# Unconstrained Neck: Omnidirectional Observation from an Extra Robotic Neck

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## ABSTRACT

Humans are born with physiological limitations in terms of the sensory and motor abilities. Due to the narrow range of motion of the neck and the small visual field of the eyes, the human visual sense is limited in terms of the spatial range. We address this visual limitation by proposing a programmable neck that can leverage the range of motion limits. *Unconstrained Neck*, a head-mounted robotic neck, is a substitution neck system which provides a wider range of motion enabling humans to overcome the physical constraints of the neck. Using this robotic neck, it is possible to control the visual/motor gain which allows the user to thus control the range and speed of his effective neck motion or visual motion.

## CCS CONCEPTS

• **Computing methodologies** → **Graphics systems and interfaces**; • **Human-centered computing** → **Human computer interaction (HCI)**; *Interaction design*; • **Hardware** → Sensor devices and platforms;

## KEYWORDS

robotic neck, vision expansion, human augmentation, biomimetics

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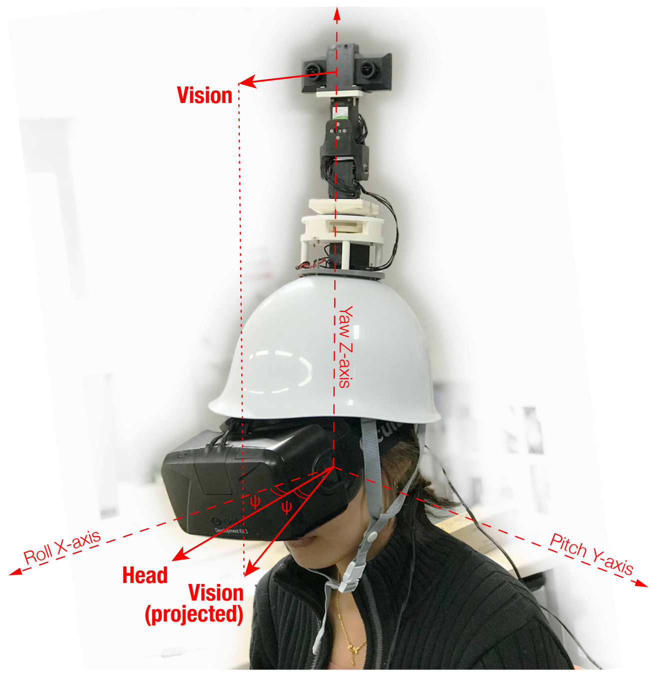


**Figure 1: The *Unconstrained Neck***

## 1 SYSTEM OVERVIEW

We utilize an extra robotic neck to achieve the *Unconstrained Neck*. The prototype consists of a stereo camera, helmet-based robotic neck with 3 degrees of freedom (DOF), and head-mounted display (HMD) as shown in Figure 1. The motorized camera is mounted at the endpoint of the robotic neck, allowing the camera and its vision direction to operate 3-axis rotations: yaw, pitch, and roll. The resulting motion of the rotation is thus a combination of the human neck and the robotic neck movements. For this system, the maximum range of motion is $-180°$ to $180°$ about the three axes, which is almost twice the range of the human neck. The *Unconstrained Neck* is driven by user's neck orientation, and the motion mapping is defined by the software. Previous work [1, 2] addressed the possibility of human visual/motor system adaptation to different gain values in the virtual environment. We apply a similar approach for this system. The visual/motor gain (g) for each axis of the system is controlled in the software side, with positive values (g>0) to amplify the speed of motion, or negative values (-1<g<0) to result in slower operation of the neck. For example, as shown in Figure 1, the gain value used g=1, the user's human head (neck) is at a yaw angle of $\psi$, and the resulting system vision (camera) is at a yaw angle equivalent to $2\psi$ (calculated by $\psi + \psi * g$). Depending on the application or scenario, this gain value can be altered to make the movements of the vision faster with a wider range of motion. Or it can be slower with a limited range of motion. This approach can be viewed as programming our body's motor system.

The system operates by wearing the helmet, with the robotic neck being mounted at the center top of the user's head maintain similar perspective (with a vertical offset of approximately 450 mm from user's eyes). The camera streams stereo images to the HMD, creating a see-through experience. The camera is configured with


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an interpupillary distance of 65 mm, and a horizontal field of view equivalent to 110° matching the used HMD settings (Oculus DK2). The coherence in vision can ease the user's incompatibility and optimize this augmented experience.

## 2 USER EXPERIENCE

When using this prototype, the users can have full omnidirectional view covering 360° surroundings with the neck action only. The users are also able to re-program their neck motion to achieve a varying values of the range of motion. When scanning, the system can substitute the movements of the torso and spine, and this makes the operation swifter and more agile. It is especially fit for people who have stiffness or disability in lower body or spine, but also can be used by health people to augment the neck motion and the spatial range of the vision. The overall experience is smooth and immersive, and naive users are able to adapt to the new visual augmentation experience within a short time.

## REFERENCES

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