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Design, Modeling and Implementation of Pic Based Wireless Control System to Eliminate Blind Spots in Vehicle Side Mirrors

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Abstract: A PIC controlled IR system for the control of vehicle side mirror system movements for the purpose of revealing blind spots is designed and implemented. The designed and built system allows the side view mirrors to be adjusted based on the driver head movement. The infrared-based head tracking system maps a predetermined coordinates for head movements and results in a triangularly computable geometry, which is fed to the PIC, based controlling system. This will cause the vehicle mirror movement via carefully selected miniature motors.

Key words: Automotive, head gesture, PIC microcontroller, wireless, infrared, control, blind spot

INTRODUCTION

Drivers cannot see all areas outside their vehicle, despite vehicles having windows and mirrors. Every driver has blind spots. Even with the use of mirrors, there are areas that are hidden from view by the panels of the vehicle.The areas, which are blocked from the driver's view, are called blind spots. It is more difficult for drivers to see children because of their small size. We should remember blind spots-particularly when vehicles are reversing e.g., out of driveways Many traffic accidents may be prevented by intelligent new cars that alert drivers to potential collisions, blind spots, lane deviations and their own inattention. Such systems may use driver's head movement and its gesture recognition as the way to reveal such blind spots by adjustment of car mirrors to suitable angles.

Gesture recognition is a complex task, which involves many aspects such as motion modeling, motion analysis, pattern recognition, machine learning and neural fuzzy systems. Gestures are expressive and meaningful body motions used in daily life, as means of communication where a computer based automatic recognition system is necessary for interpretation and signal control in an interactive and dynamic environment... In such an environment body motion can be defined as a sequence of states in a configurable space, which can be modeled, based on the following principles:

- Static start and end position
- Smooth transition forward and backward

To recognize gesture patterns based on time series (state transitions). Traditionally the Hidden Macrov Model (HMM), Artificial Neural Network (ANN) and Dynamic Programming Matching Model (DB Matching) have been used in conventional research[1-2].

In this research we describe a new mathematical model and software algorithm, which is used, in our built and tested vehicle side mirrors control system to detect head movements in real time. This is more difficult as head gestures could be short and fast particularly as it is applied in an automotive environment such as car vehicles where the driver needs to produce a control signal during a short period of time. For this reason a non-conventional PIC based control system employing IR transmitter- receiver is used[3-4].

Something distant and highly visible may distract the eye from observing something closer but less highly visible. Some claim that you only see the types of object that you are looking for, e.g. while checking to see if there's a car coming you may not see a bike. This is clearly possible, but it is not believed to be causation factor.

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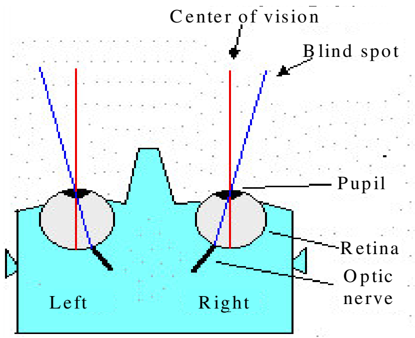

Fig. 1: Blind spots in the human eye

Every human eye has a 6° blind spot where the optic nerve meets the retina. Normally the other eye can see the portion of the view where the first eye is blind. Our brains are incredibly sophisticated at cleaning up the information from our eyes as shown in Fig. 1.

This is a position where the offside windscreen pillar is normally located; the danger is realized when stopping to let some pedestrians over a crossing, as they were hidden behind the screen pillar. Other potential danger spots are junctions, roundabouts and right-hand bends.

Every year, children are injured and killed because drivers (in some cases, parents) don't see them while backing up. A contributing factor is that larger vehicles (pickups and minivans), have larger blind spots than passenger cars. A blind spot is the area behind a vehicle that a person can't see from the driver's seat.

Using technologies and know-how from mechanical engineering, electronics, IT and telecommunications, there is a need to have on-board systems with capability to operate in harsh environments. Such systems are designed to gather and process information in order to carry out the actions necessary to achieve their designated functions such as removal of blind spots in vehicles for safer driving. To accomplish their objective, in other words, to know how to act, on-board systems operate using reaction models. The Brain of the system reacts to impulses, picked up by the sensors and transmits information and orders to the actuators, of the system. All of the components, materials and software for these systems satisfy requirements concerning size, sturdiness, energy consumption and immunity to external disturbances, the key words are: security, reliability, quality, safety, real-time, autonomy and servo assistance.

In an increasingly competitive environment, the parts manufacturer, specialized in automotive electronics, is continuing to grow, constantly reinforcing its technological edge. Among the latest innovations, the year 2000 marked the appearance of the communicating vehicle, with the integration of a WAP telephone in the car, opening new development perspectives for on-board electronic telemetric. The mobile Internet has joined forces with the car. The new concept vehicle, also integrates biometry, with fingerprint sensors for user recognition and restitution of personalized adjustments (position of seat, steering wheel, or rear view mirrors), tactile screens, an on-board camera[5-6]. However, it is not enough to automatically adjust the vehicle mirrors to a standard position related to a particular driver, what is required is a dynamically adjustable side mirror system for safer driving.

SYSTEM DESCRIPTION

The PIC micro-controller based design incorporates an Infrared sensor, which serves as an interface between the sensor and the actuator incorporated into the side mirror.

The infrared detector modules internal circuitry will attempt to increase or decrease the gain of the detection circuit proportional to the amount of ambient light striking the surface of the detector. High levels of ambient light will force the internal automatic gain-control to reduce the gain of the detection amplifier, thereby requiring a much stronger infrared signal striking the surface of the IR detector for valid detection. Increased gain due to lower ambient light levels or dark conditions means the IR detector is operating with increased sensitivity and hence will detect a much weaker IR signal than in a disturbed or noisy environment. However, by using the PWM module on the PIC this issue is resolved. The PIC microcontroller has an onboard hardware PWM module. This PWM module offers true multi-tasking operation and provides an excellent way to modulate the infrared LED at the required band-pass frequency of the detector module. Multi-tasking is the ability to process multiple tasks simultaneously. Once the PIC registers are configured to produce our required PWM frequency and the PWM output is turned ON, the designed code can go about other tasks while the PIC PWM hardware continues to emit the carrier frequency without further intervention. This multi-tasking ability allows modulation of the IR LED at the required carrier frequency while performing other tasks such as:

- Sample the output-pin of the IR detector (without stopping the PWM carrier)
- Take real-time ambient light readings with a CDS photocell

- Adjust the PWM duty-cycle to control IR output power

Using the information obtained from readings of ambient light levels, the output power of the IR LED is adjusted by varying the duty-cycle of the PWM signal. This adaptive technique allows compensating for changing environmental conditions and adapting as necessary to maintain a constant infrared energy output required for reliable reflective IR sensing under variable lighting conditions. Measuring ambient light levels is simple with the PicBasic compiler POT command.

The mirrors are driven using a Stepper Motor or DC servo, which is a built-in motor to position the mirrors. A Servo is a small device that has an output shaft. This shaft can be positioned to specific angular positions by sending the servo a coded signal. As long as the coded signal exists on the input line, the servo will maintain the angular position of the shaft. As the coded signal changes, the angular position of the shaft changes. Such motors are small and have a built in control circuitry and are extremely powerful for their size. The servomotor has a control circuit and a potentiometer (a variable resistor) that is connected to the output shaft. This pot allows the control circuitry to monitor the current angle of the servomotor. If the shaft is at the correct angle, then the motor shuts off. If the circuit finds that the angle is not correct, it will turn the motor the correct direction until the angle is correct. The output shaft of the servo is capable of traveling somewhere around 180°. Usually, it's somewhere in the 210° range, but it varies by manufacturer. A normal servo is used to control an angular motion of between 0 and 180°.

The control wire is used to communicate the angle using proportional control technique. The angle is determined by the duration of a pulse that is applied to the control wire. This is called Pulse Coded Modulation. The servo expects to see a pulse every 20 milliseconds. The length of the pulse will determine how far the motor turns. A 1.5 m sec pulse, for example, will make the motor turn to the 90° position (often called the neutral position). If the pulse is shorter than 1.5 m sec, then the motor will turn the shaft to closer to 0°. If the pulse is longer than 1.5 m sec, the shaft turns closer to 180° as shown in Fig. 2.

The 16F84 PIC Microcontroller serves as the electronic interface between the sensor and the motor. It contains 1 K words of FLASH program memory, 68 bytes of data RAM and 64 bytes of data EEPROM. While this seems like an extremely limited amount of code and data space, the PIC's incredibly compact code makes the most of it. 1024 instruction word memory actually means 1024 instructions, no less. Even immediate-mode instructions, where an operand is part of the instruction itself, takes only one memory location, as do CALL and GOTO instructions.

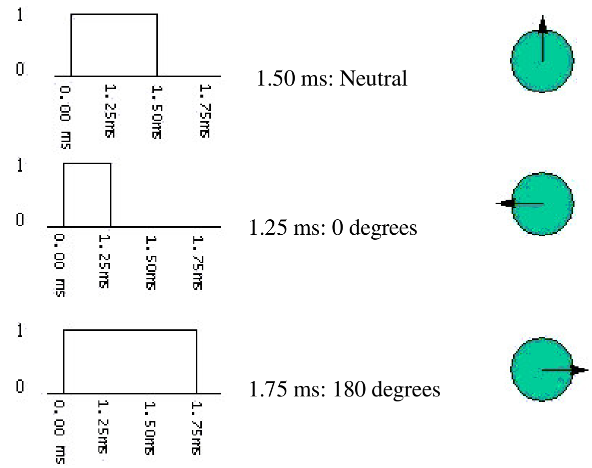

Fig. 2: Stepper motor positions

SYSTEM MODELING

Figure 3 shows the overall arrangement and positioning of sensors for system tests and verification; with Fig. 4 illustrating the mathematical tracing curve for the drivers head movement that was implemented in our PIC controlled system.

The mathematical curve representing head gesture takes into consideration an area whereby any movement of the head will not initiate mirrors movement (dead zone). This is essential, as the mirrors need not to move for simple head movements that result from natural human responses to scenes on the road or to the head movements of passengers close by to the driver of the vehicle. The limits for the dead zone is determined and implemented into the software controlling algorithms as a result of calculations on the vehicle internal space[7-9].

The curve in Fig. 10 shows a non-linear second order system, which can be described by the following state equations:

$$\begin{aligned} \dot{x} &= Ax + Bu \\ y &= Cx + Du \end{aligned} \tag{1}$$

where, u, x, y are functions of time and respectively input, output and state vectors, A, B, C and D are constant coefficients matrices and $\dot{x}$ denotes the

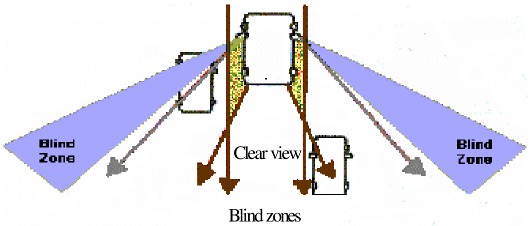

Fig. 3: Blind spots testing setup

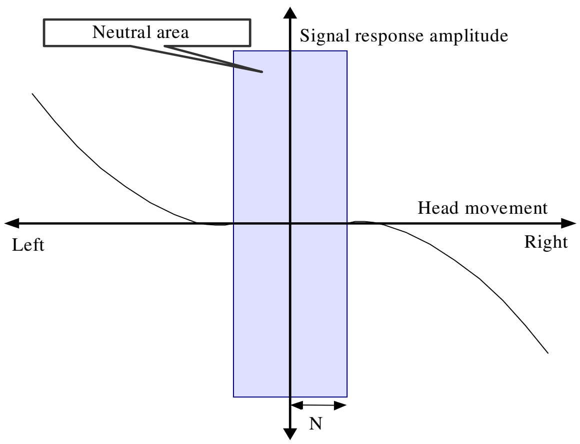

Fig. 4: Mathematical tracing function used in PIC algorithm

derivative of x with respect to time. Equation (1a, 1b) are general and applicable to multivariable systems in which case if x is an n vector, u an r vector and y an m vector, the matrices A,B,C, d would be of order nbyn, nbyr, nbym respectively. In this research we are concerned with single input, single output systems only, so that y and u become scalars and the equations become:

$$\begin{aligned} \dot{x} &= Ax + Bu \\ y &= Cx + Du \end{aligned} \tag{2}$$

where, B, C and D become a vector, the transpose of a vector and a scalar respectively. For the sec order system with $x = (x_1,x_2)^T$, where T denotes Transpose. We obtain:

$$A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

$$B = \begin{pmatrix} b_0 \\ b_1 \end{pmatrix}$$

$$C = \begin{pmatrix} c_0 & c_1 \end{pmatrix}$$

and

$$D = d_0$$

From the above equations we obtain:

$$\dot{x}_1 = ax_1 + bx_2 + b_0u \tag{3}$$

$$\dot{x}_2 = cx_1 + dx_2 + b_1u \tag{4}$$

$$y = c_0x_1 + c_1x_2 + d_0u \tag{5}$$

where, Eq. 3 and 4 are the state equations and Eq. 5 is the output equation.

The above state equations can be represented in the following general form:

$$\dot{x} = Ax \tag{6}$$

A representative point that traces out a trajectory in a state plane has a velocity vector with components $\dot{x}_1$ and $\dot{x}_2$, which are determined uniquely in terms of x_1 and x_2 in Eq. 6. The behavior of Eq. 6 can be determined from the eigenvalues given by det(A- λI) = 0. This gives:

$$\begin{vmatrix} a - \lambda & b \\ c & d - \lambda \end{vmatrix} = 0 \tag{7}$$

We need to solve Eq. 7 for real eigenvalues, for which case we obtain two distinct values. Thus, we need to perform nonsingular linear transformation from the state vector x to a new state vector x* according to:

$$x = Tx^*,\ x^* = T^{-1}x \tag{8}$$

Hence, Eq. 6 becomes:

$$\dot{x}^* = T^{-1}ATx^* \tag{9}$$

If we choose the matrix $T = (v_1,v_2)$, where vectors v_1, v_2 are the eigenvectors of A, we obtain:

$$\mathbf{T}^{-1}\,\mathbf{AT} = \Psi = \begin{pmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{pmatrix} \tag{10}$$

where, λ1 and λ 2 are the eigenvalues of Ψ which gives our new expression:

$$\dot{x}^* = \psi x^* \quad (11)$$

In our system λ_1 and λ_2 determine the magnitude and direction of head movement for adjustment of car side mirrors that result in blind spot elimination. Also both eigenvalues are dependent on each other via the following expression:

$$(x_1^*)^{\lambda 2} = K(x_2^*)^{\lambda_2} \quad (12)$$

where, k is a constant. Two cases arise:

Both eigenvalue are negative: Mirrors are moving towards a point.

Both eigenvalues are positive: Both mirrors moving away from a point.

Two algorithms are used to test our PIC controlled vehicle mirror system:

- Mirror control algorithm
- Light compensation algorithm

The first algorithm test the control signal applied to Servo Motors that adjust the position of the vehicle Mirrors. This is carried out via controlling voltage and frequency signals sent to these motors. Consequently it will result in an adjustment of mirror angels. The algorithm takes into account signal failure as it continues to check the progress of mirror movement and ensures the stability of these mirrors in its new position[10-13]. The

The sec algorithm serves to ensure the correct operation of the designated system regardless of the outside light effect that might interfere with the sensors positioned inside the vehicle. Hence, it assures the right movements of the mirrors during daytime or nighttime. Both algorithms work together using our programmable PIC controller.

As the above algorithms work hand in hand on processing the detected signals resulting from the driver head movements, the car mirror system smoothly changes to provide the driver with the right angles for safe and comfortable driving[14-20].

In comparison to similar systems, our designed and tested system is a simple, cost effective and accurate positioning system which can easily be interfaces to MCU of any vehicle engine without the need for major modification to the vehicle control system.

RESULTS AND DISCUSSION

The controlling program will direct the mirrors movements via a servo motor connected to port RA0 as a response to the two IR sensors connected to RA1 and RA2. When the output of sensor 1 is high, the servomotor starts to move until it changes to LOW and saves the new position as the newest one. When the output of sensor 2 is low, it indicates a movement by the drivers head to the right or left to reveal blind spots and after certain duration will go back to normal position as shown in Fig. 5 and 6.

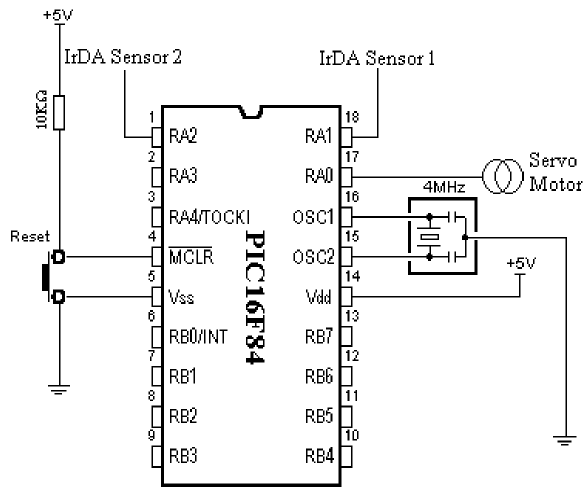

Fig. 5: The overall PIC based control system

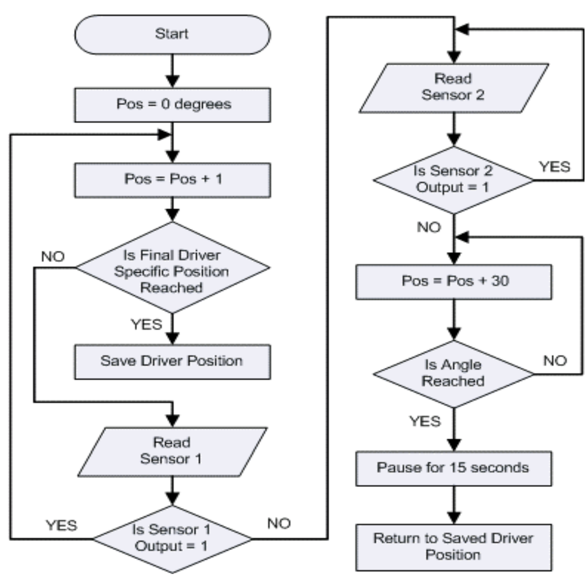

Fig. 6: Blind spots algorithm

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