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Application of Tilt Sensor in Headset Operated Surveillance Camera Control System for People with Disabilities

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Abstract: This project describes the motivation and design considerations of an economical head operated surveillance camera for people with disabilities. In addition, it focuses on the invention of a head-set operated device to control the movement of the camera, such that the camera can turn left and right according to the movement of the human head. It employs one tilt sensor, which placed in the headset to determine head position and to function as simple headset control system. The tilt sensor detects the lateral head motion to drive the left or right displacement of the camera. This system was invented to assist people with disabilities to live an independent life or even allow them to work as security personnel to earn their life. The idea can be employed in other application such as robotics, intelligent home devices and vehicle control as well.

Keywords: Camera control system, Microcontroller, Tilt sensor.

1. INTRODUCTION

Normally, the securities personal will sit in the control room and monitor the screens, which show the views from several surveillance cameras installed around the building. These cameras are static and show particular perspective of the building only. Therefore, the securities personal need to monitor different televisions all the time. Besides, these securities need to communicate with other personals, which are on patrolling the building with their walkie-talkie. On the other hand, they need to control the cameras manually with the control panels for zooming in and out the cameras as well. If the system is huge and got many cameras, it will be a tiring and boring job to monitor the whole place. Therefore, there is a need to design a system, which is easier for the security personals to a monitor and patrolling the building [1]. Human head can be used to control the cameras. A DC stepper motor will be installed to rotate the cameras according to the movement of the head. If the person turns his head left or right, the camera will turn accordingly. Besides, they can control the camera to zoom in or out by simply moving their heads as well. On the other hand, they can have the earphones and microphone just on their headset as well. This headset will have a tilt sensor to sense the movement of the head [2]. Besides, there will have a touch sensor to control the zoom in and out of the cameras. By the same time, audio from the walkie-talkie will be transfer into the earphones. A microphone will be used to communicate with others, who are on patrol [3]. The main motivation for this project is to help the disabilities people to live a better life. With a practical way to control the motor, it can help them to perform many simple activities in their daily life. With surveillance camera installed on the motor, it can help them to operate the camera and further more to enable them to view their surrounding and further more to gain a job as security personnel and earn their life.

Besides, the project also aims to design and develop the device to enable the people with disabilities, especially those with Spinal Cord Injuries (SPI) and paralyzed to enhance their quality of life.

The methodology of this project is to understand the function and the operation of various tilt sensors, to study the application of the microcontroller and its feasibility for the projects, understand the operation of a stepper motor and the ways to use an used unipolar stepping motor and to design the prototype of the sensor module, controller module and motor switching module.

2. TILT SENSOR

Electrolytic tilt sensors are capable of producing extremely accurate pitch and roll measurements in a variety of applications. They provide excellent repeatability, stability, and accuracy when operating at low frequencies, and come in a variety of packages with varying tilt range and resolution [4,5]. These rugged, passive devices can be used in environments of extreme temperature, humidity, and shock. Sensors may vary in height, pin spacing, electrolyte volume and composition, and pin and glass treatment, so there are many possible combinations of attributes for each model of sensor. To properly evaluate an electrolytic tilt sensor, its performance should be tested in conditions that closely reflect the end product's actual operating environment. Normally, vendors have Signal Conditioning Boards that can be used to interface the sensor to a host product. Both analog and microprocessor-based modules are offered. The signal conditioning board excites the sensor and provides a linearized analog or digital output to the host. Typically, a regulated DC power source is required, and provision is made for offset and gain adjustments. The board must be carefully aligned in order to provide accurate test results. However, these boards are very expensive.

As the sensor tilts, the surface of the fluid (capacitive) remains level due to gravity. The fluid is electrically conductive, and the conductivity between the two electrodes is proportional to the length of electrode immersed in the fluid. At the angle as shown in Figure 1, the conductivity between pins a and b would be greater than that between b and c. Electrically, the sensor is similar to a potentiometer, with resistance changing in proportion to tilt angle. Figure 1 shows one axis of a fluid-filled sensor tipped at 15°.

However, user cannot just attach the sensor to a 6 V battery and expect it to work. The sensor is an electrolytic cell that functions somewhat similarly to a lead acid battery, but in reverse. Instead of converting chemical energy into electricity, a direct electric current induces chemical reaction electrolysis in the fluid. Positive ions in the fluid migrate to the cathode, where they combine with excess electrons and lose some of their charge. Likewise, negative ions in the fluid propagate to the anode and combine with excess protons to lose their charge. If allowed to proceed, the reaction will eventually render the fluid nonconductive.

To prevent electrolysis, alternating current must be used to excite the sensor. The required frequency and symmetry of the AC waveform depend on the chemistry of the fluid and composition of the electrodes. The frequency must be high enough so that the process described above is reversible. For some electrolytes this frequency can be as low as 25 Hz. Other solutions require a minimum of 1000 Hz to 4000 Hz. The important aspect of Equation (1) is that calculating the coordinate transformation or axis rotation pair (u and f) is different for the two types of sensors where *p* and *r* denote vertical pitch and roll angles, respectively.

$$\theta = p = \sin^{-1}\frac{\tan P}{\sqrt{1+\tan^2 P+\tan^2 R}}$$

$$\phi = \sin^{-1}\frac{\sin R}{\cos P} = R \qquad (1)$$

As discussed in the earlier, this project is aimed to help out the Spinal Cord Injured patients, who are quadriplegic from a cervical cord injury and have retained the ability to rotate the neck [6]. They can use their movement of the head to control the surveillance camera. The camera was installed on a motor to enable the camera turn left or right according to the movement of the head. A tilt sensor, which is used to detect the position of the human's head, is installed on a headset. It will form a headset control system, which will be utilized to control the direction of the motor movement. On the other hand, there will be a touch sensor installed on the head-set to enable the user to trigger an alarm signal when the user notice some suspected scenery from the camera interface. Figure 2 shows the headset control system.

The signal from the headset is raw analog signal. This signal will be converted to digital signal and used to control the motor. A microcontroller is employed to perform a motor driver task by checking the simple logic algorithm. To put in a nutshell, the system consists of:

- Sensor Module - For detect the position of the user’s head and switching alarm signal when necessary.
- Controller Module – For converting the analog signal from the sensor module to digital signal and function as a motor driver.
- Motor Switching Module – For replacing the expensive motor driver chip and control the motor movement and direction.

The system architecture is shown in Figure 3.

3. SOFTWARE PROGRAMMING

Controller module is working as a converter, which will convert the analog signal to digital and substituting the motor driver to drive the motor on and turn according to the movement of the head. Therefore, the programming of the controller should works to fulfill the design requirement. To drive the motor turn according to the movement of the head, the output signal from the sensor module plays an important role. Therefore, the input value from the sensor module will be compare with a reference value to determine the direction of the motor. As a result, the input from sensor module will be load into microcontroller M68HC811E2 at PE0 (pin 17) and compare to the reference voltage at PE1 (pin18). The value of the conversion will be stored in ADR1 and ADR2 for PE0 and PE1 respectively. If the value in ADR1 is higher than ADR2, then microcontroller will show ‘L’ on 7-segment display and turn the motor anti clockwise. If the value in ADR1 is lower than ARD2, microcontroller will show ‘R’ and turn the motor clockwise. However, if there are if the ADR1 and ARD2 have same value, then microcontroller will shows ‘C’ and stop turning the motor [7,8]. So, the reference voltage should be set as 2V, which show the head position at the 0° of tilt. To show the characters, the port C was programmed to do the task.

For switching the motor turn clockwise or anti clockwise, a group of switching sequence should be given by the microcontroller. These sequences are universal for all the unipolar 4 phases stepping motor. All the stepping motors most probably use the same sequences. So, to turn the motor clockwise, sequence: $0A, $09, $05 and $06 are given by the microcontroller. On the other hand, to turn the motor anti clockwise, sequence: $06, $05, $09, $0A are given by the microcontroller. Between the sequences, a small interval of delay must be given to enable the internal operation of the stepping motor to be completed. Normally, the delay is about one second. Some stepping motor needs more or vise versa. Trial and error is needed for used stepping motor. For the motor used in this project, the delay is set as one second only. Port B is set to become the output of these control sequences. Table 1 shows the four step input sequences.

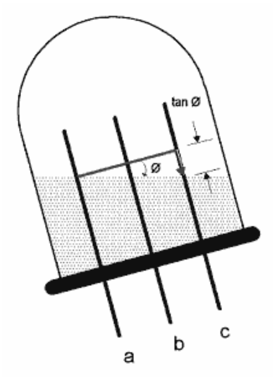

Figure 1. Single-axis view of a five-pin, fluid-filled tilt sensor in the upright position shows the physical relationship among the vial, pins and fluids when the sensor is slightly tilted

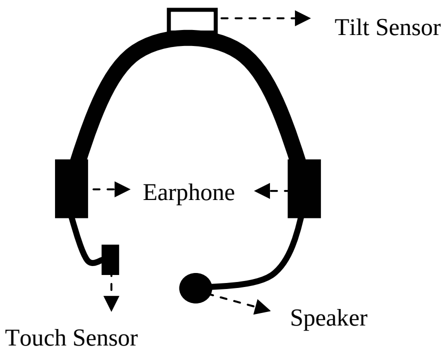

Figure 2. Headset control system

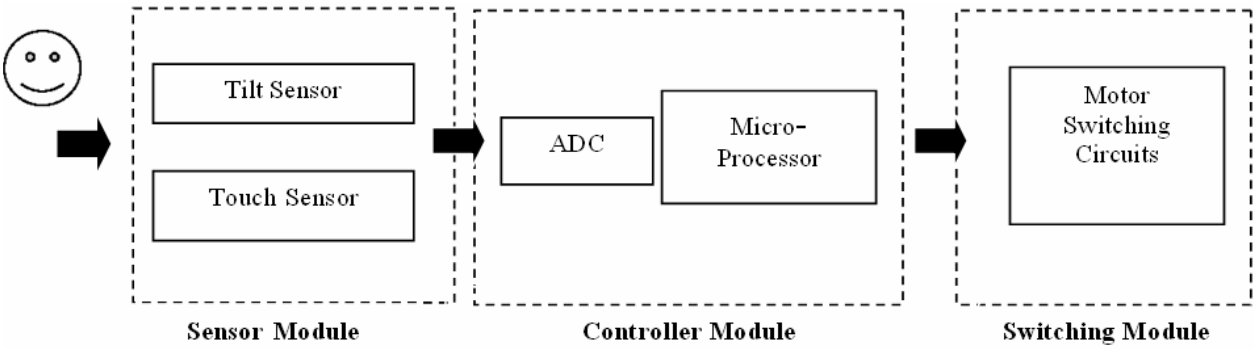

Figure 3. System architecture

Table 1. Four step input sequences

CLOCKWISE

STEP	SW1	SW2	SW3	SW4	CODE
1	1	0	1	0	$0A
2	1	0	0	1	$09
3	0	1	0	1	$05
4	0	1	1	0	$06

ANTI CLOCKWISE

4. SURVEILLANCE CAMERA

Controller module is working as a converter, which will convert the Low end Logitech Quick Cam was selected to substitute as the expensive surveillance camera. It is easy to use and economical. Besides, it is also great for video e-mails and face-to-face video calls. On the other hand, user can record live video with the user friendly software accompanied with the product. The Quick Cam version 6.0 SE software will become the main interface between the user and the camera as shown in Figure 4.

5. CONCLUSION

A headset operated control system for surveillance camera was completely developed. The user, who may be a paralyzed or spinal cord injure patient can use the head-set to control the camera turn left and right by moving their head. Besides, they also can monitor their surrounding using the interface from the camera installed on the motor. When they had seen suspected scenery from the monitor, they can puff their cheek and giving out alarm signal to the others. By the same time, they can communicate with others using the microphone and earphone installed on the headset and connected to the communication module, which is not included in the scope of the project. A simple economic electronics assistance device was developed and able to serve as a tool for people with disabilities to monitor their surrounding and even enable them to get a job in a security company.

Figure 4. QuickCam Version 6.0SE

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