Impossible outside Virtual Reality

Dr. Mar Gonzalez-Franco

Extended Perception, Interaction & Cognition (EPIC) Research Group

Microsoft Research
June 4th 2020

https://www.microsoft.com/research/people/margon/
Twitter: @twi_mar
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Abtahi, et al. (2019) I'm a giant: Walking in large virtual environments at high speed gains ACM CHI

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Let’s build systems that interface with reality

Immersion Mixed Reality for Manufacturing Training

M Gonzalez-Franco, R Pizarro, J Cermeron, K Li, J Thorn, W Hutabarat, A Tiwari, P Bermell-Garcia

FPV Drone navigation in VR

Modified DJI S900 hexacopter (right) with the stereo camera and the Tegra TK1 embedded board attached (left). 28–30 frames per second encoding speed at 1,600 × 1,080 resolution per camera/eye

Let’s build systems that interface with reality.

Complex system

- Dynamic
- Priors + Pathways
- Errors + Corrections
- Concurrent stimuli of different type
Trick the brain
Sensory Expertise
Multisensory Integration
Multisensory Integration

Input = $d_1 r_1 + d_2 r_2$

$d_i$: synaptic ('input') weights

Output of single neuron:

$R_c = A_1 R_1 + A_2 R_2$

$A_i$: neural ('output') weights

Psychophysical estimate:

$\hat{S}_c = w_1 \hat{S}_1 + w_2 \hat{S}_2$

$w_i$: perceptual weights (optimally, $w_i = 1/\sigma_i^2$)

Fetsch et al. (2013)
Nature Rev. Neurosci
Cognitive Latency to measure VR system latency


https://github.com/microsoft/Microsecond-Arduino-Latency-Clock
Visual dominance + 3D audio


Coordinate response measure (CRM) corpus

LIP CONDITIONS
Synch 14 % errors
Async 30% errors
NoLips 20% errors

Visual dominance
Recalibration of 3D Audio

Generic HRTF might be enough in Virtual Reality.
Improving source localization through cross-modal plasticity

C C. Berger, M Gonzalez-Franco*, A Tajadura-Jiménez
D Florencio, Z Zhang

Rethinking GPS Navigation: Creating Cognitive Maps Through Auditory Clues

Gregory D. Clemenson, Antonella Maselli, Alex Fiannaca, Amos Miller, Mar Gonzalez-Franco*

Microsoft Research, margon@microsoft.com

Using Voice Coil Actuators (VCA)

we can stimulate different strengths
The Uncanny Valley of Haptics

C C Berger, M Gonzalez-Franco*, E Ofek, K Hinckley
Microsoft Research
Our exploration with controllers in VR brings to the conclusion that we can reach an uncanny valley of haptics.
Let’s build systems that interface with reality.


Let’s build systems that are impossible in reality.

Let’s build systems that interface between the brain and reality.
McDuff, Hurter & Gonzalez-Franco (2017)
"Pulse and Vital Sign measurement in mixed reality using a HoloLens" ACM VRST
Mise-Unseen

using eye tracking to hide virtual reality scene changes in plain sight

sebastian marweckí, andrew d. wilson, eyal ofek, mar gonzalez franco, christian holz

1 microsoft research, redmond, wa, usa, 2 hasso plattner institute, university of potsdam, germany

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Feeling touch outside of the body

We reproduce the cutaneous rabbit illusion in VR

Motor Coin Vibrator

60ms  800ms  60ms  80ms  60ms

L1  REAL TAPS  L2

equal tactile strength

L1  L2

Microsoft
Perceived Location of the Tap

ONLY HAPTIC

HAPTIC + VISUAL

HAPTIC + VISUAL (TIMING REVERSE)

Median Location Density

* Significant difference
p<0.01

Tap
1
2
3

L1
L2
L1
L2

T1 800ms
T2 80ms
T3

T1 800ms
T2 80ms
T3
Delusions of the perceptual system

- Our brain will believe the stimuli to be real when exposed to congruent inputs
- Under correct stimulation we can affect our own body experience
Bodily illusions on avatars


EVENTLab – Universitat de Barcelona
Background

Embodiment illusion

- Normally when we have direct control (agency) of the avatar we experience embodiment: “A 1 to 1 substitution of our body”.

- Research has shown that embodiment can alter motor behavior in different ways

- Is there a common mechanism that underlies some of these motor compensations?
Sense of Body Ownership

Gonzalez-Franco et al. A threat to a virtual hand elicits motor cortex activation. Experimental Brain Research (2014)
A threat to the Virtual Body

Gonzalez-Franco et al. A threat to a virtual hand elicits motor cortex activation. Experimental Brain Research (2014)
Sense of Agency

Disrupting the sense of agency of the VB

Error Monitoring Models. Motor Control

[Image: Diagram of the Internal and External Error Monitoring Loops]

[First Person Perspective]

[References: Gallagher 2000, Frith et al. 2000]

Beyond electrophysiology: questionnaires


We have identified 6 main types of questions that are present depending on the experimental setup:

1. **Body ownership.** Present whenever there is a substitute body or body part. It is possible to have body ownership over a body that participants feel is not in the same location as their own body.

2. **Agency and motor control** of the body. Present whenever there is motion tracking and the participant can move parts or all of the virtual body.

3. **Tactile sensations.** Present whenever there is tactile or haptic stimulation to enhance the embodiment illusion.

4. **Location of the body.** Present whenever there is a substitute body or body part that is either collocated or not collocated with the participant. Participants must feel that their body is in the same location as the virtual body in order to experience an embodiment illusion. Participants may sense an out-of-body effect, or that the location of their body has drifted toward the location of the avatar. These questions are often only asked when the avatar is not collocated with the participant.

5. **External appearance.** Present when the self-avatar is a look-alike avatar or as control questions when there are shape, gender, race, clothing, or other visual modifications to the avatar different from the self.

6. **Response to external stimuli.** In many occasions during the experiment there is an event that modifies or threatens the body or body parts of the self-avatar.

Analyzed 30 famous experiments and extracted 25 questions

https://notebooks.azure.com/margon/projects/EmbodimentQuestionnairePCA
We have an implicit need to fill the spatial gap between the physical and the self-avatar bodies, whenever the system allows for these types of compensation. That is the self-avatar follower effect.

*If we drift the avatar, the user will try to compensate*
I'm a Giant: Walking in Large Virtual Environments at High Speed Gains

Parastoo Abtahi\textsuperscript{1,2}, Mar Gonzalez-Franco\textsuperscript{1}, Eyal Ofek\textsuperscript{1}, Anthony Steed\textsuperscript{1,3}

\textsuperscript{1}Microsoft Research, \textsuperscript{2}Stanford University, \textsuperscript{3}University College London

Abtahi, et al. (2019) I'm a giant: Walking in large virtual environments at high speed gains ACM CHI
Embodiment in Robots

Kishore, Gonzalez-Franco et al. MIT Presence Teleoperators (2014)
Embodiment increases haptic experiences

Many Individual Differences in Embodiment across participants

Gonzalez Franco, et al. (2019) Individual Differences in Embodied Distance Estimation in Virtual Reality IEEE VR
Enfacement
No N170 differences: same class of object

P200/N250 250-300ms self-recognition

Gonzalez-Franco et al. 2016. The neurological traces of look-alike avatars
Frontiers in Human Neuroscience
Self-recognition on Avatars

Gonzalez-Franco et al. 2016. The neurological traces of look-alike avatars
Frontiers in Human Neuroscience
Enfacement on Avatars

Enfacement on Avatars

Avatar BEHAVIOUR
Place Illusion

Presence Illusion

Plausibility Illusion

REALISTIC BEHAVIOR

Sanchez-Vives & Slater Nat Neurosci 2005

Meehan et al. Siggraph 2002
One common trait of repressive governments or laws is the emergence of an organized resistance, often involving high-ranking officials and civil figures who aren’t keen on obeying their leaders.

clear evidence of a kind of disobedience among our participants. They did not enter an “agentic” state, blindly and carefully carrying out the orders of the experimenter, as executioners of harmful behavior. Instead they fit more the profile of an “engaged follower,” someone who apparently engages but nevertheless tries to get around the specifics of the orders. Essentially, they were disobeying or quietly resisting while appearing to follow orders.
Participant concerns for the Learner in a Virtual Reality Replication of a Milgram Obedience Study

Gonzalez-Franco, M., Slater, M., Birney, M., Swapp, D., Haslam, S.A. & Reicher, S.D.
Virtual Reality Makes Avatars More Important Than Ever

Immersing yourself in an alternative universe is VR's selling point. But how do the avatars that populate these worlds impact our experiences and our behaviour?

By Emily Reynolds
Microsoft Rocketbox
library of rigged avatars free for academic and research use

https://github.com/microsoft/Microsoft-Rocketbox

Gonzalez-Franco, Ofek, Pan, Antley, Steed, Spanlang, Maselli, Banakou, Pelechano, Orts Escolano, Orvahlo, Trutoiu, Wojcik, Sanchez-Vives, Bailenson, Slater, and Lanier. Frontiers in VR (in review) "Importance of rigging for procedural avatars. Microsoft Rocketbox a public library."
Thanks!

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Eyal Ofek
Ken Hinckley
Mike Sinclair
Andy Wilson
Amos Miller
Jaron Lanier

External Collaborators

Tabitha Peck
Laura Trutoiu
Mel Slater
Max Di Luca

Visitors

Christopher Berger
Gregory Dane Clemenson
Antonella Maselli
Anthony Steed

Interns

Parastoo Abtahi
Jaeyeon Lee
Brian Cohn

Baihan Lin, Rob Kovacs, Karan Ahuja, Sebastian Marwecki, Ryo Suzuki

Ana Tajadura, Zhengyou Zhang, Dinei Florencio, Nikolai Smolyanski, Antoni Rodriguez-Fornells, Dalila Bourin, Domna Banakou, Nuria Pelechano, Sergio Orts, Ye Pan, Bernhard Spanlang, Daniel Perez Marcos, Bigna Lenggenhager
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