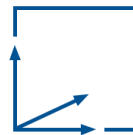# Improving Immersion with Hardware in VR Diving Simulations

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Final: Bachelor Informatics: Games Engineering

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Introduction / Motivation

- Scuba diving is fascinating but dangerous hobby

- Many people can't experience this

- Equipment is an essential part of diving

- Virtual Reality (VR) technologies can't provide the haptics of this equipment

- This lack of realism might have a bad impact on immersion

- Custom created hardware might elevate the immersion

Problem Description: Issues

- What current diving simulations or games are available now?

- What do they do right to immerse the player?

- Which piece of diving equipment is suitable as a hardware extension?

- How would such a new controller be designed and built?

- How can this new hardware be fitted into an existing simulation or game?

- Does this change result in a more immersed experience?

# Existing Solutions / Related Work

- **Amphibian:** full terrestrial diving simulation, with multitude of sensors, actuators using a VR headset.

  – Lessons learned from the project were a huge influence

- **200bar:** VR Diving simulation developed by Leonard Keil at TUM

  – Software basis for this thesis

- **Virtual Divers International (VDI):** Diving serious game for mobile with focus on realistic and educational gameplay

Goals of this Thesis

- Evaluate 200bar as proposed

- Explain buoyancy and pressure in the context of diving

- Select equipment best suited for hardware extension

- Develop and manufacture new hardware to simulate equipment

- Create use case in 200bar that relies on new controller

- Evaluate 200bar with new equipment and use case

- Outline possible future work for the new controller and 200bar

Implementation (Hardware)

- Regulator as base for controller

- Buoyancy control and air consumption to increase immersion

- Components:
  - Real regulator
  - Mass air flow sensor
  - Arduino UNO V3 microcontroller
 - 3D printed casing
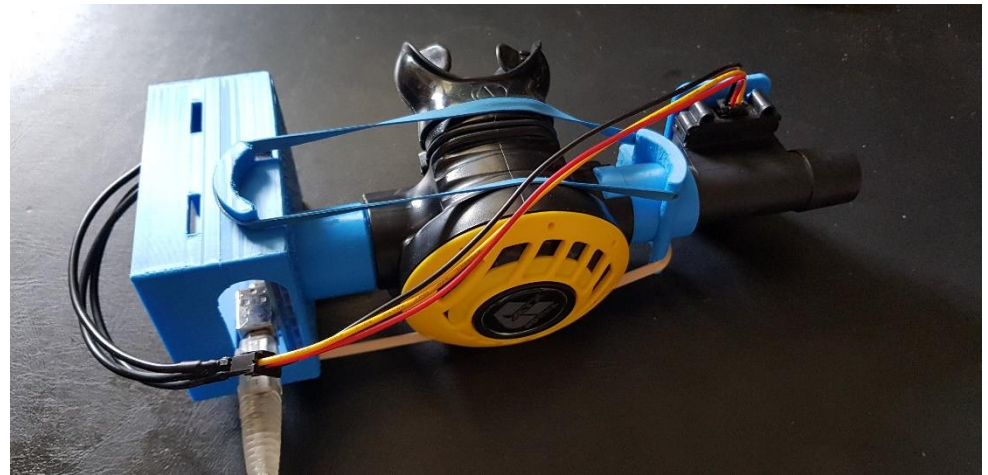
Implementation (200bar)

- New use case
  - "BCD parkour"
  - Reuse of already available level
  - Dive through hoops and measure time
  - New voice over

- Changes of existing elements
  - added sound for inflator
  - Fixed some bugs
  - Removed ability to ascend/descend by direct movement
  - Removed motion detection for swimming
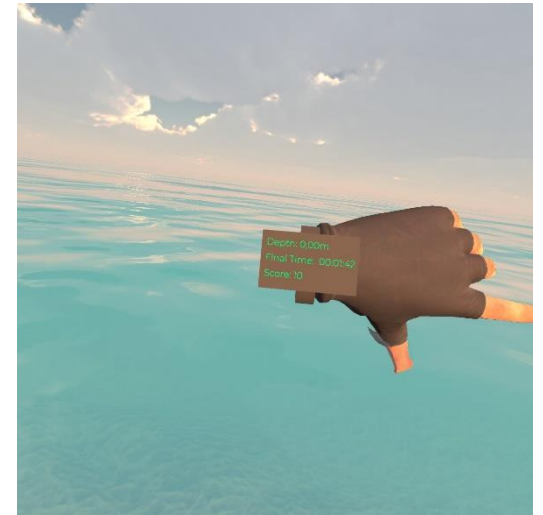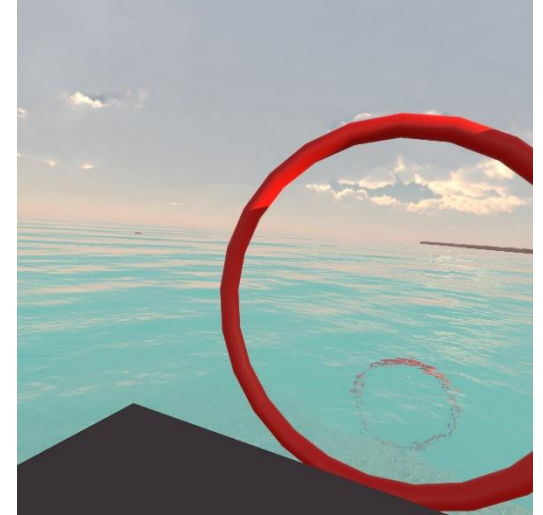
Implementation (Bouyancy Bob)

- New game using prototype
  - Used for development
  - 2D side scrolling
  - Evade fish and dive as far as possible without running out of oxygen

- Showcases the controller easier than VR
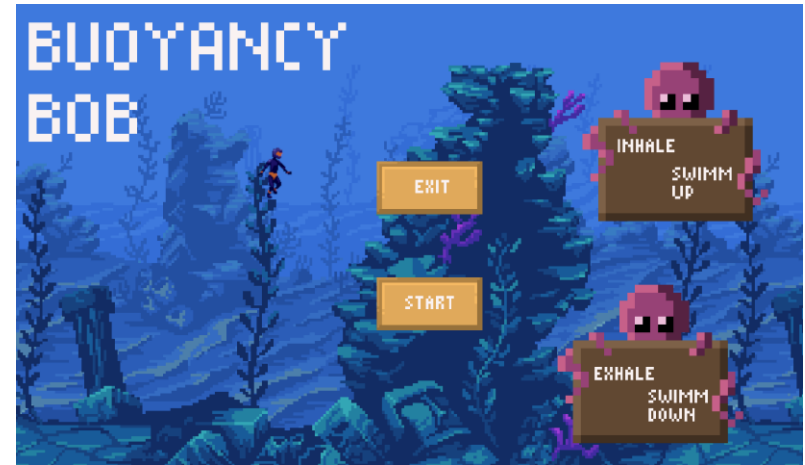
Evaluation (User Studies, Test Runs)

- 5 participants
  - Certified divers
  - Age 26-59

- 2 Studies
  - 1. 200bar when thesis started
  - 2. 200bar with new hardware controller and new use case level
  - 30 minutes of play time

- 3 questionnaires
  - Participants/Diving experience
  - Virtual reality sickness (VRSQ)
  - Immersive experience (IEQ)

Evaluation results

- First study:
  - VRSQ: 58.5
  - IEQ: 81.6
  - Main issue: missing objective

- Second study:
  - VRSQ: 47.3
  - IEQ: 97.4
  - Main issue: new controller is too heavy
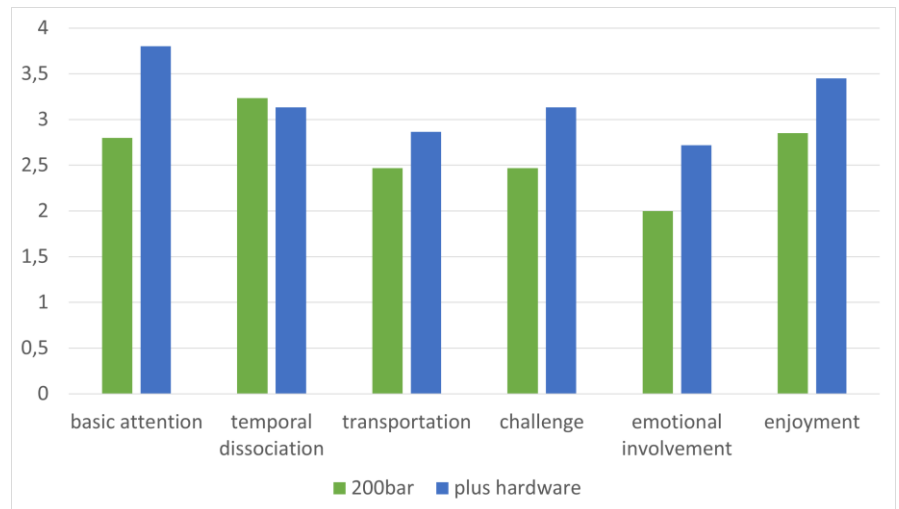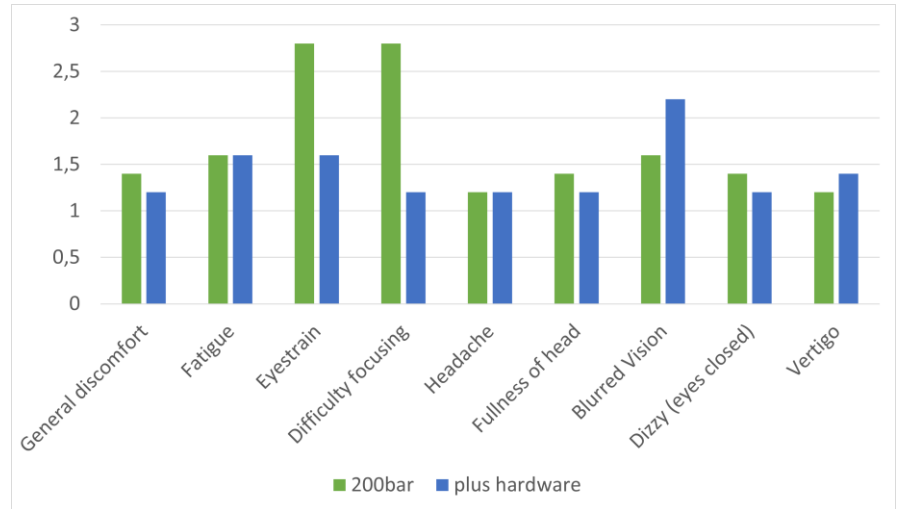
Discussion / Suggested Future Work

- Software for 200bar:
  - Add fish and other assets
  - Refine controls (posture, movement using stick)
  - Add use cases

- Hardware for 200bar:
  - Any piece of equipment

- Usage of prototype:
  - Training meditation
  - Integration in existing games
  - Sport, stealth or horror games
  - Accessibility for disabled gamers
  - Gathering data on breathing while playing

Conclusion

- Specialized hardware can increase immersion

- Easy disassembly of prototype was beneficial

- Prototype should be refined (lighter, not using a real regulator)

- Extending 200bar was tedious

  – Unity had issues with used packages

  – Used packages could not be updated

  – VR hardware refused to work sometimes