Antares arduino-based necessity-terminating autonomous reconnaissance system

Parts of the World, Asia

The Philippines is an archipelago located on the Western Pacific, north of the equator. It is situated upon the Pacific Ring of Fire — a major region in the Pacific Ocean that exhibits increased seismic and volcanic activity. Sited west of the Pacific Ocean, the Philippines spans across a typhoon belt, rendering the country affected by approximately twelve (12) cyclonic storms yearly. These geographical conditions leave the country exposed to various hazards, and potentially, disasters. Disasters, as defined by the International Federation of Red Cross and Red Crescent Societies, are abrupt events that interrupt a community's human, material, environmental, and economic functions. Such phenomena generally occur due to natural activity, yet some are induced through human actions. According to a report by ABS-CBN News last 2012, the Philippines was ranked fifth among the most disaster-prone countries in the world. Data records from the same year state that the country's casualty numbers have heightened with respect to typhoons, earthquakes, floods, building fires, and other disasters. With multiple active faults traversing different areas in the country, it is evident that the Philippine landmass is heavily prone to earthquakes with varying magnitudes and intensities.

A dissertation published by Rimando and Knuepfer (2006) focused on the Marikina Valley Fault System that extends throughout the highly urbanized cities within Metro Manila. The West Valley fault, one of the two major faults in the MVFS, is expected to produce large scale earthquakes with magnitudes of 7 or higher. In a scenario with or without a preceding disaster, a fire would pose as another major threat. A fire disaster still presents characteristic aspects of a disaster due to the highly destructive nature of a building fire. This fire disaster would pose as a considerable threat to any community as fires of vast proportions cause extensive damage to the affected areas and the environment. The Philippines, being located along the tropics, is subject to very frequent rains brought by tropical cyclones. Recurrent rainfall from tropical cyclones poses a significant threat of flooding occurrences in the country. A flood, characterized by a rapid increase in the water level of a particular area within a short amount of time, may result to massive damage in property and heavily disrupts operation of affected communities. As the country continues to expand urban horizons and develop infrastructure, it becomes more susceptible to different disasters. Numerous studies and actions have been issued towards organizing and developing an effective DRRM Plan — Disaster Risk Reduction and Management Plan encompassing all vulnerable communities. Accompanied by the advent of technology, it is imperative that the Philippines invests in utilizing modern technology for disaster mitigation and management. Establishing equipment capable of addressing gaps and improving DRRM plans is vital to develop better methods of disaster mitigation and management.

Highlighting the need for the improvement regarding disaster management plans in the country, this study is conducted to construct an autonomous system capable of (1) outputting an alarm, (2) sending a distress signal to registered phone numbers, (3) and disabling utility lines (power, water, and gas lines) in the event of a disaster to prevent further damage within affected areas. The device will utilize three sensors for three corresponding disasters — a) accelerometer for earthquakes, b) smoke sensors for building fires, and c) water level sensors for floods. Regarding device outputs, the following output mechanisms have been supported by the autonomous system: alarm issuance, GSM/SMS message transmission, valve trigger, and the electric power trigger. On a larger scale, Project: ANTARES is capable of issuing an alarm system similar to the Floodway Alarm System along Pasig Floodway. The alarm delivered by the aforementioned system encompasses a large region alerting nearby communities. In addition to that, the GSM distress capabilities of the device will issue messages to all registered individuals — an effective method of accurate disaster information dissemination. A large scale autonomous disaster alarm system is imperative to provide warning signals in a timely manner to allow affected communities to initiate their respective disaster response protocols.

METHODOLOGY

Procurement of Materials

Throughout the course of this study, different electronic components were obtained from a variety of stores. The researchers purchased two (2) Adafruit Feather M0 RFM69HCW 433MHz microcontroller units from Circuit-Help Katipunan, along with two (2) 3. 7V 2000mAh rechargeable Lithium-ion batteries. One sensor, the ADXL345 Tri-Axis Accelerometer, was acquired at e-Gizmo Mechatronix Center Manila, following the purchase of one (1) GSM SIM800L module from the same establishment. The remaining two (2) sensors, MQ-2 Smoke Sensor Module and the Funduino Water Level sensor, used in reading fire and flood levels respectively were acquired at

ElecDesignWorks Kapasigan. A separate purchase of six (6) 220-Volt relay modules was conducted at the same establishment sometime after initial procurement of materials. The researchers opted to utilize solar energy to address the device’s need for a renewable energy source. A 10-Watt solar panel was purchased from Alexan Electronics Manila. Capable of outputting power at 17 Volts, the panel was intended to power a major part of the system and reroute excess power for battery charging. To control the energy outputted by the solar panel, the researchers needed a solar charge controller. Given the lack of resources to purchase a new controller, one of the researchers managed to borrow an unused solar charge controller from an acquaintance. Hence, some parts of the autonomous system now operated under renewable solar power.

Procedures Project:

ANTARES is conducted mainly to assemble an autonomous device that (1) will trigger its alarm-distress system, and (2) disable respective utility lines to prevent further damage in the event of a disaster—earthquake, flood, or fire. The autonomous system construction procedure is divided into three phases namely: Assembly, Programming, and Testing. Each of these phases would be evaluated in their respective narrative sections.

Phase I – Device Assembly

All parts of the autonomous system have been procured through purchase from verified electronic stores. E-Gizmo Mechatronix Central, Circuit-Help, Alexan Electronics, and ElecDesignWorks all have websites dedicated to supplying support materials for all customers. The researchers referred to the respective product manual wherein all information about the specific component (e. g. pin-outs, details, function) can be found. Through these hardware manuals, the researchers were able to connect the component pins accurately without seeking support from a technician. Upon verification that all component pins and connections are functional and accurate, the component pins are soldered onto their respective places to finalize the device/autonomous system.

Phase II – Device Programming

As stated on Chapter 1, Project: ANTARES will utilize the programming platform Arduino to manufacture the device/autonomous system’s software. Over the course of this phase, the researchers referred also to the same hardware manuals from the dedicated support sites. Sections of the [hardware] manuals contained numerous versions of sample codes that encompass all possible functions of the respective electronic components. The researchers then proceeded to code the software for each respective function present in the autonomous system. All three sensors (accelerometer, smoke, and water level) have yet to be tested before calibration. Each of the four output mechanisms (alarm, GSM-SMS transmit, power and water line trigger) possess individual codes and specific algorithms planned and designed by the researchers. But unlike the Assembly Phase, the researchers had to seek assistance from support technicians. Having only limited knowledge about the Arduino software, some problems had been too difficult to address directly without professional help. Upon successful verification of the codes, the device now entered Phase III and was ready to be tested.

Phase III – Testing Phase

The researchers proceeded to conduct tests to verify integrity of the device components and software. To verify and calibrate the smoke sensor, the researchers staged controlled burns and gathered data from the [smoke] sensor's input to the Arduino Serial Plotter. This verification and calibration process seemed to produce affirmative results also with the Water Level sensor. The accelerometer, being the only sensor that outputs analog values, had a more complex testing phase. The researchers utilized the PHIVOLCS Earthquake Simulator House to gather constant values for sensor calibration. To test for output viability, the researchers had to stage controlled triggers such as fire, earthquake, and flood. Four main outputs require four different triggers; the GSM and Alarm features had to be tested for response times, while the electricity and valve switches were tested for code compliance. Testing the viability of the solar panels was also imperative. The researchers placed the solar panels in different locations under varying sunlight intensities. A multi-meter was used to measure different electrical quantities particularly voltage and current.

RESULTS AND DISCUSSION

The results of the device testing will be tackled in line with the order of the research questions. What acceleration calibration will the tri-axial accelerometer (a component of the Transmitter unit) trigger the alarm system? a) Intensity III b) Intensity IV c) Intensity V Of the three specific values above, it was found out that the acceleration calibration would be coherent to the accelerometer values of Intensity V. The aforementioned value of positive-negative eight (±8) was identified as the respective accelerometer value — the specific number within the set of numbers outputted by the accelerometer when subjected to a simulation of Intensity V. Based on the device testing conducted using the DOST-PHIVOLCS Earthquake Simulation Device, the constant value of intensity along urban areas (with respect to presence of vehicles) represent readings of Intensity III to Intensity IV. After the device (specifically the Transmission module) was calibrated to trigger in accordance to readings of Intensity IV, a passing vehicle, such as a 10-wheeler truck, would trigger the entire system, instigating a false alarm.

According to the interview statement of PHIVOLCS Research Specialist Roberto Tiglao, normal readings of the lowest felt earthquakes in Metro Manila is adherent to the value of Intensity V. The earthquake intensity tests, along with statements from PHIVOLCS specialists, implied that the autonomous system (particularly the accelerometer component of the Tx unit) should be calibrated to trigger in conformity with vibrations read as Intensity V. At what data gathering frequency calibration would the accelerometer-based component be able to perform optimally? Hypothesized values include the following: a) 1 ms (1000 readings per second) b) 10 ms (100 readings per second) c) 20 ms (50 readings per second) Of the three possible specific values listed, the autonomous system had to be calibrated to gathering and processing 100 readings per second. In the Transmitter unit’s code, data gathering frequency was set to 10 milliseconds (ms), meaning that it would gather one sample every tenth (10 th) of a second. Cumulatively, this would render the device with 100 different values to process every second and continue monitoring for set of values that exceed the constant positive-negative eight (±8).

On a statement given by Engineer Melchario Pagtalunan of the PHIVOLCS Seismological Observation & Earthquake Prediction Division (SOEPD), the devices and earthquake monitoring systems of their institution have been set to observe and monitor 100 values per second. On the subject of optimal data gathering frequency calibration, he added that any value more than 100 samples per second would be ‘ too much’ and any less would be ‘ too few’. Conclusively, the researchers have opted to abide by the PHIVOLCS sampling rate of 100 values per second to optimize device capability and mitigate the occurrence of false alarms due to ‘ too few’ or ‘ too much’ samples. The autonomous system has the following array of outputs: alarm, GSM/SMS transmit, electric power line trigger, and valve trigger. In what disaster scenario (earthquake, fire, flood) would the respective outputs be triggered?

1. In the event of an earthquake
2. In the event of a fire
3. In the event of a flood.

On the topmost row are the four of the five outputs that the autonomous system features (the fifth one being the GSM output). In the event of an earthquake, the LED color would be bright green. This color is unique to an earthquake disaster only. This applied for both the fire and flood disasters wherein the LED colors red and blue will light up respectively. On the column labeled Alarm, the value “ High” refers to “ Enable”. In all trigger scenarios (earthquake, flood, fire), the alarm will always be enabled. In line with this, the GSM module will also issue corresponding alert messages to all registered individuals. The Valve column has a unique value definition, " High" refers to " Disable". During floods and earthquakes, the system will disable water lines. In the event of a building fire, the water line will remain active. Regarding the Power column, " High" means " Disable". In all disaster scenarios, the power line will always be disabled.

CONCLUSION

The device successfully detects earthquakes, fires, and floods through accelerometer, smoke sensor, and water level sensors respectively. It was able to output an alarm and SMS via GSM module. Based on the data gathered, the following conclusions are drawn.

The optimal value for the accelerometer's earthquake detection is the value closest to representing Intensity V earthquakes.

The devices and sensors would operate optimally if calibrated to gather and process data at 100 samples per second. It also complies with PHIVOLCS standards matching their calibration rates at 10 millisecond intervals.

There are respective output responses for each disaster. For each output, the autonomous system will enable and disable corresponding outputs. All tests conducted on the device have yielded affirmative results further proving the functionality of the device.

Through pursuing this study, the researchers have proven that it is possible to assemble an autonomous device that is capable of

issuing an alarm,

transmitting GSM-SMS messages,

triggering power and pipe lines in the event of a disaster to prevent further damage in affected areas.