Transition and Motion Sensing System with Nintendo Wiimote and Infra-Red LEDs Array

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Abstract. In this work, a gesture and motion sensing system is explored with the Nintendo Wiimote and infra-red LEDs array. With the eminent Nintendo Wiimote controller, the personal computers and terminals can be connected to the system easily via Bluetooth wireless communication system. Although there are many devices that can be used to track the gesture and motion, they are able to connect to another device easily. The developed system is capable of making different applications as the interfacing problem has resolve. C# programming language is used to develop the graphical user interface and the mathematical algorithm. In order to verify the developed system, the transition of presentation slide is tested. By adjusting the sensitivity and threshold via mathematical formula, the gesture and motion sensing system is working excellently.

1. Introduction

This research is generally about capturing finger motion and position in air that may establish an interaction with a Personal Computer (PC). The system may replace the already existing input devices such as mouse, keyboard and other devices. By implementing this technology, users may save space in terms of the placement of the hardware and also be much more interactive with technology [1] [2]. Till to date there are several studies of hand motion tracking and its usage for PCs. The integrated devices may be also carried around and connected wirelessly to any PC, which expands the simplicity of their usage.

Currently, touch screen technology are gaining popularity as many companies such as Apple are producing tablet PCs and cell phones that uses touch screen instead of the regular keyboard [3] [4]. While this technology is still widely used, this project is to research on the possibility of further enhancing the human interacting with technology where the user feels that he is fully in control. This technology is relatively new and still widely being experimented with.

In order to detect human motion, the infrared seemed to be the most promising. The basic idea of this research is to transmit the Infra Red (IR) to the finger [7]. Once the finger comes in contact with the IR rays, it will reflect the IR rays back to the IR camera which will capture its position. Therefore, by detecting the motion, the device will then interface with the PC to change its presentation slides.

Again, the objectives of this project is to replace the already existing input devices such as mouse, keyboard and other devices also want to move from wired to the wireless. This project also to research on the possibility of further enhancing the human interacting with technology.

2. Programming and System

Figure 1 show the flow chart of the program and detection development process and technique. Time is a very important factor in determining the execution of the system for direction decision taking. The flow chart is used to set the outline of the program. The software is developed by taking into account of the error and tolerances of the transition and motion detection.

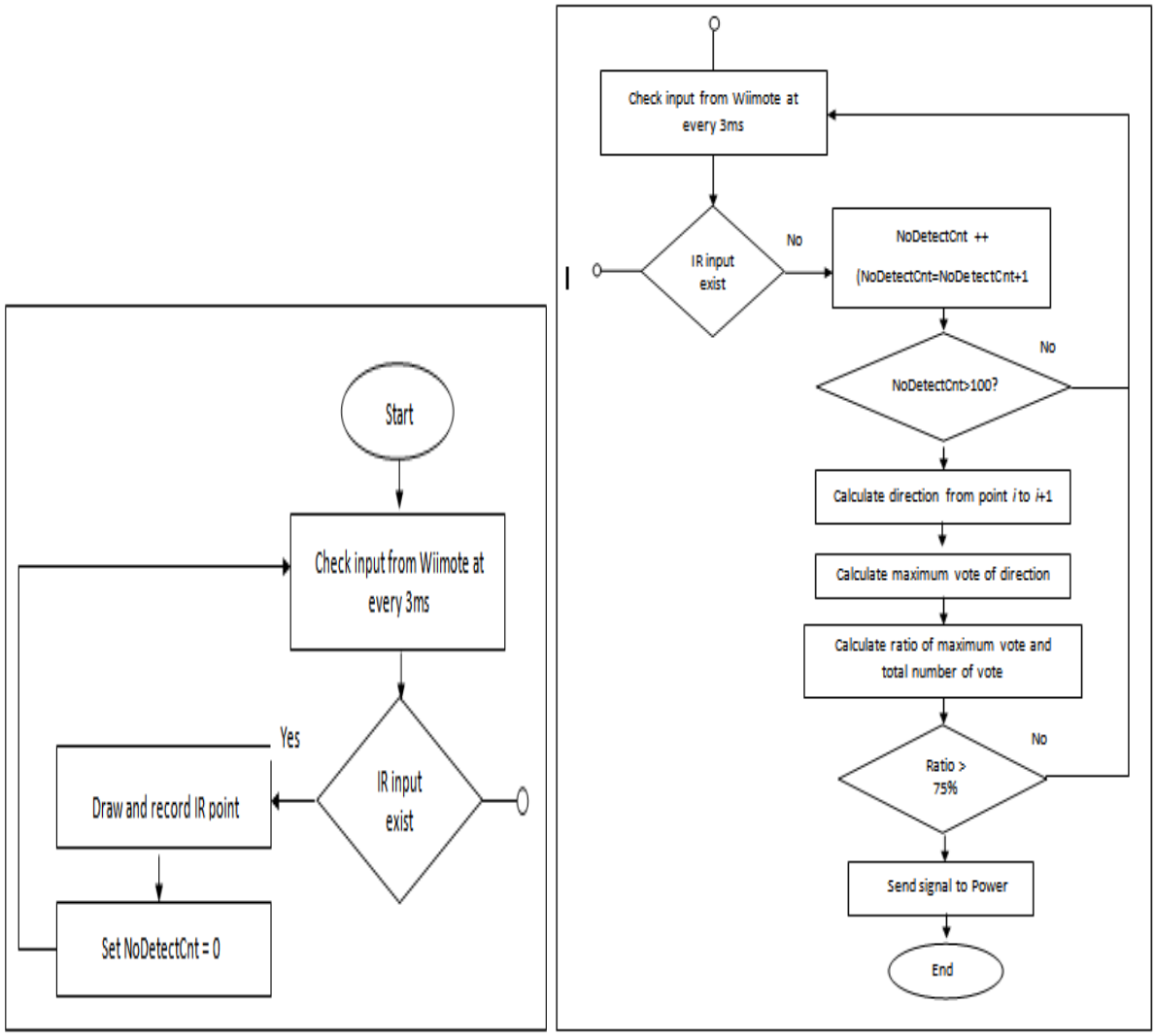


Figure 1. Flow chart of the program.

The Wiimote is used to detect the motion of the finger with the reflected IR rays. There will be some uncertainties must take into account when developing the prototype. The tolerance and error of finger movement has to be addressed in order to ensure the developed prototype is processing the intended movements.

3. Motion and Transition Detection

The Wiimote detects direction in the opposed way. Hence, the left and right have to be detected in opposed way too. Table 1 shows angles and related directions of the finger motion which respect to Wiimote.

Table 1. Angles related to direction of motion.

Direction	Degree (°)
Up	$45 < \theta \leq 135$
Right	$135 < \theta \leq 225$
Down	$225 < \theta \leq 315$
Left	$315 < \theta \leq 45$

The developed program read and calculates the directions from one point to next point. The direction is calculated with applying the tangent formula as shown in figure 2.

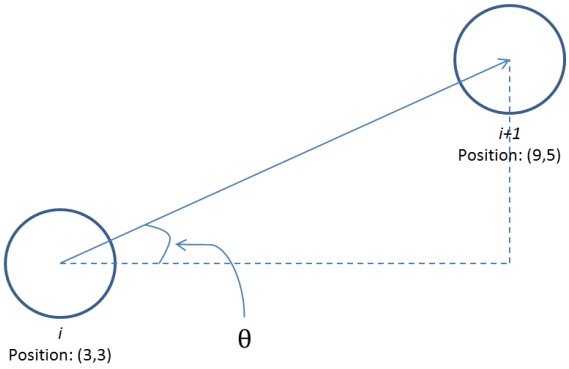


Figure 2. Transition from a point to another point.

Therefore, the developed program will calculate the angle for the transition as show in figure 2 as below

$$angle, \theta = tan^{-1} \frac{y_{i+1} - y_i}{x_{i+1} - x_i} \quad (1)$$

With developed system, the calculated result shows that the transition is the left since the angle 18.43° lies within the range of $315° < \theta \leq 45°$. However, the program may have certain of error of result in determine the final transition and direction of movement.

4. Movement Plotting and Velocity

Figure 3 illustrates the circle used to indicate the movement. The width and height are fixed at 20 pixels accordingly. A Graphical User Interface (GUI) is created for the detection system in order to show the direction and average velocity of the movement. A window is created within the GUI in order to plot the movement and transition of the object. This will indeed help the user to understand the details of his movement.

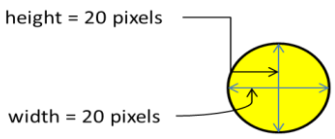


Figure 3. Direction indication and plotting.

The average speed is also presented in the GUI. With the information, the user is able to judge the speed of the finger motion. The average speed can be calculated with the basic mathematics formula as below:-

$$average\ speed, v = \frac{distance}{time} \quad (2)$$

The distance is calculated from an initial point to the next detected point with the Pythagoras theorem. The hypotenuse would be the required distance. The distance is obtained by calculating the hypotenuse of the triangle as shown in figure 4.

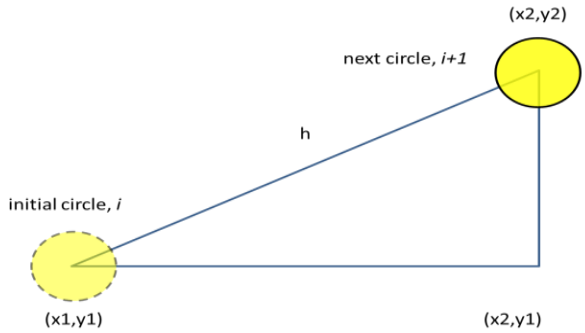


Figure 4. Hypotenuse of a triangle.

$$hypotenuse, h = \sqrt{(x2 - x1)^2 + (y2 - y1)^2} \tag{3}$$

In order to obtain the velocity the time required to transit from one point to another point is recorded. The time will be recorded in a similar way as the distance, from an initial point to another point as shown in figure 5.

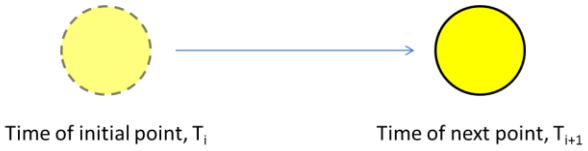


Figure 5. Transition duration from initial point to another point.

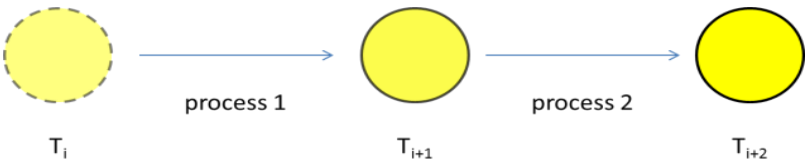
The transition duration from the initial point to another point is determine with the formula as below

$$T = T_{i+1} - T_i \tag{4}$$

After that, the average velocity of the whole motion is calculated with the formula as below

$$average\ velocity = \frac{\sum velocity}{number\ of\ processes} \tag{5}$$

The number of processes can be obtained as shown in figure 6 by taking the total number of points and subtracting the number by 1.



$$\boldsymbol{number\ of\ processes = total\ points\ (circles) - 1} \tag{6}$$

Figure 6. Examples of 3 points with 2 persons.

5. Transition of the Movement

In order to determine the finger movement, the percentage of votes is calculated. This would allow the user to move at a certain angle along the intended direction.

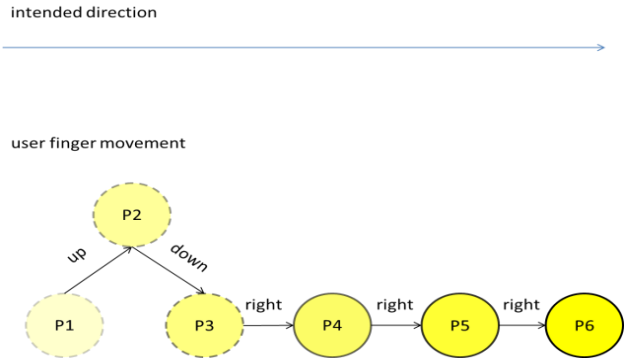


Figure 7. Transition of the finger or object

From the figure 7, the user intended to move his finger to the right, but there are some tolerances. While moving toward right, the finger might move up and down. In this case, the program would collect the number of votes of each direction and calculating the direction of the highest votes. Referring to the figure 7, the collected votes are as shown in table 2.

Table 2. Number of votes for each direction

Transition	Up	Right	Down	Left
P1-P2	1			
P2-P3			1	
P3-P4		1		
P4-P5		1		
P5-P6		1		
TOTAL VOTES	1	3	1	0

After the highest votes are calculated, the direction will be chosen in order to change the presentation slides to the left or to the right accordingly. In the case of the directions obtained the same number of votes, the text “open-ended” will be showed in the GUI and system will not perform any tasks. In order to stringent the detection, the percentage of votes is calculated. The following formula is used to calculate the percentage of votes of a specific direction:

$$Percentage\ of\ votes = \frac{number\ of\ votes\ in\ one\ direction}{total\ number\ of\ votes} \times 100\% \quad (7)$$

6. Hardware Setup

In order to test the developed software and GUI, the passive making system is setup. Since the passive marker system is selected for this system, the reflected IR rays are collected by Wiimote to track the motion and transition. Figure 8 shows the fabricated IR LEDs array for the detection system.

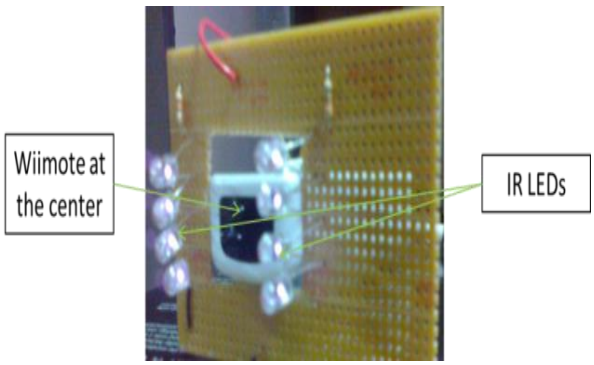
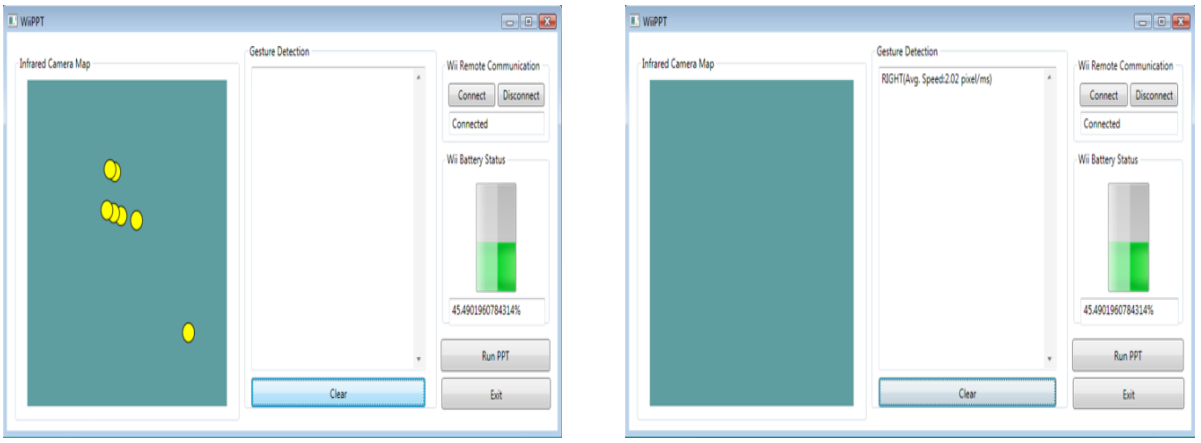


Figure 8. Wiimote and IR LED array

The detection system is tested and the results are recorded accordingly. A stringent constraint is set and adjusted in order to fine tune the detection as shown in figure 9 (a) and (b). It was hypothesized that the indicators may be scattered and direction is not able to processed and analyzed by the developed program correctly. The test is conducted successfully with the Wiimote and IR LEDs array.



A. Indicators are scattered. **B.** Proper setting and the direction is determined.

Figure 9. Motion sensing system analysis.

7. Discussion and Conclusion

In this work, point-to-point tracking method is used in determine the motion. The system samples the movement every 3ms and plots the movement at the specific coordinate in real time. Since the points are analyzed from one point to another, the system calculates and checks all the information along the intended direction. The transition and motion sensing system with Nintendo Wiimote and Infra-Red LEDs array is successfully developed. The Wiimote library is used for integrating the Wiimote and developed GUI. Besides that Microsoft library is used to control the transition of the presentation slides. The tracking algorithm is program according as describe in this paper in order to execute the decision or procedure for detection system.

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