Design of Swinging Somatosensory Game Rehabilitation System

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Abstract. This study designed an arm-swinging somatosensory game for physically uncoordinated personnel, which realized the movement attitude acquisition, data transmission, and motion-driven game character movement. The measurement results show that in the range of 0.3g to 0.5g, the probability distribution of the ordinary person is twice or more the accuracy of the limb dissonance in the face of the same action, which proves that the game has the ability to detect and measure the reaction speed of the person. It can be used as a standard for rehabilitation levels. In addition, the game calculates relative data of the acceleration and uses which to stimulate the movement of the game character, which relaxed the threshold. Therefore, it can stimulate participation interest and promote rehabilitation.

1. Introduction
The development of human social civilization is accompanied by the aging of society, which is due to the extension of life expectancy and the degradation of birth rate. The prolonged life expectancy and poor living habits increase the proportion of strokes and social disability [1-3]. The uncoordinated patient's recovery is the common aspiration of the patient's family and society. Rehabilitation studies have shown that exercising more on one side of the arm and artificial intervention can speed up recovery. But for most patients, repeated boring rehabilitation exercises and high rehabilitation massage costs slow down the pace of recovery. The somatosensory game is a new type of electronic game that is performed (operated) by detecting changes in the movement of the limbs. However, most of the somatosensory games retain the handle, and the operation and the somatosensory effect of the game handle are not direct [4-7]. Another type of somatosensory game is the way of visually collecting data. There is processing delay in visual collection, so it can't replace the touch screen game [8, 9]. At the same time, the visual processing price is often high and cannot be widely used. Mechanical sensors have fast sensing speed, high sensitivity and good stability, but they need to wear corresponding wearable equipment, but they are still used by researchers.

In this paper, the directional acceleration sensor is used as the detection limb motion collector. The Super Marie game interface is compiled by LabVIEW, and the saved data is recorded. The data is processed to measure the effect of hand rehabilitation.

2. The design of the game
The system needs to detect the upward, downward, forward and backward movement of the limb. After the data is accepted, the noise is removed and transmitted to the computer [10]. The LabVIEW PC game interface detects the data and drives the animated character movement according to the
proportion of the game interface. At the same time, the detected data is saved, and the overall design is as follows

2.1. Limb motion detection method
We selected the commercially available MPU6050 six-axis attitude angle sensor to detect the hand swing motion data and fix the accelerometer on the glove. The sensor adopts the northeast sky coordinate system, which can detect the angles of the three directions (x, y, and z) of the hand. The acceleration and other data are calculated on the basis of the angle. Both angle and acceleration are important reference indicators for limb detection, but in this paper, the motion acceleration is mainly studied.

2.2. PC software data acceptance interface
The upper computer LabVIEW communicates with the serial interface instrument through VISA, and provides a set of independent standard I/O low-level functions that can be easily called. By calling these standard functions, VISA will automatically retrieve the corresponding interface driver routines based on the actual interface type, thus enabling data reception and transmission.

2.3. Game character

2.3.1. The design of the character. The game character selects the strict custom control type (Strict Type Def.), because the selected game character is a control that is not included in LabVIEW, and the control is required to be updated every time, after each subsequent call, the control can use the update. In the form, and the controls in each VI (the function of the Lab view) are consistent. In the LabVIEW startup interface, select the custom control, select the new Boolean in the custom control window, and then create a PNG format image of the Mary character. The image is used to replace the logical "true" state of the Boolean control; select the previously imported image and import it again into the clipboard to replace the logical "false" state of the Boolean control. Thus design of the image of Super Mario is finished.

2.3.2. Dynamic movement design of game characters. To implement the dynamic movement of the control (Super Mario character) during the running of the LabVIEW program, first create a Position property node for the control to be moved in the back panel, select All Elements, and then convert the Position node to the written state. At the input end of the node, a control cluster is generated. The cluster contains Left and Top variables. After the program is run, only the corresponding coordinates are input to the left and the Top.

2.3.3. Data acceptance. The serial communication module should be divided into several parts such as data collection and data extraction processing display, so multiple cycles are required at the same time, and the “producer and consumer” loop structure in LabVIEW satisfies the need to run multiple processes at the same time. And will not affect the execution speed. The main loop executes in parallel with the slave loop, the main loop performs data acquisition, and the data is saved from the loop. The main loop generates and passes data to the "element to queue" function, and controls the loop speed through the "wait (ms)" function, choosing to wait for 65ms. Returns the data in the queue from the loop and stores the data in an array.

The VISA serial communication parameter configuration method is as follows. First, use the VISA Resource name control parameter module to configure the serial port number, baud rate, data bit, stop bit, and check bit; then use the time delay function to match the VISA device clear function block. The input and output buffers of the device are cleared, then the VISA Read function reads the data in the device specified by the VISA Resource Name, and finally opens the session connection with the VISA resource, which takes up the system resources of the computer, so when the VISA program ends All open session channels must be closed. LabVIEW provides the VISA Close function for this purpose.
This function closes the communication process of the device specified by the VISA Resource Name parameter and releases the computer system resources occupied by the VISA Session.

The data sent by the sensor module to the upper computer is divided into three data packets, namely acceleration packet, angular velocity packet and angle packet, and three data packets are sequentially output. When the baud rate is 115200, 1 frame of data is output every 10 ms. The data is sent in hexadecimal form, with 11 data per packet and a total of 33 data. The data is configured in the VISA Read function so that each time 33 data is read from the device specified by the VISA Resource Name and stored in an array.

2.4. Limb movement data transmission.
Different steps in the game interface require Mary to jump different lengths or heights, corresponding to different accelerations. The acceleration data collected by the experiment is a series of irregular sinusoids, and the game extracts the maximum value of each acceleration data.

Each time the sensor module sends 33 hexadecimal data sequentially to the upper computer. Therefore, when parsing data, we firstly have to determine what kind of data packet the packet is, then determine the value of the second data of each packet of data; X (Y, Z) axis acceleration low byte is the 2nd (4th, 6th) bit of the array. X (Y, Z) axis acceleration high byte is the 3rd (5th, 7th) bit of the array; X (Y, Z) axis angle low byte is the 24th (26th, 28th) bit of the array, X (Y, Z) axis acceleration high byte is the 25th (27th, 29th) bit of the array.

Taking the X-axis acceleration as an example, for the first, extracting the zeroth bit and the first bit in the array of stored data, to determine whether it is 0X55 and 0X51. If yes, the data packet is an acceleration package, extract the second and third digits in the array, convert it into a hexadecimal integer string, and then concatenate the two strings with the high byte in the first low byte after the resulting character. The string is re-transferred to a numerical value. Thirdly, the X-axis acceleration is obtained by using the calculation formula. The other two-axis accelerations are calculated as the X-axis acceleration of the three-axis angle analysis method. Finally, the acceleration value is obtained by using the shift register. Compare with the previous time value until the maximum value is obtained.

The game moving distance is calculated allows acceleration data, and then the Super Mario character start to move.

3. Data measurement and analysis

3.1. Measurement method
To drive Super Mario forward, backward, up or down, the person needs to swing his arm in the appropriate direction. Data records show that each person has his or her own unique motor response for the same distance. This kind of reaction is random, in order to accurately drive the movement of the characters, the personnel need to try repeatedly. The data obtained are divided into two categories, including longitudinal measurement data and lateral measurement data. Longitudinal data refers to the acceleration measured by different participants for the same distance. When the response is not appropriate, the game personnel need to self-correct. Lateral measurements are pointers to different distances that require different accelerations. When the response is not appropriate, the game player needs to constantly self-correct.

3.2. Measurement results and analysis
Figure 1 is the acceleration raw data measured within 200s, from which we extract the maximum value of each measurement. The max value is shown in Figure 2.
Figure 1. Acceleration raw data measured within 200s.

Figure 2. The acceleration maximum is evenly distributed from 0 to 360 degrees. In which, the black square and the blue dot is respectively the maximum acceleration of each limb movement.

Figure 2 is a typical example of the obtained longitudinal contrast data which is uniformly distributed on a plane of 0-360 degrees with the maximum value of the acceleration value of each swing arm as a radius. The black square point (data A) is the maximum acceleration measured by ordinary people, and the blue dot (data B) is the maximum acceleration measurement point of the limb uncoordinated person. It can be seen that the blue point is more dispersed. It shows that the acceleration of the limb uncoordinated person varies around a central value, but the standard deviation of acceleration is larger, and the speed of self-correction is smaller than that of normal people.

Calculate the standard deviation $\sigma$ from the data, the equation (1) is as follows, where $v_i$ is the residual.

$$\sigma = \left( \frac{v_1^2 + v_2^2 + \ldots + v_n^2}{n-1} \right)^{1/2}$$  \hspace{1cm} (1)

The standard deviation of data A is nearly twice the standard deviation of data B. In order to more clearly compare the dispersion of the values, we use the Normal distribution formula to plot the probability distribution curves of the two types of data. The equation (2) is as follows

$$y = \frac{1}{\sigma \sqrt{2\pi}} e^{-(v_i^2)/(2\sigma^2)}$$  \hspace{1cm} (2)

The calculation results are shown in Figure 3. The black line A is the distribution curve of the ordinary person, and the blue line B is the distribution curve of the uncoordinated person. In the range
of 0.3g-0.5g, when the area of the data A is marked as approximately 68% of the whole area, data B has only 33% of that, and this measurement is stable rather than accidental. It is proved that this game have the ability to assess the limb health condition of the game players.

![Figure 3](image)

Figure 3. The normal distribution of the two data, in which A, B respectively presents the data obtained by normal player and the uncoordinated player.

In order to meet the needs of special groups, the game uses relative value instead of absolute value to drive the character. Therefore the game was more appropriate to the uncoordinated players, which will stimulate the interest of the uncoordinated players, and thus promote the long-term training and rehabilitation process.

4. CONCLUSION
This paper designed a game-based rehabilitation system that includes a game software interface compiled with Lab VIEW and hardware for collecting limb motion data. Use the acceleration sensor to detect the swing of the hand, send the motion parameters to the game interface, match the game action, and drive the game character to move. Comparing the detected hand movement parameters with the game demand parameters, it is found that each person has unique sports characteristics. The hand-poor patients have a larger range of motion than ordinary people, and the values are scattered. Within the same threshold range, the accuracy is less than 2/3 of the one of the normal person data and below. It shows that the system can be used to detect and assess the level of limb rehabilitation of patients. In addition, from the perspective of game experience, it is necessary to use the relative value of acceleration drive the character, so as to stimulate the interest of the game, and then promote limb rehabilitation.

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