An Improved Design of an Automatic Detection Balance Tray with an Accelerometer, Four Servo Motors, Four Force-Sensitive Resistors and an MCU Expansion Board

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***Abstract*-- When an user props up the tray while walking the tray often vibrates and liquids may splash out. This proposal is an improved design of an automatic detection balance tray (ADBT) by using a triaxial accelerometer module, four force-sensitive resistors (FSR), four servo motors, four LEDs, and an MCU expansion board. The triaxial accelerometer module detects the tilt angle of the tray. The MCU expansion board controls the four servo motors which are utilized to balance the tray. The four FSRs in the tray will sense the carried item positions. The four LEDs in the four corners of the tray show both the weight distribution and the position of the carried items to remind the user in order to prevent the items on the tray from falling down.**

I. Introduction

One design uses the acceleration module to control the servo motor, so that the robot arm can maintain the balance [1]. Another design also uses an accelerometer to measure the movement speed of an user, and then uses the acceleration values to calculate the walking speed [2]. Some other designs use a smartphone with the acceleration measurement [3]. This design uses an ADBT combination of the triaxial accelerometer module, a microcontroller, four LEDs, four FSRs, and four servo motors as shown in Fig.1. The triaxial accelerometer module is used to measure the roll by showing the pitch. The MCU expansion board will read the acceleration values to calculate the angle change. This board then controls the four servo motors to balance the ADBT. In addition, the accelerometer continues to measure the walking speed of the user to select the balance sensitivity. The four FSRs, which are located on the tray, detect the position of the carried items on the ADBT. These FSR values will be used to control the four LED lights at the four corners of the ADBT. This LED on/off is used to remind the user to reduce any potential tilt which might result in a falling down situation.

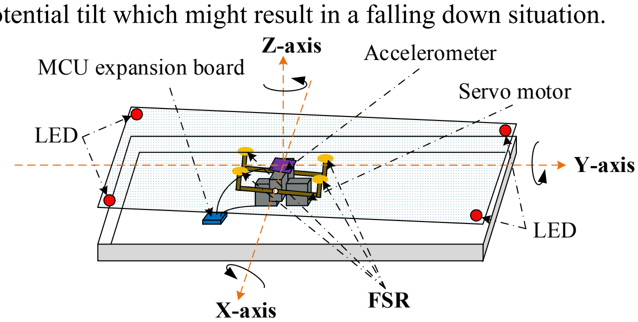

Fig. 1. The schematic of the ADBT

II. Hardware Architecture

Fig. 2 shows the ADBT hardware architecture which includes a triaxial accelerometer module, an MCU expansion board, four servo motors, four FSRs, and four LEDs. The FSR is located at the middle ADBT bracket with an anchor. When an user places the items on the tray, the weight of the items will change the resistance value of the FSR. The resistance value of the FSR will be sent to the MCU expansion board and then to the LED brightness control. If the carried items are biased in favor of the specific side, then the LED will be brighter which shows that this direction is heavier. This reminding function is used to alert the user to maintain balance to avoid any tilt which will result in a falling down of the ADBT. The triaxial accelerometer of the ADBT also senses a user's walking speed. The proportion values of the walking speed will be sent through both a data line and a clock line which transmit the read data to the MCU expansion board. This MCU expansion board reads the sensing data in order to control the direction of the servo motor to return to the original ADBT balance level.

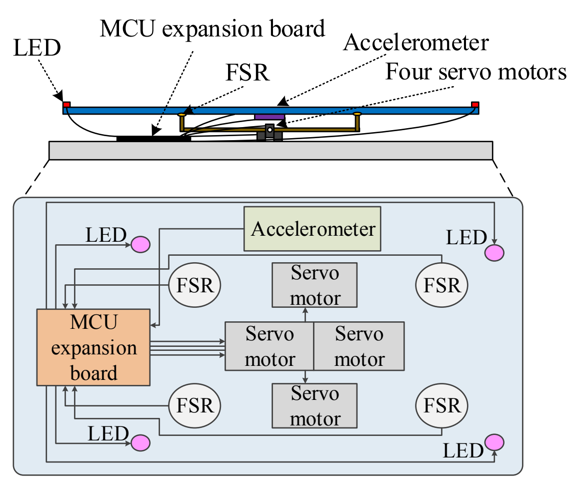

Fig. 2. ADBT hardware architecture.

III. Software Modules

Fig. 3 shows the ABDT flowchart. When the user props up the ADBT, the four FSRs detect the placement of any carried items and at the same time, the MCU expansion board has to control the LED brightness to remind the user. The triaxial

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accelerometer data are sent into the MCU expansion board in order to judge the ADBT balance level. The MCU expansion board will convert the acceleration values for the angle value of the ADBT to control four servo motors to balance the tray back to the correct horizontal level. When the ADBT has reached a correct balance, the triaxial accelerometer module will also detect the walking speed of the user. The MCU expansion board will choose the balance sensitivity based on the walking speed. To save power consumption, when the ADBT stays idle for more than 10 seconds, the system will switch into the standby state.

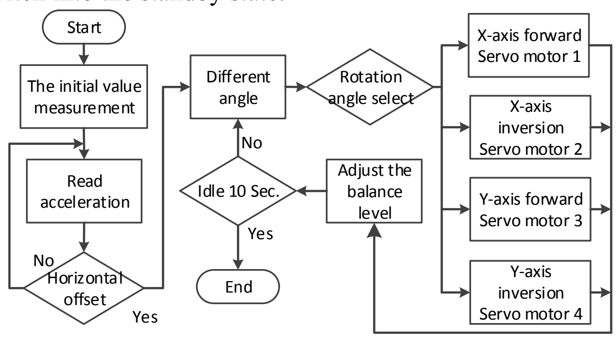

Fig. 3. The ADBT flowchart.

The top of Fig. 4 shows the system flowchart that this design uses to adjust the balance sensitivity based on the measurement of the user's walking speed. This design starts the ADBT sensitivity with a modest selection to initiate the balance procedure, but when a user's walking speed is greater than or less than this range, the system will automatically switch into a higher sensitivity or a lower sensitivity in order to maintain an ample balance speed with a reduced power consumption. The bottom of Fig. 4 shows a reminder function flowchart of the ADBT carried item placement. This design places the four FSR to measure the weight distribution of the carried items and shows the weight distribution by the LED lights located at the four corners of the ADBT.

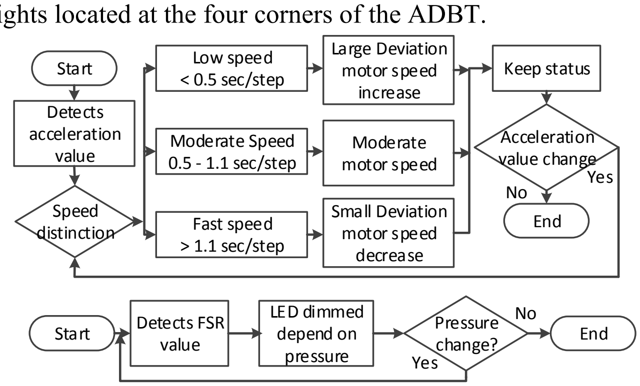

Fig.4. A flowchart showing the balance sensitivity adjustment process and the reminder function process.

IV. Results of Our Experiment

Table I shows this ADBT's specifications. This design can compensate its maximum angle range of 30. This design measures a user's walking speed which is divided into three classes. At first, this design begins with a moderate sensitivity to compute the balance of the ADBT. When the user's walking speed is relatively fast this design switches to a quicker balance model. When the user walks slowly, this ADBT does not need to maintain a higher sensitivity. In this lower sensitivity, the rotational speed of the servo motor will be slower in order to save the power consumption.

TABLE I
ADBT Specifications

Balance Sensitivity	High	Moderate	Low
Balanced angle range	≤30°	≤30°	≤30°
Control angle accuracy	<1°	≤2°	≤3°
Servo motor response time	<10ms	<10ms	<10ms
Servo motor speed(Sec/60°)	0.15	0.3	0.45

Table II shows the power consumption of the ADBT modules. The servo motor rotation needs to constantly drive and compel the ADBT to return to a balanced level since the power consumption of the servo motor will be relatively large. When the MCU expansion board must read the acceleration values from the triaxial accelerometer module, the MCU expansion board and the accelerometer will continue to operate. The FSR, which is used to sense the carried item weights as a result of the variation of the resistor values, consumes little power

TABLE II
The Power Consumptions of Each ADBT Module

	Standby	Operation
Accelerometer module	7.375 mW	7.375mW
Servo motor ╳ 4	0 mW	500 mW
MCU expansion board	27.1 mW	27.1 mW
LED ╳ 4	0mW	75mW
Force-sensitive resistor	0mW	1.96mW

V. Conclusion

This design, an improvement of the previous tray design, includes the reminder function whereby the FSR weight senses the carried item positions and shows the weight distribution by the four LEDs at the four corners of the ADBT. In addition, when the user props up the ADBT, this design can change the balance sensitivity based on the user's walking speed in order to save power consumption. In the future, the human-computer interaction continues to enhance the user's variation estimation, such as when using a more athletic stance. In order to design a more ergonomic use of the tray, the authors will design a more energy-saving ADBT.

Reference

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