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Visual Prosthesis Control Using Optical See-Through Glasses

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Our research in NeuroScience is currently focused on the development of new intelligent neuroprosthetic approaches, primarily for the hand. This involves the use of 3-D computer-aided design (CAD), multi-material polymer printing, finite element method (FEM), deep learning and augmented reality methods.

Introduction & State of the Art

- We propose a robust and everyday-life suitable hand prosthesis control using augmented reality glasses and tracking.
- State of the art approaches for controlling neuroprosthesis of the upper limb are using electromyography (EMG) sensors or brain machine interfaces [3].
  - ⟹ These concepts come with high costs for complex and expensive systems as well as exhausting calibration and/or learning procedures.
  - ⟹ Acceptance of the patients for such systems is thereby restricted. [4][5]
- Normally, grasping with a prosthetic hand is visually controlled just as grasping with a healthy hand.
- Using augmented reality with optical see-through glasses and an accurate tracking method offers the possibility to control the prosthesis with minimal movements of the viewing direction.

System Description

- The prosthesis includes seven infrared LEDs arranged in LED triplets that are used to track the prosthesis in 3D space.
- The user wears augmented reality glasses equipped with a camera with infrared filter. Therefore, the image captured by the camera mainly contains the LED blobs, in case that they are inside the camera's field of view.
- The configuration of the LEDs' positions enables to determine the orientation (rotation) as well as the position (translation) of the marker using pose estimation [6] with respect to the user's point of view. This transformation can be used to continuously update the position and orientation of an overlayed virtual command window visualized by the augmented reality glasses.
- The prosthesis' orientation and position can inversely be used to determine movements of the user's head, which equals a movement of the camera with respect to the prosthesis marker.

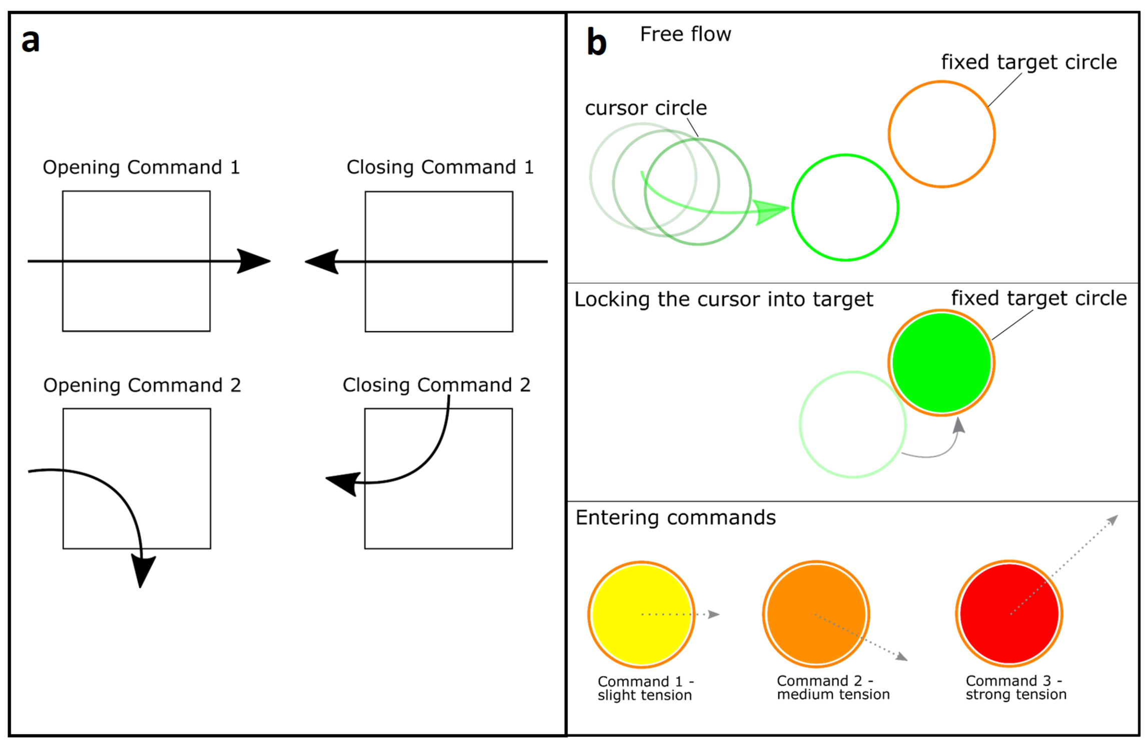

Figure 2: Two different visual control mechanisms [1][1]: (a) Crossing the rectangle with viewing ray triggers up to 16 different commands. (b) Circular cursor and circular target. When the two circles are superimposed they snap into each other. Attempting to move the cursor further controls the grip strength of the prosthesis.

- A fixed virtual line perpendicular to the glasses representing the viewing direction of the user is intersected with the virtual command plane.
- Consequently, the user gets the possibility to draw commands on the virtual command field which controls the prosthesis' effectors. In Figure 2, two different possibilities for visual control mechanisms are shown.

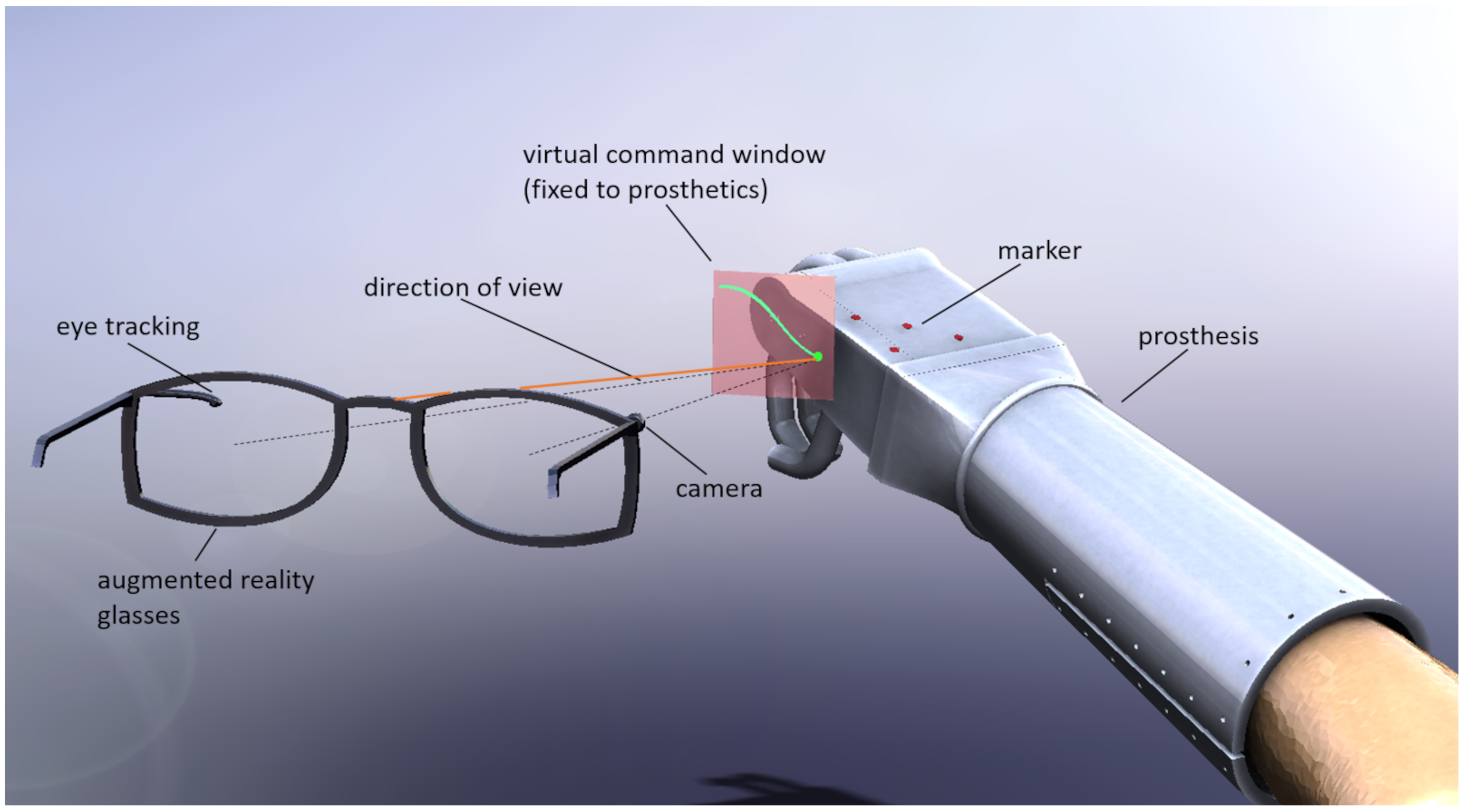

Figure 1: System overview of the visual prothetics control [2][1]

Results

- The control mechanisms shown in Figure 2 were tested using the end effectors shown in Figure 3.

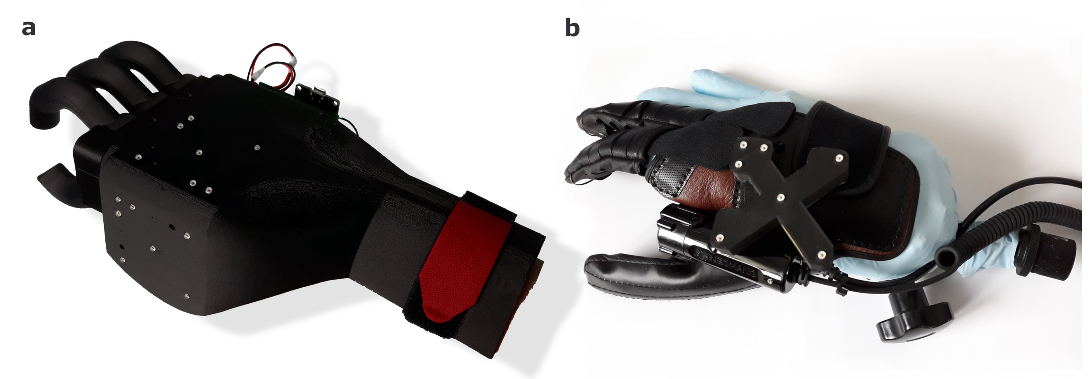

Figure 3: Two end effectors used for evaluating the system [1][1]. (a) Gripping system for healthy user. (b) Motorized orthosis NeoMano by NeoFect.

- Fixed overlay with respect to the prosthesis is feasible.
- Only minimal head movements are necessary to draw commands with sufficient accuracy [1].
- The overlaid elements are only visible when the user looks at the prosthesis, so there is no disturbance to the field of view [1].

Further research

- Using artificial intelligence, the processing of the commands is expected to become more robust and reliable.
- The system has to be tested in a clinical trial to evaluate its acceptance by the patients.

S.H., H.H., and A.O. are inventors on patent application DE 10 2019 108 670.1 submitted to the German Patent and Trade Mark Office (DPMA), and on U.S. patent no. 16/836,746 submitted to the United States Patent and Trademark Office (USPTO) by Offenburg University that covers the invention of the presented new method.

An introductory video can be found here:

References:

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