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Geometric Transformation Technique for Total Hip Implant in Digital Medical Images

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***Abstract*— The use of geometric transformation is extremely crucial in the medical field because it can assist surgeons in carrying out pre-surgery process effectively and properly. This study aims to produce techniques and algorithms that can be used to implement the implant transformation process such as rotation and reflection on medical images. The main objective of this paper is to show the hip joint implant transformation algorithm used in x-ray images of hip joint patients. The computerised hip joint replacement process developed by a group of researchers from the Industrial Computing Research Group, Faculty of Technology and Information Science, Universiti Kebangsaan Malaysia shows how the implant transformation process being perform. The code of two transformation algorithms (rotation and reflection transformation) were shown in this paper. The example showed that by using the suggested transformation, the position of the hip joint implant can be manipulated to obtain the optimal position on the x-ray images of patients.**

Keywords- Transformation; rotation; image; implant; total hip; geometric.

I. INTRODUCTION

Computer graphic is one essential part of the Information Technology (IT) field. There are three key elements that support the computer graphics such as database, graphics algorithm and programming language [10]. The use of computer graphics is beneficial in terms of fast drawing, better designing of a product, no repetition of the drawing work and quickly and efficiently transformation for object manipulation operations. Examples of graphical object manipulation are the scaling, translation, rotation and reflection [6]. Object manipulation in computer graphics is also known as geometric transformation.

Geometric transformation is one element in the field of computer graphics. Objects can be manipulated over an image (JPEG and BITMAP) using basic algorithm transformation such as translation, rotation, scaling and reflection [2]. An object can be transformed according to the user's requirements. For example, in most of the computer graphics software, the user can rotate or move the drawn object. With geometric transformation, a sketch or painting work can be produced better [8]. The use of geometric transformation is not just limited to the usual image as JPEG, but it can also be used on DICOM medical images (DCM).

Preoperative templating is an important part of a total hip replacement process (THR) [11]. In this study, the fundamental transformation of total hip implant on medical images in digital format (DICOM) will be conducting to determine the implant position. It is quite complicated as the transformation done using the medical image format that does not only contain a picture, but a variety of patient's information [5]. Thus, an algorithm or a technique needs to be produced, so that implant transformation process can be performed on the medical images.

II. OBJECTIVE AND SCOPE

The main objective of the research is to produce algorithms for geometric transformation of hip implant in medical images. During this research, the computerized hip joint replacement (developed by a group of researchers from Industrial Computing Research Group, Universiti Kebangsaan Malaysia) will be using to show how the fundamental transformation such as rotation, translations and reflection can be performed on DICOM images. Two geometric transformation algorithms that are discussed in this paper are rotation and reflection.

III. RESEARCH BACKGROUND

There are two theories of geometry implemented in the computer graphics such as Affine geometry theory and Euclidean geometry theory [7]. Affine theory known as Affine transformation is a combination of a linear transformation (rotation and scaling) and the nonlinear transformation (translation) by using the matrix. In geometric

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transformation, there are several types of transformation that are often used. Among them are translations, scaling, rotation and reflection. Translations operation is to change the original position of an object to a position parallel to the common axis of the x-axis and y-axis [1]. Rotation operation is a certain range of objects on the rotation axis based on the degree required. Scaling operation is used to change the size of the object. While the reflection operation is used to change the object to a position opposite to the axis. In computer graphics, transformation calculations performed with the aid of the matrix and vector operations. Figure 1 and Figure 2 shows examples of the basic transformation processes in computer graphics.

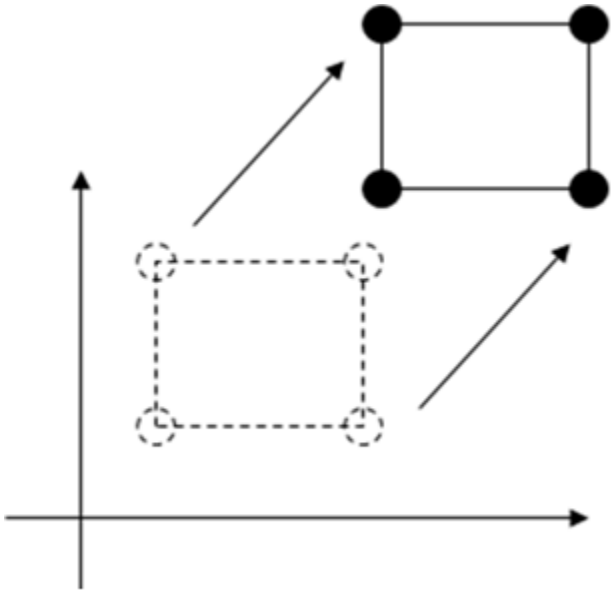

Figure 1 Translations

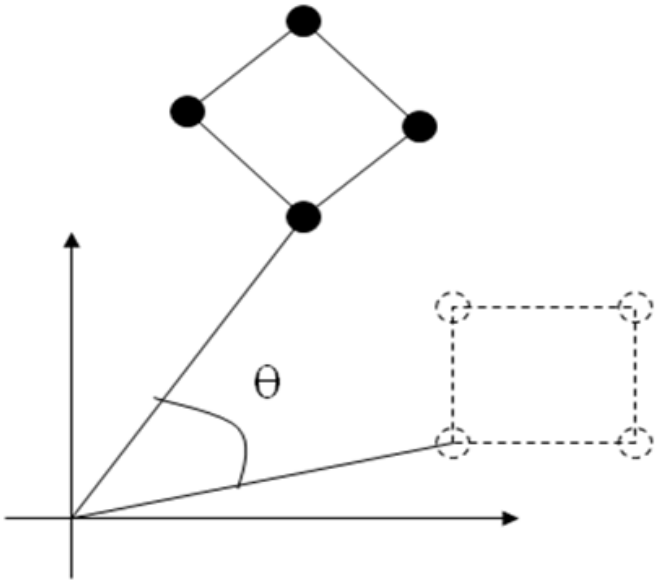

Figure 2 Rotation

Normally the process of object transformation is only made to the common images such as JPEG and BITMAP. In this research, digital medical images (DICOM) are used to indicate the process of object transformation carried on it. DICOM is a standard format used in medicine for sharing and viewing of medical images such as Computed Tomography Scan (CT SCANS), Magnetic Resonance Imaging (MRI) and Ultrasound [4]. This DICOM standard developed by National Electrical Manufacturers Association (NEMA) in collaboration with American College of Rheumatology (ACR) [12]. A DICOM file stores patient information such as patient name, image dimensions and the data itself. Table 1 shows examples of pixel data for DICOM images.

Table 1 Examples attributes of DICOM

Name	**Tag**	**Type**	**Description**
Pixel sample	(0028.0002)	1	Number of sample
Row	(0028,0010)	1	Number of row
Colum	(0028,0011)	1	Number of colum
Bits Stored	(0028,0101)	1	Number of bits per pixel
Pixel data	(7FEO.OQ10)	1	Pixel data for image

Table 1 shows the attributes in identifying and describing a medical image. Information may consist of the image position and orientation, image pixel, image type and all that describe the image. The data are extremely important because it can be used in the object transformation process of hip implant. For this study, the DICOM images were provided by the Medical Centre of Universiti Kebangsaan Malaysia (PPUKM). Figure 3 shows examples of DICOM digital medical images.

Figure 3 DICOM image

IV. MATERIAL AND METHOD

In this research, digital artificial hip joint implant has been generated using AutoCAD 2008 software. To ensure the implant is properly positioned on a DICOM image, the implants (in this study, the implant will be consider as a digital object) should be manipulated. In other words, the transformation process needs to be done for the digital implant to be placed properly. The study will show how the implant can be manipulated on the digital medical image using the basic transformation processes such as translation, rotation and reflection. Figure 4 shows the object manipulation technique used in the geometric transformation.

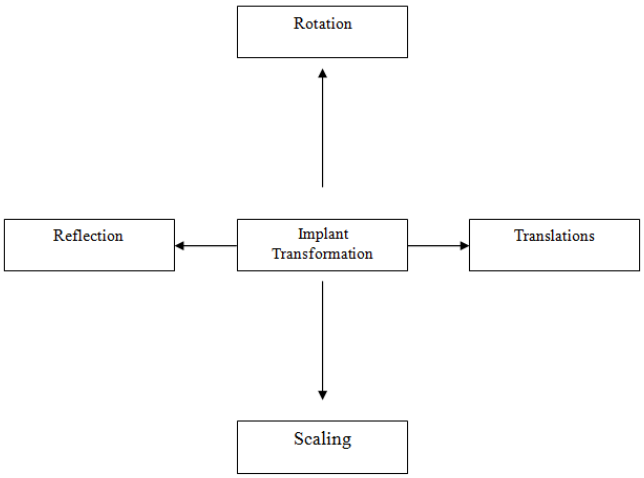

Figure 4 The geometric transformation process

A. Rotation Algorithm and Coding

The rotation process is used to rotate or turn an object based on the angle of rotation required by the user. The Java coding below shows (Fig. 5) the algorithm used to make the rotation of the hip joints implant.

```
public void rotateStem (MouseEvent e) (
this.varMouseXCurrent = e.getX ();
this.varMouseYCurrent = e.getY ()
xDifference int = 0;
yDifference int = 0;
xDifference + = (this.varMouseXCurrent - this.varMouseXPrevious)
this.magnification;
yDifference + = (this.varMouseYCurrent - this.varMouseYPrevious)
this.magnification;
this.varMouseXPrevious = this.varMouseXCurrent;
this.varMouseYPrevious = this.varMouseYCurrent;
if (xDifference> 0 | | yDifference> 0) (this.stemImgAngle -= 1)

Else ( this.stemImgAngle + = 1; )
if (this.stemImgAngle> 360)  this.stemImgAngle = 0; )
Else if (this.stemImgAngle <0th) (
this.stemImgAngle = 360;
```

Fig. 5 Rotation algorithm coding

B. Reflection Algorithm

As widely known, the reflection transformation or reversal is to change the original object orientation to a position opposite to an axis. Therefore, the resulting object can be known as the twin object with inverted features. The following Java coding shows the algorithm to perform the reflection transformation on medical images. The algorithm below (Fig. 6) shows the transformation of reflection performed on the x-axis and y-axis.

```
/ / Flip the stem x-axis
public void flipXStem () (
BufferedImage bi;
AffineTransform tx = AffineTransform.getScaleInstance (-1, 1);
tx.translate (-this.varImageIconStem.getImage (). getWidth (null),
0);
AffineTransformOp op = new AffineTransformOp (tx,
AffineTransformOp.TYPE_NEAREST_NEIGHBOR);
bi = op.filter (image2BufferedImage
(this.varImageIconStem.getImage ()), null);
this.varImageIconStem.setImage (bi);
repaint ();
)
/ / Flip the y-axis stem
public void flipYStem () (
BufferedImage bi;
AffineTransform tx = AffineTransform.getScaleInstance (1, -1);
tx.translate (0,-this.varImageIconStem.getImage (). getHeight
(null));
AffineTransformOp op = new AffineTransformOp (tx,
AffineTransformOp.TYPE_NEAREST_NEIGHBOR);
bi = op.filter (image2BufferedImage
(this.varImageIconStem.getImage ()), null);
this.varImageIconStem.setImage (bi)
repaint ();
```

Figure 6 Reflection algorithm coding

V. RESULTS AND DISCUSSIONS

As discussed in the previous section, the computerized hip joint replacement process used to perform this study. Geometric transformation process is using to move the digital implants on digital medical images. Figure 7 shows the actual positions of the hip joint implant. To move the implant into place properly, a translation transformation process should be implemented. Figure 8 shows the implant that has translated.

Figure 7 Default position for implant

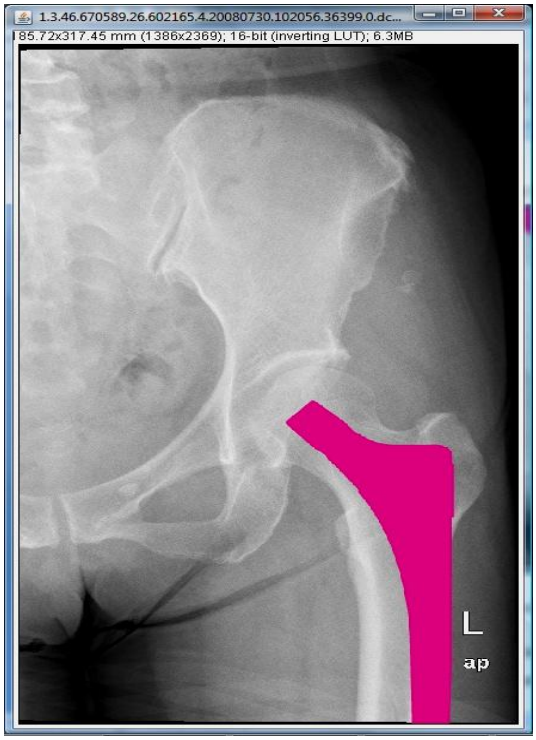

Figure 8 Translated implant

In figure 8, it can be seen that the position of the implant (object) is still not in the desired position. Implants should be rotated to get the optimum position. Figure 9 shows the implant which is rotate using the rotation transformation.

Figure 9 Implant that have been rotated

Implants in figure 7, 8 and 9 are for patients requiring hip joint on the left leg. However, if the patient needs an implant for the foot to the right hip joint, the implant can be reflected using a reflection transformation. Figure 10 show the implant is already experiencing a reflection of the transformation process.

Figure 10 Reflection

VI. CONCLUSION

The use of geometric transformation in the field of computer graphics is particularly vital to manipulate an object. It helps users in carrying out work that related to graphics. Geometric transformation can be implemented not only on standard images such as JPEG and BITMAP, but it can also be used for digital medical images [3]. In this research, digital hip joint implant was successfully transformed according to user requirements. This implant should be suitably translated and rotated to obtain the optimal position on the x-ray images of patients. aa. Finally, the ability to accurately determine the digital implant position on medical images will improve accuracy of preoperative templating of THR [11].

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