Computational Health Informatics

IARIA

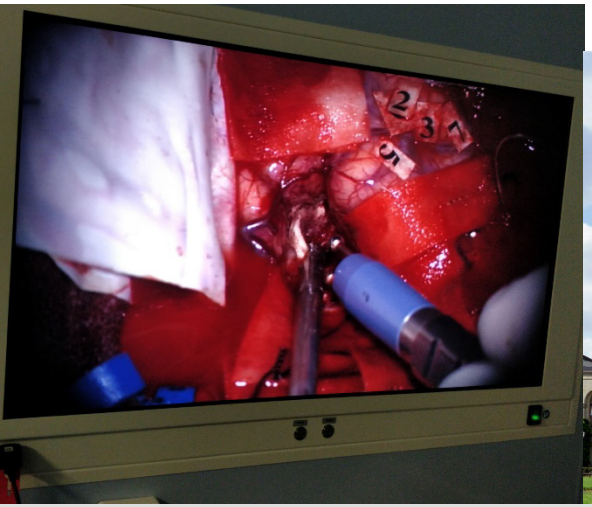
Leibniz Universität Hannover

Patient Feedback During an Awake Craniotomy Using Virtual Reality

Alexander Moryäner, **Tobias Holst**, Igor Merkulow, Gabriele von Voigt

Computational Health Informatics (CHI), Leibniz University Hannover, Germany

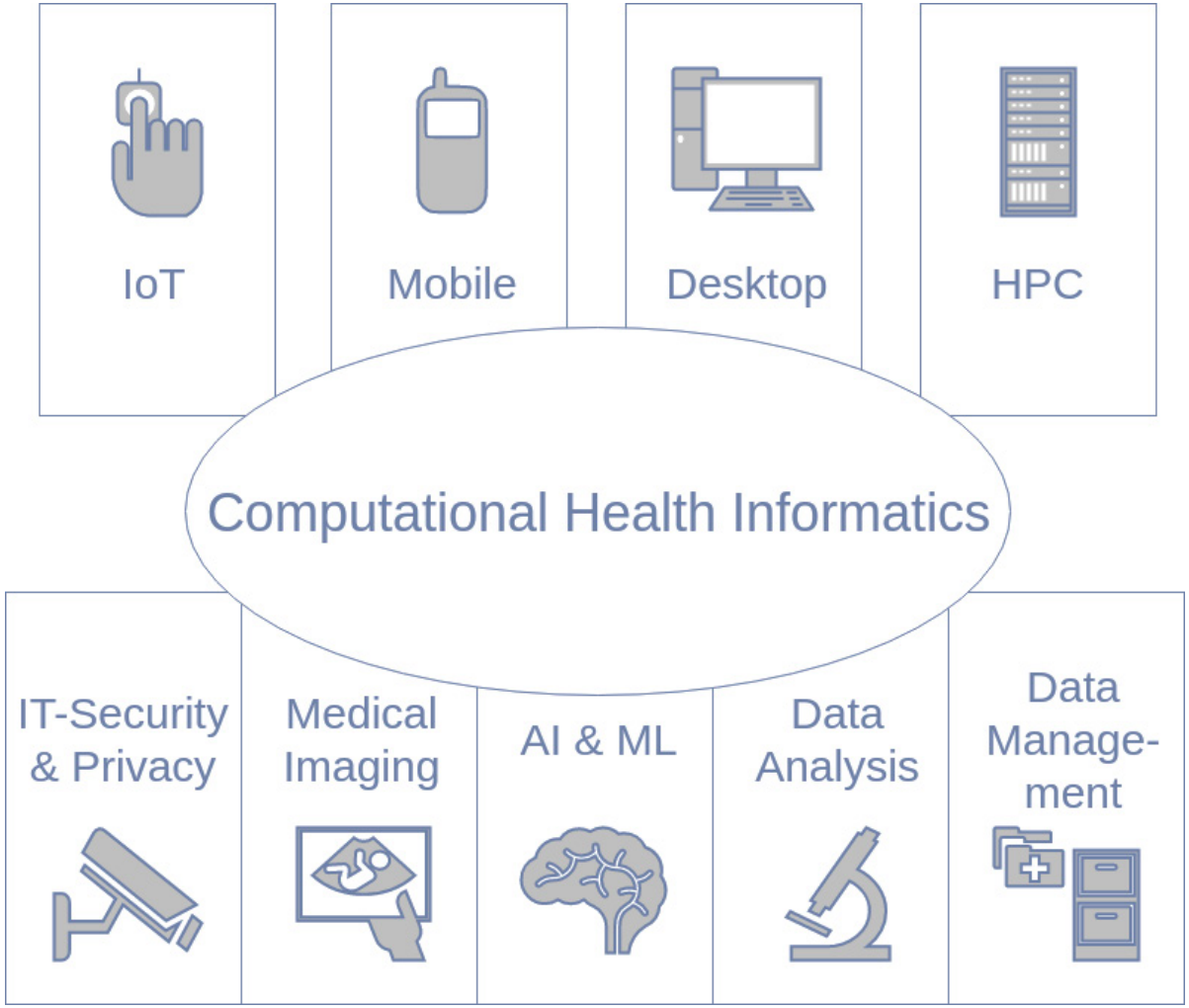
Contact email: holst@chi.uni-hannover.de



Tobias Holst

Tobias Holst received the master's degree in mechatronics engineering from the Leibniz University Hannover, Germany in 2016 and began working on his doctorate as a computer scientist in the field of "Computational Health Informatics" at the same university in 2017.

Computational Health Informatics at the Leibniz University Hannover, Germany



Motivation

- For some patients awake surgery is the best way to avoid the risk of surgical deficits [1]
- Main advantage: intraoperative brain mapping [2]
- This outweighs the psychological disadvantages [1]
- Current brain mapping: recognising and naming images or texts to read aloud [3]
  - This tends to be cumbersome and error-prone
- Our improvement: Use of Virtual Reality (VR) technology
  - More expressive and complex stimuli

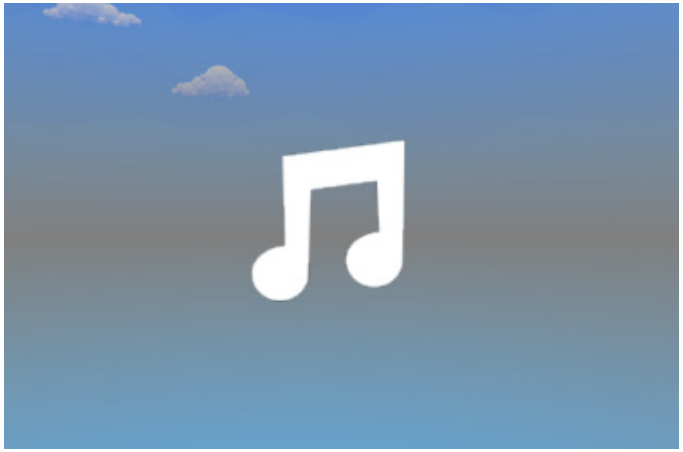
➢ **Work in progress**

Application Features

- Main goal: support the physician during brain surgery
- Full spectrum test of sensory stimulations and according responses
- Most important: sight
- Two tests include hearing as well
- Preoperative familiarisation necessary
  - to have a baseline or reference point
  - to prevent anxiety
  - to test the sensitivity to Virtual Reality sickness

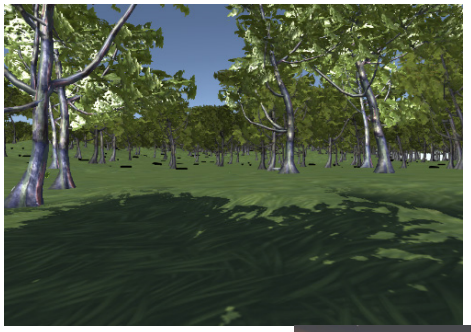
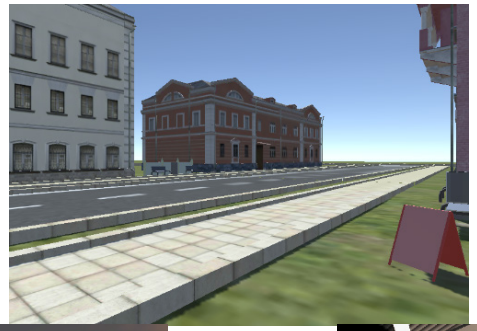
Image Recognition

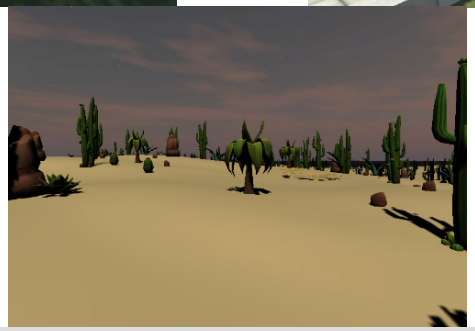
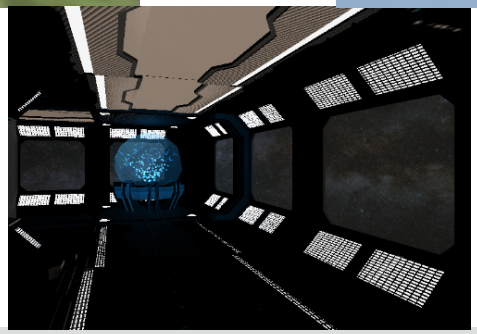
- Provides 80 different two- and three-dimensional images
  - Easily extendable, to include patient specific images
- 3D-objects allow a complete 360° view



Interaction With a Complex Situation/Environment

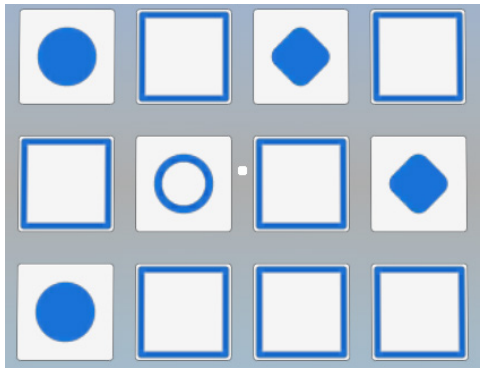
- Common sceneries: forest, desert, town
  - All with vegetation, earth conditions and animals
- Uncommon and more challenging sceneries: space station, room made of coloured cubes

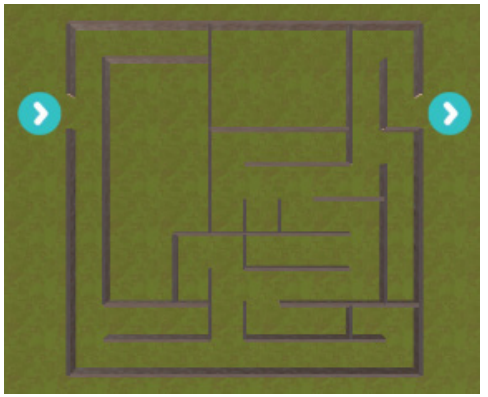



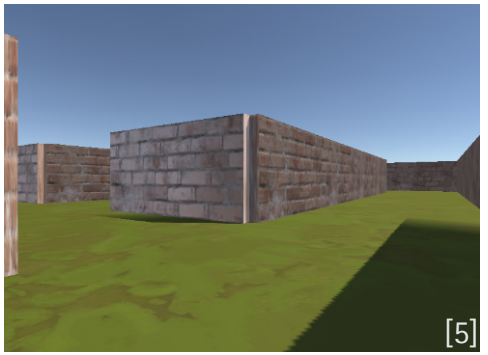



Memory Function

- The memory and short-term memory are important to human beings
  - Thus it could/should be tested during the awake craniotomy
- We implemented the memory game "pairs" and a labyrinth escape situation
  - Patient is asked to memorise the path from entrance to the exit from the bird's eye view
  - The app switches to the person's field of view requesting him to navigate to the exit of the maze
    - This test also aims to estimate the spatial ability and the sense of orientation, i.e. if the patient uses the same dead-end repeatedly







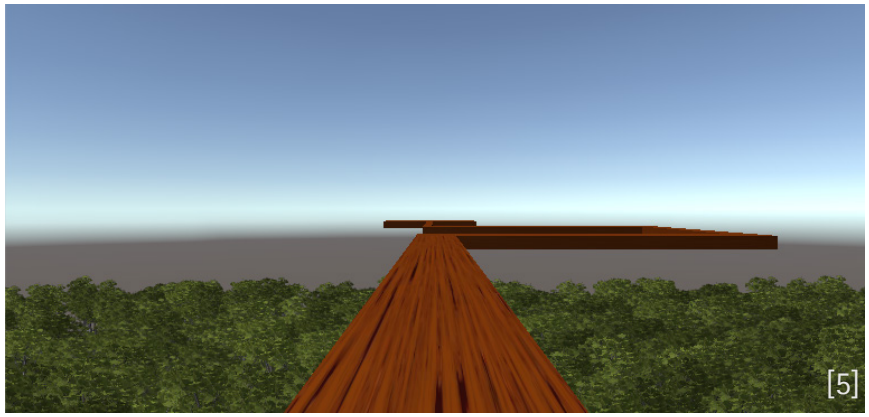
Reflex and Reaction

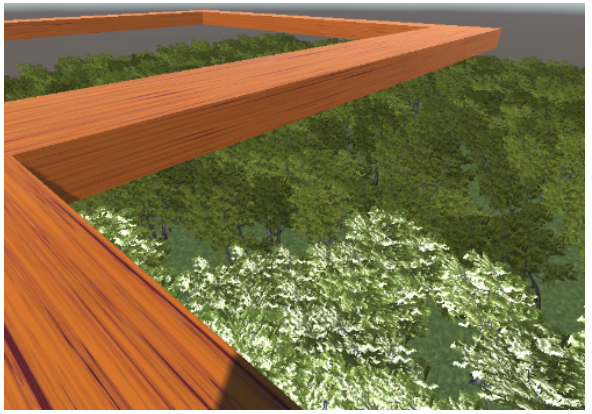
- Previous tests: neither standardised, nor a measurement of patient's reaction time
  - This can be an important indicator of his condition
- We implemented two tests to estimate the patient's reflexes and reactions:
  - Supervising physician lets a spider appear unexpectedly
  - Patient has to stop a ball by pressing a button
    - The ball appears from a random direction with varying speed

[5]

Hand-Eye Coordination

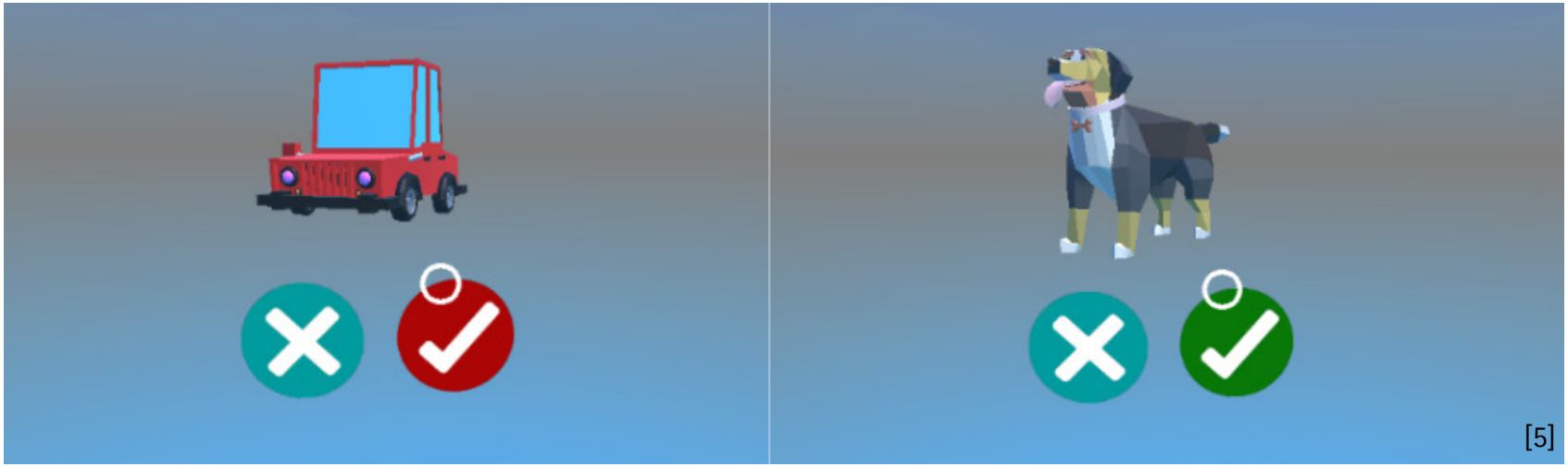
- Test of the accuracy of coordination ability
- The patient has to walk virtually on a narrowing wooden beam placed in midair





Auditory Perception

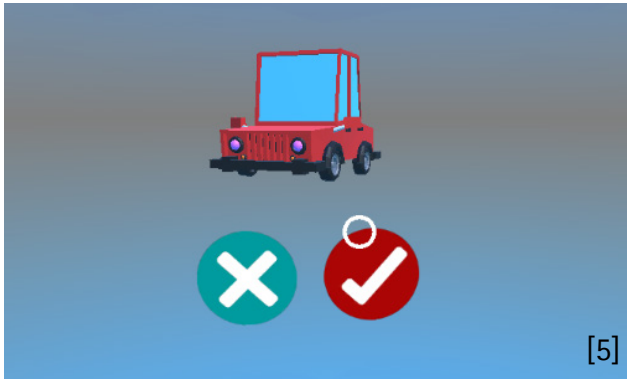
- The app provides a typical hearing test:
  - A sound is coming from the left, right or both sides and the patient has to choose the corresponding button with the controller
  - Correctness of the answer is visualised by the change in the button colouring



Combination of Visual and Auditory Perception

Final test combines seeing and hearing:

- Patient has to match a 3D-object with a sound
  - Correct or incorrect selection is indicated by a colour change
- Mistakes or inaction are important signs



Realisation – Technical Setup

- Project setup contains an Android-based smartphone
  - VR app, central processing, and as visualising gear
- Pair of "Destek V4" VR glasses
- Gaming controller used as steering device for the app
- Additional control screen for the surgical team for verification of test results


[5]

Realisation – Technical Setup

- Smartphone VR holder instead of full-fledged VR glasses due to the cost factor and higher flexibility
- Android Operating System (most common mobile OS) for development of the VR app
- Head tracking (the regular way of navigation in VR environments) is not possible due to the head fixation
  - Steering has to be done with an external device - A game controller emerged as the best-suited device so far
  - To meet the requirements on the wireless signal interference in the medical setting it can be connected by wire instead of Bluetooth

Implementation Requirements

- An intuitive and easy to use user interface has to be developed for all user groups with a special focus on the patients
- Important functional requirements *(complete list in our paper)*:
  - The use of the app should not require any special knowledge or experience.
  - The patient should not endure any additional risks compared to an awake craniotomy without the app.
  - The app should never cause any hassle or stress for the patient.
  - The app must not interfere with any other device in the operating theatre.
  - The app should be implemented with special regards to IT security due to the highly health-critical environment.
  - ...

Implementation Details

- The app and the 3D-scenery were implemented using Microsoft Visual Studio with Unity
  - Unity is a set of tools primarily used for the game development, allowing creating feature-rich environments with natural physical conditions
  - The main user interface was also designed with Unity
- To create the stereoscopic images we used the Google VR SDK for Android

Conclusion

We presented our work to a group of three surgeons:

- They agreed: our approach shows promising potential
- Further development of the technical setup necessary to meet the specific requirements of awake surgeries
- Highest benefit: Availability of more specific and flexible tests than with state-or-the-art procedures
  - Especially for further brain functions (short-term memory, situational perception and combination of senses)
- Great Improvement: Ability to adapt the VR environment to patient's personal or professional interests and preferences
- In addition, it could potentially reduce the stress and anxiety during the surgery at the same time [4]

Conclusion

- Another insight resulting from the discussion with surgeons: Our approach is one step ahead of the current state of the brain mapping
  - It adds the possibility to test currently unmapped functionalities
    - For example it is still not fully understood which brain regions affect spatial ability
    - Additional research is necessary in this area to tap the full potential of this approach
- The consensus was that this is not only a new opportunity but also the future

Future Work

In our future work we will address the following shortcomings:

- Usage of VR prevents eye contact between neuropsychologist and patient
  - This is in contrast to the regular interpersonal communication
- Extending the supervisor interface with additional information and better test control
- Test the setup under clinical conditions

Computational Health Informatics

IARIA

Leibniz Universität Hannover

Patient Feedback During an Awake Craniotomy Using Virtual Reality

Thank you for your attention!
Any questions?

Alexander Moryäner, **Tobias Holst**, Igor Merkulow, Gabriele von Voigt

Computational Health Informatics (CHI), Leibniz University Hannover, Germany

Contact email: holst@chi.uni-hannover.de

With friendly support from Prof. Christian Rainer Wirtz, Prof. Ralph König, Dr. Gregor Dursun,
Clinic for Neurosurgery at the University Medical Center Ulm/BKH Günzburg, Germany.

References

- [1] M. Milian, M. Tatagiba, and G. C. Feigl, "Patient response to awake craniotomy – a summary overview", Acta Neurochirurgica, vol. 156, pp. 1063–1070, 2014, doi:10.1007/s00701-014-2038-4.
- [2] G. M. Ibrahim, and M. Bernstein, "Awake craniotomy for supratentorial gliomas: why, when and how?", CNS oncology, vol. 1, issue 1, pp. 71-83, Sep. 2012, doi:10.2217/cns.12.1.
- [3] O. Sacko, V. Lauwers-Cances, D. Brauge, M. Sesay, A. Brenner, F. E. Roux, "Awake Craniotomy vs Surgery Under General Anesthesia for Resection of Supratentorial Lesions", Neurosurgery, vol. 68, issue 5, pp. 1192-1199, May 2011, doi:10.1227/NEU.0b013e31820c02a3.
- [4] W. O. C. Lopez, P. Navarro, M. Ibarra, C. Rocha, and J. D. Gomez, "Creation of an original system of virtual reality, augmented and neurogaming for the education and entertainment of the patient in the operating room and impact on his stress in craniotomy with awake patient", 69. Jahrestagung der Deutschen Gesellschaft für Neurochirurgie (DGNC) Joint Meeting mit der Mexikanischen und Kolumbianischen Gesellschaft für Neurochirurgie, Münster, 2018, https://www.egms.de/static/de/meetings/dgnc2018/18dgnc305.shtml, retrieved: Sep. 2021.
- [5] A. Moryäner, "Development of a Remote-Controlled Virtual Reality App for Therapy Support", Bachelor's thesis, Leibniz University Hannover, 2018.