AUGMENTED REALITY USER INTERFACE

LAIDLAW SCHOLERSHIP UNDERGRADUATE PROGRAMME

UCL | 香港大學 THE UNIVERSITY OF HONG KONG | LAIDLAW SCHOLARS

1. INTRODUCTION

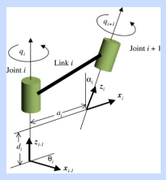
- BACKGROUND: With growing popularity, virtual reality (VR), especially immersive VR, is now creating novel ways for a variety of social interactions including entertainment, education, training and so on. Inside virtual platforms, avatars are a most essential part of the user interface since users are represented as avatars to better experience virtual interactions. Therefore, an obvious indication would be that improving the avatar quality can upgrade the User interface thus providing better user experiences.
- PREVIOUS WORKS: L. Izzouzi and A. Steed have integrated the open-source Microsoft Avatar Library into Ubiq—an augmented reality (AR) platform supporting a massive number of interactions, to create two contrast avatar systems. Afterwards, several lab experiments for users to experience both the Microsoft Avatars—the more realistic one and Ubiq's original floating Avatar—robot-like, are launched with the purpose of collecting useful behavioral data about how people are influenced when represented differently during non-verbal social platform interactions.
- INNOVATIVE POINT: On top of the previous experiments, there are some ways to improve the experiment by making the Microsoft Avatars more flexible and real. Therefore, this project tried to inverse kinematics (IK) method implemented onto avatars' hands and fingers inorder to to improve the realness and flexibility of the avatars. Under the better contrasting conditions, it's hoped that people's preference for virtual images can be more precisely analyzed, dedicating to the development of AR user interfaces.

2. RELATED TOOLS

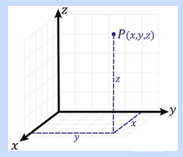
- The MoveBox open-source toolbox: MoveBox is an open-source toolkit published by Microsoft for avatars to better animate the captured movements of users. It contained open-source code for detecting and imitating upper and lower body movements and facial movements. For avatars to achieve real-time imitation, the motions are tracked by a depth camera and processed through the codes. For example, the codes contained inside IK hand-tracking file are able to detect and mimic users' hand movements like finger bending with low latency and high accuracy.
- Unity software and built-in platform Ubiq: In general, Unity is a popular cross-platform engine that provides many toolkits for developers to publish 2D/3D and AR/VR applications, while Ubiq is an AR virtual platform under Unity that links single user into a broader network to achieve interactions among a great population. They both have high-level user interfaces to restore what's in reality and help users get immersed. Like objects in reality—except they are generated by C# code, Ubiq's procedure of creating an object is called 'defining', sharing and maintaining an object is called 'spawning', and both Unity and Ubiq call a group of closely related objects 'prefab'.

3. SUPPORTING METHOD-- INVERSE KINEMATICS (IK)

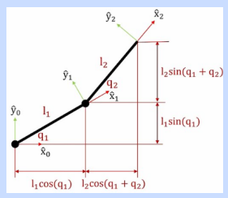
- Cartesian coordinate: The coordinate for marking overall reality positions which can be directly measured from the observers' views.
- Joint coordinate: The coordinate for marking physical force analysis for each important joint which can better analyze how the movements are generated from robots-- avatars would be similar.
- Kinematics: Kinematics is a method to control robots, avatars in this case, to perform certain movements. This process can be represented as the math procedure of transforming joint matrix-- denoting information from the joint coordinate, into Cartesian matrix-- denoting information from the Cartesian coordinate. For example, denote the Cartesian space matrix X, the joint space matrix P, and the transformation matrix T, then the procedure would be finding: X = TP.
- Inverse Kinematics: Inverse Kinematics is a term originated from the term Kinematics. "Inverse" showed that instead of transforming the joint matrix into the Cartesian matrix like the kinematics process, it does the opposite. Instead of already knowing the avatars' changes in joint angles, IK examines the positions first and then uses them to do the backward calculation to obtain the angles of joints. For example, denote the Cartesian space matrix X, the joint space matrix P, and the transformation matrix T, then the procedure would be finding: P = inverse(T)X.



the Joint coordinate



the Cartesian coordinate



Example

$$\mathbf{x} = \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} l_1\cos(q_1) + l_2\cos(q_1+q_2) \\ l_1\sin(q_1) + l_2\sin(q_1+q_2) \end{bmatrix}$$

$$\mathbf{q} = \begin{bmatrix} q_1 \\ q_2 \end{bmatrix} \in \mathbb{R}^2$$

$$\mathbf{x} = \mathbf{f}(\mathbf{q})$$

$$\begin{bmatrix} q_1 \\ q_2 \end{bmatrix} = \mathbf{f}^{-1}(\mathbf{x})$$

4. ANALYZATIONS AND FINDINGS

- Integration: On top of the previous works, this summer mainly tried to implement Microsoft's open-source code MoveBox into the existing Ubiq Avatar system. After doing related research on the internet, analyzing the current Microsoft Library and Ubiq's avatar functioning structure and procedure, it was found out that the avatar-spawning scripts and avatar-defining scripts were independent, and most importantly, the original avatar-defining scripts came as one whole prefab. This showed that the new Microsoft Avatar prefab can be directly inserted into the Ubiq system without making changes to the spawning process.
- Coding Possibility: By the above mathematical analysis, obtaining a joint matrix requires all information of all joints. After analyzing important code scripts, it was found out the original joints were all similarly coded, indicating that one could add new joints by simply duplicating and making minor changes and this went the same with adding anchors.
- Realization possibility: By the above mathematical analysis, there would be different solutions when encountering more joints. However, these solutions are only dependent on certain joints' parameters in the existing code.

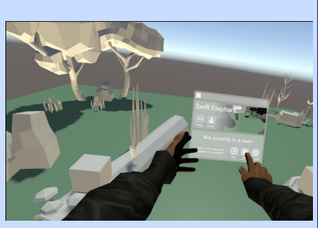
5. MAIN PROCEDURES

- Setting up the environment: For starters, it's important to ensure that the software versions match with the hardware. Virtual Reality experiences can be supported on several systems like the Meta Quest and HTC Vive and usually require headsets to collect visual information. Connecting the headset to computers needs the support of GPU-matching graphic cards and environmental toolkits. Afterwards, the overall environment needed to be set up for all three packages—the Microsoft avatar library, MoveBox toolkit and Ubiq to function normally. This required the correct version of Unity and MoveBox toolkit package.
- Establishing communication between user and virtual avatars: After setting up the environment, the next step would be to establish connections between the headset and computer by implementing camera packages and manipulating the settings inside the Unity inspector slot to suit a specific headset and hand-tracking model. Then the IK hand-tracking package in MoveBox should be merged into the original Microsoft Avatar prefab, along with the successfully set camera, to create a new package object that has the capability of detecting and mimicking headset users' finger, hand and arms' movements.
- Implementing new features into avatars: Replace the Ubiq's original avatar with the new object package, thus fitting the newly improved Microsoft Avatars into the Ubiq network. Then code adjusting was performed. According to the functioning procedure of the inverse kinematics (IK) methods, more joints and complex topology were required, leading to more variables to define and process in code as well as more anchored sensors to be created inside prefabs. After fixing up the codes inside the avatar's scripts, corresponding anchor sensors were added by inserting new game objects into the avatar prefabs. With the two above steps settled, the next step would be to adjust the angle parameters until the avatar's hands and arms look normal as in reality.
- Demonstrating and recruiting participants: Finally, after successfully implementing the IK method into fingers and hands, a demonstration documentation or video would be made. Since the ultimate goal of the project is to study human behaviours, recruitment for active participants would be needed. As a consequence, hand-tracking IK along with other improvements by other peers in the group including implementing facial tracking and lower-body IK would be merged into one whole showcase to attract people's attention and interest.

1) Set up the environment to connect the headset

2) Build the avatar

3) establish connections between the user and the avatar



4) Insert avatar onto Ubiq platform and create corresponding joints

6. CONCLUSION AND PERSPECTIVE

With new avatars more vivid and flexible, there are several benefits. firstly, the User Interface can be raised to a higher level thus providing people with better user experience. Secondly, it provides a more distinguished contrast against old avatars, thus people's preference for virtual images can be more precisely analyzed. All of these results above will lead to a higher recognition of AR and VR, which promote the development of virtual platforms and new ways of interaction.

Student: Cao Nuanyu
Faculty of Engineering
Host University: ULC
Supervisor:
Dr. Anthony Steed
Department of Computer Science, UCL
Dr. Zhongrui Wang
Department of Electrical and Electronic Engineering, HKU