

Research of the Real-time Drawing System Based on 3D Movement Tracker

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Abstract—The 3D model technology of virtual plant has been widely used in agricultural research fields. However, in most cases, the process of achieving the coordinate information of the plant and building the 3D model of the plant is done separately, so the error could not be analyzed directly. The purpose of this paper is to utilize VC++ and OpenGL to build up a real-time drawing system based on 3D movement tracker—Polhemus Fastrak. Using the method of combining programming of Microsoft Basic Class(MFC) and OpenGL to create drawing window and connect Polhemus Fastrak, the real-time drawing system has been made. The visible modes of the dynamic drawing system and the error through comparing the appearance and area of the images to the physical objects have been discussed. Taking square, circle, triangle and real plant leaves as test examples, the area errors are less than 10%, and the average error is about 4.9%, which improve that the drawing system is feasible.

Index Term—real-time, drawing system, virtual plant, 3D model, OpenGL.

I. INTRODUCTION

In order to realize the morphological structure of a real plant 3D visualization of quantitative description, scholars come up with the idea which is based on the growth of plant simulation model and the form of 3D visualization technical framework. Modeling a 3D model, recording the biomass and the pest information through the data collection of plant tree growth model, and it can describe the physical parameters and biological parameters of model in different growth periods and different conditions. Realizing quantitative simulation in plants growth process, which can provide the accurate evidence for understanding the plants growing status of trees, moisture and nutrient requirements and the dosage of pesticides[1-2].

However, so far, the model has been found after the information accessed, analyzed and processed, which means that model information acquisition, and data accessed are two independent parts, in this way, it is difficult to know the influence of the coordinate obtain error to modeling[3-4].

This paper was to research the real-time digital model based on two-dimensional. It meant that the acquisition of object coordinates and formation of digital 2D model was being done at the same time, which made the space coordinates visualization. And this technology was used to research plant leaves' 2D model, which could not only discover the bigger errors in the coordinate information acquisition, but also observe model establishment and information acquisition real-time. And through the software's analyses, such as VC++ OpenGL and 3D movement tracker—Polhemus Fastrak, with real-time graphics for research object, real-time graphics program with basic mapping was drew and function in the Windows operating system was extended. Then the appearances of the object like the squares, triangles, round and leaves were used to analyze graphical effects, functional applications and error range.

II. SYSTEM SOFTWARE AND HARDWARE

A. Process of OpenGL Rendering

OpenGL first converted objects to describable geometric objects vertex and the image pixels, after executing a series of operations, these data would be changed into a Pixel data eventually [5-6]. The graphics generation process is shown in Fig. 1.

B. Accuracy Analysis of 3D Movement Tracker

The 3D movement tracker Fastrak can trace six degrees of freedom movement. Fastrak tracking system uses electromagnetic field to locate the position of the object and the direction. This technique uses three single launcher assemblies, and the launchers' centers are fixed at the same location and then produce low magnetic field around. Then a single receiver is employed to detect the vector magnetic field with putting the detection signal into the mathematical algorithm and calculating the azimuth and direction of the receiver to transmitter.

This issue could depend on the data of the paper, in the radius of 60-120cm, doing error analysis again. The object analyzed is spherical launcher at hemispheres with drawing the following data.

When $Y = 0\text{cm}$, $Z = 45\text{cm}$, X axis errors is shown in Fig. 2 as the horizontal axis for X axis and the vertical axis for error value.

Manuscript received August 10, 2010; accepted September 10, 2010.

* Tiansheng Hong is the corresponding author.

This work was supported by the National Natural Science Foundation of China with the Serial Number of 30871450.

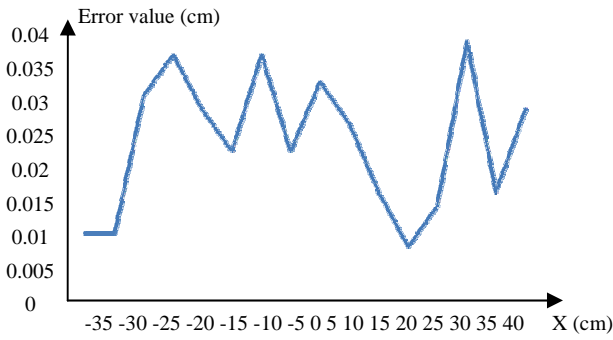
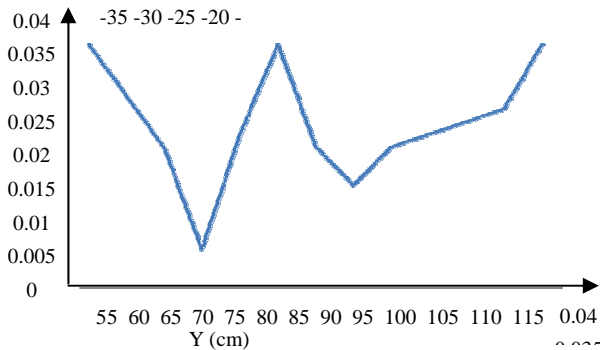
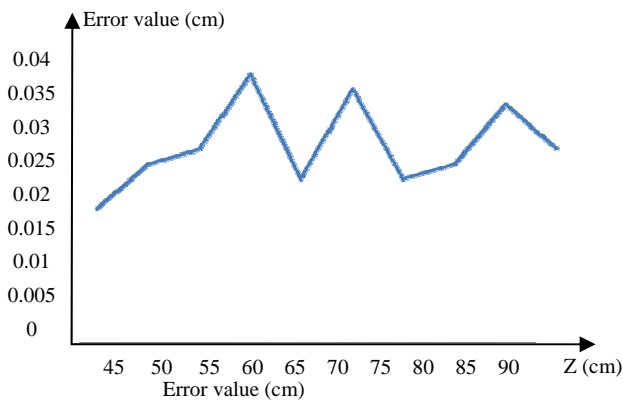


Figure 2. X axis Errors of Fastrak

When X = 85cm, Z = 45cm, Y axis errors is shown in Fig. 3 as the horizontal axis for Y axis and the vertical axis for error value.



When X=85cm, Y=0cm, Z axis errors is shown in Fig.4 as the horizontal axis of Z axis and the vertical axis for error value.



It can be observed from the above errors. At the hemispheres, the distance is between 55-115cm to the center of spherical emitter, and the space with 35-40cm wide, 45-90cm high. As the shadow shown in Fig. 5, the absolute errors were less than 4%.

III. 3D VIRTUAL PLANT MODEL ESTABLISHMENT

A. OpenGL Graphics Program Based On MFC Dialog and Fastrak Connection

Consisting of CAboutDlg, CDetail, CDrawTree, CMyDlgOpenGLApp, CMyDlgOpenGLDlg and COpenGL, complete tasks were cooperated such as

drawing window's creation, Fastrak driver, real-time graphics and restore coordinate information, plants' 3D model display and the detailed information. Fig. 6 is used for showing the flowchart of the diagram program.

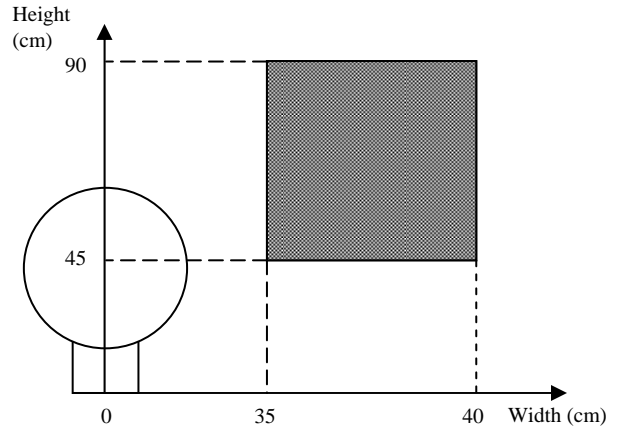


Figure 5. Error analysis of Fastrak space

B. Establishment of the Window of Program Drawing

Firstly, MFC dialog engineering MyDlgOpenGLDlg, stretching dialog box was created. And then its size was made fit for subsequent drawing windows.

Secondly, based on the COpenGL, tectonic drawing environment was created, including adding OpenGI_32.lib and glu32.lib in the connection Settings of VC++ to the call of the graphics programming interface of OpenGL. With proper numerical initialization PIXELFORMAT- DESCRIPTOR structures to definition pixel format, shading description form was created. And then OpenGL programming environment was established.

Thirdly, MFC ClassWizard was used to add response function called WM_CREAT for COpenGL class. In OnCreate function, pixel format was set, and the drawing description form called HDC was created.

Fourthly, COpenGL object was added in CMyDlgOpen-GLDlg, creating drawing window and settings window's attribute.

Finally, after completing the steps above, it's still needed to set in MFC libraries, because the OpenGL program should use files such as glut.h, glaux.h, opengl32.lib, glu32lib, glaux.lib and opengl32.dll. There are still some specific steps such as clicking on the SETTING in the PROJECT, selecting LINK property "pagein" in the popup dialog box, and adding opengl32.lib, glu32.lib, and glaux.lib to object/librarymodules.

Additionally, the OpenGL graphics rendering should be paid attention to. The drawing description form HDC should be ensured not to be deleted or released. Otherwise, the followed OpenGL could be affected.

C. Building Fastrak Driver

The Fastrak driver is written in COpenGL, and it could be connected to Fastrak and read coordinate information dynamically. The parts of code below are Fastrak connections by system.

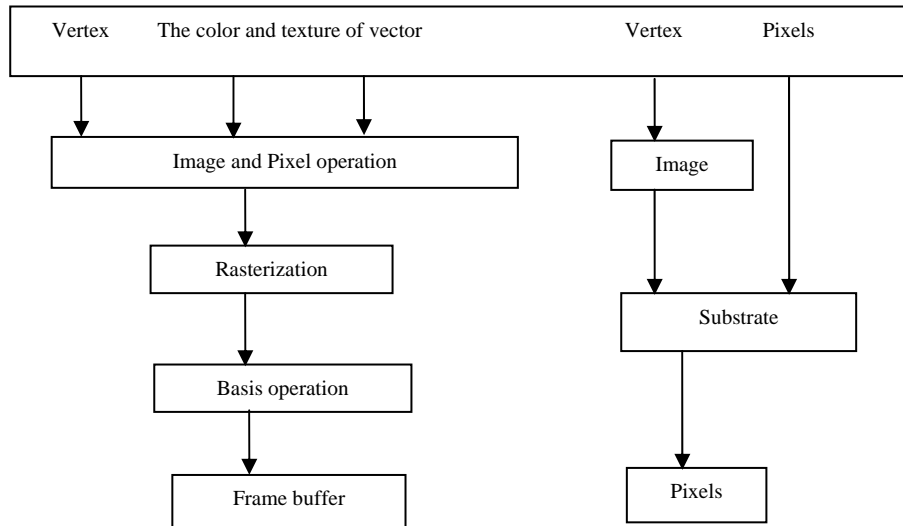


Figure 1. Process of rendering graphics

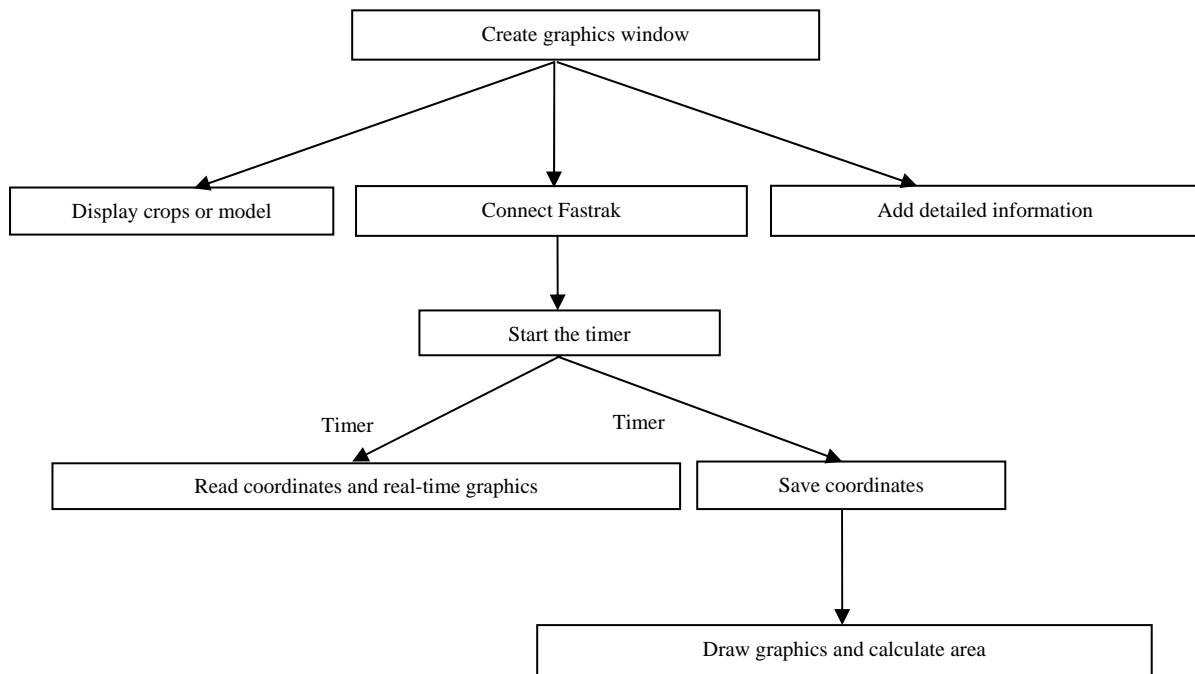


Figure 6. Flowchart of the diagram program

```

.....
void COpenGL::getConnect()
{
if(!FT_OpenUSBConnection()
&& !FT_OpenSerialConnection(1,115200))
{
    MessageBox("Unable to connect to the
Fastrak");
}
int connectionType = FT_IsConnected();
if (connectionType == 2)
    MessageBox("USB connection already
open");
else
    MessageBox("USB connection is not
open");
}

```

.....

Fastrak can read 6 dimensions of information from the 3D movement tracker. This program uses three dimension coordinates, respectively, X, Y and Z axis coordinates, to realize real-time graphics.

D. The Characteristics of the Timer

The characteristic of the timer is that Windows will put a WM_TIMER messages into the message queue every time [7-9]. The instruction orders are as follows,

SetTimer (): Set the timer.

KillTimer (): Destruct timer.

This program has set two timers, and their execute cycle time are 1ms. One of the two timers is read the coordinates information from Fastrak, realizing real-time graphics. Another one is used for reading a coordinate's information and saving it in a text document.

E. Establishment of 3D Virtual Plant Model

Program provided a plant of 3D model in the real project in CDrawTree. The coordinate information of plant measured by Fastrak was stored in file named tree, and each leaf and branch was stored separately.

After leaves and branches were tested, it could draw the 3D model through cutting the leaves into many small triangular. The main functions of this program provided a virtual 3D plant model visualization technology, and provided the direction for the next deeply research [10].

F. Information of Reading and Area Calculating

The function dataSave() can save the coordinates at the text document with user's name. The function OnBUTTONReDraw() and OnBUTTONGetArea() can draw the model on screen based on the coordinates information in text document. The area can be calculated.

The area calculation method is shown as Fig.7; the algorithm cuts the area into many small intervals. When ΔX is small enough, the intervals could be regarded as a rectangle which is ΔY long and ΔX wide. The total area could be got through calculating this little rectangle area.

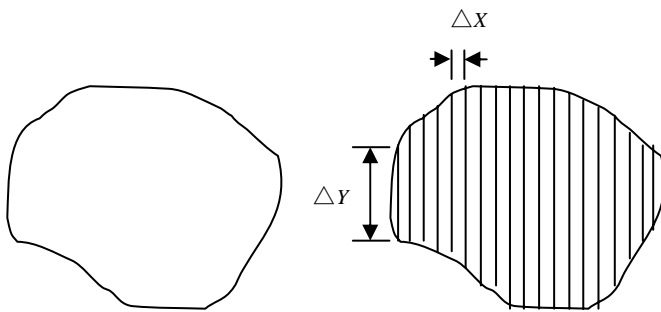


Figure 7. Model of area computation

IV. PROGRAM FUNCTION INTRODUCTION AND THE ERROR ANALYSIS

A. Program Interface

The program interface is as shown in Fig. 8.

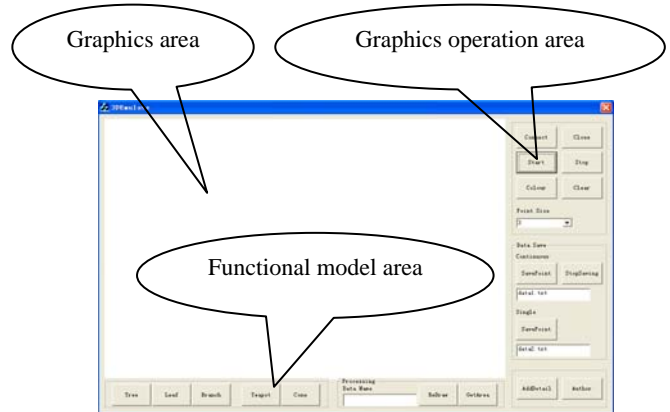


Figure 8. Main interface of the program

The program main interface is mainly divided into three areas—the graphics area, graphics operation area and functional model area. The graphics area realizes 3D model drawing and display. Graphics operation area has 3D motion tracking instrument, drawing function switch, drawing tools such as line color, line thicknesses, and so forth, coordinate information preservation and add detailed information, etc. And the functional model area is realizing show the 3D model. The plants' coordinates has been obtained on the graphics area, and the past real-time drawing images on the graphics area again were displayed, and the required area was calculated meanwhile.

B. Graphics Area

For graphics area, it's sized for 750mm × 540mm, establishing a parallel projective view of orthogonal matrix in graphics area. It's shown in Fig. 9-11. Images could be drawn at the 3d space which is in the distance X axis 55-100cm and Y axis 25-25cm to transmitters' center, and distance 55cm high above the bottom of spherical transmitters.

Fig. 12 gives a two-dimensional template including square, triangle and circle.

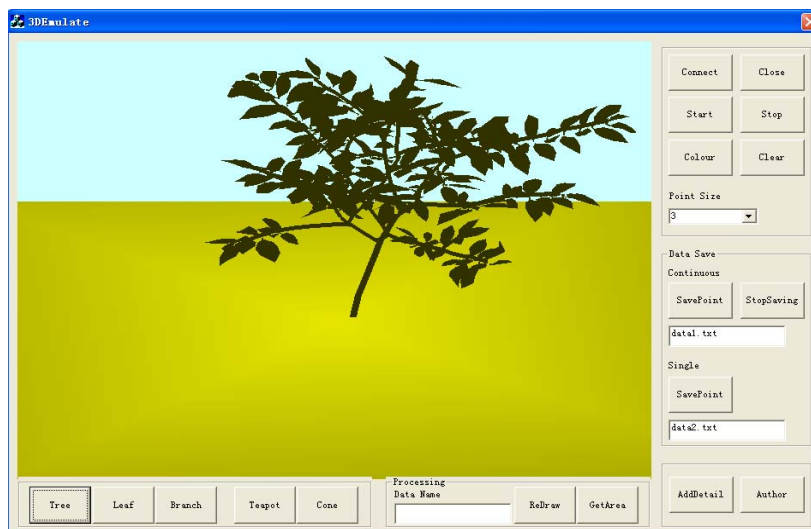


Figure 9. 3D model of plant

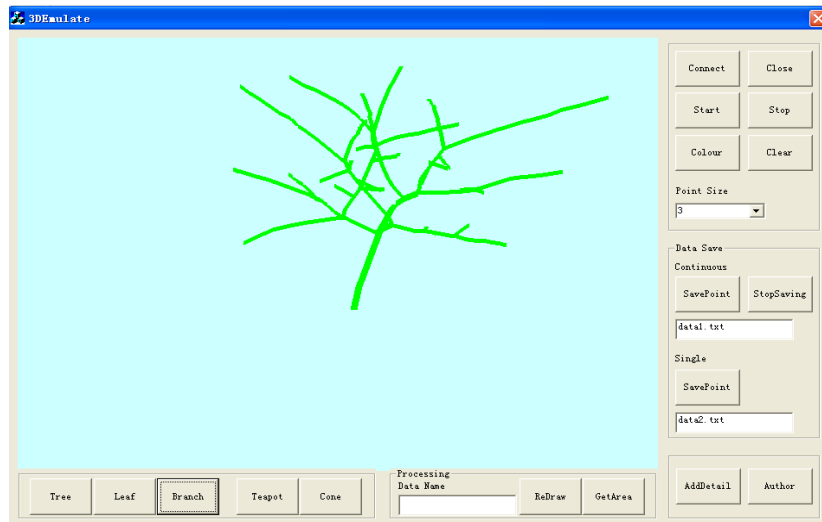


Figure 10. 3D model of the plant branches

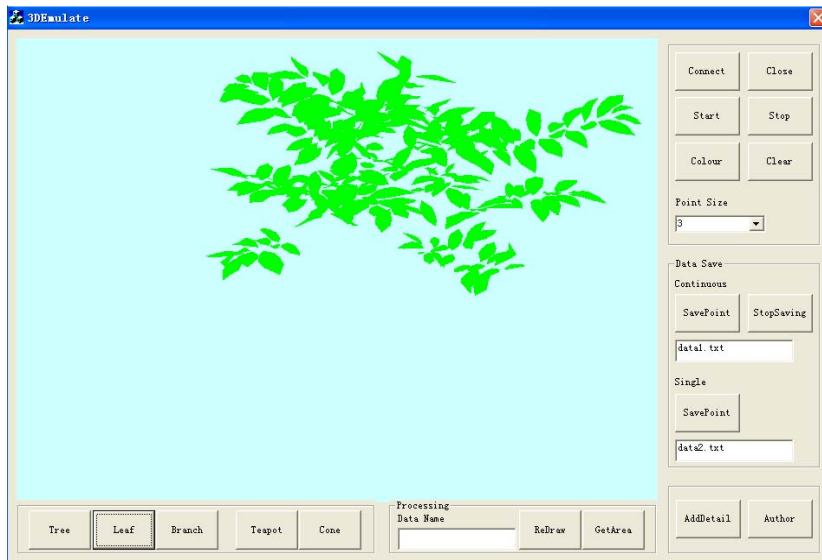


Figure 11. 3D model of the plant leaves

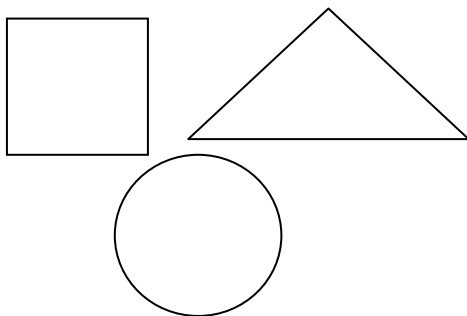


Figure 12. Graphics template of geometry complex

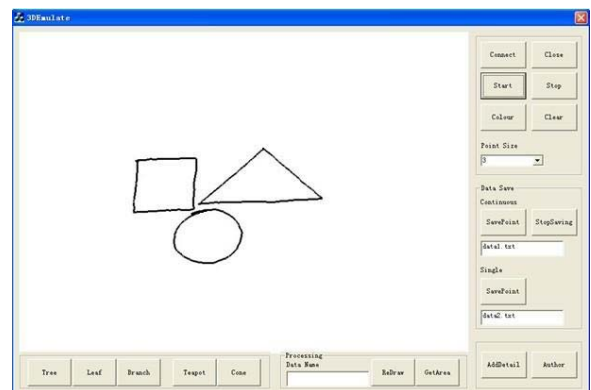


Figure 13. Interface of real-time graphics rendering

As Fig. 13 shown is the result in the graphics area, which is using Fastrak's agent pen to depict Fig. 13 template's graphics line in real-time. From the result, the image's appearance and spatial structure are as the same as the template.

C. Graphics Operation Area

Graphics operation area can be divided into three parts. The first part can realize the basis operation. It is shown as Fig. 6, and the function of each button is followed, as is shown in Fig. 14.

Connect: Connect the program and Fastrak.

- Close: Exit.
- Start: Set the timer1 start.
- Stop: Close all the timers, and stop drawing.
- Colour: Change the color of line.
- Clear: Clear the window.
- Point size: Change the line width.

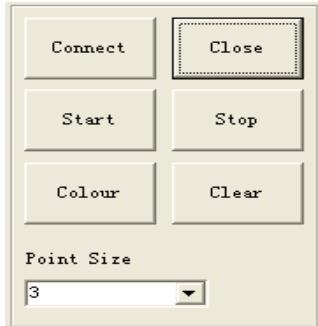


Figure 14. Display of basic operation area

The second part is to realize saving coordinate information. It is shown as Fig. 15, and the function of each button is followed.

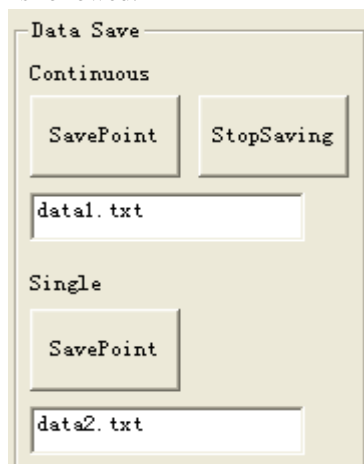


Figure 15. Display of data saving

Save Point (under the continuous) means starting the timer 2, and saving the coordinate per 1ms. Stop Saving means closing the timer 2, and saving the coordinate temporary. And the other "Save Point" means saving the coordinate just one time.

The third part has two buttons (shown as Fig. 16), AddDetail and Author. Click AddDetail button will pop-up information dialog box. Users can enter the graphics detail information at column of "AddDetail", shown as Fig. 17. If users drew a image of a leaf, so users can input name, leaves area, dry weight and dampness and other information at the column of "AddDetail".The default file's name is info.TXT .

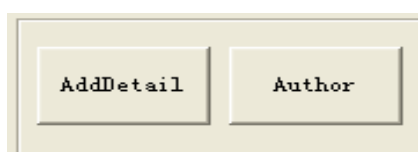


Figure 16. Buttons of adding detail

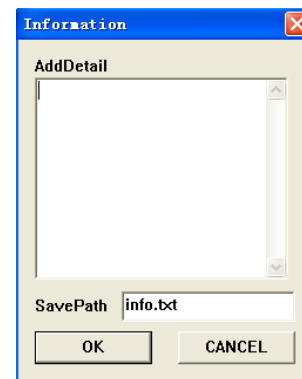


Figure 17. Dialog of adding details

D. Functional Model Area

Functional model area for information processing, while users in real-time drawing process, save the coordinate information, and then open the program again or clear the screen, the functions of area could be used, input the names of the text document of the coordinates information at column of "Data Name", click "ReDraw" button, then the image would be shown on the graphics operation area. And click "GetArea" button, calculate the area of the image. The more details of the coordinate's information describe, the more similar to the original, and the area will be more accurate.

Comparing of the template images with the real drawing images is shown in Fig. 18.

Table 1 Lists the actual area, rendering absolute error between model area and the actual area as the followed form through observation and comparison of the absolute errors. It can be seen from Table 1, the absolute errors are commonly below 10%, the average of absolute of the relative error is 1.635 cm², and the average value of the absolute errors is 4.905%.

The algorithm for area the program is using the integral summation, and the sequence of vertexes of X is from small to large. When drawing, the appearance will choose clockwise or anti-clockwise direction to draw, so the area will be calculated precisely. But the above triangle is drawing edge by edge, so it will make a bigger error.

E. Error analysis

Firstly, the 3D motion tracking Fastrak instrument measured coordinate information will have error, secondly, when users drawing and measuring, the hand will shake and then will make another error. And it can produce superposition between errors. The main reasons causing errors can be divided into the objective and subjective factors.

From the objective factors and the instrument principle, three-dimensional sports tracker is through detecting the low-frequency magnetic produced by sphere launcher to determine the coordinates information, everything which can influence the magnetic field will be introduced the error. As metal objects, the other

TABLE 1 ANALYSIS ERROR BETWEEN REAL-TIME RENDERING IMAGE AND PHYSICAL OBJECTS

Graphics classification	Area of graphics area S_1 (cm^2)	Area of physical object S_2 (cm^2)	The relative error (cm^2)	The absolute error(%)
Square	46.370	49.000	-2.630	-5.367
Triangle	30.845	28.125	2.720	9.671
Circular	51.120	50.265	0.855	1.701
Single leaf	11.231	11.564	-0.333	-2.880

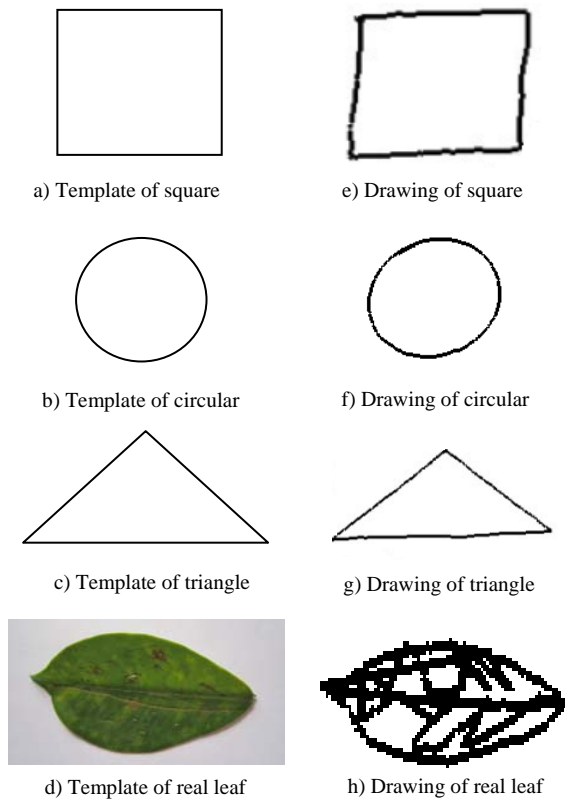


Figure 18. Comparisons of the template models and the drawing ones

electromagnetic measurement and the materials of tested objects will affect the accuracy.

From the subjective factors, when users measure, his hands always shake, it make the coordinates offset, so the actual physical objects' edge and textures scanning is not 100 percent, and the agent pen of 3D movement tracker can obtain 6 dimensions , the pen also will produce error because of different angle, so it will make difference errors every time.

V. CONCLUSIONS

Firstly, this paper analyzes the purpose and related research situation at home and abroad. Most of the models in the coordinate information acquisition and model creation are independent, not enough directly, it is difficult to know the influence of the error produce by coordinates acquisition to the model creation. Secondly, it introduces and analyzes the drawing system software and hardware this paper used. Thirdly, it introduces the system program frame, the process of drawing window's

foundation and the main functions. Fourthly it displays and introduces the function of the program, through the comparison and the error analysis of the object, to demonstrate that the system is feasible.

The core of this paper is using 3D movement tracker Fastrak to realize real-time space drawing under OpenGL virtual 3D model of VC++. Fastrak's accuracy is $\pm 4\%$ in particular space coordinates range, OpenGL has strong graphic development function, and the combination of both make real-time graphics model practical. The real-time graphics this paper presents, and the object coordinates acquisition and digital model generation, are done at the same time, in order to realize the visual space coordinates read. Compared with the physical objects, the absolute errors were commonly below 10%. The average of absolute of the relative error was 1.635 cm^2 . The average value of the absolute errors was 4.905%.

ACKNOWLEDGMENT

This work was supported by the National Natural Science Foundation of China with the Serial Number of 30871450.

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