Game Over!
On measurement and optimization of presence

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Abstract

With reality and ICT blending, we live in a Computer Aided Reality (CAR). Nevertheless, we still have the feeling that we can distinguish between reality and artificial realities. This notion yields the question: When do humans experience reality as computer aided (or artificial)? This article contributes in answering this question by i) adopting the construct presence and discuss its value to assess users' experienced reality; ii) providing suggestions on how to measure presence via biosensors; and iii) presenting a low fidelity research setup to assess users' presence in CAR.

Introduction

The influence of ICT on our society shows a constant, monotonic increase. It is hard to calculate its impact, as it changes and interacts with virtually all of society's aspects. Nevertheless, its influence is undeniably there. One of its manifestations is virtual worlds and, in particular, Virtual Reality (VR), which have been promising for over 20 years. Regrettably, up to the start of this decennium, due to their technical complexity and cost, VR has never made it to the general public [1]. However, throughout the last years several low cost technologies have been introduced that can help to alter reality: Microsoft's Kinect provides a low cost object tracking device [2]; Oculus Rift provides a Virtual Reality headset (or Head Mounted Display, HMD) for 3D gaming[1]; and Jaguar's Virtual Windscreen[2] provides advanced augmented reality for their cars. Moreover, low cost high-level programming languages such as 3D Studio Max (Autodesk, Inc.) and Quest3D (Act-3D B.V.) enable the generation of virtual worlds [3].

Recent ICT progress yields the question: *When do humans experience reality as computer aided (or artificial)?* Measuring behavior in reality is already well studied, mainly in social and behavioral sciences. However, behavior is less studied in Computer Aided Reality (CAR) [4,5] and, consequently, a comparison cannot be made in a straightforward manner. Most often the construct presence is used to indicate user's experience in CAR. Therefore, we want to develop a measurement technique to determine the users' presence, in any reality, including CAR. This would provide us with a measurement tool to determine the distance in users' experienced presence between a CAR and everyday life's reality.

What is it that we call reality?

In Book VII of *The Republic*, dated 360 B.C., Plato describes his allegory of the cave. He questions our reality, which could as easily be an illusion. This touches upon the foundations of philosophy and physics; but also on what we now denote as CAR. Both traditional branches of science question axioms that are often taken for granted. With ICT's progress, one can question what axioms can be maintained in a CAR, where all that seems to matter is what

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[1] URL: http://www.oculusvr.com/ [Last accessed on July 17, 2014]

[2] URL: http://www.digitaltrends.com/cars/jaguars-virtual-windscreen-turns-real-life-into-a-video-game/ [Last accessed on July 17, 2014]

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we experience. So, with the current technology push, Plato's work is perhaps more timely than ever. For the interested reader, see also Kant's work on analogies of experience [6].

Here, we will illustrate basic notions such as mentioned above and illustrate their use in daily practice. To limit the scope of the basic notions and bring it to engineering practice, we define CAR: any reality that is partially generated, designed, or altered via information, computing, and/or communication technology. CAR can interact either passively (e.g., as in a movie or virtual tour) or actively (e.g., biofeedback or augmented reality). Either way, it is perceived by at least one of our senses (not necessarily vision). It includes VR, virtual worlds, and games but also mixed reality, augmented reality, and reality itself (in particular, as envisioned by Ambient Intelligence, AmI).

Presence (and immersion)

The term presence is often interchangeably used with the term immersion. According to Slater et al. [7] presence and immersion describe two different concepts. Immersion refers to a quantifiable set of technological properties, whereas presence refers to a user's subjective state of consciousness. With a high sense of presence, judgments about a product's design can be considered more valid and reliable. Whether a user feels present in a CAR depends on a large number of factors. Presence is affected by the technological, immersive aspects of the CAR and the personal characteristics of the individual [7; cf. 8,10].

Slater et al. [7] stated that the immersive character of CAR (e.g., VR and games) is determined by the:

- number of sensory systems (in particular vision, sound, and touch),
- extent that information is provided from any direction,
- extent that external noise is excluded,
- correspondence between the user's behavior and the system's feedback, and
- degree of sensory richness - or realism.

The variables associated with these technological characteristics that define the level of immersion include the field of view, perceptual realism, multimodality, free control of actions, and digital representation of the body. Variables associated with the individual that make up the user's experienced presence include motivation, ability, willingness, flow, and prior experience, amongst others [7,9]. The former set of variables are defined by the system's technical specification. The latter set of variables is harder to pinpoint.

Between realities: Closing the gap

There is no single, accepted paradigm for the assessment of presence [4]. Often the approach is twofold: subjective measures and objective corroborative measures (e.g., posture and physiological responses). Various questionnaires have been introduced and nearly all showed to be useful. In contrast, corroborative measures have been used little and, so far, have not shown to be reliable. Consequently, mainly questionnaires are used [4,5]. However, these questionnaires only suffice for offline, post-hoc research or, alternatively, users' sense of presence is interrupted to ask users to complete them, which should be prevented.

There are two traditional approaches in tackling the behavioral measurement problem of capturing user's presence: i) data driven: continuous autonomous feedback mechanisms and ii) knowledge driven: a nomological model on presence. On the one hand, we adopt the data driven approach in our effort to capture user's sense of presence. For this goal, we can use biosensors to capture users' sense of presence as it suits a well-established continuous autonomous feedback mechanism for various domains and applications and biosensors can be embedded in various products [10,11]. On the other hand, we aim to add knowledge to the theoretical framework of presence. For this approach, we suggest to explore four theoretical frameworks:

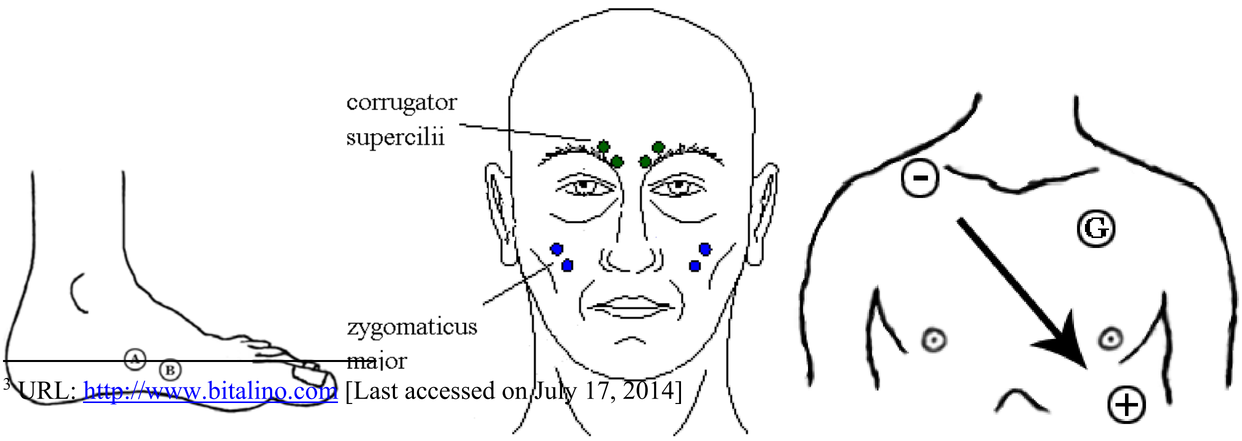
1. Csikszentmihalyi's Flow-theory: The psychology of optimal experience [9,12];
2. Russel's arousal, valence, and dominance model [8,11];
3. Ekman's discrete, basic emotions [8,13]; and
4. Silvia's appraisal theory of interest. "This suggests a sweet spot of interest, where information that is novel and complex but still comprehensible." [12].

Each of these four theoretical frameworks is established but, simultaneously, debated [14] and includes constructs related but different from presence. Riva et al. [13] describe "a circular relation between presence and emotions: on the one side, the feeling of presence was greater in the 'emotional' environments; on the other side, the emotional state was influenced by the level of presence". Baños et al. [15] reported similar conclusions, although they also reported an interaction effect between emotion and immersion on presence. However, their experimental sample sizes were small, emotion and presence were solely assessed by questionnaires, and Riva et al. [13] only tested two emotional states. The question is how the four frameworks and the affiliated empirical evidence relate to each other and how much of the recorded variance on the construct presence they can explain. To enable cross-validation of the continuous autonomous feedback mechanism, existing, validated presence questionnaires will be used.

Unveiling the level of presence: Methods and apparatus

Riva et al. [13] and Baños et al. [15] unveiled a relation between emotions and presence. However, their results seem to suggest that emotions fulfill a mediating role in user's experienced presence. Either way, biosensors can be employed to determine emotions [8,9,10,11,13] and, consequently, can provide valuable information on experienced presence. We used the low cost, modular, wearable BITalino[3] sensor kit to measure biosignals (sample rate: 1000 Hz; 10-bit/6-bit; Class II Bluetooth v2.0 data transmission) [16]. For details on the BITalino sensor kit, see their website and [16].

Emotion is decomposed in its two main dimensions: arousal and valence [8,10,11,15]. Arousal is assessed using ElectroDermal Activity (EDA), recorded midway between the proximal phalanx and a point directly beneath the ankle to prevent motion artifacts [17]. Valence is assessed using facial ElectroMyoGraphy (fEMG) of the corrugator supercilii and zygomaticus major [11]. ElectroCardioGraphy (ECG) is recorded, using the modified Lead II placement, which can unveil information concerning both dimensions [8]. With all these sensor that record these signals, with each participant a new set of standard pre-gelled, self-adhesive, disposable electrodes was used. The placement of the electrodes for each of the signals is shown in Figure 1. Additionally, a LUX light sensor was placed on the PC's TFT screen for the synchronization between the PC and the BITalino sensor kit.



[3] URL: http://www.bitalino.com [Last accessed on July 17, 2014]

Figure 1. Positioning of the electrodes. From left to right, the electrodes for electrodermal activity on the foot (adapted from [17]), facial electromyography of two muscles (adapted from [18]), and the modified Lead II placement for electrocardiography (G denotes the ground ground electrode).

Figure 2. Left: Screenshot of the game, where a weapon bought disappeared. Right: A four-dimensional Likert scale questionnaire to assess the emotional state of the player, as was prompted after each of the three games.

Instead of an expensive full fetched and expensive VR environment (e.g., a CAVE [1]) or an obtrusive apparatus such as Oculus Rift[1], we have chosen a game as our test bed. The game Call of Duty: World at War (i.e., a first-person shooting game) [19] is used to assess users' presence when playing it. To assure an optimal immersion, frame rate was set on 30 fps with high quality graphics to maximize the visual realism [3]. In the game's zombie mode, the goal is to survive as many waves of enemy zombies as possible. With every passing wave, the number and speed of opposing zombies increases. The incremental nature of the difficulty level is in line with Csikszentmihalyi's theory of flow for the optimal experience (mostly for beginning players) [9] and, hence, is expected to be a viable candidate for measuring presence. The acceleration in difficulty was increased with 75% per wave of zombies, compared to the original settings. This limits the playing time of advanced players and, more importantly, assures users to allocate sufficient workload and attention to the game and, hence, to increase the chance on a sufficient level of presence. Additionally, the game was altered in various ways to force a, so called, break in presence (BIP) [7]. A BIP is defined as a transition in response patterns from virtual to real [7]. These adaptations included unexpected teleportation, disappearing of weaponry, and a change of type of symbols used in the game; see also Figure 2, left. The orders of execution of these adaptations were experimentally controlled. No further adaptations to the game were made. Each of the participants both played the game and, subsequently, answered four questions. five times; see also Figure 2. Hence, essentially, the participants were able to play the game without any constraints.

Conclusions

Reality is altered by ICT. In practice, we are already living in a Computer Aided Reality (CAR). Traditionally, CAR was considered to be a virtual world, a game, VR, or something related. However, with reality and ICT blending (creating AmI or the Internet of Things) and a strict separation of both becomes more and more impossible, this division seems to lose its usefulness [cf. 6,8]. This raises attention to Plato's question [cf. 6]: What is reality? However, nowadays, the more interesting question is: When is reality experienced artificially? To answer this question, we pose to use the construct presence [4,5,7] and exploit its relation to emotions [13,15]. This article contributes in answering this question by i) discussing the complexity of the constructs reality and presence; ii) provide concrete suggestions on how to measure presence; and iii) presenting a low cost, modular, wearable research setup [16] to assess user's level of presence in a gaming environment [19]. This approach can be easily extended to other CAR (e.g., augmented reality) and with the use of other (embedded) biosensors.

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