HRI interface comparisons (VR, AR, bio-signal-based)

Sebastian Hirt

Agenda
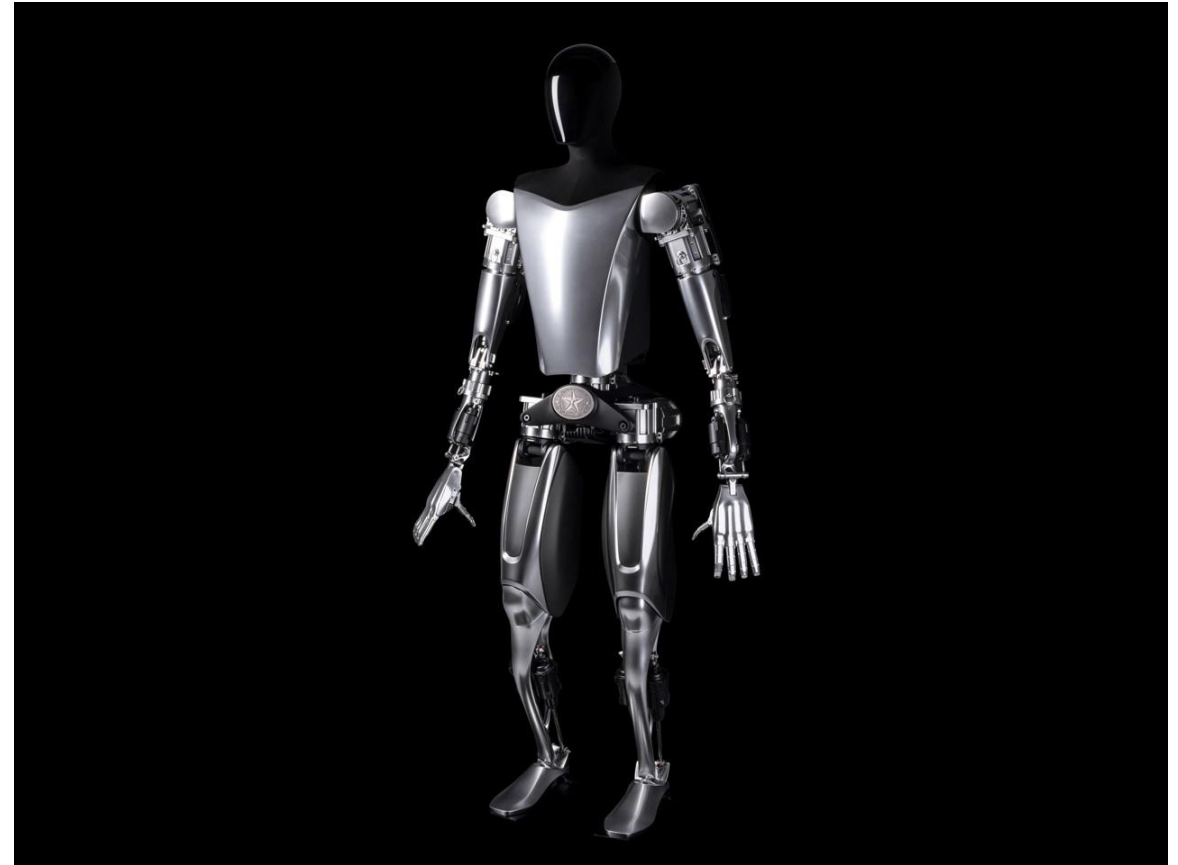
FAU

Why compare?

- Best option for current use in industry

- Dictate direction of future research

(Boston Dynamics, 2022)

(Tesla, 2022)

Agenda

Specific Example for VR

Omnipotent Virtual Giant for Remote Human–Swarm Interaction

- Control over swarm of robots like a swarm of ants

- Oculus Rift headset with Leap Motion

- Placing virtual objects in path of robot via environmental manipulation

- Zoom in and out of the virtual environment

- Teleoperation possible

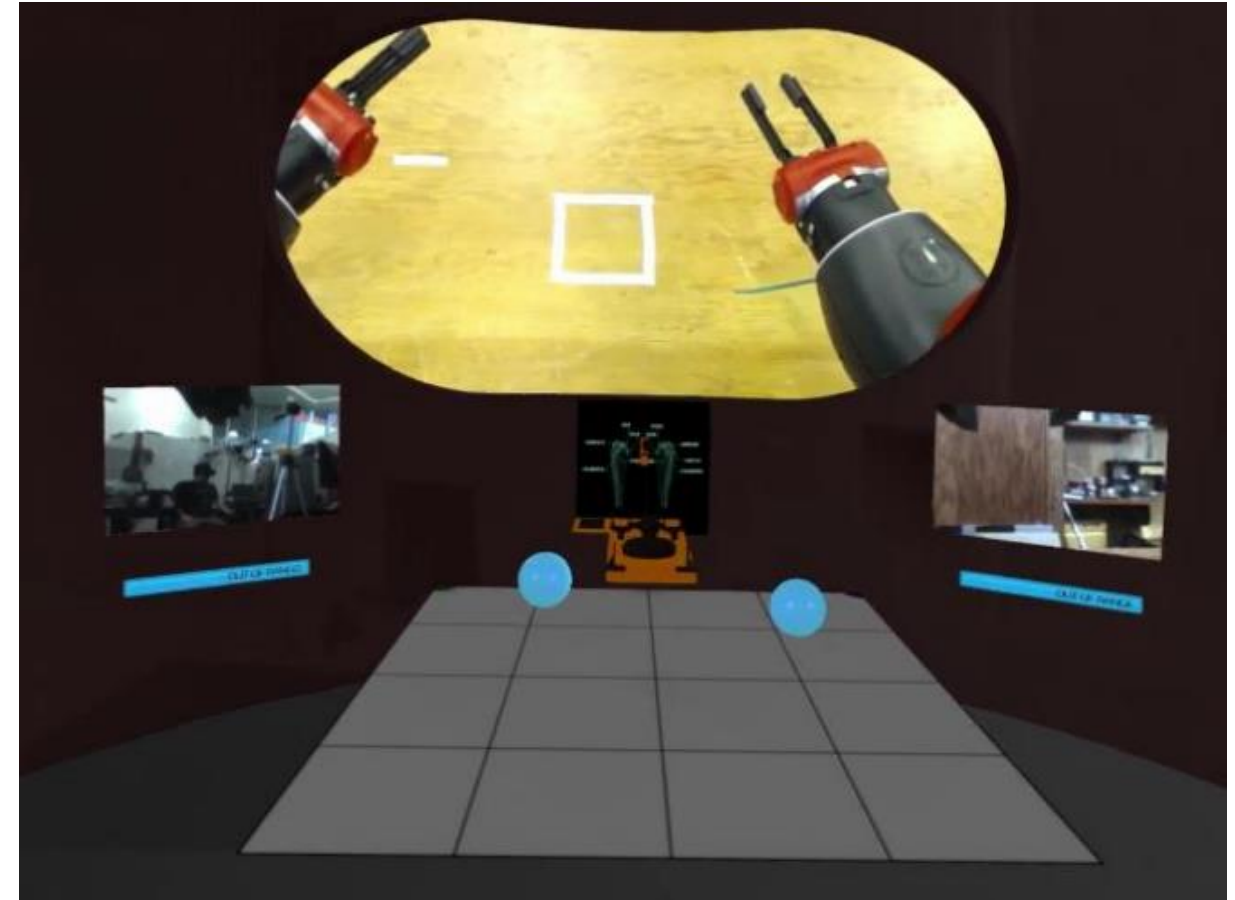- Intuitive and feasible but might need training
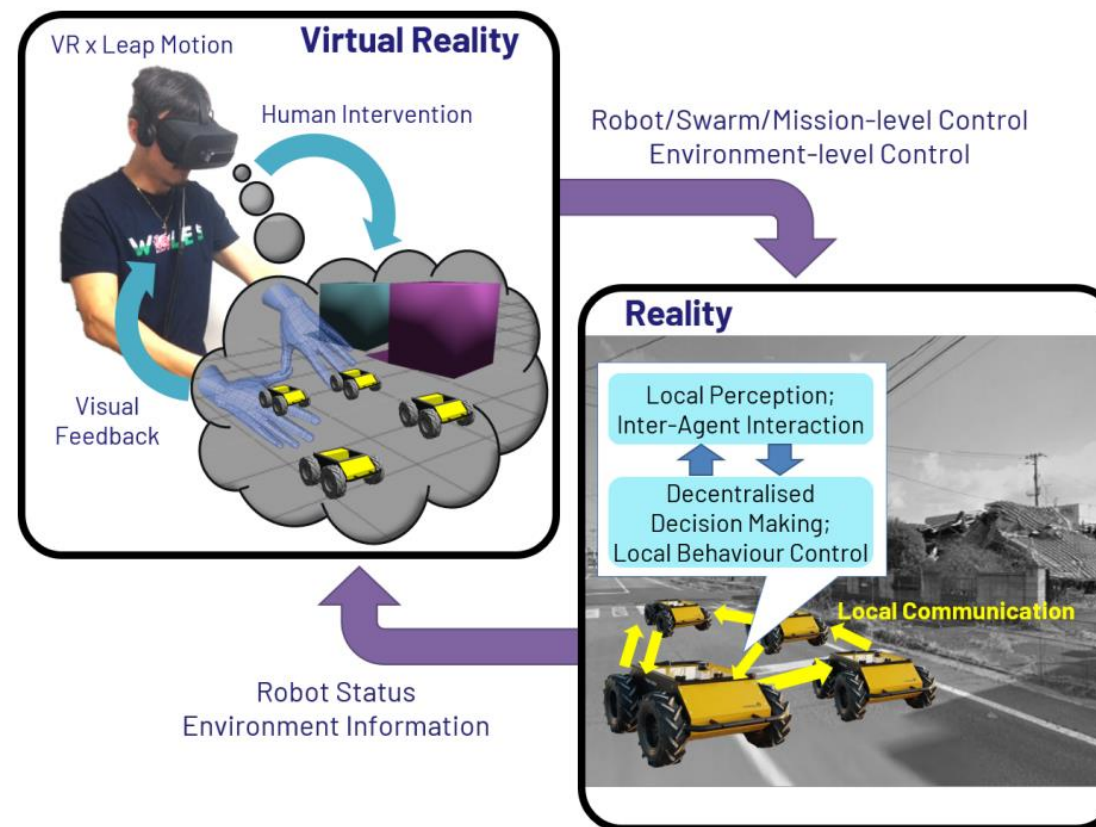
(Jang et al., 2021)

Specific Example for VR

Baxter's Homunculus: Virtual Reality Spaces for Teleoperation in Manufacturing

- Control robot arms with VR controllers

- Oculus Rift headset with default controllers

- Teleoperation for work in unsafe environments

- Collocation in robot head
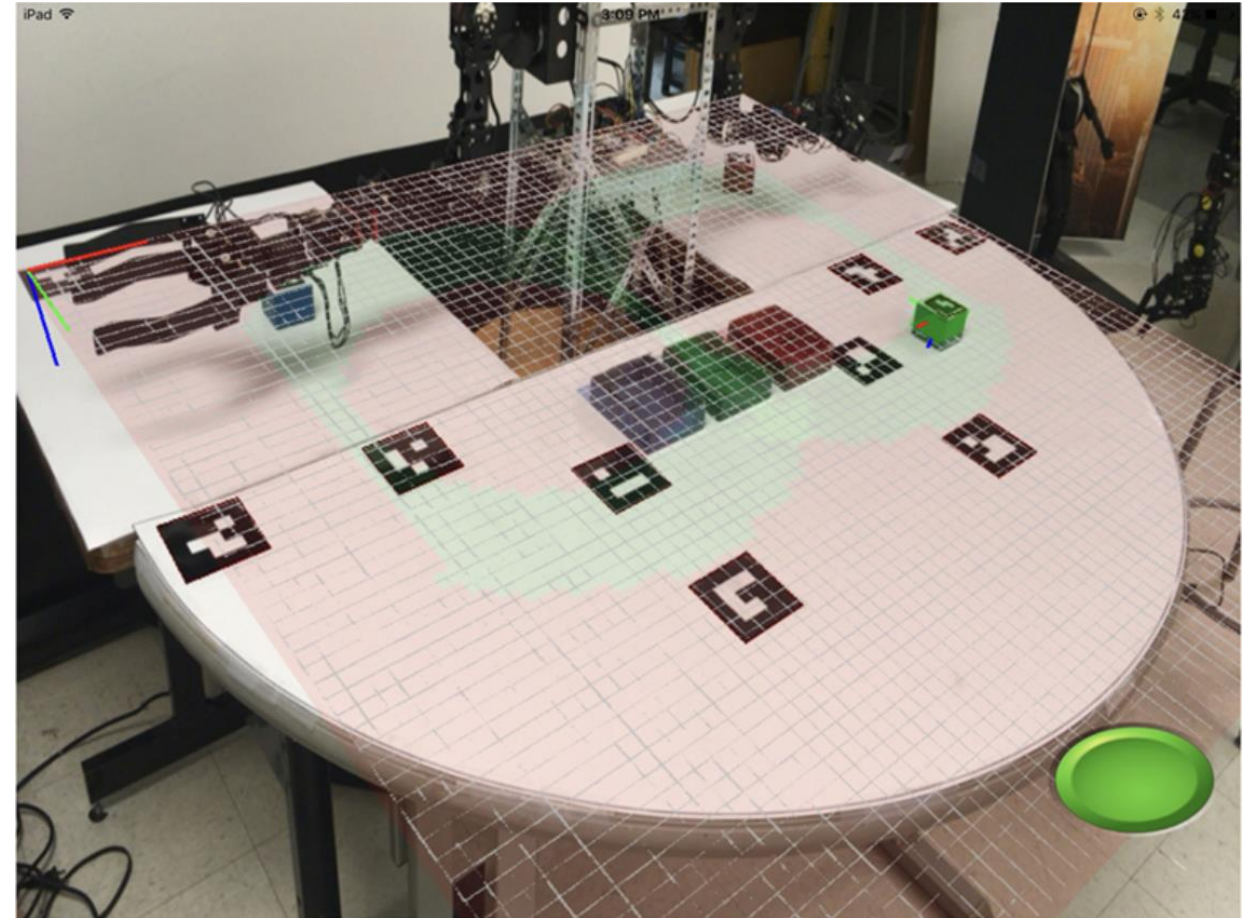
- Pick up and place blocks

(Lipton et al., 2017)

Agenda

Mobile Mixed-Reality Interfaces That Enhance Human–Robot Interaction in
Shared Spaces

- Visualization of information about robot in shared space

- Mobile tablet as camera and controller

- Environmental markers on table

- Showing range of motion of robot

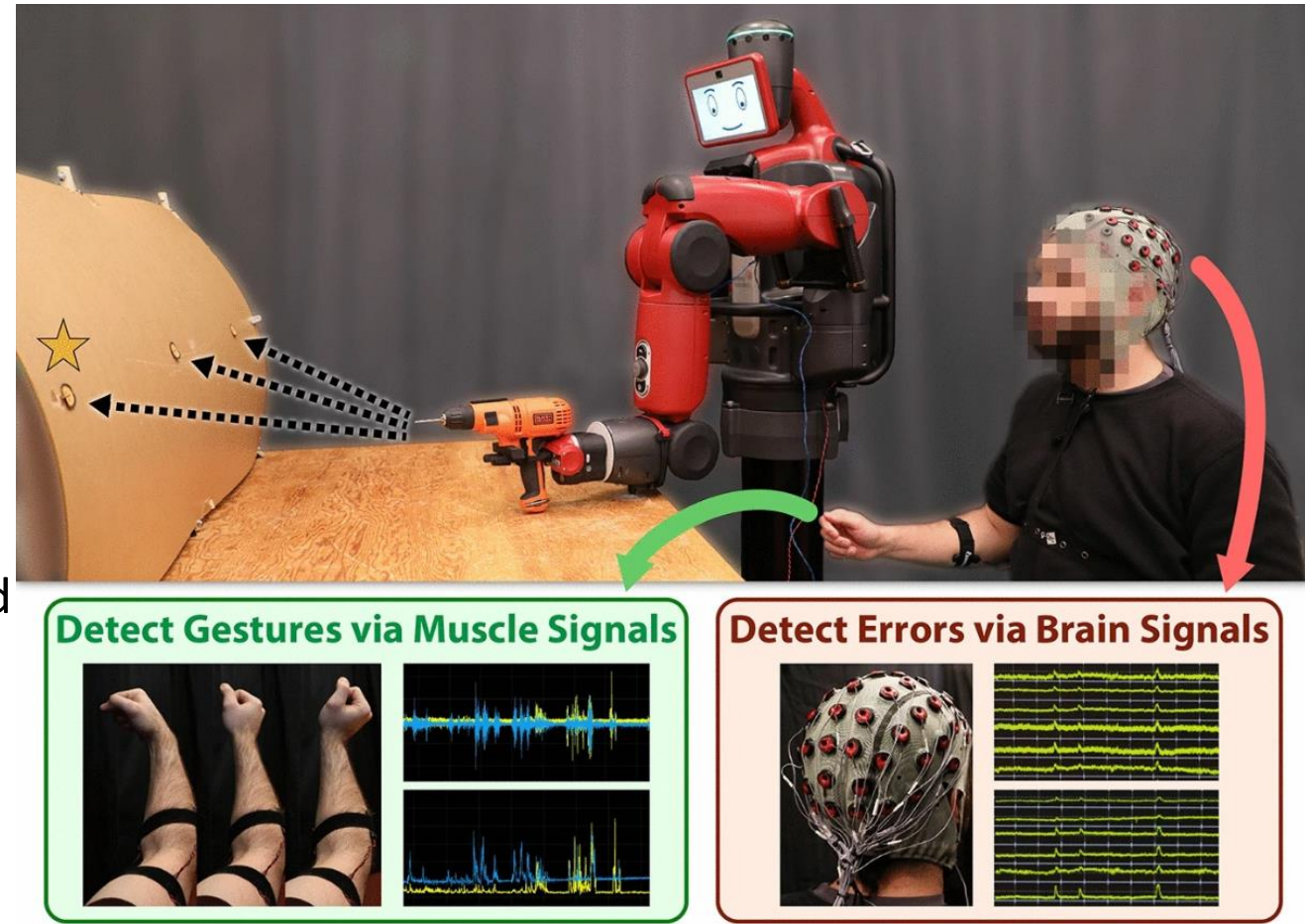- Pre render potential future moves of the robot

(Frank et al., 2017)

Agenda

Specific Example for bio-signal-based

Plug-and-play supervisory control using muscle and brain signals for real-time gesture and error detection

- Classification of left- and right-hand gestures via muscle signals (EMG)

- Error recognition through brain function (EEG)

- Combination in hybrid system

- Tested on 7 subjects (plug and play) to reduce barrier of entry for new users

- Shows potential, but more training data needed for higher reliability

Detect Gestures via Muscle Signals

Detect Errors via Brain Signals

(DelPreto et al., 2020)

Agenda

Use Cases

- VR

  - Teleoperation

  - Swarm control

- AR

  - Display important robot information
    (range of motion/wear and tear)

- Bio-signal-based

  - Control robot with mind (EEG) or muscles (EMG)
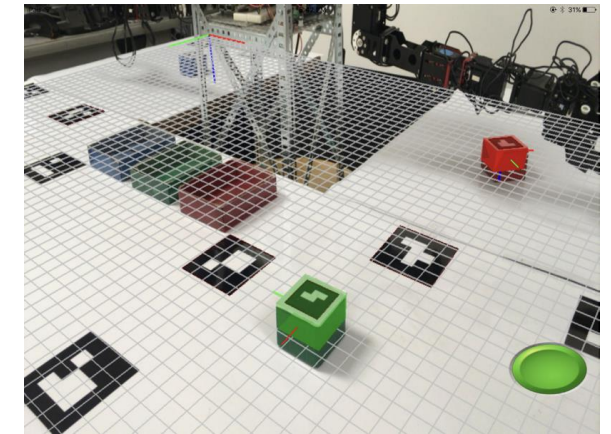
(Frank et al., 2017)

(Lipton et al., 2017)

General comparison

Devices

- VR
  - Meta Quest 2/Pro
  - Valve Index
- AR
  - Tablet/Smartphone
  - Google Glasses
- Bio-signal-based
  - Wrist band
  - Electrode hat

(Lipton et al., 2017)
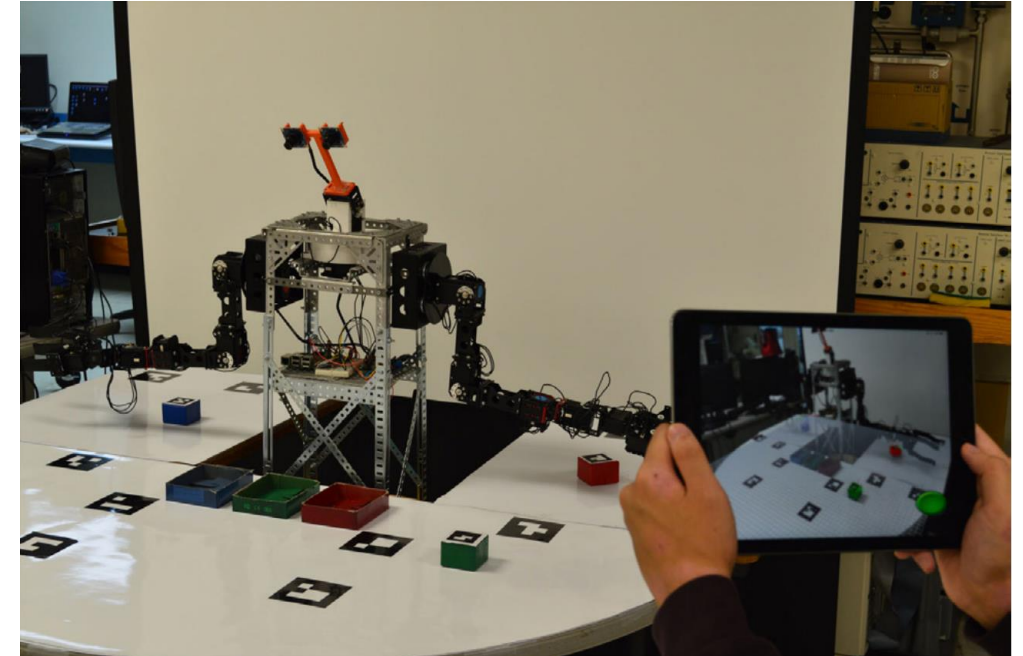
(Frank et al., 2017)

(DelPreto et al., 2020)

General comparison

Cost

- VR

  - Expensive Headsets

  - Cheaper through consumer products

- AR

  - Low end cheapest solution

  - High end more expensive than low end VR

- Bio-signal-based

  - Difficult to evaluate, mostly custom devices

Technology	Device	Cost ($)
VR	Meta Quest 2	450
VR	Valve Index	1079
AR	I-Pad	449
AR	Galaxy Tab S8	200
AR	Google Glasses	999
Bio-signal-based	EEG electrode hat	1500

General comparison

Future potential

- VR

  - Taking over control of "almost fully" autonomous systems remotely

- AR

  - Integration into traditional glasses or even contact lenses

  - Increase trust in everyday robots

- Bio-signal-based

  - Implants/EEG: huge potential to merge with robots and full control of a robot with a human's thoughts

Agenda

Best path forward

- End goal:

  - Bio-signal-based control of robots with human thoughts

- Intermediate steps:

  - Gradual development of all three technologies

    - VR

      - Ability to wear headsets for longer

      - Training programs

    - AR

      - Better integration into glasses

    - Bio-signal-based

      - Higher reliability necessary to be save to use

Thank you!

Literature

Tesla Artificial Intelligence & Autopilot. (2022). Retrieved 7 February 2023, from https://www.tesla.com/AI

Boston Dynamics Spot Product Page. (2022). Retrieved 7 February 2023, from https://www.bostondynamics.com/products/spot

Jang, I., Hu, J., Arvin, F., Carrasco, J., & Lennox, B. (2021). Omnipotent Virtual Giant for Remote Human--Swarm Interaction. *2021 30th IEEE International Conference on Robot & Human Interactive Communication (RO-MAN)*, 488–494. IEEE.

Lipton, J. I., Fay, A. J., & Rus, D. (2017). Baxter's homunculus: Virtual reality spaces for teleoperation in manufacturing. *IEEE Robotics and Automation Letters*, *3*(1), 179–186.

Frank, J. A., Moorhead, M., & Kapila, V. (2017). Mobile mixed-reality interfaces that enhance human--robot interaction in shared spaces. *Frontiers in Robotics and AI*, *4*, 20.

DelPreto, J., Salazar-Gomez, A. F., Gil, S., Hasani, R., Guenther, F. H., & Rus, D. (2020). Plug-and-play supervisory control using muscle and brain signals for real-time gesture and error detection. *Autonomous Robots*, *44*(7), 1303–1322.

Dianatfar, M., Latokartano, J., & Lanz, M. (01 2021). Review on existing VR/AR solutions in human–robot collaboration. *Procedia CIRP*, *97*, 407–411. doi:10.1016/j.procir.2020.05.259

Meta Shop. (2022). Retrieved 7 February 2023, from https://www.meta.com/de/en/quest/products/quest-2/

Steam Valve Index Shop. (2022). Retrieved 7 February 2023, from https://store.steampowered.com/valveindex

Apple IPad Shop. (2022). Retrieved 7 February 2023, from https://www.apple.com/shop/buy-ipad/ipad

Samsung Tablet Shop. (2022). Retrieved 7 February 2023, from https://www.samsung.com/us/tablets/galaxy-tab-s8/buy/

Open BCI Shop. (2022). Retrieved 7 February 2023, from https://shop.openbci.com/collections/frontpage

Robertson, A. (2019). Google announces a new $999 Glass augmented reality headset. Retrieved 7 February 2023, from https://www.theverge.com/2019/5/20/18632689/google-glass-enterprise-edition-2-augmented-reality-headset-pricing

Robertson, A. (2017). Oculus Rift and Touch are now $200 cheaper. Retrieved 7 February 2023, from https://www.theverge.com/2017/3/1/14779460/oculus-rift-touch-vr-bundle-price-drop-200