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Pac-Man Game Using Hand Movement without Keyboard and Mouse

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Abstract

The game "Pac-Man" is a widely famous and well-loved game in video arcades all over the world. In this paper, we propose a function to substitute central points of hand coordinates for direction keys of the game. With this function, we can play the game with several simple hand movements and without a keyboard or a mouse. The movements of a monster in the game could be performed by those of a hand since it can get video images in MFC(Microsoft Foundation Class) dial log by extracting pointers of the hand. To extract skin color, a binary RGB (Red, Green, and Blue) is transformed into a binary YCbCr video image without brightness. Several operations of product, hybrid median filtering, and AND are performed, in order to get a better video image quality. The central point of a hand can be found by use of the mean of two central points after the central point of a minimum boundary rectangle and a hand is found.

Keywords: *Pac-Man, skin color, hybrid median filtering, minimum boundary rectangle*

1. Introduction

The Pac-Man was produced for animation in the United States of America a long while ago and was used for various application productions. Even though Pac-Man is a very simple game, it is highly addictive. In 1980, a company named Namco in Japan developed this arcade game. In those days, Pac-Man was a very successful and sensational game in the world [1-2]. Pac-Man was a very famous product, as much as the game Galaga, and was reproduced on various consoles. It has the BGM (Background Music) sound with a catchy tune and pretty characters in the game and requires simple operations for a user.

Adrian David Cheok *et al.* [3] defined Pac-Man as a mobile broadband entertainment system on the basis of physical health and ubiquitous computing. R. Heckel [4] says that three major characters of the Pac-Man are Pac-Man, Ghost, and Marble, and they are handled according to their scenario. A research [5] proposed a Pac-Man game by use of hand color and central point. This paper is kind of a research expansion of [5].

A research [6] on hand movement proposed a method to infer a three-dimensional hand position from a two-dimensional input video image that is acquired by a monocular camera, through making use of a Belief Propagation algorithm in probability graph model. Another research [7] proposed a method to extract an end point of a hand and to recognize a hand movement by use for augmented reality applications. One other research [8] suggested a technique to discriminate the start and the end of continuous

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movements as well as to recognize a movement. The research is on the basis of gestures by tracing and recognizing the movement of a hand and its distance. This research [9] presented a tracing system for face and hand to recognize sign language. The system induces a domain of the hand after using a skin characteristic, detecting its skin color, and its skin domain. Also, a research [10] showed an innovative method to recognize a hand movement. The research uses information of skin color and boundary energy and moment method to get a palm center.

2. System Structure

Our research has two major characteristics. The one is that a user can play the game by use of simple hand movements without any keyboard and mouse, and the other is that the game substitutes the central point of hand coordinate for direction keys. A pointer of hand is extracted from video images of MFC dial log through a web camera. We consider the following three considerations:

1) Testing whether a video camera operates or not

2) Recognizing a pointer and considering compatibility with game controller

3) Considering whether a game performs or not and whether a motion is recognized with gearing a key

The whole structure of the system is as follows in Figure 1.

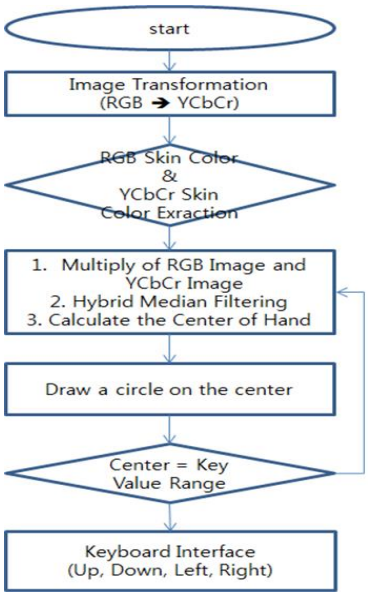

Figure 1. System Structure

3. Location of Monster and Extraction of Skin Color

3.1. Second-order Headings

By finding a coordinate point of a Pac-Man, the movement of a monster can be changed according to the movement of the Pac-Man. In case of two or more monsters, an algorithm to besiege the Pac-Man is added. This algorithm could be implemented when the Pac-Man is located in the top, the bottom, the left, and the right of the monster. The algorithm when the Pac-Man is located above the monster is as follows.

Even when the Pac-Pan is located in the bottom, the left, and the right of the monster, its algorithm is all the same (its direction of Step 1 differs).

When the Pac-Man is located above the monster
Step 1: Finding a monster above
Step 2: Choosing a monster in the shortest distance
Step 3: Moving the monster toward the Pac-Man

This algorithm is effective when the Pac-Man is located in the far top, the far bottom, the far left, and the far right of the monster. For example, when the Pac-Man is located in the far top of the monster, it must move to the left, the right, or the bottom of the monster. If the Pac-Man goes downward, there should be a passage. When the Pac-Man is located in the far top of the monster, the direction of the monster exists by its side. Even when the Pac-Man is located in the bottom, the left, and the right of the monster, its algorithm is all the same but the direction to move differs.

3.2. Extraction of Skin Color

In our research, RGB color video images are used in order to find out skin color as a basis. The RGB video image is then transformed into YCbCr one. The two video images are operated by product so as to get better video images with high quality. For the convenience of recognition, several operations of product, hybrid median filtering, and AND are performed.

In general, the range of RGB colors is as follows; Red is 0~255, Green is 0~255, and Blue is 0~255. Each has 256 color densities. According to the combination of its three colors, the color of black is (0, 0, 0) and the color of white is (255, 255,255). YCbCr is a color space that expresses colors with brightness (lightness component) and a chrominance of two colors. YCbCr is a color model that separates brightness from color information. The domain of skin color could be found if the color information in RGB model is changed by use of YCbCr model.

In this paper, Let us assume that R is 91~255, that G is 74~240, and that B is 41~229. The part of skin color is performed with 255 (white) and the part besides skin color is performed with 0 (black). This method has a demerit that it is worst when affected by the light. So, to make up for this demerit, the skin color is filtered with YCbCr video image one more time.

When a skin color is extracted by transforming RGB video image into YCbCr, the equation of the transformation is as follows.

$$\begin{aligned} Y &= 0.299*R + 0.587*G + 9.114*B \\ Cb &= -0.1687*R - 0.3313*G + 0.50*B + 128.0 \\ Cr &= 0.50*R - 0.4187*G - 0.0813*B + 128.0 \end{aligned} \quad (1)$$

This equation transforms an RGB color into a YCbCr color and designates a skin color by use of a critical point of Cb and Cr without Y (brightness). Therefore, the skin color is transformed into white (255) and the other color besides the skin becomes black (0).

The overlapped part is then extracted by the product operation of RGB video image and YCbCr video image. For the original video image, several (three to five in general) hybrid median filtering operations are performed and AND operations are also done. The median value is found and used in doing median filtering. So, a desired video image cannot be had since there are some missing segments of the internal video image, angular parts, and corners. Hybrid median filtering [11] could remedy the shortcomings. It is an algorithm that is suitable

for noise elimination and boundary conservation. The algorithm to perform hybrid median filtering is as follows in Figure 2.

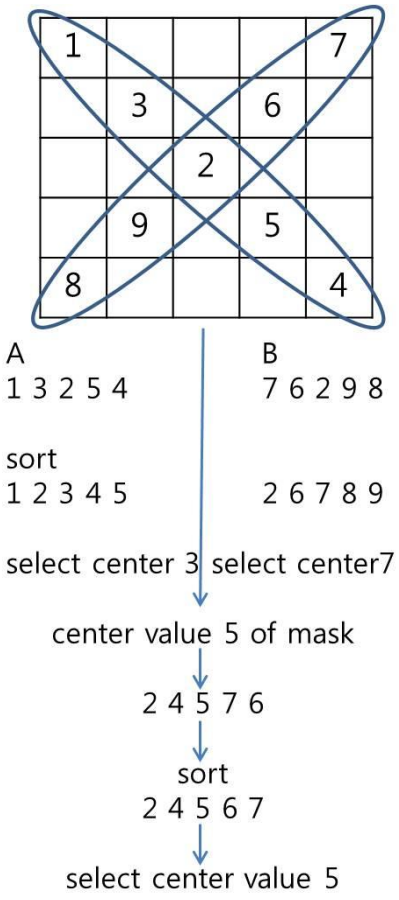

Figure 2. Hybrid Median Filtering Algorithm

4. Center of Gravity and Motion

Above all, the center of gravity of a hand can be found on the basis of Minimum Bounding Rectangle. And then, the method of [10] is used. Lastly, a new center of gravity is found by use of the average of these two gravity centers. A minimum boundary rectangle has an average value of minimum rectangles, x_{1min} and y_{1min} as well as x_{1max} and y_{1max} in Figure 3. The center of the rectangle is the one of hand domain.

The next method was proposed by a research [12]. The center of an object in a video makes a very important role in many application systems. The area of white part in binary video image is expressed in equation 2 and is the sum of all white pixels.

$$I_b = \sum_{x=x1}^{x2} \sum_{y=y1}^{y2} I(x, y) \qquad (2)$$

In binary video images, I_b expresses the sum of white domains when the horizontal domain is from *x1* to *x2* and the vertical domain is from *y1* to *y2*. If the strength of brightness for each

pixel is set up by use of the weight of the point, the center of the area becomes the same as the center of the gravity (equation 3).

$$CenterX = \frac{\sum_{x=x1}^{x2}\sum_{y=y1}^{y2} yI(x, y)}{I_b}$$
$$CenterY = \frac{\sum_{x=x1}^{x2}\sum_{y=y1}^{y2} xI(x, y)}{I_b} \quad (3)$$

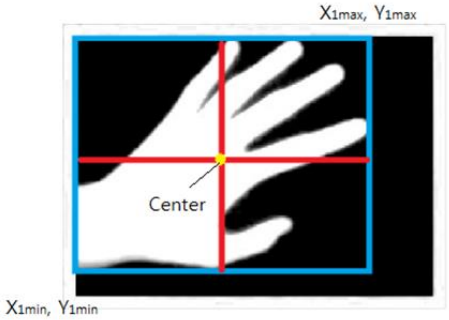

Figure 3. Center of Minimum Bounding Rectangle

According to an extracted center of gravity, the Pac-Man moves upward, downward, to the left, or to the right. A circle moves into the domain and the domain is defined by the starting point and the ending point of coordinate. In this paper, only the movements of right, left, top, and bottom are considered.

5. Experiment

The second and following pages should begin 1.0 inch (2.54 cm) from the top edge. On all pages, the bottom margin should be 1-3/16 inches (2.86 cm) from the bottom edge of the page for 8.5 x 11-inch paper; for A4 paper, approximately 1-5/8 inches (4.13 cm) from the bottom edge of the page.

For an experiment, Windows 7 and Visual Studio 2010 C++ were chosen as an operating system and programming language respectively. A hand is input through a camera (Figure 4), a transformation into RGB video image is performed. R is from 91 to 255, G is from 74 to 240, and B is from 41 to 29. The part of skin color is 255 (white) and the part besides skin color is 0 (black). The resulted video image is as follows (Figure 5).

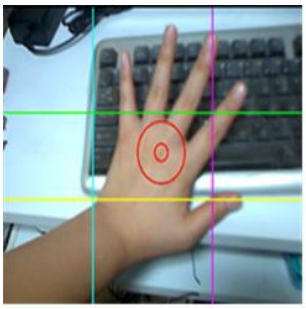

Figure 4. Hand Video Input by Camera

Figure 5. RGB Video

An RGB video image is transformed into a YCbCr video image. A skin color is designated by use of a critical point of Cb and Cr without Y (brightness) (Figure 6). The skin color is transformed into white (255) and the other color besides the skin becomes black (0).

Figure 6. YCbCr Video without Y

Figure 7. Product of RGB Video and YCbCr Video without Y

The overlapped part is extracted by the product operation of RGB video image and YCbCr video image (Figure 7).

Figure 8. AND Video Image after Hybrid Median Filtering

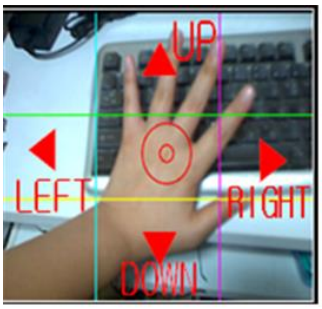

Figure 9. Gravity Center of Average and Binarization and Movement

For the original video image, several (three to five in general) hybrid median filtering operations are performed and AND operations are also done (Figure 8).

Figure 9 shows the movements of the top, the bottom, the left, and the right by use of the mean of two central points after the central point of a minimum boundary rectangle and the central point of a white domain.

Table 1 shows the average number of movements and errors in case of ten games.

Class	The Average Number of Movements	The Average Number of Errors
Top	324	15
Bottom	245	14
Left	311	19
Right	309	18
Average	297.25	16.50

Table 1. The Average Number of Movements and Errors

In Table 1, there are averagely 16.50 errors for 297.25 movements. The causes of these error occurrences are arranged as Table 2.

Table 2. The Causes of Error Occurrences

Rank	Causes of Error Occurrences
1	Diagonal Movement (Not operated)
2	Fast Movement (A gravity center of a hand is not found)
3	Irregular Movement (The velocity of Pac-Man is irregular)

6. Conclusion

This paper proposed a Pac-Man game that is operated not by keyboard or mouse but by hand movements. A gravity center by use of minimum boundary rectangle of a hand is found on the basis of the average of pixel domain center of a hand. A video image is inserted by use of camera. The location of a monster is changed according to the movement of a hand by use of pointer extraction. In order to detect a skin color, a binary YCbCr video image is transformed with the exception of brightness in a binary RGB video image. The two video images are operated by product so as to get better video images with high quality. For the convenience of recognition, several operations of product, hybrid median filtering, and AND are performed. Our research has a merit of using no mouse and keyboard but has a demerit of causing errors. It would be better to use a mobile sensor.

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