SOCIETY OF PHYSICS STUDENTS
An organization of the American Institute of Physics

SPS Chapter Research Award Proposal

Project Proposal Title	Thermal Imaging for Determining Heat Loss From Structures on TLU Campus
Name of School	Texas Lutheran University
SPS Chapter Number	7209
Total Amount Requested	$2,000

Abstract

Students in the TLU Applied Physics program are interested in pursuing engineering-related career trajectories. To support that interest, TLU SPS proposes to design and construct a low-cost drone vehicle for data-gathering, starting with producing a thermal map of our campus. The thermal map will be used to effectively measure heat loss from campus structures.

Proposal Statement

Overview of Proposed Project

This research aims to address the question of how much heat is being lost from the structures on our campus at Texas Lutheran University in Seguin, Texas. Heat loss from buildings leads to unnecessary expenses for heating and cooling. By developing a detailed temperature map of the structures, we hope to identify regions of significant heat transfer between the inside of the building to the outside of the building, whether that be due to conduction, convection, or radiative emission. By knowing the specific details of the thermal signatures of each building, time for repairs and maintenance can be used most efficiently.

Measuring heat transfer in and out of a structure is typically done by making temperature measurements inside a building. This may be due to the fact that it is logistically difficult to access all parts of the building, even if the structure is a single story. We proposed to circumvent the use of ladders, cherry-pickers, or the dangers of walking on rooftops by outfitting a small low-cost drone vehicle with a thermal imaging camera that can be used to make a detailed map of the campus and all its structures. The application of drones for carrying out a wide variety of tasks is becoming increasing popular. It is expected that at least one million privately owned drones will be in flight this year (Amato, 2015).In addition to outfitting the drone with the low-cost thermal imager, we plan to outfit the drone with other environmental sensors and a standard camera. In order to log data, the drone will be outfitted with a custom Arduino-based data logger.

Drone data will be used to create a thermal map of the campus and help determine which buildings are in need of better insulation/which buildings could be radiating excessive heat into the atmosphere. Knowing which buildings are running inefficiently could motivate the campus to be more aware of the amount of energy being consumed per year and possibly influence ideas on climate change by starting a conversation about how energy might be used more efficiently on our campus. Tangible evidence of wasted energy can be a way to start the conversation about how we might be better stewards on our campus and beyond.

Our focus here is on engaging students in an interesting research project that will yield data that can be analyzed using interesting physics concepts. But, ultimately the project would be beneficial for TLU in terms of cost reduction for the school and in promoting the idea of scientific service for our peers, professors, and the public, something that Sigma Pi Sigma holds highly. By applying the currently available low-cost, but robust technologies of small drones and cell-phone cameras, we believe that this project could lead to a larger scale investigation into how human consumption of energy can impact the world around us all.

Background for Proposed Project

Current research indicates that the average American household spends an estimated $1,500 per year in energy wasted to a “leaky” house (Peixe, 2013). If that data accounts for a single household, imagine how that cost might scale when considering a much larger structure such as a college dormitory or large professional building. The costs of energy for heating a cooling have a domino type effect on the overall cost-of-living. Beyond the cost aspect of lost energy, personal comfort levels are affected by this “leakiness” for thermal energy. By measuring heat loss from campus structures, we would be able to reliably predict where insulation should be placed inside buildings and dormitories to maximize energy loss.

Thermographic methods for detecting the amount of heat trapped inside a certain structure have been employed by energy auditors who a variety of thermal sensors and then evaluate the data recorded. One example is the use of a simple infrared temperature meter, commonly used by technicians for maintenance and repair of heating and air conditioning systems for determining the temperature of air coming from vents. This thermal technology is incredibly accurate in determining the variations in heat concentration. (Thermographic Inspections, 2005).

Here, we hope to go beyond simply scanning one or two simple structures and evaluate the amount of heat transfer from an entire university campus. This data would be helpful in determining how much energy is being consumed by the small campus community.

A drone would be used to fly over and examine the top of the buildings. The drone would be constructed and programed to log data as it is looking over and around the structures. By having thermal images and camera images, we will be able to accurately identify regions where there is significant heat transfer, above and anywhere around all the buildings on campus. In addition, we will be able to develop a 'big picture' thermal map of our campus by using GPS data on the drone. The availability of low cost drones makes this project feasible, and the physics of the heat transfer will be accessible to the junior level students that will lead the project.

Expected Results

After successfully mounting a data logger and thermal sensor to a constructed drone, the goal will be to clearly see the amount of heat lost throughout the campus and ultimately reduce the costs of installing more efficient insulation around campus. From this raw data, we will construct maps, and use the images to develop models for the heat transfer in and out of the buildings.

Description of Proposed Research - Methods, Design, and Procedures

Timeline for the project:

- Spring 2017 – Summer 2017
    - The project will begin in Spring 2017. We will build the drone vehicle and begin testing the functionality of cameras and other sensors. We have adequate support facilities here in the TLU Physics Department. During late January and February, we will design and acquire the parts for building the drone, as well as the finding the best low-cost sensors that will be mounted to the drone. Weight specifications will be established in order to design and build an adequate device. We have the support of our advisor, Dr. Toni Sauncy who has agreed to help us acquire the materials and supplies during the summer terms.
      GOAL: Drone flies by April 1, 2017
    - The next several weeks should be spent calibrating and testing the capabilities of the instruments mounted on the drone.
    - By the end of April – to early May, we should be ready to begin preliminary data acquisition. The first plan will be to focus on a single, older building on campus, examine the data and begin to develop a rigorous data analysis process. The process will be shaped as we examine the data and determine the most effective way of using the data to draw conclusions. This will include developing appropriate simulations.
    - Most of the students involved in this work will be doing summer research, either at TLU or at other sites around the country. In order to continue collaboration on the project over the summer, we plan to work via online shared documents, and web-based meetings.

    - The group will meet at least three times during the summer in order to examine data and begin developing appropriate analysis and simulations.
- Fall 2017
    - The fall will be devoted to further acquisition of data and the development of an understanding of how heat transfer occurs in the structures we have examined.

Plan for Carrying Out Proposed Project

Personnel of the student-led group:

- Daniel Morales
- Patricia Snow
- Emily Churchman
- Ramiro Nava
- Oakley St. Vincent
- Andrew Hamilton

- This group of students are all natural science majors, with a majority of them being members of the Society of Physics Students or chemistry affiliated with a background in physics
- This project will be conducted mainly in the physics department, with focus being in the labs for space to build and program these drones/data loggers
- Contributions of faculty advisors or the department (equipment, space, etc.) include
  Dr. Toni Sauncy is our SPS Chapter advisor, with an expertise in interfacing and electronic instrument development she will work with us on designing and building the drone, as well as the selection of the sensor devices. Dr. Calving Berggren, Assistant Professor of Physics has expertise in computational modeling and simulations. He will work with us on developing the models for examining our data and understanding the heat transfer mechanisms.

Project Timeline

The timeline is detailed above in our methodology section.

Budget Justification

In order to carry out this research project, a drone will need to be built and a sensor will need to be equipped to that drone. It is proposed that two drones be needed to create a more accurate thermal map compared to simply using the small angle of one smartphone and its thermal attachment.

Bibliography

Amato, A. (2015, 4 16). *Drone Sales Numbers: Nobody Knows, So We Venture a Guess*. Retrieved from DroneLife: http://dronelife.com/2015/04/16/drone-sales-numbers-nobody-knows-so-we-venture-a-guess/

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