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Design and Implementation of Somatosensory Teaching Pendant System Based on Android Platform

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Abstract: *The control mode of the existing teaching and playback type display device is usually a joystick control or an entity or a virtual button control of the device. According to the requirement of robot teaching and the development of the Android platform, a somatosensory teaching method based on Android platform is proposed. This method aims at obtaining robot motion speed and direction through the reading of the gravity sensor in the teaching pendant and wirelessly transmitting the motion data to the robot controller so as to control robot motion. What's more, this function has been applied to the Descartes coordinates of the injection molding machine proving its reliability and convenience and related equipment has been displayed in the third China Robotop successfully.*

Keywords: *Android, Somatosensory, Robot, Teaching Pendant, Gravity Sensor*

I. Introduction

Teaching pendant is an important part of an industrial robot. In the traditional teaching pendant process, the robot motion is controlled through the rocker or the button on the teaching pendant, so such teaching pendant usually has the features of heavy weight and difficult manipulation. Along with the popularization of various mobile terminals, robot teaching pendants trend to be portable. Currently, the operating systems specially developed for mobile intelligent terminals include Apple iOS system, Google Android system and Microsoft Windows Phone system[1]. Therein, Android system is a free open-sourcing operating system based on Linux platform, and compared with other operating systems, Android system has such advantages as strong openness, rich third-party development, excellent built-in service and strong support by Google[2], thus widely applied in the robot teaching pendant industry.

MEMS sensor in mobile equipment is widely applied in such fields as games and navigation due to its high performance, low power consumption, high reliability, etc[3,4,5]. In Android2.3 gingerbread system, Google provides the following eleven sensors for the application layer, namely magnetic sensor, direction sensor, light sensor, acceleration sensor, proximity sensor, gyroscope sensor, pressure sensor, temperature sensor, gravity sensor, linear acceleration sensor and rotation vector sensor[6].

In this paper, the gravity sensor is taken as the subject of the somatosensory teaching pendant to obtain the sensor data through the method provided by Android system platform. Afterwards, the acquired data is smoothed and filtered to obtain the inclination angle of the equipment, and these data are transmitted to the controller through wireless network, and then the controller controls robot actions according to different commands.

II. General Design

As shown in Fig.1, the teaching pendant process of the robot is divided into four parts, namely operator, teaching pendant, controller and robot. Therein, the teaching pendant is the man-machine interaction window, and the teaching pendant is used for the operator to check the motion, production and fault information of the robot and control the motion state of the robot, and the controller as the brain of the robot is used to control the motion of various axes of the robot through controlling the servo driver.

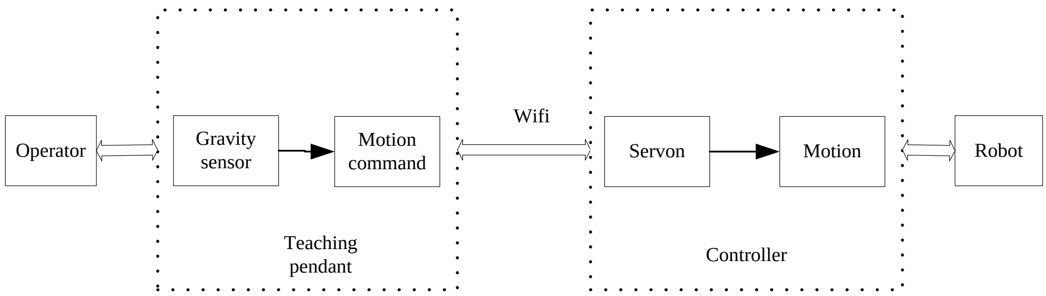

Fig.1 The teaching pendant process of the robot

For robot teaching pendant, the operator needs to observe the robot and the pose of the held tool relative to the operated object as well as operate the teaching pendant to repeatedly adjust the operation pose, the motion parameter and the process parameter of the robot at the teaching pendant point. The data in line with the operation requirements are recorded before the teaching pendant is transferred to the next point. After the whole teaching pendant process is completed, the recorded data are practically adopted for the robot, and the robot pose recorded at the teaching pendant point can be reproduced through certain interpolation and smoothing calculation.

This paper is mainly focused on the teaching pendant. As for hardware, the mobile intelligent terminal embedded with gravity sensor is needed for the design. As for software, the design concept based on Android system is adopted to establish the sensor framework through android.hardware packet and call relevant functions in SensorEventListener class to acquire the data of the sensor on the equipment. Afterwards, the acquired data are smoothed and filtered to obtain the inclination angle of the equipment, and then these data are transmitted to the controller through wireless network, and then the controller controls robot actions according to different commands.

2.1 Main program interface design

The main program interface is as shown in the Fig.2. The left side presents the robot state display column for displaying the position information of the robot, and the right side presents the function selection column including manual function, automatic function, program function, IO, device, variable, browser, setting and log management function. The operator can click to enter the corresponding function interface. Click Manual button to enter the teaching pendant interface. The teaching interface is shown in Fig.3. At this interface can operate the robot motion.

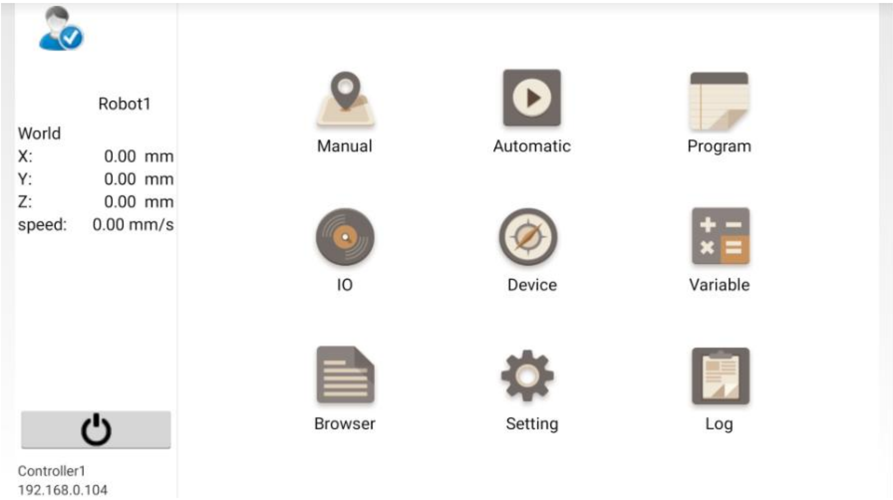

Fig.2 The main program interface

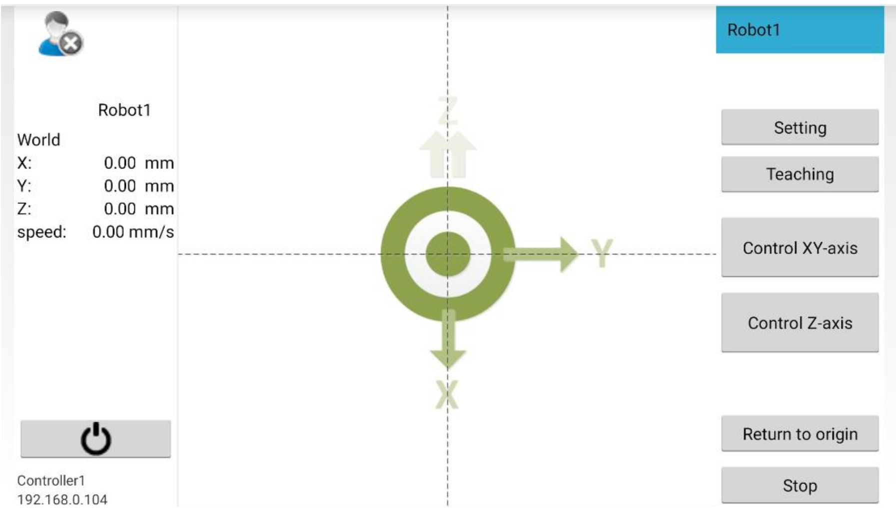

Fig.3 The teaching interface

2.2 Workflows of teaching pendant and controller and communication protocol design

2.2.1 Workflows of teaching pendant and controller

Workflows of teaching pendant and controller is as shown in the Fig.4. The controller ceaselessly broadcasts its state through UDP and establishes a TCP service terminal. After receiving the broadcast packet, the teaching pendant sends TCP connection request to controller IP address. After connection establishment, the user needs to log in to verify the operation authority. After verification success, the user can acquire equipment information from the controller and sends various commands and parameters.

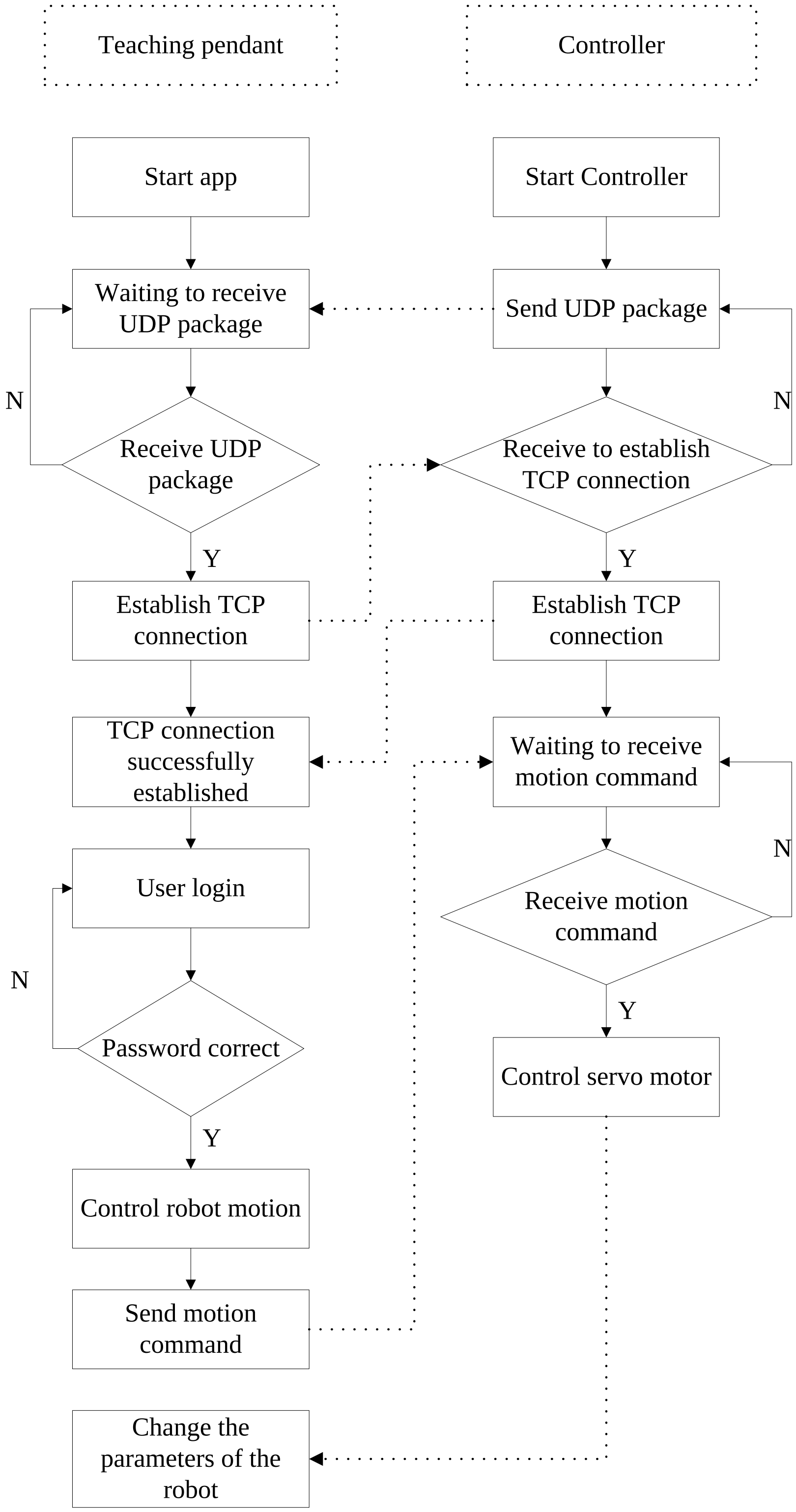

Fig.4 Workflows of teaching pendant and controller

2.2.2 Communication protocol between teaching pendant and controller

Socket is the application layer and TCP/IP protocol communication abstraction layer, Socket is a set of interfaces, in design mode, Socket design is the facade pattern of the TCP/IP protocol, the content of complex hidden in the socket interface behind the user without concern of the agreement, only can use the Socket interface. Socket communication is to establish a connection between the two sides can be directly transmitted data, the connection can be achieved when the active push information, and do not need to send a request to the server every time by the client. So this design chooses Socket communication.

UDP multicast address: “224.0.1.2”, port number: 10945, port number of TCP service terminal: 1946. TCP communication format is JSON format, and the port number of TCP service terminal is 1946. The communication between the teaching pendant and the controller is realized through TCP connection, and the packet format is as shown in the following Table 1.

Table 1 Communication protocol

Frame header	JSON string length	JSON string
“!!”: teaching pendant to controller “&&”: controller to teaching pendant	4 bytes. Big Endian(High-byte first)	{“cmd”: Command String, “data”: Data for this command}

III. Implementation of Somatosensory Teaching Pendant

The somatosensory teaching pendant needs the sensor in the teaching pendant. Android platform can provide various sensors for the users, and the users can select one or more of these sensors as needed. The use of this paper is gravity sensor.

3.1 Relevant sensor classes

3.1.1 Establishment of SensorManager object

SensorManager object as the sensor management service of the system is used to manage the called sensors as follows: firstly call getSystemService(Context.SENSOR_SERVICE) method of Contex to obtain SensorManager object, and then call getDefaultSensor(int type) method of SensorManager to obtain the designated type of sensor.

3.1.2 Sound monitor registration and cancellation

In onResume() method of Activity, registerListener(SensorEventListener listener, Sensor sensor, int rate) of SensorManager is called to register the sound monitor for the designated sensor. As for the three parameters in the method, listener is the sound monitor for monitoring sensor event, and sensor represents the sensor object, and rate is used for setting sensor data acquisition frequency.

In onStop() method of Activity, unregisterListener(SensorEventListener listener) of SensorManager is called to cancel the sensor.

3.1.3 The method of SensorEventListener

onSensorChanged(SensorEvent event) method and onAccuracyChanged(Sensor sensor,int accuracy) method must be implemented for sensor event trigger[7].

When sensor reading is changed, onSensorChanged(SensorEvent event) will be called. In this method, the sensor data can be acquired and more or less processed.

When sensor accuracy is changed, onAccuracyChanged(Sensor sensor,int accuracy) method will be called. Parameter sensor represents the sensor, and accuracy represents the new accuracy of the sensor.

3.2 Somatosensory teaching pendant

The key of the somatosensory teaching pendant is the gravity sensor. The gravity sensor is used to measure the gravity components of the gravity on the three axes so as to obtain the inclination direction and angle of the teaching pendant according to the three components. Robot teaching pendant speed and direction are determined by the inclination direction and angle of the teaching pendant. During sensor registration, the sampling frequency of the sensor can be designated, but such sampling frequency is only used for system prompt, and the practical sampling frequency may be higher or lower than the designated sampling frequency. For the same sampling frequency, the practical sampling frequency of the same equipment may be changed under different motion states. For example, when the equipment direction is rapidly changed, the sampling frequency of the gravity sensor becomes very large; but when the equipment direction is slowly changed, the sampling frequency of the gravity sensor becomes very small[8]. Therefore, in order to obtain smooth teaching pendant speed, the data of the gravity sensor should be processed by low-pass filtering.

The somatosensory teaching pendant interface is as shown in the figure: the left side presents the state column for displaying the motion parameters of the robot, and the right side presents the teaching pendant setting column. A user can click “Button” to enter the teaching pendant setting interface to set such information as teaching pendant speed and teaching pendant step, and return to the teaching pendant interface after setting. Meanwhile, the user can press “Control XY-axes” button to control the robot motion along X-axis and Y-axis through front and back or left and right inclining the teaching pendant, or press “Control Z-axis” button to control the robot motion along Z-axis through front and back inclining the teaching pendant.

IV. Test Flow

For testing, it is necessary to connect the wireless network of the teaching pendant to the wireless router of the controller and then start the teaching pendant program to automatically establish TCP connection with the controller. The user can set the teaching pendant information in the teaching pendant interface and controls the robot motion through somatosensory teaching pendant after setting. The setting interface is shown in Fig.5. Then, the user can press “Control XY-axes” button to control the robot motion along X-axis. The tested equipment is the injection-molding robot, as shown in the Fig.6.

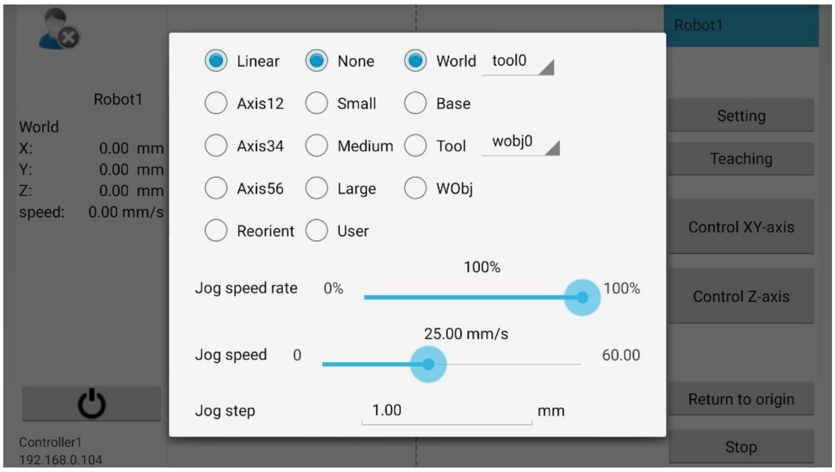

Fig.5 The setting interface

Fig.6 The tested equipment

V. Conclusion

This teaching pendant controls robot motion through the gravity sensor on Android intelligent terminal, thus reducing teaching pendant cost and weight. Meanwhile, this teaching pendant method is developed on the basis of Android platform, so it is only necessary to install the corresponding App on Android intelligent terminal for convenient transplantation. Several field tests prove the accuracy of the method and the convenience of the operation. The teaching pendant speed can be changed at any time according to different inclination angles, without the need to manually input the teaching pendant speed, so this teaching pendant is more humanized.

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