CaneXR: Building A Cane-Based XR Controller For Knowledge Work

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Abstract

While extended reality (XR) has gained traction in entertainment, its application in knowledge work remains limited. This is partially due to challenges of existing interaction methods on facilitating prolonged, high-precision operations without fatiguing the user. Previous research suggests that a "cane" shaped design may mitigate these issues by providing ergonomic arm support. However, designs exploring this configuration are lacking. We present CaneXR, a cane-based controller with ergonomic arm support that provides controls with five degrees of freedom and operates a 3D cursor in the 3D space for object manipulation. We conducted a pilot study on its usability and received positive feedback on the adoption of support. Based on the results, we presented improvement opportunities to iterate on this prototype and expand its supporting features.

paper

video

CaneXR

Thanks for your interest!

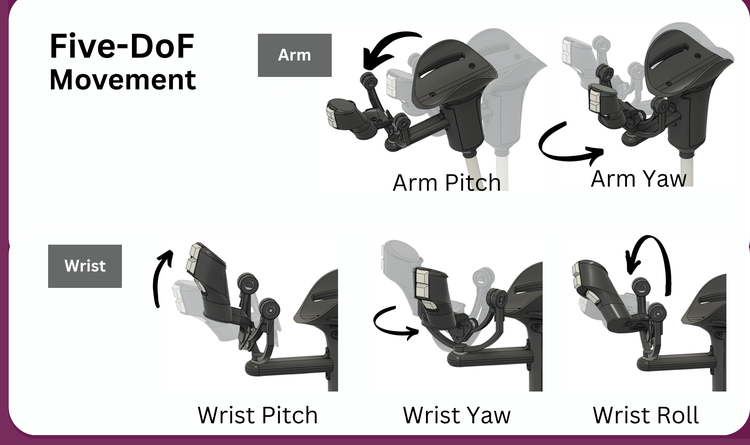
Please stay tuned for our future work!

CHI 2025
April 26–May 1, 2025 in Yokohama, Japan

Between “Support” and “Mobility”

CaneXR addresses the gap between traditional desktop environments for knowledge work and immersive Virtual Reality (VR) settings. Desktop setups offer comfortable, rested arms for high-precision tasks, but restrict user mobility and the benefits of infinite 3D space offered by XR. Conversely, current VR interactions often require sustained mid-air hand movements, leading to arm fatigue ("gorilla arm") and hindering precise, prolonged operations. Our CaneXR interface stands between “support” and “mobility”: It’s an ergonomic controller designed to provide both mobility (supporting locomotion and 5 degrees-of-freedom arm movement) and comfort (allowing the arm to rest, thus reducing fatigue). CaneXR aims to facilitate prolonged, high-precision knowledge work within immersive XR environments.

CaneXR



Hardware Design: *Five-DoF Dynamic Support*

CaneXR’s hardware design, designed for ergonomic support and precise control, comprises three main components:

- ***Cane Stick with Arm Rest:*** Support the user's arm from the ground up. Allows comfortable resting and enables 2-DOF movements on the user’s arm: forward-backward (pitch) and left-right (yaw).

- ***Three-Axis Gimbal System***: Attached to the cane stick. Facilitates 3-DOF movements on the user’s wrist: pitch, yaw, and roll. Critically, the design positions the rotational center at the user's wrist joint to move naturally.

- ***Hand Stick with Palm Rest:*** Allows the user to rest their hand while gripping it. It features a tilted design for comfort and incorporates three buttons (Select, Rotate, Hold) for interaction (details see Interaction Design section).

Interaction Design: *3D Cursor Control*

CaneXR utilizes a **3D cursor** for object manipulation in the XR environment, chosen to leverage the micro-movements enabled by the arm support.

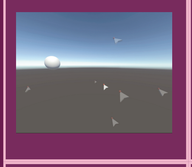
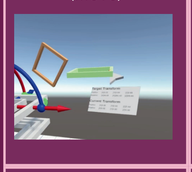
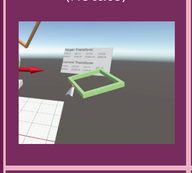
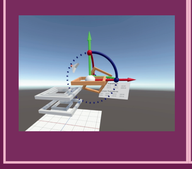
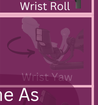
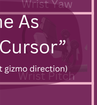
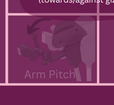
- ***Move Cursor: Clutch In/Out***

Different from most XR interactions where the user’s hand is always engaged in the control, CaneXR’s cursor only moves when the user press the “Hold” button - a “clutch in/out” mechanism to decouple hand-cursor movements and allow the user to relax their hand freely without affecting the cursor position.

- ***Manipulate Object: Free or Gizmo***

Users can hover over an object and select it with the “Select" button. Once selected, the object can be manipulated in two ways:

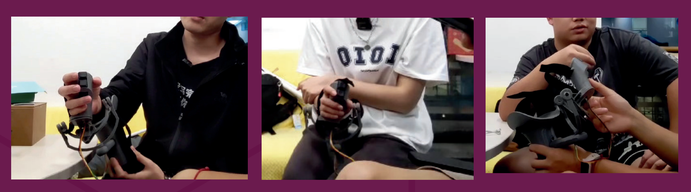
- **Free manipulation** (directly dragging the object to control its position or rotation);
- **Gizmo manipulation** (drag one of the gizmo handles to change the object’s position / rotation on a single dimension).

Operation	Button	Movement		
			Arm	Wrist
Move Cursor 	Hold Button 	X	 Arm Yaw	 Wrist Yaw
		Y		 Wrist Pitch
		Z	 Arm Pitch	
Free Manipulation (Move) 	Select Button 	X	 Arm Yaw	 Wrist Yaw
		Y	Same As “Move Cursor”	 Wrist Pitch
		Z	 Arm Pitch	
Free Manipulation (Rotate) 	Rotate Button 	Yaw		 Wrist Yaw
		Pitch		 Wrist Pitch
		Roll		 Wrist Roll
Gizmo Manipulation (Move/Rotate) 	Select Button 	+/-	 Arm Yaw	 Wrist Yaw
			Same As “Move Cursor” (towards/against gizmo direction)	 Wrist Pitch
			 Arm Pitch	

Balancing Hand Weight

Since the weight center is different from the rotation center, a spring solution is implemented within the gimbal system to counterbalance the weight of the hand.

Pilot Study



A qualitative pilot study was conducted with four XR experts to gain preliminary insights into CaneXR's usability, where participants watched a demonstration video and shadowed the movements with the CaneXR controller. Participants then provided feedback on the tangible interface and interaction design.

Key Findings:

- Support: Participants noted the potential for arm support to reduce fatigue but felt it might limit movement.
- Precision: Participants expect the support to improve precision and increase hand position awareness.
- Button Design: Concerns arose about button comfort and positioning, with suggestions for different switch types.
- Cursor Control: Initial cursor control was faster than expected, indicating a need for adjustment.
- Hand Pose: Opinions varied on the vertical resting hand pose, with some preferring a horizontal position for comfort.