Using ARToolKit for 3D Hand Position Tracking in Mobile Outdoor Environments

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Introduction

This poster presents how we have used the ARToolKit to develop a cheap and low cost 3DOF (degrees of freedom) hand tracker, allowing us to use a video camera (see figure 2) mounted on the head to track the motion of the hands of the user (see figure 1) as real world X, Y, Z values. This tracker is most useful when working in mobile outdoor environments, as traditional tracking technology (magnetic, ultrasonic, acoustic) is not available. When using mobile computers outdoors, traditional desktop devices such as mice and keyboards do not work well, and so we have developed purely glove based user interfaces based on our ARToolKit hand tracker.

Fig 1 – Hand tracker in use outdoors

Gloves and Video Cameras

We have designed a custom pair of gloves which have two 2cm x 2cm fiducial markers glued onto the thumbs (see figure 6). The size of the markers is the best size for working within arms reach of the user's head. A PGR Firefly camera is mounted on the head mounted display of the user (see figure 2), and captures the video for ARToolkit.

Fig 2 – Front view of backpack and 1394 camera on HMD

Calibration Problems

An important note for ARToolKit is that it generates 6DOF matrices for each fiducial marker, but these are in the coordinate system of the special distorted camera frustum model, and not in real world coordinates. If the calibration for the camera is not perfect (the ARToolkit calibration process does not always generate good results) then extra uncompensated errors are introduced into the results and it is unusable for tracking (see figure 3). In traditional applications (such as simpleTest) the calibration of the camera is unimportant, as the 6DOF matrix for the fiducial is in distorted camera coordinates, but is then rendered using the same camera frustum, and so the errors cancel out. When used as a tracker, we input the values into a 3D scene graph, and we cannot use the supplied 2D projection camera frustum. As a result, errors during the calibration process are noticed and so these need to be repaired to make a useable tracker.

Fig 6 – Gloves with 2cm x 2cm fiducial markers

Fig 3 – Coordinate system with Z axis for original and normal cameras

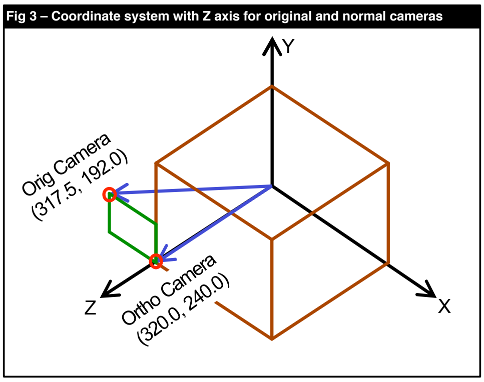


Fig 4 – Original ARToolkit camera_para.dat file, with errors

$$camera = \begin{bmatrix} 780.54 & 0.54 & 304.64 & 0.0 \\ 0.0 & 762.30 & 208.68 & 0.0 \\ 0.0 & 0.0 & 1.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.0 \end{bmatrix}$$

$$size = (640,480) \quad centre = (317.5,192.0)$$

$$focal = 26.3000 \quad sizefactor = 1.009989$$

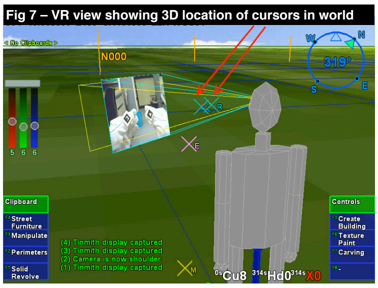
Fig 5 – Straightened orthogonal version of above data

$$camera = \begin{bmatrix} 780.54 & 0.54 & 320.0 & 0.0 \\ 0.0 & 762.30 & 240.0 & 0.0 \\ 0.0 & 0.0 & 1.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.0 \end{bmatrix}$$

$$size = (640,480) \quad centre = (320.0,240.0)$$

$$focal = 26.3000 \quad sizefactor = 1.009989$$

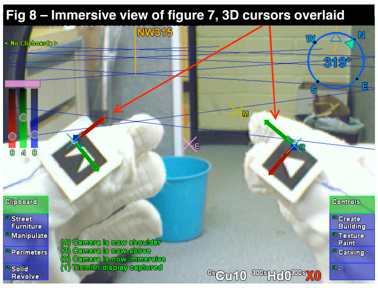
Fig 7 – VR view showing 3D location of cursors in world



Calibration Repairs

In the default supplied calibration file, the Y axis is 48 pixels from the centre of the camera, and although the camera is probably straight, the calibration process estimated this incorrectly. However, we can correct this quite simply by adjusting the centre point in the calibration file for ARToolKit. Figure 4 shows the original calibration values for the ARToolkit default camera, while figure 5 shows the version with the centre point adjusted. We can see this change in the camera axes graphically in figure 3.

Fig 8 – Immersive view of figure 7, 3D cursors overlaid



Results

The 3D tracker produces acceptable position tracking which is within the bounds of the fiducial marker. Detecting 3D orientation is more error prone and the accuracy jitters over 20-30 degrees. As a result, we use this tracker as a 3D cursor on the HMD. Using two cursors it is possible to derive a 3D orientation. Figure 7 shows the cursors floating in 3D space front of the user in the VR view, and figure 8 shows these same cursors overlaid over the fiducial markers.

ARTOOLKIT

More Info at http://wearables.unisa.edu.au and http://www.tinmith.net

Please visit the Wearable Computer Lab and Tinmith web sites to find out more information about this project, as well as other interesting projects currently in progress.

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