Design and Implementation of an Embedded Home Surveillance System with Ultra-Low Alert Power

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Abstract--To reduce the power consumption we use outdoor sensors which wake up the microcontroller with power management for the indoor ultrasonic and PIR sensors which provide a majority voting mechanism to enhance the sensing reliability.

I. INTRODUCTION

Lately embedded surveillance systems are frequently used in home, office, factory or highway vehicle monitoring and image detection, but this application requires a high performance core, which works against some advantages of embedded systems, such as low power consumption and low cost [1]. Other researchers have constructed an external signal to trigger the embedded surveillance system by means of a PIR sensor, which is triggered when an intruder enters the monitoring area. During the long time when there is no intruder, the standby power consumption is very large.

In this paper the low-power sensors are placed near home windows and doors where an intruder must pass through. When an intruder enters the sensing area, the sensors wake up the sleeping MCU (Micro Controller Unit) which starts the power supply for the indoor sensors and for the sensor signal transmission to the embedded system. For the indoor sensors, we use the MVM to improve the sensing reliability [2]. The embedded surveillance system determines the sensor results and then decides whether to start the Web camera to capture images and upload these captured images to the Web page through the Internet. We use the MCU's sleep mode to reduce the alert power consumption for home security when there is no intruder, to improve the traditional surveillance system without wasting power.

II. SYSTEM ARCHITECTURE

Fig. 1 shows the embedded surveillance system which has two groups of sensors, indoor and outdoor. The outdoor sensor group contains a number of PIR and pressure switches placed near windows and doors of a home. When the outdoor sensors sense an intruder, the MCU is woken up and turns on the power for the indoor PIR ultrasonic and PIR sensors for the Majority Voting Mechanism. When this is completed, the decision signal passes to the embedded board GPIO (General purpose input and output). The software module of the embedded board turns on the Web camera to capture images, and the embedded system uploads them by means of the Web server through the Internet. The user can view the images captured by the home surveillance system through the Internet. Fig. 2 shows the system architecture.
We use Embedded Linux in the embedded board software. The software scans the embedded board GPIO pins, and when any input pin is high, this represents a sensor sensing an intruder. The embedded system turns on the Web camera to capture images.

B. Hardware modules

To reduce the power consumption of the alert state we combine pressure switches and PIR sensors [3]. The pressure switches used are thin and placed on the ground. When an intruder invades the area nearby the pressure switches, the PIR sensors wake up the MCU. For indoor, we use PIR sensors and multi-frequency ultrasonic sensors. In the ultrasonic sensors we use a typical oscillator chip to design a square waveform generator and adjust the resistances and capacitance to generate a multi-frequency ultrasonic transmission. The ultrasonic transducer transforms the voltage waveform into an ultrasonic transmission and the transducer of the receiver transforms the ultrasonic transmission into the voltage waveform. Since the receiver may experience external interference at different frequencies, it is necessary to screen the filter signals outside the receiving frequency and the signal input to the amplifier and the comparator; other ultrasonic sensors are also susceptible to refractive interference, so we use several ultrasonic sensors at the receiving end, the count of the total number of ultrasonic sensors, always being the majority of the sensors triggered, is after the vote sent to the MCU.

III. IMPLEMENTATION RESULTS

Table I shows the power consumption of a single sensor group if there is no intruder. In this case the power consumption of a single PIR sensor group is about 1 mW, when a PIR sensor detects an intruder it increases to 7.3 mW. The pressure switch sensor consumes 0 W because there is no intruder to turn on the circuit. If the pressure switch senses an intruder it increases its power consumption to about 0.25 mW. The ultrasonic sensor group needs to constantly transmit and receive signals, so it consumes a certain amount of power, around 256 mW. Table II shows the comparison between our design and other products. We have used a number of indoor PIR and ultrasonic sensor groups in that design. Because the continuing intrusion detection consumes more power, around 3.23 W, in this present design we add PIR sensors and pressure switches where the intruder must pass through, thereby reducing the power consumption to 1.8 mW from 3.23 W for the alert state, an improvement of 1700 times.

<table>
<thead>
<tr>
<th>System State</th>
<th>Alert State Power Consumption mW</th>
<th>Detection State Power Consumption mW</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIR</td>
<td>1.05</td>
<td>7.35</td>
</tr>
<tr>
<td>Pressure switch</td>
<td>0</td>
<td>0.25</td>
</tr>
<tr>
<td>Ultrasonic sensor</td>
<td>Not in use</td>
<td>256.08</td>
</tr>
</tbody>
</table>

IV. CONCLUSIONS

In this design we use a small sensor group with low power consumption for the detection of an intruder. The MCU stays in a sleep state unlike the traditional surveillance system, which stays in the detection state. We reduce the power consumption, similar in the alert or the sleep state, by 1,700 times and use two sensors to improve the detection stability of the alert state. In addition we reduce unnecessary memory consumption for the constant capture of images without an intruder in comparison with previous surveillance systems.

References