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Design of Electronic Security System in Restricted Areas on MSP430 Processor

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Abstract

In present day's security from unauthorized humans (intruders) and fire/flame is one of the essential concerns especially in industries, banks, airports, railway stations and other restricted areas. Therefore, we introduce an Electronic Security System (ESS). The ESS provides the attentive message from flame as well as intruders. The proposed system generally consists of 3 devices namely PIR sensors, MSP430 and GSM. The flames and intruder are recognized by PIR. These activities are feeding to HMM, which are synthesized by wavelet transform. When there is an action occurs within the sensor range, then signal from sensor is processed by biorthogonal wavelet transform and then feeding to HMMs. The detection of intruder and flame is updated according to the HMM producing the highest probability. After that the alert message is sent to authorize person using GSM.

Keywords: Electronic Security System, Wavelet, GSM, HMM, MSP430, PIR

1. Introduction

Unauthorized Humans and fire are the main concerns for safety issues in shopping malls, forest areas, bus stations etc. Therefore, to provide safety we introduce an Electronic Security System (ESS). In earlier days, IR based Normal EPS (NEPS) was developed. In this, whenever a person walk across the device, then IR is activated. Although this device is efficient in detecting the intruders, but the response time to detect the fire is high. But the usages of NEPS are limited since the IR sensors are limited to 30m LOS. To conquer above problems/issues, we introduce PIR based ESS with high accuracy and low latency in detecting the flame and intruder. The PIR itself act as a single-pixel camera. The coverage area of a PIR sensor is varies with regard to the type of PIR sensor. In this, we are utilizing the IS9B PIR sensor with radius of 5m, this is sufficient to cover up the majority rooms with high ceilings. As a result, PIR based systems provide a cost-effective solution to recognize the unauthorized persons and fire issues especially in large rooms.

In this HMM based fire flicker method is used for recognizing the flame in videos. To realize HMM, wavelets are used because these signals are do not influence by the slow variations occurring in moving scene. The rest of the paper organized as, Section 2 describes the technical background of the proposed method; Section 3 describes the hardware implementation of ESS; Section 4 describes the data processing and HMM models; Section 5 describes experimental results and Section 6 describes the conclusion.

2. Technical Background

The PIR is sense by IR radiating moving objects within the range. The PIR produce "logic 1" when detect the flame moving object and "logic 0" when detect the no-flame moving objects. In this, only moving persons are recognized. Instead of using directly PIR sensor output, an analog signal is extracted from the PIR output and it is sampled. As a result, signal processing strategies can be developed using discrete-time sensor signal and then feeding to HMM. After recognizing the motion object or flame then processor provides the signal to the buzzer and displays on the LCD. In this manner, it is possible to build up intruder and flame recognition strategies.

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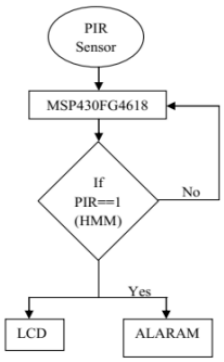

Figure 1. Flow diagram of proposed system.

3. Hardware Implementation

The given below Figure 2 represents the system level block diagram of ES system.

3.1 Power Supply

The proposed method requires two kinds of power supplies. They are

- Power 1 (3v)
- Power 2 (5v)

Power 1 (3v): It is given to MSP430 and PIR sensor module. As MSP430 is designed for 3v, it is given from either battery or from MSP430 USB debug interface through JTAG.
Power 1 (5v): It is given to LCD display.

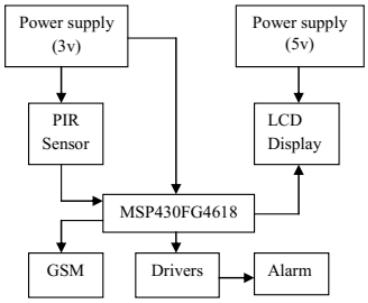

Figure 2. System level block diagram.

3.2 PIR Sensor

It captures the analog signal (represents strength of the signal) and generates the binary output from read-out circuit. Whenever a motion occurs within the coverage area due to hot body, then the strength of the signal will be increased. This phenomenon occurs due to variations in atmospheric temperature. However, the motion occurs due to intruder motion taking place in front of the sensors. In this the differential PIR sensor distinguishes between intruder and flame. The given below Figure 3 represents circuit diagram for capturing the analog signal output from the PIR sensor and is adopted from[2].

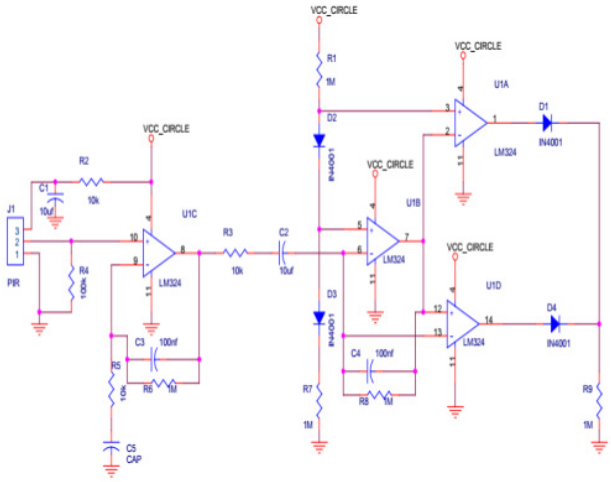

Figure 3. The third generation of circuit diagram for capturing the analog signal output from PIR sensor.

The give below Figure 4 represents the experimental board setup for capturing the analog signal output from PIR sensor.

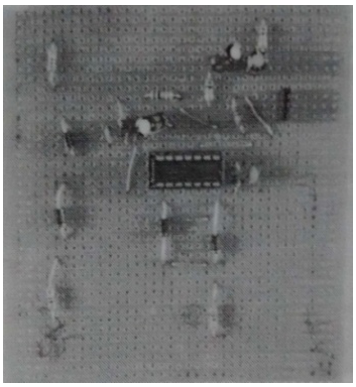

Figure 4. The experimental board setup for capturing the analog signal output from PIR sensor

The given below Figure 5 represents the internal structure of PIR.

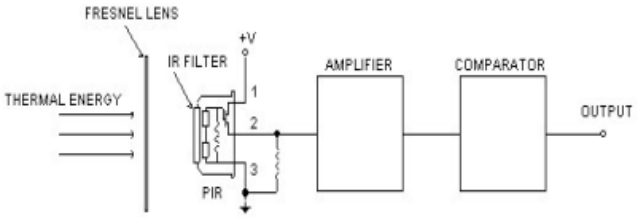

Figure 5. Internal structure of PIR adopted from[1].

The given below Figure 6 and 7 represents the digital and analog output of PIR when no activity occurs within the sensor range.

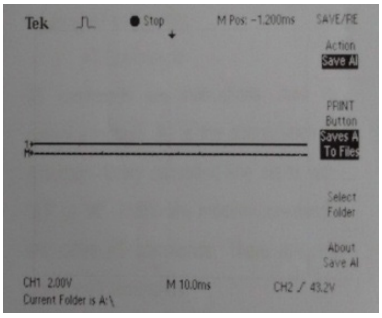

Figure 6. Digital output of PIR sensor when there is no activity within the range.

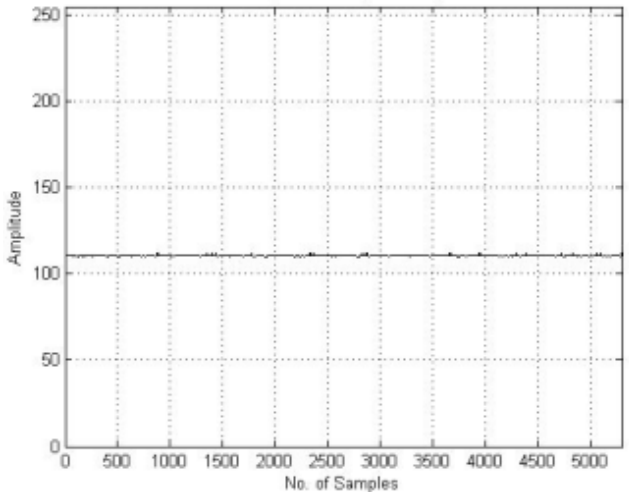

Figure 7. Analog output of PIR sensor when there is no activity within the range.

The given below Figure 8 represents the PIR sensor signal of intruder walking at 3m.

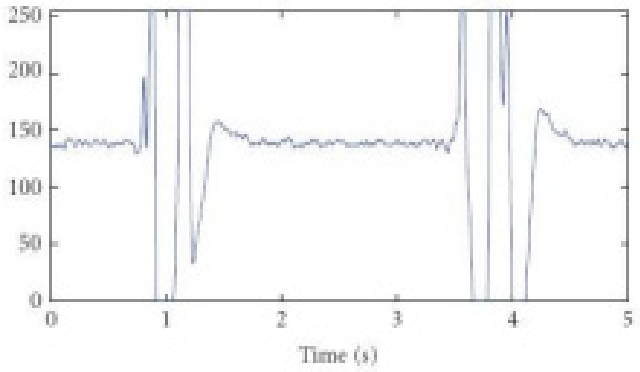

Figure 8. PIR sensor signal of intruder walking at 3m.

The given below Figure 9 represents the PIR sensor signal of flame at 3m.

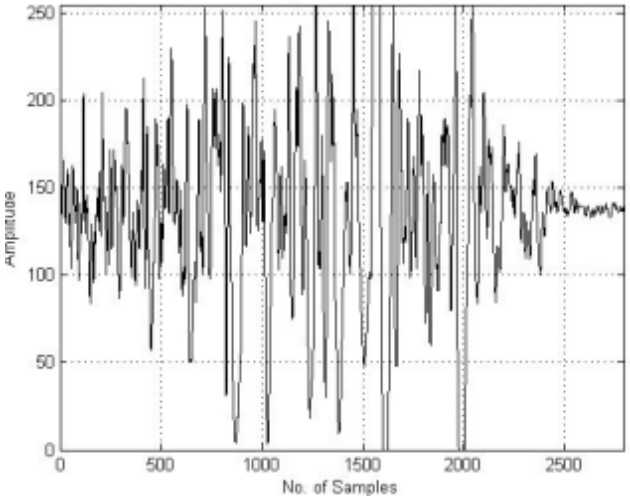

Figure 9. PIR sensor signal of flame at 3m.

The output of PIR sensor (analog signal) is applied to MSP430 processor. In MSP430, the PIR sensor signal is processed by wavelet transform and then feeding to HMM classifier. In Section 4 discuss about processing of sensor signals and HMM models.

3.3 Controller, GSM, LCD

The output of the PIR goes to controller. The controller process the sensor output and the signal is given signal is given to LCD and alarm. If the intruder or flame is identified then corresponding message is sent to security rooms through LCD, alarm and GSM. The given below table1 represents AT commands are sent to mobile through GSM.

Table 1. AT Commands adopted from[1]

AT commands	Meaning
AT+CMGS	Send message
AT+CMSS	Sent message from device
AT+CMGW	Write message to memory
AT+CMGD	Delete message
AT+CMGC	Send command
AT+CMMS	More messages to send

4. Data Processing and HMM Models

Here, two kinds of triple hidden Markov models are introduced to identify the fire, motion of human being and these models are trained by wavelet transform of PIR signals. After training the PIR signals, the sensor signals are fed to HM Models. These models' generating the highest probability determines the event (fire or no-fire) of the signals.

Generally there is a bias in the output of PIR signal, which is varies in accordance with room temperature. The bias in PIR is removed by biorthogonal wavelet transform. Let us consider x(n) be a sampled version of output of PIR signal. The coefficients of wavelet signals [w(k)] are obtained from first stage decomposition , corresponding to [12.5Hz, 25Hz] frequency information of the x(n) is determined by integer arithmetic HPF, analogous to Lagrange wavelets[3] followed by decimation.

The system function of LPF is given by

$$H_{LPF} = \frac{1}{2} + \frac{1}{4}(z^{-1} + z^{1}) \quad (1)$$

and corresponding system function of HPF is

$$H_{HPF} = \frac{1}{2} - \frac{1}{4}(z^{-1} + z^{1}) \quad (2)$$

In this the coefficients of wavelets [w (k)] are used as a feature parameter in HMM. Two 3-state HM models are used to classify the flame or no-flame events. This arrangement shown in below Figure 10. In HMM state S1 represents the no activity within the coverage area of PIR that means $|w(k)|$ is below the non-negative threshold 'T', where T is calculated based on the background noise level. The value of T is estimated by the algorithm as in[4].

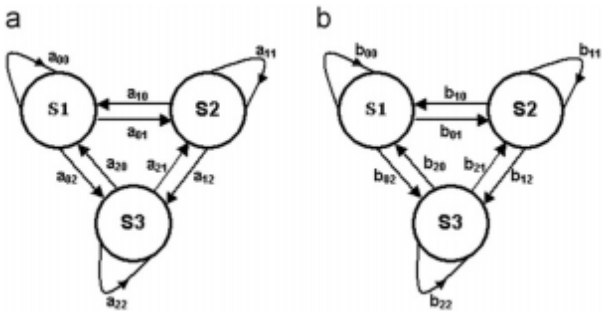

Figure 10. Two triple state Hidden Markov models are used to classify. **(a)** Flame. **(b)** No-flame events.

The Figure 11 and 12 represents background signal and its absolute value of wavelet transform.

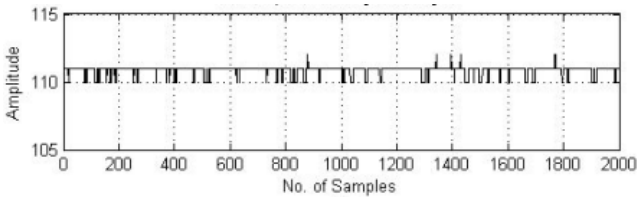

Figure 11. Output of PIR for background noise signal.

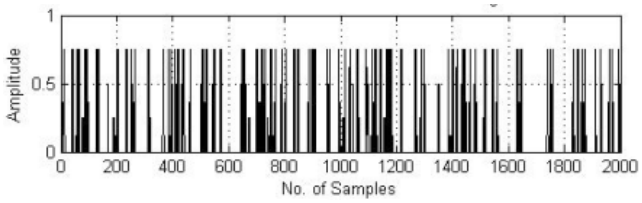

Figure 12. The absolute value of biorthogonal wavelet transform of background.

The state, S2, which corresponds to an increase, in consecutive wavelet coefficient values, is occurs when

$$w(k) - w(k-1) > T \quad (3)$$

is satisfied. Similarly, state S3, which corresponds to a decrease in consecutive wavelet coefficient values, is occurs when

$$w(k) - w(k-1) < T \quad (4)$$

is satisfied.

For the training of the HMMs, the state transition probabilities for intruder and fire models are estimated from 100 consecutive wavelet coefficients covering a time frame of 3 seconds. During the classification stage, a state history signal consisting of 50 consecutive wavelet coefficients is computed from the received PIR signal. This state sequence is fed to the flame and no-flame models in current windows. The model yielding highest probability is determined as the result of the analysis of PIR sensor data.

5. Experimental Results

The analog signal is sampled and quantized (8 bits) with a sampling frequency of 50 Hz. Analysis and classification strategies are implemented with C++ running on a PC. The sampled version of analog signal is fed to the PC

through RS-232 serial port. In this paper, we are utilizing the IS9B PIR sensor with radius of 5m, this is sufficient to cover up the majority rooms with high ceilings. In our system we record flame or no-flame events at a distance of 3m. For flame data, we burn a piece of paper and record the PIR output. For the non-flame data, we record walking person sequences.

The given below Figure 13 shows the experimental setup of proposed method. The proposed system consists of GSM, LCD, MSP430 and PIR sensor. Sensor recordings containing different intruder movements and fire of paper at a radius of 3m are used for training the HMMs corresponding to different events. Thresholds for defining the states of HMMs are estimated using an evolutionary algorithm, since the underlying cost function to be minimized has proved to be multi-modal and non-differentiable.

Figure 12. Experimental setup of proposed method.

6. Conclusion

In this paper, a PIR based Electronic Security System using MSP430FG4618 processor was proposed. The output of PIR (analog) is digitized with a sampling frequency of 50Hz and 8 bits. Hidden Markov models corresponding to various intruder activities and flame flicker process are developed and trained off-line using the wavelet coefficients. A class of event occurs (flame) when the HMM corresponding to flame action produces the highest probability. The proposed algorithm and the system effectively detected the intruder and flame.

7. References

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