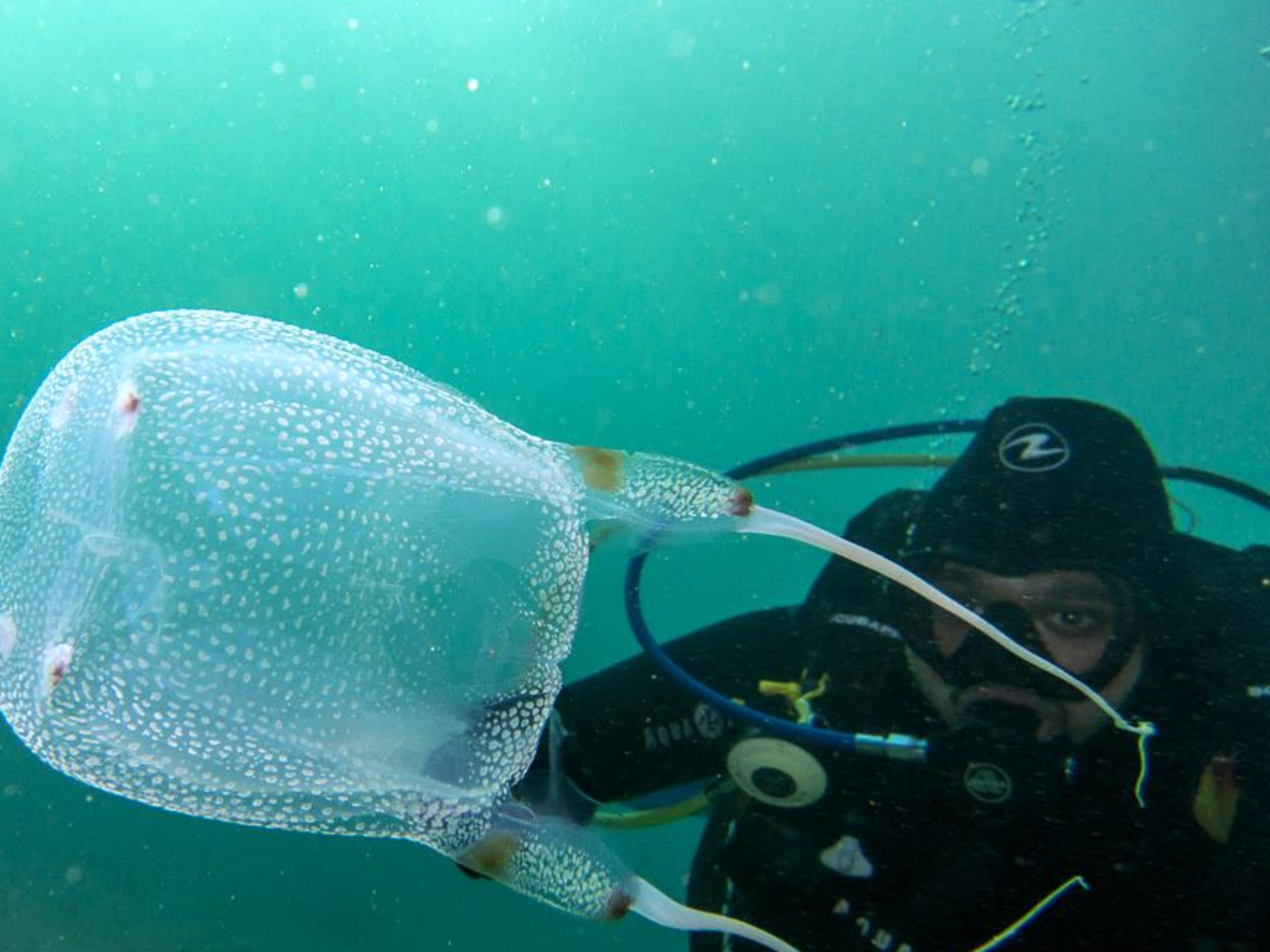


Immersive Scuba Diving Simulator Using Virtual Reality

Dhruv Jain, Misha Sra, Jingru Guo, Rodrigo Marques,
Raymond Wu, Justin Chiu and Chris Schmandt

Immersive Scuba Diving Simulator Using Virtual Reality







AMPHIBIAN — IMMERSIVE SCUBA DIVING SIMULATOR

RELATED WORK

1. Scuba **PC Games**
2. **Cave-like** Simulation System
3. Immersive **Pool Simulations**

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Scuba PC Games



World of Diving
<http://divegame.net>

Cave-like Simulation

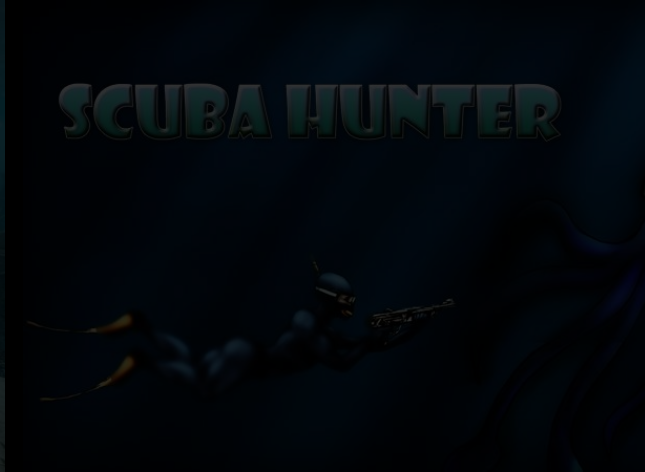
A person wearing a yellow long-sleeved shirt and black pants is standing in a virtual environment. They are holding a glowing green object in their right hand. The environment is dark with blue and purple lighting, suggesting a cave-like simulation. The person's arms are outstretched, and they appear to be interacting with the virtual world.

eve.hut.fi

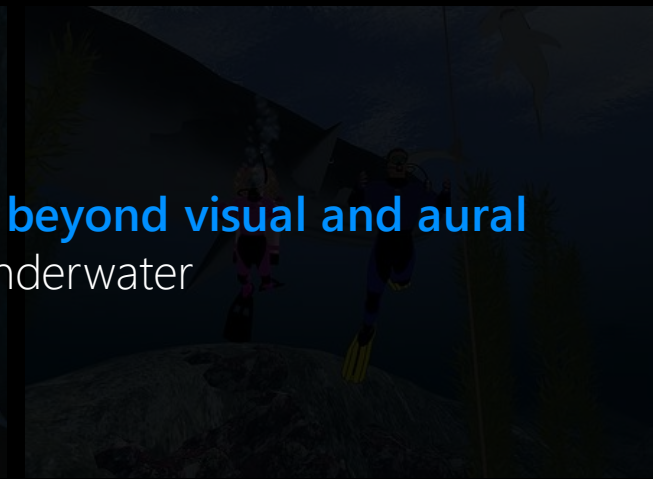
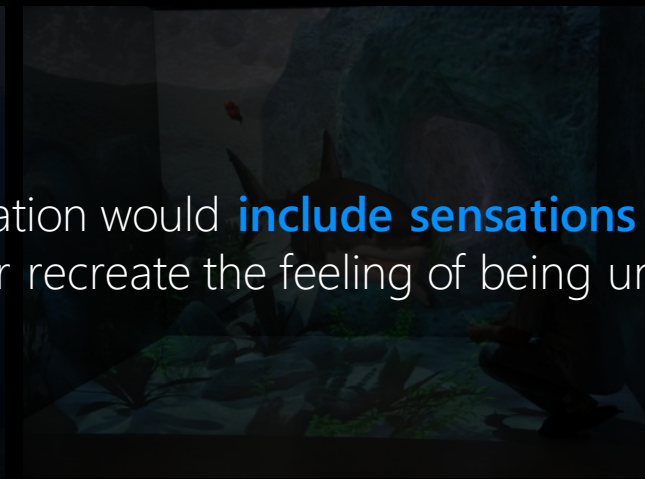
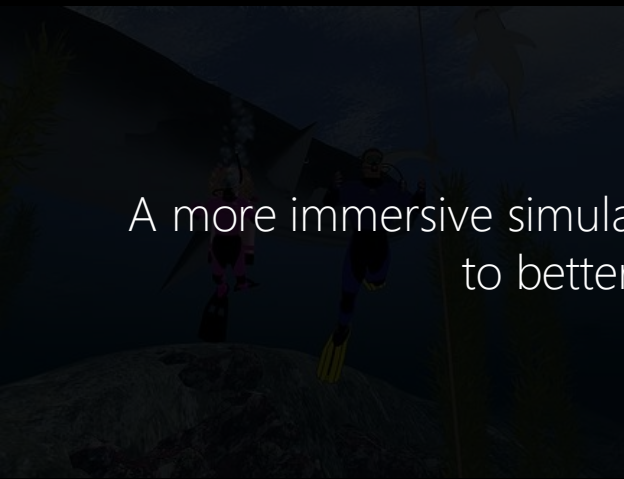
Virtual Aquarium
Takala et al., 2005

RELATED WORK

1. Scuba **PC Games**
2. **Cave-like** Simulation System
3. Immersive **Pool Simulations**



EVE eve.hut.fi



A more immersive simulation would **include sensations beyond visual and aural** to better recreate the feeling of being underwater



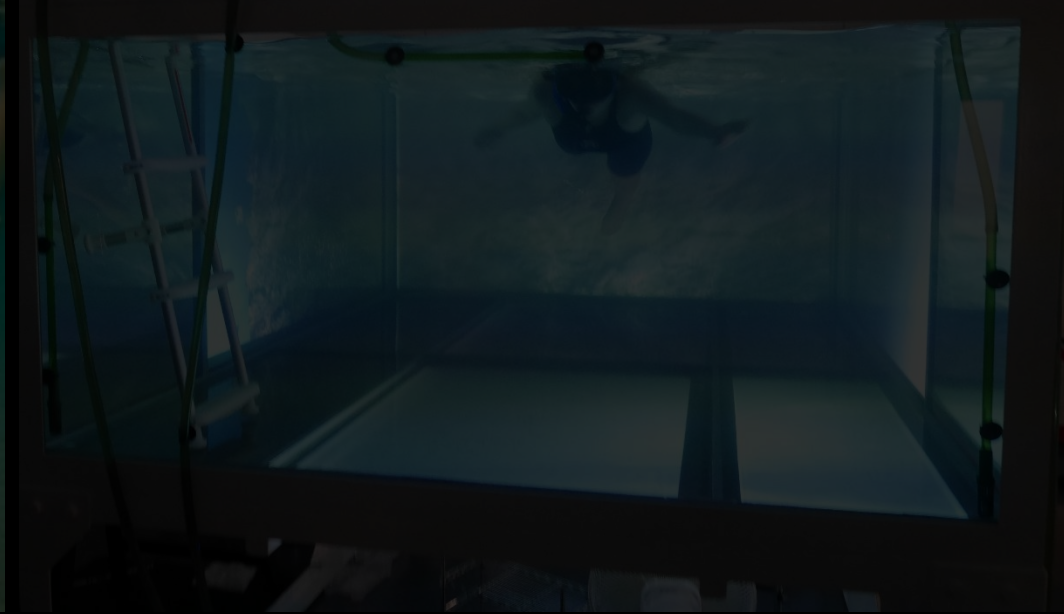
RELATED WORK

1. Scuba **PC Games**
2. **Cave-like** Simulation System
3. Immersive **Pool Simulations**

Pool Simulation

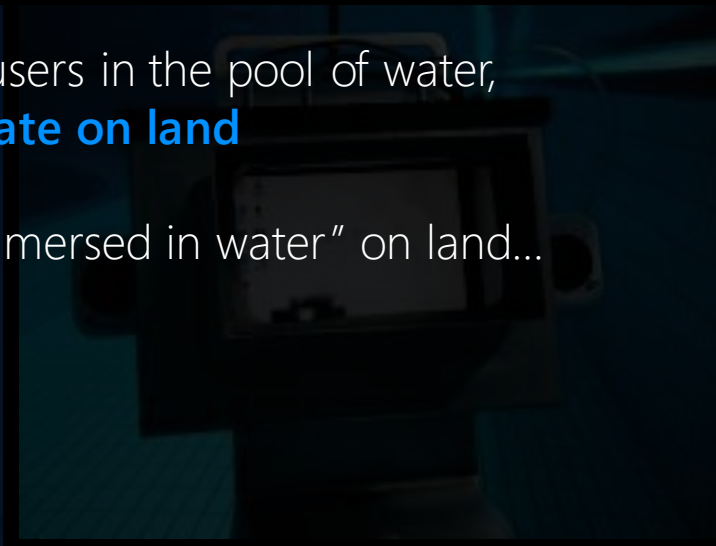
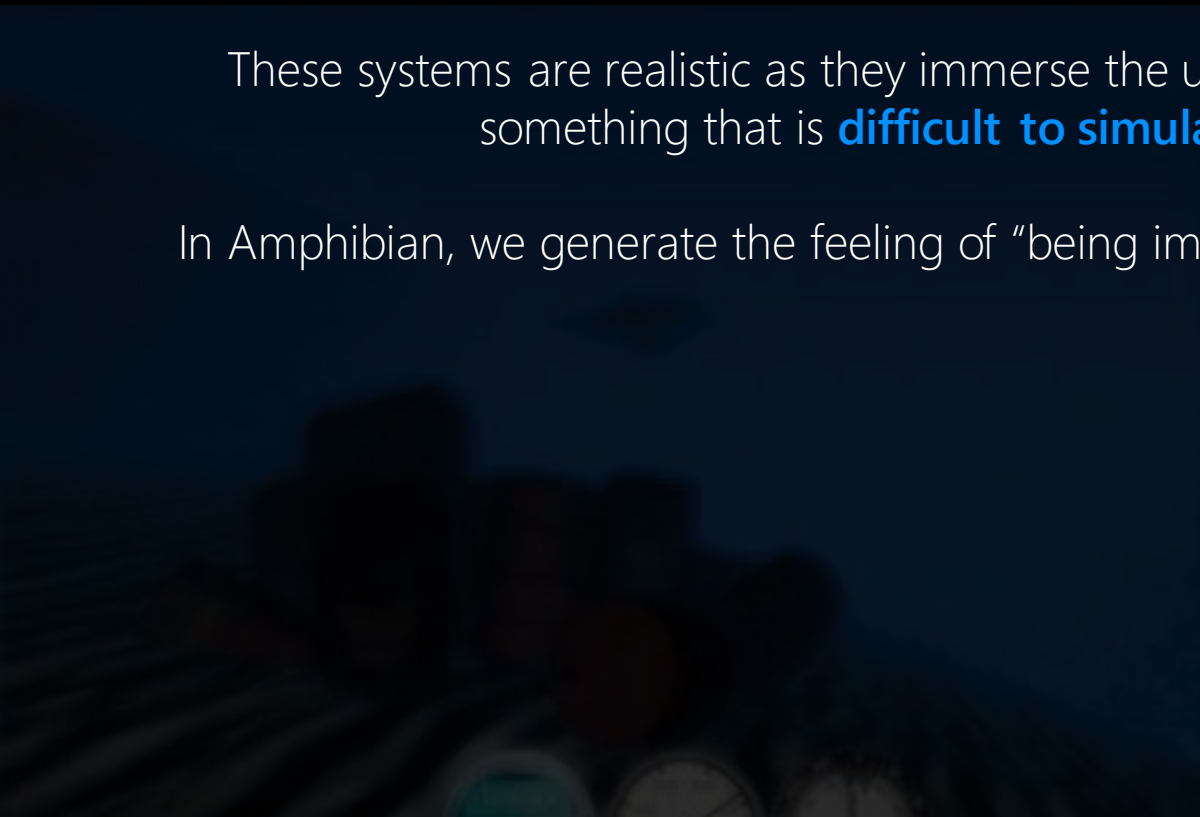


AquaCave
Rekimoto, 2014



These systems are realistic as they immerse the users in the pool of water, something that is **difficult to simulate on land**

In Amphibian, we generate the feeling of “being immersed in water” on land...

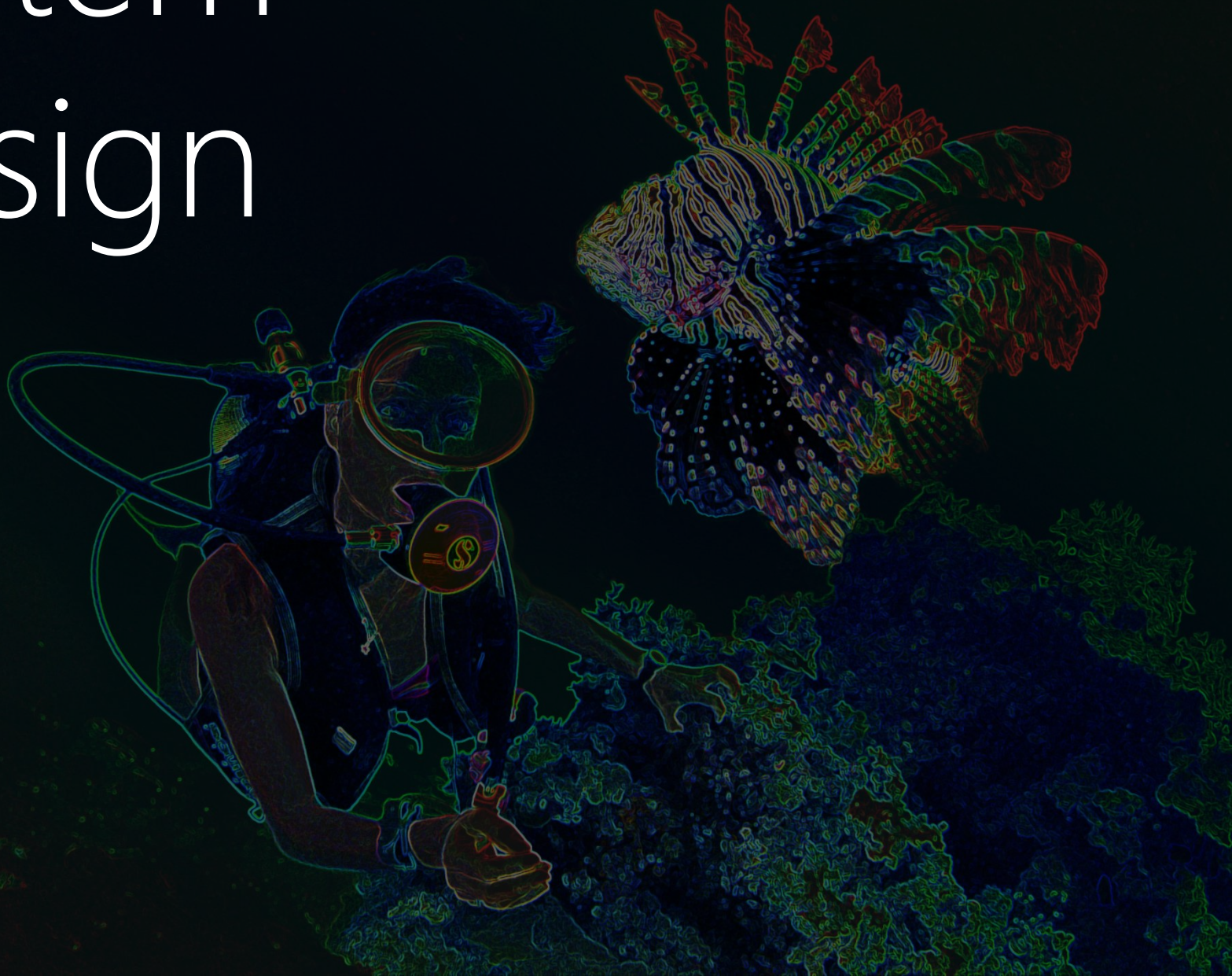


Our strongest contribution is the

**simulation of unusual
sensations like buoyancy,
temperature, breath
control, and more...**

which have not been significantly
explored in other related simulators

System Design



An underwater photograph showing the surface of the water at the top, with sunlight filtering through the water, creating a shimmering, dappled light pattern on the seabed below. The water is a deep teal color, and the light creates a complex, organic pattern of bright and dark spots across the bottom.

Underwater is an **inhospitable** environment



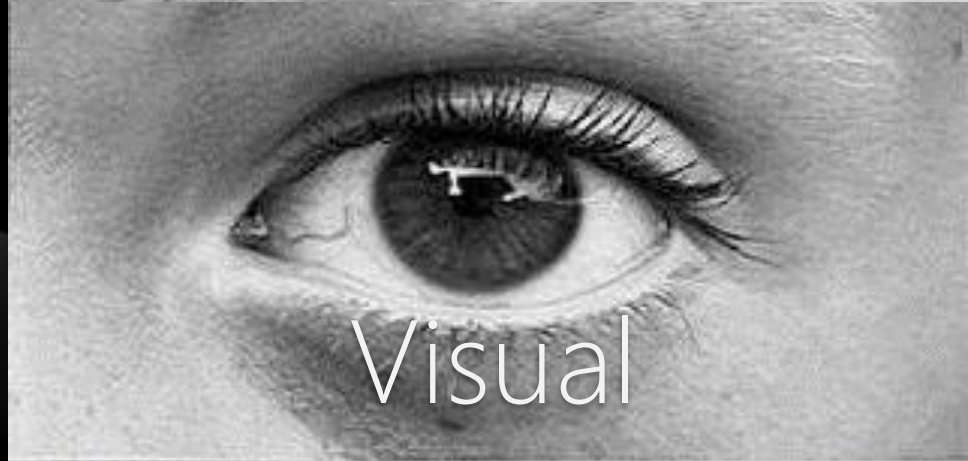
Kinesthesia



Breath



Temperature



Visual



Audio



Touch



Kinesthesia







Birdly
Rheiner et al., *SIGGRAPH*, 2014



Swimming Across the Pacific
Chen et al., SIGGRAPH, 2004

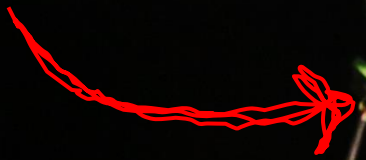


Breath





Oculus
Development Kit 2





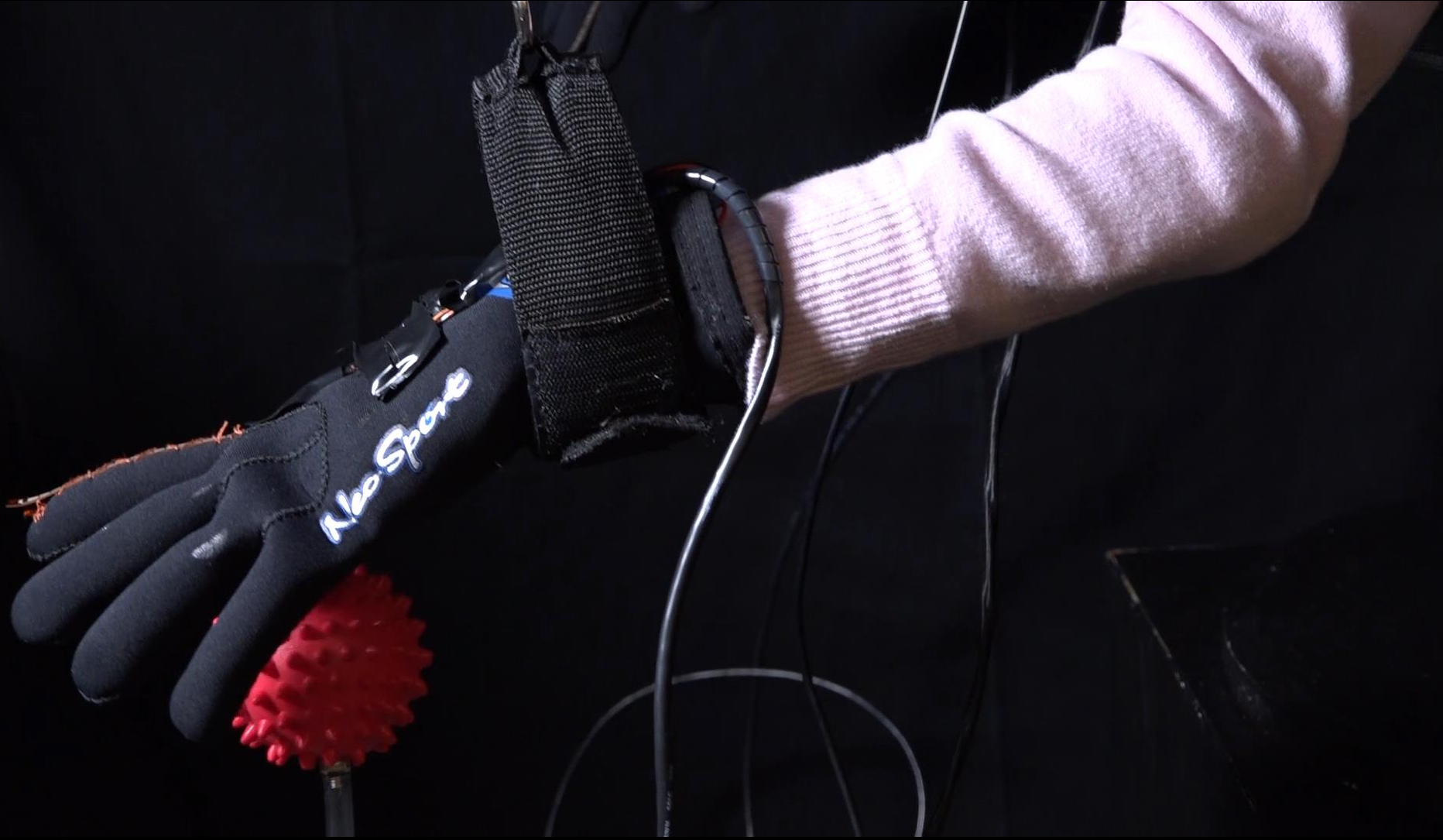
Temperature decreases
with ocean depth

39°F
(4°C)

55°F
(13°C)

thermocline







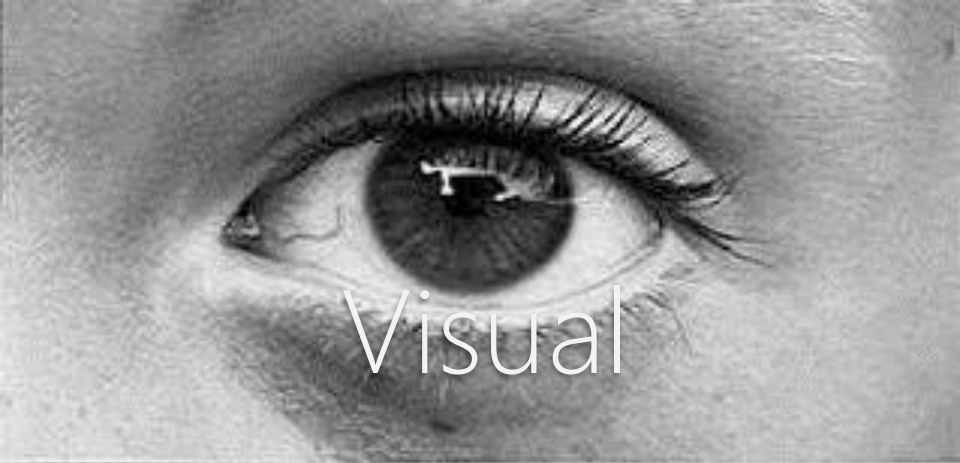
Kinesthesia



Breath



Temperature



Visual

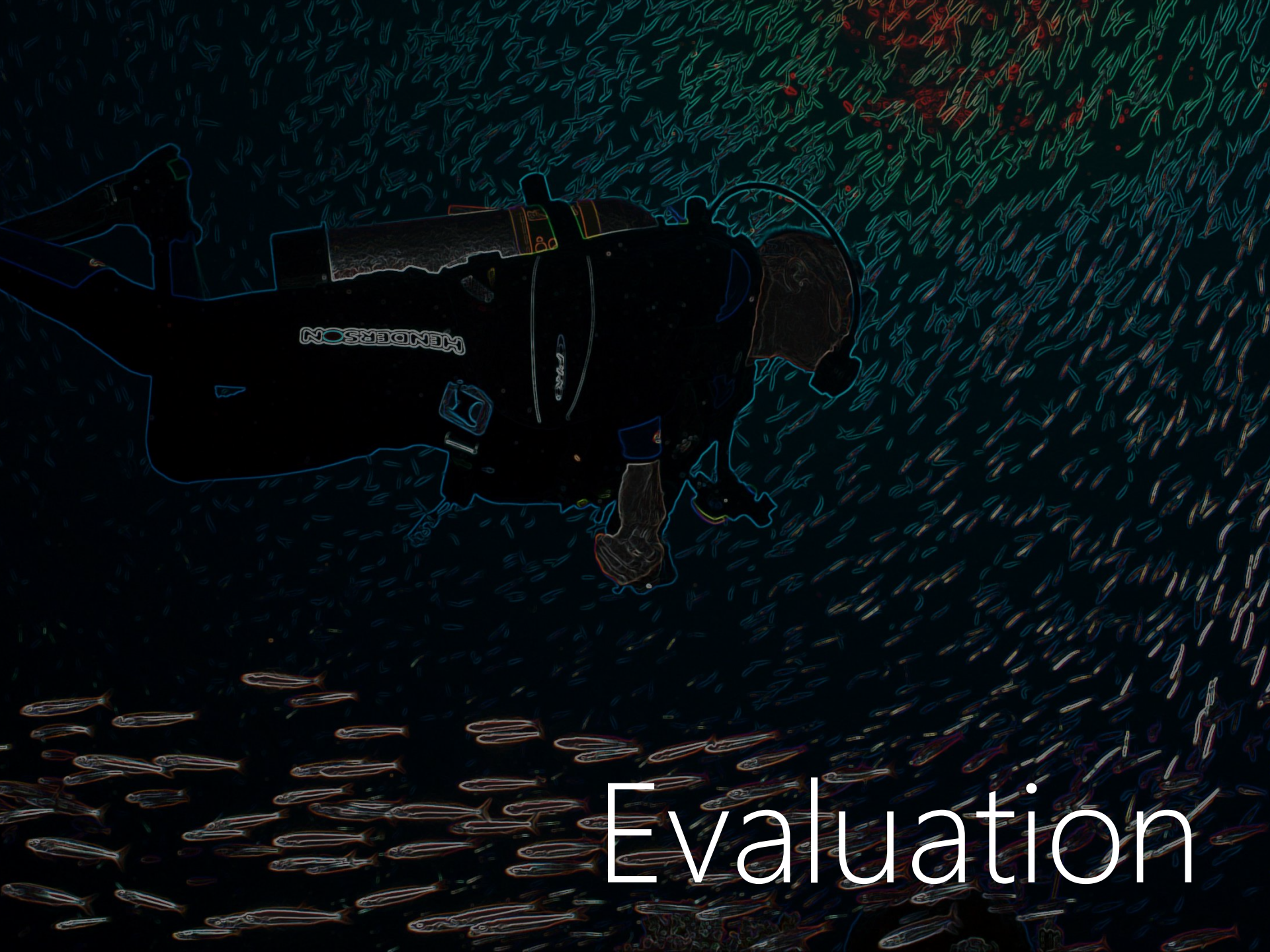


Audio



Touch





Evaluation

Evaluation



Divers Needed for a Virtual Reality Scuba Diving Simulator Study at MIT

Have you completed 25 scuba dives? Are you over 18? How is your chance to experience a fully immersive virtual reality diving simulator at MIT!

Our research team at the MIT Media Lab is developing a simulator that enables people to experience immersive scuba diving in a convenient terrestrial setting. You will rest your torso on a platform with your arms and legs supported in elastic exercise bands to get into the swimming position. You will also put on an Oculus Rift and swim in the enchanting underwater world with beautiful corals, striking fishes and magnificent wrecks.

We are recruiting certified divers who have completed at least 25 dives and are 18 years of age or older. This study includes experiencing scuba diving in the simulator and a brief interview of your experience. We are collecting data to further improve the design of the simulator. You must be in good health, less than 6'2" tall, weigh less than 220 lbs and be able to comfortably lie down on your torso for 15 minutes. You also need to be able to raise your arms above your head easily and without discomfort. If you do not meet these criteria, you may not be able to participate in our study.

Study sessions will be conducted at the MIT Media Lab. The study will take up to one hour and you will be compensated \$20 for your time. You may at any time opt out of the study if you feel uncomfortable in any way without any consequences.

If you are interested in participating, please email Diruv Jan (djan@media.mit.edu) with the following information:

- Number of completed dives
- Two or three possible days/times to meet between March 9 and March 15 (including weekends)

Oceans cover 70% of the earth and yet we know more about the moon. Divers, we need to make people experience the majestic world out there! Please step forward.

Sincerely,
Diruv Jan
Research Assistant
MIT Media Lab
75 Amherst Street, MA 02139
<http://diruvjan.info>

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Goal

- How our system **compares to the real-life scuba diving?**

Participants

- 12 participants (ages 18-61, 5 females)
- **Experienced divers**; More than 25 dives before the study


Procedure

- Total time – avg. **45 min / diver**
- Three steps – system experience, open-ended interview, two questionnaires – immersion and presence

“ Degree of **immersion** of a system can be objectively assessed as the **characteristics of the technology** ”

– Slater and Wilbur, 1997



A woman with long hair is sitting on the ground in a field, leaning against a wooden fence. She is wearing a dark long-sleeved shirt and dark pants. The ground is covered with dry leaves and grass. In the background, there are trees and a grassy field. The lighting is soft, suggesting late afternoon or early morning. The quote is overlaid on the right side of the image.

Presence is the state of
consciousness, the sense
of being in the virtual
environment

– Slater and Wilbur, 1997

Evaluation



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If you are interested in participating, please email Drury Jan (djan@media.mit.edu) with the following information:

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Sincerely,

Drury Jan
Research Assistant
MIT Media Lab
75 Amherst Street, MA 02139
<http://druryjan.info>

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Goal

- How our system compares to the real-life scuba diving?

Participants

- 12 participants (ages 18-61, 5 females)
- **Experienced divers**; More than 25 dives before the study

Procedure

- Total time – avg. 45 min / diver
- Three steps – system experience, open-ended interview, two questionnaires – **immersion** and **presence**

iGroup Presence Questionnaire

Witmer-Singer Questionnaire



Findings

FINDINGS

1 How **present** were the users in our system?

2 How **immersive** was our system?

3 How did immersion **effect** presence?

Presence: 4.96/7

2 How **immersive** was our system?

3 How did immersion **effect** presence?

A close-up photograph of a person's hands holding a small electronic component. The component has a white plastic connector with several pins. Two wires, one red and one black, are attached to the component. The background is dark, and the lighting is focused on the hands and the component.

Temperature was not noticed.

Presence: 4.96/7

Immersion

Breathing was the **most realistic**.

People liked **graphics** (e.g. fish, rocks) and **audio** (e.g. sound of bubbles).

Kinesthesia was the least appreciated part.

Tactile had mixed reactions.

Temperature was not noticed.

3 How did immersion **effect** presence?

Presence: 4.96/7 ←

Immersion

Breathing was the **most realistic**.

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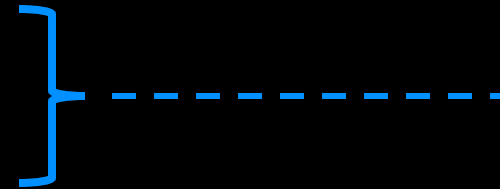
Temperature was not noticed.

Immersion -> Presence

Spatial Presence: 4.92/7

Involvement: 5.12/7

Realness: 3.44/7



Presence: 4.96/7

Immersion

Breathing was the **most realistic**.

People liked **graphics** ↑ (e.g. fish, rocks) and **audio** ↑ (e.g. sound of bubbles).

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Immersion -> Presence

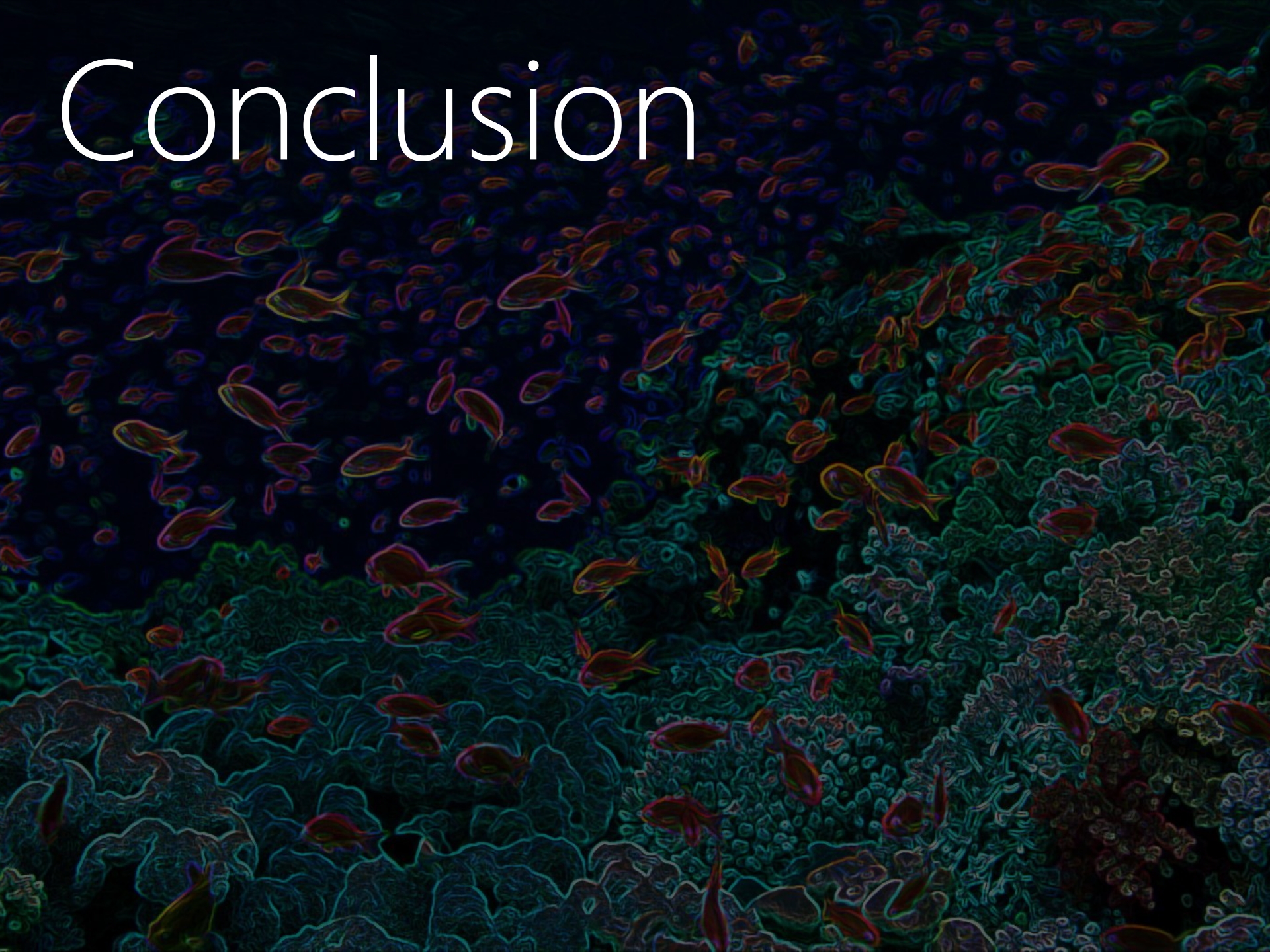
Spatial Presence: 4.92/7 ↑

Involvement: 5.12/7 ↑

Realness: 3.44/7 ↓

Though the participants were **present** and **engaged** in the virtual world, they **did not** **behave** as if they were scuba diving for real.

Conclusion



The strongest contribution of our VR Scuba diving simulator is the **simulation of unusual sensations** like breathing, temperature, kinesthesia and balance

While some characteristics of the system were realistic, the **implementation of some elements** could be changed for higher immersion







General Insights

- 1** For building a simulator, it is not necessary to replicate every single sensation
- 2** Sometimes, a literal translation of a physical action does not carry over well into a VR simulation

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All the elements in the simulator need not be replicas of their real world equivalents, and as designers we can use some creative license while also keeping system usability and user comfort in mind ...



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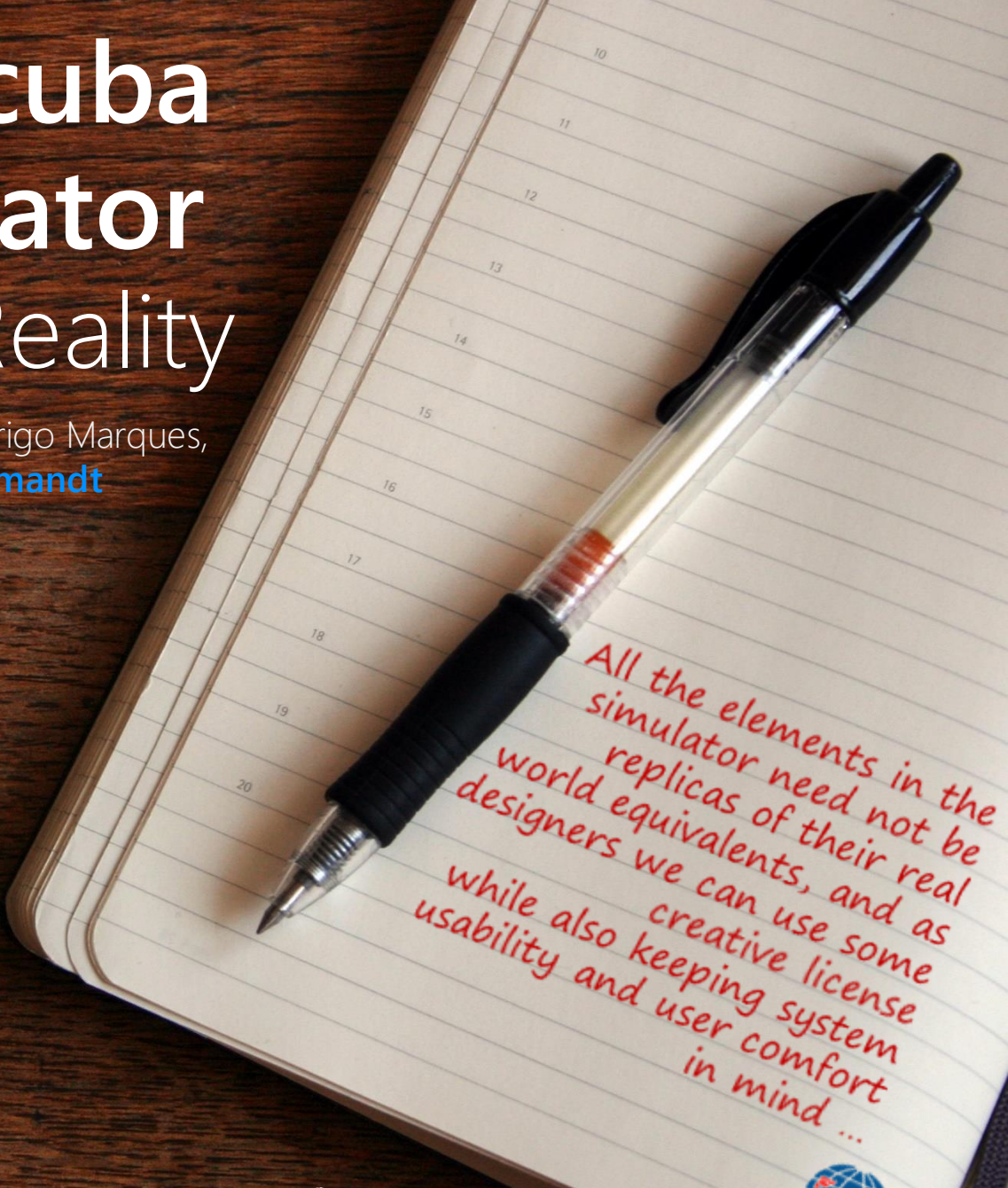
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All the elements in the simulator need not be replicas of their real world equivalents, and as designers we can use some creative license while also keeping system usability and user comfort in mind ...

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Dhruv Jain, Misha Sra, Jingru Guo, Rodrigo Marques, Raymond Wu, Justin Chiu and Chris Schmandt

Present at UIST!
@higherDefender



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