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Modeling the Analog Response of Passive Infrared Sensor

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Abstract

Passive infrared (PIR) sensors are sensitive to infrared (IR) rays and are mostly used for motion detection. In this paper we propose a mathematical model that enables better understanding of the analog response of the PIR sensor, the Fresnel lens, and the associated electronic circuitry. The proposed model relates the sensor's analog output waveform to the width of sensing element, and speed of movement and distance of the subject from the PIR sensor. Experiments were performed to capture the sensor's analog output waveform corresponding to the subject's movement through the sensor's field of view (FoV) at different distances, and the relationship of the sensor's peak-to-peak output voltage with distance and speed of the subject. The simulation results are shown to match reasonably well with the experimental results.

Keywords: Passive infrared sensor, sensor modeling, Fresnel lens

1. Introduction

Passive infrared sensors have gained in popularity due to the massive development of embedded systems and the Internet of Things (IoT). They are used as a low cost motion sensor that responds when an infrared (IR) emitting subject (humans or animals) passes through its field of view (FoV). Applications of PIR sensor range from monitoring wild life activity [1] to human identification [2], and are used in both indoor and outdoor environments. Most often the digital output of the PIR sensor is used, however there have also been some attempts at exploring the raw or analog output [3, 4, 5, 6, 7].

Zappi et al. [3] extracted features from the analog output of PIR sensors to predict the direction of movement of a subject and count the number of subjects in its FoV. They placed three PIR sensors in a row with different orientations. Two scenarios were considered: (i) three people walking in a line, and (ii) three people walking side by side. Using features, such as the number of peak pairs, direction of the first peak, duration of the second peak, from the analog output of the PIR sensors the authors achieved an accuracy of 100% in predicting direction of movement and an accuracy of 89% in predicting the number of people. In a follow-up paper [8], they used two PIR sensors to estimate the direction of movement and the zone through which the subject had moved along a hallway. Machine learning techniques were applied on features extracted

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