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Article

Project Tarzan: Transportable Arduino-Based Natural Disaster and Human Activity Detection Device for Forest Sanctuary Zones and Natural Habitats

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Abstract: The project aims to provide sustainable, affordable and efficient forest safety monitoring. Each sensor used was calibrated. The sensors used are PIR sensor for human presence detection, sound sensor for high frequency (>90dB) noise level from illegal logging, and gas sensor for smoke from forest fires or burning. Signals from deployed unit are sent to phone application via Bluetooth. Standardized system field testing shows that TARZAN is effective for early detection of unwanted human activity, as well as illegal logging, burning, and forest fire detection.

Keywords: Bluetooth, Illegal Logging, PIR Sensor, Phone Application.

1. Introduction

Most of our reserved forest and natural sanctuaries are diminishing due to the detrimental effects of illegal logging, deforestation, commercialization activities, agriculture land conversion, as well as natural threats like forest fires. As a result, the biodiversity of the plants and other organisms dwelling in these natural habitats slowly decline in number. As of today, the community lacks a real-time monitoring system that monitors any human-inflicted or natural disaster and provides a sustainable solution in preserving the forests and natural sanctuaries in the long run.

Currently, forests and other natural sanctuaries are guarded and monitored by wardens, which takes a lot of work and effort. Furthermore, other technologies in the market offer solutions to forest protection but these are costly and are not as efficient in serving its function. TARZAN may serve as an effective device for forest threat detection since all sensors used are low-cost, and signals received by the microcontroller are straightforward and simple to interpret, which results in speedy information processing and transmission. The simple electronic architecture of TARZAN also makes it more accessible to the public. Moreover, TARZAN may be the first device to offer human presence, forest fire, as well as illegal logging and burning detection all in one device.

Modern technology solutions for forest protection offer different ways in fire detection, such as the forest surveillance and monitoring system designed for the early detection and reporting of forest fires (Brogi, 1998). Other equipment heavily focuses on video recording and image processing which delays its function and requires installation which might hinder its portability. This is why TARZAN uses simple analog sensors in order to increase the efficiency of the signal interpretation. Some devices used wireless sensor networks and online websites as data storage and communication (Zhang, 2009), but these situations may only apply for urban areas where internet is readily accessible. TARZAN is based on a system designed to be a coordination of a central processing site and remote communication subsystems linked via radio (Lakshmanan, 2006), which is more feasible especially in the forest areas where radio waves prevail.

The main objective of the project is to develop a portable, sustainable, and efficient alternative for forest and natural habitat protection. It specifically aims to:

i. detect human presence via Passive Infrared (PIR) sensor.
ii. detect above normal high frequency sound levels caused by illegal logging via sound sensing.
iii. detect possible illegal forest burning or fires via smoke gas sensor.

2. Methodology

2.1 Materials

Two HC-SR501 PIR (Passive Infrared) sensors, a CZN- 15E potentiometer based sound sensor, an MQ-2 gas sensor, piezoelectric buzzer and Arduino microcontroller.

2.2 Fabrication of device

Each sensor in the input section is calibrated and interpreted by the Arduino microcontroller according to their corresponding functions. The PIR sensors are mainly used for human motion detection, the sound sensor for illegal logging, and the gas sensor for the detection of forest fires in the area.

2.3 Signal Communication

The communications module composed of an XBee radio transceiver module on both the transmitting and receiving end of the communication, with the transmitting part as the deployed TARZAN unit and the receiving end as the stationary TARZAN receiving unit, at a maximum line-of-sight communication distance of 90m. The receiving unit interprets the radio signals sent by the deployed node, and sends the received information to an Android application via Bluetooth. This enables the forest warden to receives alerts or status of the deployed TARZAN module through a smartphone.

2.4 System Testing

After calibration and communication module set up, TARZAN is then tested based on a standardized system test by Adriansyah & Dani (2014) in order to check whether the detection and communication modules are both functional through the entire functional process of the device.

The input section composed of two HC-SR501 PIR (Passive Infrared) sensors, a CZN- 15E potentiometer based sound sensor and an MQ-2 gas sensor. The output section comprised of a piezoelectric buzzer. Each sensor in the input section was calibrated and interpreted by the Arduino microcontroller according to their corresponding functions.

The PIR sensors were mainly used for human motion detection, as the sensors detect the change of infrared radiation in range when humans are

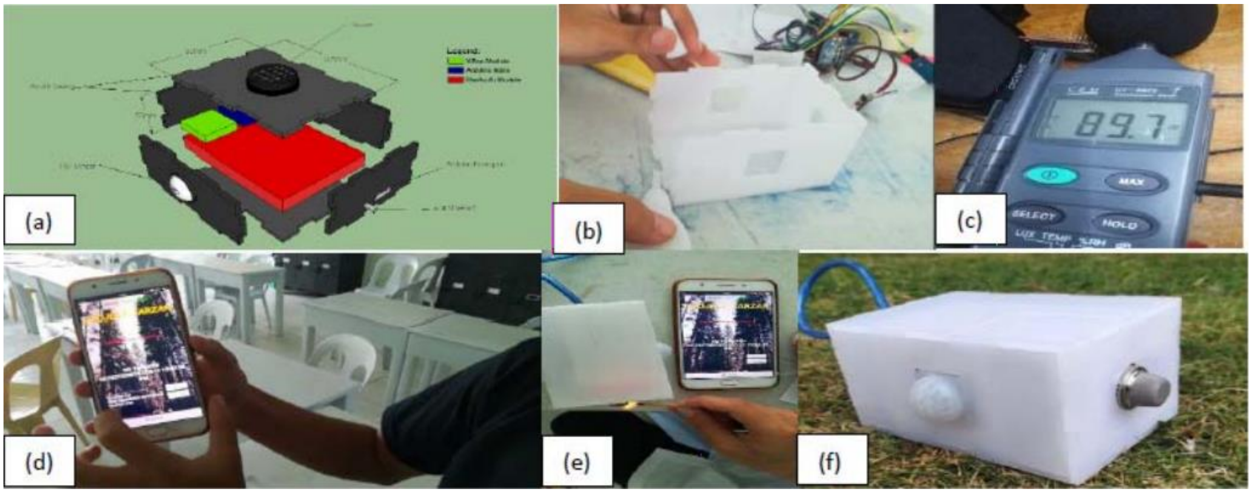

Figure 1: Development of TARZAN. (a) Schematic diagram, (b) Fabrication of device, (c) Calibration of sensors, (d) Sensor Communication Setup to Android app, (e) Standard System Test for TARZAN, (f) Finished product of TARZAN deployed module.

present. As the sensor detected the infrared radiation from humans, it changed the signal output from LOW to HIGH, with the HIGH state indicating human presence was detected in the area. A built-in potentiometer was also used to adjust the sensitivity of human presence detection for up to 7 meters.

The sound sensor was used to detect a certain sound level. When the detected sound reached the sensor's minimum threshold, sensor sends fluctuating signals to the Arduino. The sensor's sensitivity was adjusted and calibrated for noise levels of 90dB and above via a potentiometer, which was the typical range of sound intensity levels that were emitted by chainsaws (Tunay & Melemez, 2008), and is accurate for detection of illegal logging activity in the area.

The gas sensor was also applied for the detection of smoke and LPG gases in the area. It will send a distinct increase in analog signal value proportional to the amount of smoke that entered the sensor.

3. Result and Discussion

The signal outputs for each sensor were monitored and graphically plotted accordingly before and after detection. As seen in Figure 2, all calibrated sensors reacted according to the expected theoretical out come after each sensor testing. For the sound sensor, the analog signals were constant at 1023 a.u. before a 90dB noise was released, and the sensor's readings fluctuated with a distinct peak at 32 a.u. upon the release of 90dB signal, making it capable for isola-

Table 1. Results of the Standard System Test of TARZAN

	TEST	FUNCTION	PROCEDURE	RESULT
1	PIR Sensors	Used for Human Detection	Alerts "THREAT DETECTED" when human passes	FUNCTIONAL
2	Sound Sensor	Used for Illegal Logging Detection	Alerts "THREAT DETECTED" when chainsaw is detected (>90dB)	FUNCTIONAL
3	Gas Sensor	Used for Forest Fire Detection	Alerts "THREAT DETECTED" when smoke from forest fire is detected	FUNCTIONAL
4	Buzzer	Used as actuator for detection	Emits alert sound when threat is detected	FUNCTIONAL

Note: Standard System Testing revealed that the device parameters in detecting forest calamity are all functional and accurate, because upon a threat detection from at least one of the set parameters, a message from the TARZAN deployed module was sent to the android phone application, along with the alert status and time of occurrence.

ting noise detection of sound levels greater than 90dB associated to chainsaw noise.

The PIR sensor transmitted a constant digital signal output at 0 a.u. (LOW) when no humans were detected, and upon human detection, the sensor released a constant digital signal of 1 a.u. (HIGH), making it capable of detecting human presence. The gas sensor released an average of 71.93 a.u. when no fire is detected, and rises to an average reading of 179.77 a.u. upon the detection of fire, serving as an effective method in accurate fire detection. All these readings before and after detection were subject to further statistical analysis, and it revealed that the readings before threat detection were normal based on the standard Shapiro-Wilk Test for normality, and they are significantly different with the readings after the threat detection at $\alpha = 0.0001$, making the signal processing of the readings accurately distinct before and after detection. After signal 5 testing, the entire TARZAN system was tested based on a standardized test for electronic systems (Adriansyah & Dani, 2014).

4. Conclusion

Project TARZAN is capable of detecting human pre sence sensing noise values above 90 decibels and fire detection as well, which makes it a viable product for early detection of unwanted human activity. Project TARZAN serves as a capable, affordable, and sustainable option for forest and sanctuary protection over a long period of time, making it one of the first of its kind to use smart detection technologies in keeping our forests safe.

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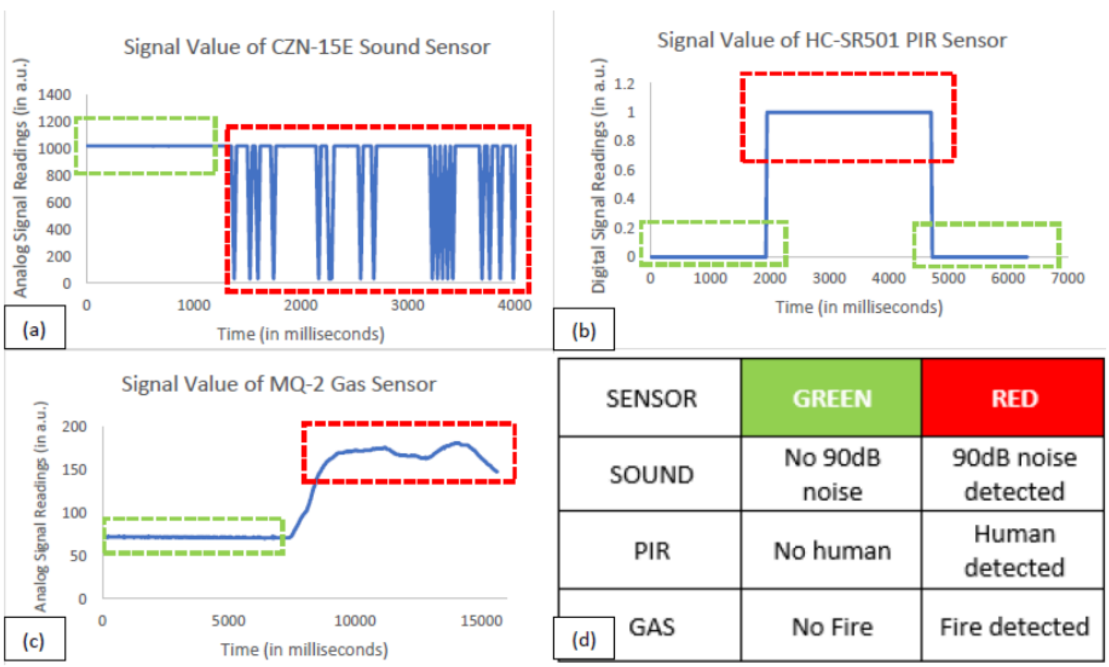

Figure 2: Signal outputs of the different sensors upon system testing. (a) Sound Sensor, (b) PIR Sensor, (c) Gas Sensor, (d) corresponding legend of the highlighted region.

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