.</td>
<td>33</td>
<td>Acrophobia</td>
<td>RCT</td>
<td>VRET (N = 17)</td>
<td>3</td>
<td>BAT</td>
<td>VRET = In Vivo</td>
<td>6 months, stable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In Vivo Exposure (N = 16)</td>
<td>3</td>
<td>AQ</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Krijn et al.</td>
<td>37</td>
<td>Acrophobia</td>
<td>RCT</td>
<td>VRET: HMD (N = 10)</td>
<td>3</td>
<td>BAT</td>
<td>HMD = CAVE &gt; WL</td>
<td>6 months, stable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VRET: CAVE (N = 14)</td>
<td>3</td>
<td>AQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>WL-control (N = 11)</td>
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<td></td>
<td></td>
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<tr>
<td>Krijn et al.</td>
<td>26</td>
<td>Acrophobia</td>
<td>Crossover design</td>
<td>VRET + VRET CSS (N = 14)</td>
<td>4</td>
<td>AQ</td>
<td>VRET = VRET CSS</td>
<td>6 months, stable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VRET CSS + VRET (N = 12)</td>
<td>4</td>
<td>ATHQ</td>
<td></td>
<td></td>
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<tr>
<td>Krijn et al.</td>
<td>59</td>
<td>Fear of flying</td>
<td>RCT</td>
<td>VRET (N = 30)</td>
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<td>FAS</td>
<td>VRET = CBT</td>
<td>No</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>CBT (N = 23)</td>
<td>2-4</td>
<td>FAM</td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Bibliotherapy (N = 19)</td>
<td></td>
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</tr>
</tbody>
</table>

*Treatment A is equally effective as treatment B.

\[N\] per condition estimated; VRCBT, virtual reality cognitive behavior therapy; MS, motion simulation; APGT, attention placebo groups therapy; WL-control, waiting list control; FU, follow-up; VRET CSS, virtual reality exposure therapy plus cognitive self-statements; AQ, Acrophobia Questionnaire; ATHQ, attitude towards Heights Questionnaire; BAT, behavioral avoidance test; FAS, Flight Anxiety Situations Questionnaire; FAM, Flight Anxiety Modality Questionnaire; FHF, flying history form; FFS, Fear of Flying Scale; GFFQ, General Fear of Flying Questionnaire; QATF, Questionnaire Attitude Towards Flying; LSAS, Liebowitz Social Anxiety Scale; SSPS, Self-Statement Questionnaire during Public Speaking; FNE, fear of negative evaluation; PDSS, Panic Disorder Severity Scale; ASI, Anxiety Sensitivity Index; FQ, Fear Questionnaire (Agoraphobia Subscale); PBQ, Panic Belief Questionnaire; ACQ, Agoraphobic Cognitions Questionnaire; BSQ, Bodily Sensation Questionnaire; AQ (I), Agoraphobia Questionnaire; Al, Agoraphobia Index; CAPS, Clinician Administered Posttraumatic Stress Disorder Scale; IES, Impact of Event Scale; BDI, Beck Depression Inventory; EEG, electroencephalograph; BWM, brain wave measurements; RR, respiration rate; SR, skin resistance; HR, heart rate; ST, skin temperature.

![Table 1 – Overview outcomes studies VRET [10].](image_url)
Introduction

How?: Worlds, Events & Integrators

REAL  VIRTUAL  AUGMENTED  MARKER

Problem  Trigger an Event  Action

Fig.6 – Different Realities

Fig.7 – Event Driven System: Problem vs. Action

Sensors Integration using Physiological Signals:

- EDA (Electrodermal Activity) – Relates to Skin Conductivity.
- ECG (Electrocardiogram) – Relates to Heart Activities.

Both Sensors are used cooperatively to monitor Emotional States.
Relevant Related Work
AR Exposure System

Augmented Reality (AR)

- **Exposure therapy [1-2]:** Exposure for Immersive, Adaptive and Reactive Augmented Reality.
  - Interactive AR, Natural Feature Tracking, Gesture recognition

- **Cyber therapy [21]:** Different approaches of AR applications in adaptive therapy and interaction systems.

Virtual Reality (VR)

- **Exposure therapy [3-5]:** Exposure for phobias, Therapy for anxiety and specific phobias, and Therapy for anxiety disorders.

Augmented Reality based exposure therapy system for phobia treatment:

- Allows patients to see virtual fear stimuli overlaid onto the real world and to fully interact with them in real time.

- Create a controllable and interactive system with a visually realistic context through:
  - Gesture Recognition
  - Physiological Sensors

- As a life-like system, allows full parameterization over stimulus intensity and other factors necessary for an effective exposure therapy system.
Relevant Related Work

Benefits of AR Exposure System

- According to Choy et al. [13] exposure therapy is a very effective treatment for specific phobias.

- According to Cote et al. [3] exposure therapy can be challenging and expensive to provide appropriate therapeutic stimuli as a result of:
  - Patients confronted with intense fear inducing situations.
  - So many people not seeking for treatment.
  - People refusing treatment.

- Although, according to Hoffman et al. [14], immersive virtual reality (VR) systems were found to be effective for exposure therapy:
  - They separate users from the real world.
  - He studied the addition of real elements to a VRET system by using a real toy spider that provided tactile feedback, and found that VR plus tactile augmentation was more effective than VR alone.
  - Therefore, being able to physically touch the virtual fear stimulus increased the degree of realism, the sense of presence, and the experienced anxiety during treatment.

- More recently, according to Azuma et al. [15], Milgram et al. [16], and Juan et al. [17], AR systems:
  - Provide either direct or ‘mediated’ perception of the real environment, real artifacts and our own bodies.
  - May increase ecological validity and effectiveness of virtual exposure treatment by embedding virtual fear stimuli directly into the real environment.
Relevant Related Work
AR Exposure System Composition and Open Issues according Andreas et al. [1,2]

AR System uses:

- A basic hardware and software setup with clients wearing a head mounted display with an attached USB camera to track AR markers (Kato et al. [18]).

- Virtual 3D models of fear stimuli are overlaid on top of these markers and animated with predefined basic motion.

<table>
<thead>
<tr>
<th>Disadvantage</th>
<th>Benefit</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>The use of visual markers for tracking. This gives the patient, a clue that a fear stimulus is going to appear at particular position.</td>
<td>Allows patients to use real objects or their Hands to interact with the stimuli [11]. However, this type of interactivity has so far not been implemented in AR based exposure therapy (ARET) systems.</td>
<td>Juan et. al. [16] used special ink that was only visible to a camera sensitive to infra-red light, but there were are no evaluation results presented using this system So far.</td>
</tr>
<tr>
<td></td>
<td>AR technology as a basis for an exposure therapy system are very promising.</td>
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<tr>
<td></td>
<td>AR affords interesting opportunities to create unique therapeutic environments by letting clients interact with virtual fear stimuli in the real world.</td>
<td></td>
</tr>
</tbody>
</table>
Relevant Related Work

Andreas et al. Conceptual Architecture [1,2]

Current System: osgART + OPIRA [11-12]

- **Is a C++ cross-platform development library** that simplifies the development of Augmented Reality or Mixed Reality applications.

- **It combines computer vision based tracking libraries** (e.g. ARToolKit, ARToolKitPlus, SSTT) with the 3D graphics library OpenSceneGraph.

- **Is a mature and widely-used rendering library.**

- **Based on OpenGL**, it provides a high-level interface to low-level OpenGL calls, and adds a comprehensive set of features to enhance performance and streamline development.

- **Performance is enhanced** through various culling and optimization techniques.

- **Development is simplified through cross-platform support**, windowing support, image and model loaders, and utility classes for all manner of scene-graph related activities.
This Thesis Goal
Extended Conceptual Architecture

Current System:
- Does not allow Sensors reading and Events mapping in AR.

Integrated System:
- Allows Sensors reading and Events mapping in AR.
- Allows parameters definition for Events (thresholds for triggers to fire up).
- Allows recording of Session Data.
- Allows Visualization of historical Data.

Events Mapping Module:
- Captures Sensors Data and interacts with the AR System, based on triggers fired from already defined parameters.
- Data captured from Sessions, are returned for further analysis and evaluation. It imply baseline redefinition for next sessions.
- Visualization of sessions is allowed, based on historical data kept during the sessions.

Fig.7 – Event Driven System: Problem vs. Action
Original Knowledge and Practices to the area of Augmented Reality and HCI.

Create a generic and reusable software platform that:

- Extend the already existent concept of adaptive AR interfaces, using emotional state indicators extracted automatically from physiological signals
- Structure the relations between sensorial events and AR events

Create applications that allow demonstrate results in the domain of exposure therapy.
Proposed Achievements and Current Results

Progress

- **Activity 3: Analysis Phase (March 1, 2015 – April 30, 2015)**
  - Expected achievements: Technical Analysis of AR, Sensors and Frameworks; Prototype
  - Expected publications: 1 workshop publication, and 1 technical report

- **Current Results:**
  - Technical Analysis of AR, Sensors and Frameworks
  - 1 Workshop publication

- **Status:** Still Ongoing

- Due to the feedback received from jury the original plan has suffered significant alterations, to accomplish this I had to accomplish the following steps:
  - Problem redefinition
  - Related Work research
  - Exposure AR Framework research
  - AR Framework Research
Deviations and Work plan updates

• Comparison between the proposed success indicators and current achievements:
  • The prototype was not build, because there was an adjustment regarding the work focus.

• Work under review and to be submitted:
  • Expected to publish a paper and technical report.

• Achievements, which were not planned and happened during the course of this work
  • Redefinitions of concepts associated to Related Work focus. To prove the concept It was necessary to define one specific area of study. The selected area is related to “Affective Interaction” with Sensors integration in the context of Augmented Reality (AR). The integration is based on Events and Action (active triggers).

• Plan dates must be reviewed.
Questions?
References


[6] Thomas D. Parsons et al.; “Neurocognitive and Psychophysiological Interfaces for Adaptive Virtual Environments”; University of Southern California, USA


The End

Thank You...

☺