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Design and Development of Sports Management Information System Based on Acceleration Transducer

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Abstract

This paper analyses and compares the acceleration sensor: ADXL330, ADXL345, ADXL203, and points out that the acceleration sensor functions in sports management system. Sports management system is the main controller in motion process command each node controller through the sensor to collect the movement process of the ADXL system the human body each point in three coordinate axes acceleration component. The article presents design and development of sports management information system based on acceleration transducer. Design of sports information management system based on three axis accelerometer can quickly and accurately collect human motion information, which provides a new method for the study of sports.

Keywords: *acceleration transducer, sports information management system, MEMS*

1. Introduction

Any body movement from the beginning to the end, the acceleration of every part of the body is changing all the time. If repeat any action, change law of the acceleration is also very close to the. So, as long as the three axis accelerometer placed in a feature point measured human body, can be accurately the feature points in the motion process of X, Y, Z three component acceleration acquisitions. Then, through the mathematical calculation of the acceleration component, can field health training, sports training, the game control.

Acceleration is changing all the time. Through mathematical calculation of the acceleration component, you can get the trajectory and the dynamic process of the point of information. The plurality of feature points to the data collected to conduct a comprehensive analysis; we can find the detailed information of measured body movement, so as to realize the digital motion information. The motion acceleration information acquisition information processing platform main body when walking or running, and the processing of information or forwarded to a high-end computer was analyzed, so that the processing platform can be widely used in health training, sports training, system development and other fields.

Human body motion capture technology is widely used in the motion analysis, medicine, biological engineering, and special effects in movies, sports scientific research training and other related fields [1]. At present, researchers mainly use the optical and 2 kinds of sensor, optical motion capture instrument need specific space environment, multiple high speed cameras, it is expensive and distance measurement sensor movement is limited. Capture instrument compared with measured distance, there are no specific requirements on space, easy to wear and low cost, easy to use in practice.

The development and utilization of sports information resources of modern information technology acquisition, processing, storage, transmission and use of sports information resources, improve the sports information resource availability, applicability and effectiveness, improve its digitalization, database and network level, realize high sharing, and promote the rapid and healthy development of sports undertakings.

ADXL203 is high precision, low power consumption and a single iMEMS IC chip with dual axis accelerometer, the output signal voltage adjustable. Output as a proportion and acceleration into analog voltage signal, and it is proportional coefficient 1000mV/g. The

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accelerometer can measure the dynamic acceleration, and can be used to implement static measurements such as the acceleration of gravity, then can replace the tilt angle sensor for tilt measurement.

Athlete information management system through the athletes timely information gathering, real-time updates and centralized storage management, through the training, transportation, material, such as a series of occupation period placement track record, realize the whole process management of athletes life occupation period. The athletes, coaches and other information systems provide infinitely interconnected query, based on the development of athletes, the sports statistics more perfect analysis function, and space for the development of the future and to improve the quality of sport project provides analysis and forecast the trend, to provide data information aided better for sports decision makers.

System consists of multiple sensor nodes, each sensor independently of the controller, and a plurality of nodes in sensor networks. The sensor nodes placed the feature points in the human body to be measured, the main controller during exercise command each node controller through the ADXL345 collection in the process of motion of each point on the axis of the three acceleration components. The article presents design and development of sports management information system based on acceleration transducer.

2. Analysis and Comparison of Acceleration Sensors

ADXL330 is a three axis (x axis, Y axis and Z analog output acceleration sensor, the acceleration component, the three directions can be calculated, the motion direction sensor spatial point at the moment of spatial location and other information, through the processing of information, the details of the action. At the same time to detect a plurality of feature points of the human body, and make a comprehensive analysis of the data, you can get the information of human motion.

The MMA7260Q is a low cost, single chip, three axial are high sensitivity accelerometer; micro machined structure based on the surface, the integrated signal conditioning circuit, single pole low-pass filter and temperature compensation, and has 4 different sensitivity selection modes [2]. The cut-off frequencies of the filters have been set at the factory before, without the need for external adjustment. At the same time it contains a sleep mode, making it ideal for small, battery powered portable equipment. MMA7260Q in X, y, Z3 axes with high sensitivity to read low gravity level fall, tilt, mobile, placement, vibration and swing, it is the first single chip similar products in the three axial acceleration sensor.

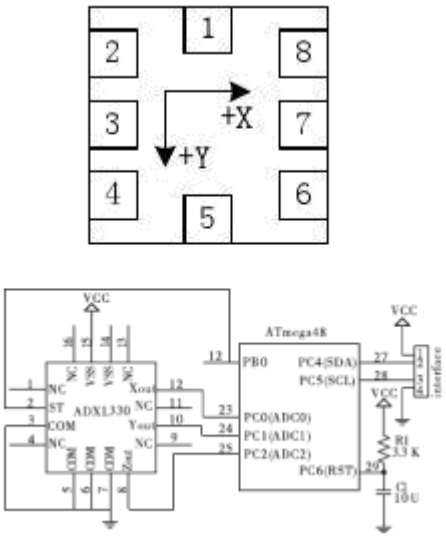

Figure 1. The Circuit Principle Diagram of Sensor Network Node

ADXL203 typical measurement in the range of ± 1.7 g, the accelerometer can measure the static or dynamic measurement of acceleration; 3500g can withstand the limit acceleration. The pull-down current is less than 700 μ A, sensitivity to 1000mV/g. The accelerometer at – 40 ° C to 125 ° C temperature range, temperature sensitivity with ± 0.3%; zero offset accuracy of ± 25 mg; with the solution is less than 1 mg in less than 60 Hz bandwidth (0.06 ° tilt) stability and better than 0.1 mg/ ° C. Using 5 × 5 × 2 mm LCC package. The ADXL203 pin package and pin functions as shown in Figure 1.

The design of the system, the acceleration sensor ADXL330 as the accelerometer, and it is the change of acceleration measurement of human walking. ADXL330 is a motion signal processing ADI 3 axis accelerometer, the MEMS sensor and signal conditioning circuit together, the working voltage is 2.O ~ 3.6V, current 3V supply voltage conditions for 320} tA, power consumption current is reduced to 200tA (pressure condition 2.0V power down), 50% (power consumption than the typical value of similar devices". ADXL330 can also be by adjusting the duty cycle to achieve lower power consumption, its typical wake-up time is lms. ADXL330 rated high impact strength up to 10kg, using the LFCSP package, 4mmX4mm × 1.45MM volume light, very suitable for the application of the design.

This system uses the MMA7260Q three axis acceleration sensor and TIMSP430 built-in (/), with 8; 5 low power mode, suitable for application in automatic signal acquisition system. MMA7260Q supply voltage at 2.2V ~ 3.6V, the output signal in 0V ~ 3V, power can be shared with MSP430 single chip microcomputer, and the output signal can be directly input to the MSP430 A/D channel without transformation of the signal voltage.

Gait is a person walking posture. As a biological characteristic, it is not influenced by the distance, non aggressive, hard to disguise, less affected by environment and other unique advantages, so it has attracted much attention in recent years. The medical asynchronous morbid, hemiplegia and disease prevention, diagnosis and rehabilitation can also play the auxiliary effect is very significant. Moreover, in the modern sports training also can be used to monitor the athletes through the gait characteristics of consumption, the accuracy of the movements, so as to develop a scientific training program.

When the system has the acceleration, the intermediate plate will drift. The intermediate plate moves, it to one side (the fixed panel) distance increases, and to the other side of the distance reduced accordingly, this change in distance can be used to characterize the acceleration. The G2CELL panel to form the capacitor and two back to back, when the middle panel with the change of acceleration and moves, the capacitance between the two panel will change, C=A ε /D. Where A is the panel area, ε dielectric constant, D panel spacing. In the ASIC (application specific integrated circuit) using switch capacitance measurement of G2CELL capacitance value, and calculated from the difference of acceleration data. ASIC then the signal modulation and signal filtering (using switched capacitor), and it is the output voltage to the acceleration.

The most common ADXL203 application is for inclination measurement. Space range accelerometer to the gravity vector is used as a benchmark to measure object. When the accelerometer sensing axis and the vertical (i.e. sensing axis), it is the most sensitive to the change of inclination, tilt changes every 1 ˚, output variation of G 17.5mg; when the induction shaft with the level of 45 ˚ angle, inclination changes every 1 ˚, output g changes only 12.2mg; and when the induction shaft close to parallel with the direction of gravity (sensed acceleration close to the +g or -g), inclination changes every 1 ˚, an output of almost no change. With increasing tilt measurement, it is measurement accuracy.

The X and Y axis accelerometer placed horizontally can be used as a biaxial inclinometer to measure the inclination. The output analog voltage signal VX, VY converted into the corresponding g value variation of AX, AY. The tilt angle calculated by Formula 1 X, Y axis pitch angle (pitch) and tilt angle (roll) [3].

$$S_q = \frac{q_a}{a}$$

$$u_1 = \frac{-Kq_a}{C + (1+K)C_F} \quad (1)$$

In the formula 1, charge sensitive Sq usually takes a small value, feedback capacitance CF range is generally 100-10000pF). Type shows that acceleration and output voltage signal proportional to U, and inversely proportional to the capacitance CF feedback, but also affected by the cable capacitance is small, this is one of the main advantages of the charge amplifier. Analysis can be accomplished by piezoelectric acceleration sensor and the charge amplifier measuring system and the measured vibration acceleration by the above.

X, Y axis measuring signal ADXL203 output respectively through the low pass filter, and then through the differential input to the ADC, the VIN (-) termination voltage 2.5V. In order to get higher precision, we give ADC external 2.5V reference voltage. In addition, in order to filter out the noise power supply, using 0.1U and 10u capacitors in parallel access power supply circuit for power supply decoupling.

Plate inspection quality block its support plate and the middle plate is composed of.G2Cell constitutes a flat capacitor and two back to back, when the system is given a acceleration, detection of affiliated mass middle plate will deviate from the non acceleration position, so it to one side fixed electrode distance will increase, at the same time to another a fixed plate distance will decrease. Therefore the value of capacitance change with the distance between the plate changes, this is the acceleration measurement. The capacitance value through capacitance voltage converter converts the voltage value, into the gain amplifier, filter.

Piezoelectric acceleration sensor belongs to the inertial sensor; the working principle is based on the piezoelectric effect of certain substances based on accelerometer, vibration, and the piezoelectric elements on the force changes. When the measured vibration frequency is much lower than the natural frequency of the accelerometer, change the force and the measured acceleration is proportional to, the non electric physical quantity acceleration measured into electricity. Because the output signal of piezoelectric sensor is a weak charge, and the sensor itself has a lot of resistance, so the output energy is very small, it is difficult for circuit. Therefore, usually used for signal charge amplifier as the measuring circuit of signal.

ADXL330 is heat convection type three axis acceleration sensor, a signal conditioning voltage output, the maximum measurement range is ± 2 g, X and Y axis of the bandwidth from 0.5 Hz to 1600 Hz, Z axis bandwidth from 0.5 Hz to 550 Hz, with good g zero bias stability and good sensitivity accuracy. ATmega48 microcontroller with 8 Channel 10 bit AD converter, at the highest resolution sampling rate can be as high as 15 kS/s, analog input pins of the microcontroller ADC0-ADC2, three output shafts of the acceleration sensor ADXL330 acquisition [4]. The output of ADXL203 is an analog voltage signal, can be directly used for AD sampling. Company ADuC847 microcontroller, which integrates 24 bit Delta - speed can reach 420kSPS and ADC. The hardware connection diagram is as shown in Figure 2.

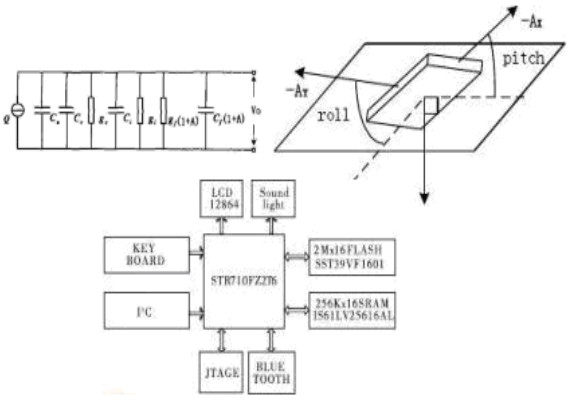

Figure 2. The Hardware Connection Diagram

The noise in the output signal of the sensor, the ADC conversion result error, and it is affecting the accuracy. On the other hand, AD is the effective input noise; quantization noise will affect the accuracy of the ADC conversion. The delta sigma ADC exploits over sampling principle, by means of digital filtering and decimation, remove the band quantization noise and improving the resolution of ADC, improve conversion accuracy.

The change of acceleration of ADXL330 acceleration sensor to detect the human body movement, after the high resolution, high precision PxI ~ 4495 data acquisition card converts the analog signal output acceleration sensor into a digital signal, and transmitted to the computer terminal, designed by Labview combined with Matlab algorithm and software, real time display of the motion state of human body, achieve seamless link data acquisition and real-time processing, display.

Main controller uses ARM chip STR710FZ2T6, with a 4 channel 12 bit A/D converter, 256 KB on-chip FLASH and 64 KB on-chip RAM, serial interface includes 2 SPI, 2 I2C, 4 UART and HDLC, SC and MMC interface, also provides CAN and USB interface, 4 16 real time clock and timer, watchdog timer (WDG), 48 general purpose I/O pin, can satisfy the design requirements.

The A/D conversion circuit in the analog voltage signals into digital signals, the system uses the CMOS A/D converter TLC1549 with a 10 bit successive approximation A/D switched capacitor converter and structure based, it has the internal sample and hold circuit, and differential high impedance voltage reference input, disturbance, can according to the proportion of range calibration conversion range, total unadjusted error up to ± 1LSB Max (4.8mV) etc.. It through a three state output (DATAOUT) and 2 inputs (including I/OCLOCK (I/O clock) and CS) is connected with the AT89C51 of P10 to P12 interface, which not only simplifies the system design, reduce the occupied area of the circuit board, but also improve the reliability, high resolution.

A master-slave star network topology can take between each node controller and main controller, using the I2C communication. The main controller of the sensor nodes to upload information, analyze information and make the corresponding data processing, output data to the application of secondary development of two.

A low cost single chip three axis accelerometer. The capacitive acceleration sensor signal conditioning technology, Dan Ji low pass filter and temperature compensation, and provides four kinds of acceleration measurement range, respectively: ± 1.5gn, ± 2gn, ± 4gn and ± 6gn.MMA7260 also has a very high sensitivity, when the measuring range select ± 1.5gn, sensitivity to 800mV/gn. Using the 6mm * 6mm * 1.45mmQFN package, ultra small size, only very little board space. Moreover, MMA7260 provides a sleep mode, is ideal for handheld devices are battery charging. It has three axial detection function, the portable devices capable of intelligent response the position, and orientation and mobility changes.

This paper introduces the structure and principle of ADXL203 accelerometer, tilt measurement gives it with the ADuC847 circuit, and analyzes its. The circuit has the characteristics of simple realization, high precision.

The accelerometer signal after filtering processing, you can step counting according to the filtered signals. Principle of step count: because when walking is a process of the instantaneous acceleration of moving, so initially that jump in a moment of great acceleration, shows that people who take a step. We set a threshold value / V / T according to the acceleration signal, in the moment before the T acceleration signal is below the threshold value M, and at the moment t backdoor limit value is higher than M, then the pedometer plus 1, so you can calculate the total number of steps in the whole sampling time.

3. Design and Development of Sports Management Information System Based on Acceleration Transducer

When people walk through the distance, speed, and it is acceleration to describe the behavior of human walking. Based on the characteristics of human motion acceleration, and it is the acceleration parameters to simulate human walking model, the acceleration sensor (ADXL330) to obtain the acceleration signal of human body, and the signal processing algorithm to calculate the human walking step number. Firstly, define three different directions: the vertical acceleration, the forward and backward.

Human body motion capture system by micro sensor human motion parameters is placed in the human body, the micro sensor includes a ADXL345 acceleration sensor, gyroscope IMU3000 and HMC5883 magnetometer, assembled two orthogonal, they are respectively measured acceleration, angular velocity and the magnitude of the magnetic field.

The sensor is composed of a surface Micromachined Polysilicon mechanism and a differential capacitor. The polysilicon structure is supported by a spring in the top of the

polysilicon, wafer, and center plate and differential capacitance is connected with the movement. In the differential capacitance is fixed on bottom plate plus two equal amplitude, and it is a phase difference of 180 ° Fang Bo. In under the effect of acceleration, polysilicon structure can generate offset, pulls the center plate sliding differential capacitor, the two capacitor value is different, then generates a voltage in the center electrode, sensor output square wave [5]. The output square wave amplitude and the measured acceleration is proportional to it.

In sports training as an example, in the study of human motion parameters, main research generally includes body force, velocity, displacement, limb trajectory space position, and the above parameters, can be through the body by the measuring point acceleration calculation. Power formula is as follows:

$$F=ma,$$
$$v=v_0+\int adt \quad (2)$$

Where, F is as the movements of the limbs strength; m equivalent mass movements of limbs; a is the acceleration, velocity, V; V_t, V_0 as the initial velocity; $\int adt$ is as the integral of acceleration on time.

People focus on the walk to have a little to move up and down. The waist of the displacement is most obvious, so the pedometer on his belt is most suitable; the ADXL330 is a three axis (X axis, Y axis and Z axis) simulation acceleration sensor output, just as the sensor is vertical, forward and lateral direction of three III. ADXL330 x, y and Z three axis data output represents the human walking three direction acceleration value.

Six axis fusions is technology of sensorfusion products. The integration of X, and it is the angular velocity sensor digital output. It built three axis gyro and digital motion processing engine, with second IC port, can be directly with the three axis digital accelerometer connected, in its interior will be the value of the acceleration the value of the six axis gyro and data fusion, reduce the dense motion processing in CPU, built-in FIFO and sensor bus (sensor bus) can reduce the system operation time, reduce system power consumption.

Through film analysis on the determination of single ring section of the acceleration of the movement, but by the displacement of image analysis to calculate the velocity (derivative) and acceleration (two derivative), according to the experience, usually up to use a derivative, two order derivative tend to lose one's beyond recognition, thus the kinematic data to drive the mechanical data is almost not possible.

This system is mainly composed of single axis gyroscope LY530AL, LPR530AL, dual axis three axis MEMS accelerometer ADXL345, three axis MEMS electronic compass HMC5843 and MCU MC9S08QE8. The single axis gyroscope combinations X, Y direction and Z direction of the dual axis three axis gyros, their signals are collected by ADC module single-chip microcomputer MC9S08QE8, and the acceleration signal and the electronic compass signal is transmitted through the I2C bus to the single chip microcomputer. The 9 signals in the MCU after the first treatment, and it are by the SCM in the attitude calculation algorithm procedures to obtain attitude information's.

Due to the periodic acceleration signal of human body movement, as measured by the X, y, Z axis acceleration will have obvious periodicity, for simplicity, pedometer algorithm design on Z axis acceleration signal as the processing object.

The performance of ADXL203 is tested in the typical 5V voltage and calibration. In fact, the supply voltage VS can choose between 3V~6V. Choose a different supply voltage; an accelerometer performance will naturally change. The output voltage and the acceleration of the ADXL203 is proportional to, when the supply voltage is changed, the sensitivity will be changed accordingly, affect the measurement accuracy. For example, when VS=3V, the output voltage proportional coefficient is 560mV/g. 0g corresponding output voltage is proportional to VS, its value is VS/2.

This part mainly completed the preliminary design step counting algorithm based on Matlab and Labview software design, motion information collected by the data acquisition card, we obtained a set of human walking acceleration data from human walking, acceleration and acceleration data obtained by Matlab wave.

With the development of MEMS (MEMS) of talent showing itself, there appeared a variety of sensor based precision manufacturing technology for MEMS, using two pieces of dual axis accelerometer, can measure the static angle joint. In dynamic measuring process, the

previous method is difficult to eliminate the interference of inertial acceleration motion of lower limb, the effect is not ideal. The actual research and it is in addition to static demand when the angle, more need to obtain the dynamic body in 3D space angle, angular velocity and range. Based on the model of three axis sensor on the combination of software and hardware design method of kinematic and inertial navigation corresponding.

Study the feasibility of using acceleration sensor to directly measure the acceleration method, reliability, detection of acceleration sensor technology validity, objectivity, acceptability of. The output voltage value of acceleration sensor, using integral smoothing method to determine the initial part of moving angular velocity, through the comparative study of angular displacement and acceleration are obtained by integrating the video link motion results.

ADXL203 ST feet for the self level input end. When the ST pin is connected to VS, accelerometers into self inspection mode, this will produce static electricity in the sensor center plate, which offset. The accelerometer output voltage value can be judged whether the normal function of the accelerometer. Self checking, typical voltage changes the output of 700mV (corresponding to 700mg acceleration). In the non self checking mode, ST pin can be open or connected to COM terminal.

ADXL345 is the digital three axis accelerometer, can be used for high resolution of up to ± 16g acceleration (13) measurement, 22 of its internal AD converter, with 16 binary complement in the form of output, through SPI or IC interface to access. IC detects 3Y axis of the water plane, Z axis and horizontal line perpendicular to it. ADXL345 axis acceleration of gravity SDO/ component, calculate the tilt angle. X, 2ALTADDRESS pin is connected to the ADDRESS pin, grounding, I2C address is 0x53, 0XA6 write, 0xA7 read the IC communication interface, as shown in Figure 3 [6].

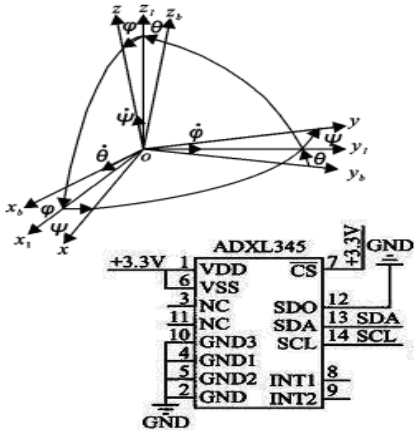

Figure 3. ADXL345 Digital Three Axis Accelerometer Structure Diagram

CS pinout diagram in ADXL345 is used to control the selection of I2C or SPI communication protocol, for high level representation using I2C protocol, and the SDA and SCL pins are connected to the I2C pin on the MC9S08QE8 bus. Electronic compass HMC5843 supports dual voltage, wherein the pin VDD core voltage pin VDDIO, external I/O voltage, the voltage mode in the system, namely the core voltage and external I/O voltage of the same.

Sports information management system for three axis accelerometer based on ADXL345 designed in this study can quickly and accurately collect human motion information provides a new method for observation, the study of human movement.

Acceleration waveform real-time display of the operation interface design, comparison of results obtained by one step test repeated step counting data and real data show: the statistical error of the system was controlled within 1%, precision to achieve the expected goal.

Through the micro inertial technology combined with navigation, strap down inertial navigation system in accordance with the principle of the gyroscope, accelerometer and magnetometer and with common component measurement unit, meet the design requirements of capturing human motion in the 3D space information. This system can simplify the circuit design; reduce the power consumption of the system, the compression space size.

4. Conclusion

The article presents design and development of sports management information system based on acceleration transducer. The ADXL203 output signal bandwidth determines the measuring accuracy. By filtering noise density, improve the measurement accuracy. Its output signal bandwidth is typically 2.5KHZ. Filtering the signal, it can effectively prevent the frequency aliasing. According to the change of XOUT, ADXL203 allows the filter capacitor size at the foot of the YOUT to set the output signal bandwidth requirement. But to ensure that its output signal bandwidth can not exceed half the size of the sampling frequency is AD conversion. When the signal bandwidth is further reduced, can reduce noise, improve the measurement accuracy.

ADXL345 is the iMEMS technology, the digital output of three axis accelerometer based on the measuring range, with ± 2G, ± 4G, ± 8g, ± 16g variable. 32 FIFO memory chip within the zone can cache the data, thereby reducing the processor's burden and reduce the power consumption of the system. I2C or SPI digital interface ADXL345 has higher resolution and sensitivity, 3 mm × 5 mm × 1 mm ultra small package, 40 ～ 145 μ A ultra low power and standard, which is very suitable for mobile devices. Sports information management platform developed in this paper, can be accurately, real-time management of human motion information, provides a new method for observation, the study of human movement. The design method of this system has the characteristics of simple hardware interface, software programming convenient, practical, has a certain reference value in practical data acquisition process.

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