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MANIPULATING VIRTUAL OBJECTS IN AUGMENTED REALITY USING REAL OBJECTS

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It is important to give input information without other device in AR system. One solution is using hand for augmented reality application. Many researchers have proposed different solutions for hand interface in augmented reality. Analyze Histogram and connecting factor is can be example for that. Various Direction searching is one of robust way to recognition hand but it takes too much calculating time. And background should be distinguished with skin color. This paper proposes a hand tracking method to control the 3D object in augmented reality using depth device and skin color. Also in this work discussed relationship between several markers, which is based on relationship between camera and marker. One marker used for displaying virtual object and three markers for detecting hand gesture and manipulating the virtual object.

1. VIRTUAL OBJECTS INTERACTION

A. Camera and marker relationship

Augmented reality is a displaying virtual object in the real world. One way to display virtual object is using special markers. Currently, there are number of libraries, with specific markers, that can detect markers and put some virtual object relatively to detected marker. One of such kind of library is ARToolKit library, which use size-known square markers as a base of coordinates [4]. After detecting marker, ARToolKit gives transformation matrix, which defines the position of the marker in the camera coordinate system. Rotation and translation information are stored in transformation matrix [4].

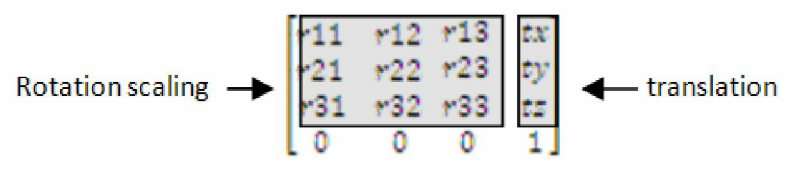

Fig. 1. Rotation and translation matrix [4]

To get relation between different markers, relation between camera and marker is used. For interaction two different markers we must know the transformation matrix of these markers. Using this information it is possible to find the position of point in one coordinate system in another coordinate system. [4]

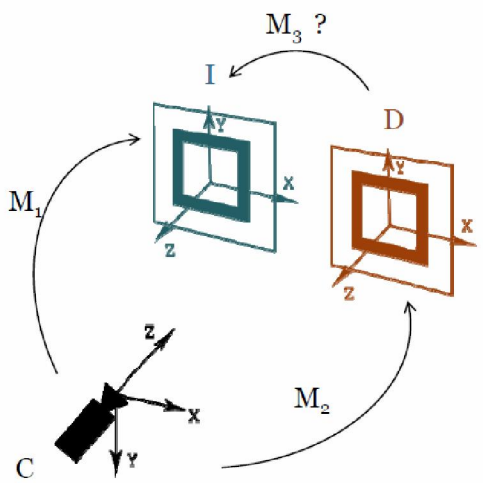

Fig. 2. Relation between markers [4]

Consider you have three coordinate systems (CS) labeled as *C*, *I* and *D* as shown in figure 1.

M_1 – the transformation matrix that transform the representation of a point from CS *I* to its representation in CS *C*.

M_2 – the transformation matrix that transform the representation of a point from CS *D* to its representation in CS *C*.

M_3 – the transformation matrix that transform the representation of a point from CS *I* to its representation in CS *D*.

ARToolKit library give the information about M_1 and M_2 matrices. Using these matrices we must find M_3.

$$M_1 = M_{C\leftarrow I} \Rightarrow M_1^{-1} = M_{I\leftarrow C}$$

$$M_2 = M_{C\leftarrow D}$$

$$M_3 = M_1^{-1} M_2 \Rightarrow M_{I\leftarrow D} = M_{I\leftarrow C} M_{C\leftarrow D}$$

Using M_2 we can easily convert the point from one CS to another.

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = M_3 \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

B. Hand gesture recognition

Three ARToolKit markers used to hand gesture recognition. One marker is placed at the end of the thumb, second marker at the end of index finger, and third marker in the middle of these two fingers, near the palm as shown in figure 2.

After processing input image, ARToolKit gives information about four vertices of detected marker. Using this information we can easily find line segments of detected marker as shown in *figure 3*.

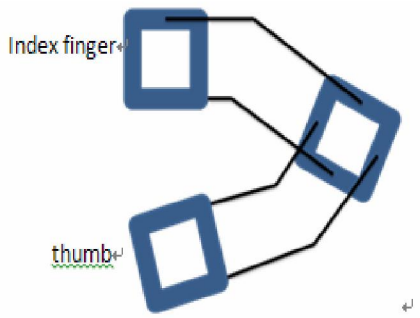

Fig. 3. Location of the markers on the hand

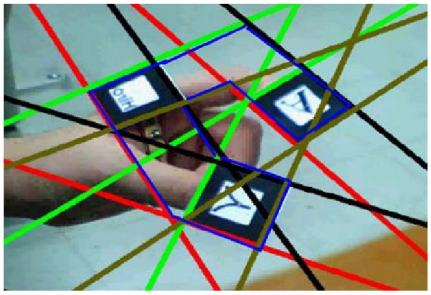

Fig. 4. Line segments of markers

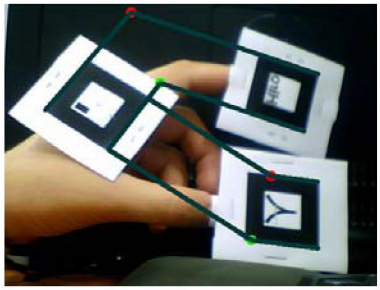

Fig. 5. Hand gesture

In the *figure 3* you can see lines in that order in which we found them. If we always use this order we can define some lines, and intersection points of these line segments can be used to find hand gesture as shown in figure 4.

C. Algorithm of manipulating virtual object.

This algorithm is one approach of manipulating virtual object using other markers. 4 markers are used for this algorithm, 3 of them to recognize hand gesture and one for displaying virtual object as shown in figure 5. [5] We can denote next variables:

P_1, P_2 – **finger point coordinates**

P_1', P_2' **translated finger points to virtual object coordinates**

P_m – **middle point of two finger coordinates**

P_o – **milde point of two finger coordinates in object CS**

and make following steps to manipulating virtual objects:

1. Check if P'_1 and P'_2 are inside the object
2. Continue only if both fingers are inside of object.
3. Store the point in the middle of P_1 and P_2 (in world CS P_m, and in object coordinate system P_o).

4. Store rotation degree between states of fingers line about z-axis. Rotation is calculated as a degree between the previous and current stage of the line, connected by the center point of the finger and the center of the marker placed near the palm.

5. Rotate the object original transformation matrix about P_0 (on z-axis)

6. Calculate the current point P_m

7. Translate the object about the difference between current P_m and stored P_m.

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ТОЛЫҚТЫРЫЛҒАН РЕАЛДЫЛЫҚТАҒЫ ВИРТУАЛДЫҚ ОБЪЕКТІЛЕРДІ НАҚТЫ ОБЪЕКТІЛЕРДІҢ КӨМЕГІМЕН БАСҚАРУ

Мәліметті қосымша құралдардың көмегінсіз енгізу – толықтырылған ортаның басты мәселелерінің бірі болып табылады. Аталмыш мәселенің алдын алу мақсатында толықтырылған орта қосымшаларында адам қолы пайдаланылады. Зерттеушілер ұсынып отырған гистограммалық талдау және байланыстырушы фактор осы мәселені шешудің бірден-бір мысалдары. Қолды танып білудің ең сенімді жолдарының бірі – жан-жақты бағытқа іздеу жүргізу, дегенмен мұның да кемшіліктері бар. Атап айтатын болсақ: есептеуге жұмсалатын уақыттың көптігі және ортамен адамның қолының түстері бірдей бола алмайтындығы. Қолдың бағыты арқылы, құрал тереңдігімен тері түсін қолдана отырып, толықтырылған ортадағы 3D объектілерін бақылау тәсілі осы жұмыстың басты ұсынатын жаңалығы болып табылады. Сонымен қатар, бұл жұмыста бірнеше маркер арасындағы байланыс қарастырылған. Бұл жердегі әрбір маркердің белгілі бір қолданысы бар: бір маркер виртуалды объектілерді бейнелеп көрсету үшін, ал үш маркер виртуалды объектілерді басқару мақсатында қолданылады.

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УПРАВЛЕНИЕ ВИРТУАЛЬНЫМИ ОБЪЕКТАМИ В ДОПОЛНЕННОЙ РЕАЛЬНОСТИ С ПОМОЩЬЮ РЕАЛЬНЫХ ОБЪЕКТОВ

В системе Augmented Reality (AP) – дополненной реальности среди задач компьютерного зрения актуальна задача ввода информации без посторонних устройств. Одним из важных решений является использование рук для применения дополненной реальности. Из анализа гистограмм и подключения фактором, предложенных многими исследователями, можно убедиться в существовании различных решений для ручного интерфейса в дополненной реальности. Хотя различные направления поиска являются одним из надежных способов признания управления рукой, в настоящее время существующие способы занимают слишком много времени для расчета, предлагаемый фон рисунка также должен отличаться цветом кожи руки. В работе предлагается метод отслеживания руки для управления 3D-объекта в дополненной реальности, возможности использования глубины устройства и цвета кожи. Кроме того, в этой работе обсуждается связь между несколькими маркерами, которая основана на отношениях между камерой и маркером. Один маркер используется для отображения виртуальных объектов и три маркера для определения жеста рукой и управление виртуальным объектом.