Statement of Purpose:
The purpose of this project is to apply and use the multidisciplinary skills acquired in the classroom to design and implement automated system which cultivates algae and then utilize it to create a viable fuel for use in a diesel engine. The growing necessity of finding alternative fuel sources that are sustainable, cheaper, and more economically friendly is what prompted the proposal.

What is a photobioreactor?
A bioreactor is any manufactured or engineered device or system that supports a biologically active environment. A photobioreactor is a bioreactor that incorporates some type of light source to provide photonic energy for the reactor. They are more useful than open environments because it helps prevent/minimize contamination, prevents water evaporation, and permits higher cell concentrations.

There are three main types of photobioreactors:
Vertical, flat pane, and tubular. Tubular photobioreactors are what are mainly used for the cultivation of algae.

Extraction Methods:
There are two methods to extract algae oil from algae: mechanical and chemical. These two methods are further classified.

Chemical methods: hexane solvent method, soxhelt extraction, supercritical fluid extraction. All three of these chemical methods present safety and health issues. Also, the supercritical extraction requires high pressure equipment that is energy intensive. Also, the upkeep for these methods are more expensive due to the machinery and the chemicals. For these reasons, we have chosen to use a mechanical method for the extraction process.

There are two types of mechanical methods: expression/expeller press and ultrasonic-assisted extraction.

The expeller press is similar to how seed oil is extracted. After drying the algae, it goes through the press and the oil is separated from the rest of the biomass.

The ultrasonic-assisted extraction uses ultrasonic waves to break down the algae cell walls. Once the cell walls break down, the cell contents are released.

Key Issues:
The downside about algae biodiesel production is that it is very costly to start up and most production is at a commercial level.
The process is still relatively new, so the implementation of a small scale operation is difficult because a large amount of time must go into testing growth rates and different extraction methods.
The AQS Copter is designed to enter high risk areas where hazardous air conditions may be present. This will aide Firefighters and Police in rescue operations and will also help other Engineers see structural damage from a safe distance. The concept of using the helicopter as a tool for rescue operations stemmed from the limitation of ground based surveillance robots and the physical limitation of human beings to be in hazardous conditions for extended periods of time. It will also be used to find any people trapped by fallen debris.

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**What is the AQS Copter?**

The helicopter has four rotors which provide stability in flight and improved maneuverability compared to single rotor helicopters commonly used by Police and news organizations. It is piloted from the base station using a hand held controller with customizable controls. The main feature is both front and bottom mounted cameras that provide live video feedback to the operator. This helicopter can also be operated in low light conditions with the LED installed under the front camera.

Under the main body of the AQS Copter will be three gas sensors which will sniff out Carbon Monoxide, Natural Gas, and Carbon Dioxide. Each sensor will send data to the onboard microcontroller for processing. All of the data collected from the sensors will be transmitted back to the operator using a pair of X-Bee Wi-Fi modules.

The operator will be able to navigate over obstacles such as fallen debris and enter buildings or houses from the top floors which are unreachable to ground based robots and humans. They can also check for signs of life from the live video on either the front or bottom

**Methodology**

The implementation of a flying device for surveillance and air quality testing in buildings has long been overlooked in the past. There is only so much ground vehicles can do as they often fail to overcome obstacles such as stairs and fallen debris. The project aims to assist different sectors of government such as police officers and firefighters as well as companies whose purpose is to identify contaminants in the air.

The idea of implementing a flying device of this nature came from the observations of the limitations in ground vehicles as well as hand-held sensors which can place a person’s life in danger. With this in mind, the concept of a flying device was born. Whereas a helicopter usually only contains a single blade on top of its structure for lift the AQS Copter will have four individual blades. Having four blades will give the AQS Copter greater maneuverability as well as the ability to hover for short periods of time. The AQS Copter will have on-board cameras which will transmit video to the operator.

The operator will be able to control the AQS Copter through simple joystick movements using a hand-held device in a safe location. In addition to being controlled through a hand-held unit, the AQS Copter can also be piloted using a joystick or similar controller connected to a computer.

On board the AQS Copter will be a micro-controller powered by a DC battery source. The micro-controller will serve as a way to process the air quality information taken by the various sensors that will be mounted around it. The AQS Copter will have sensors that will test the air for substances such as: Carbon Monoxide, Carbon Dioxide, and Natural gas. Upon detection of hazardous contaminants the AQS Copter will transfer the information to the operator.

**Key Issues**

The key issues with this project are weight and battery life. Currently, the AQS Copter can maintain flight for approximately 10 minutes and carry a weight of 2 pounds or 1kg.

The solution to these problems would be replacing the current motors with high performance, fuel powered motors. This would require a commercial company to design a similar helicopter at an increased cost.. However, further additions can be made to the initial design to take samples of other hazards or for research purposes. For example soil samples may be taken for building construction or mining operations.

**Data Transmission**

The X-Bee (pictured below) is a Wi-Fi module designed to transmit packets of data from transmitter to receiver. One of these modules is mounted to the bottom of the helicopter to transmit sensor data to the receiver. On the receiving end, the packets will be decoded and the data will be displayed for the operator to make decisions on what steps will be taken to ensure the safety of the rescue operators.

The Arduino pictured below is mounted on the AQS Copter. We will be taking advantage of the Arduino's Pulse Width Modulation capabilities to power most of the sensors and the X-Bee. The arduino will also collect and send the data to the X-Bee to be transmitted to the receiver. Lastly, it will control the on-board LED flashlight which is used to allow the operation of the AQS Copter in low-light conditions.
What is Machine Learning?
Machine learning is a method of teaching a machine, in this case an algorithm, to make educated predictions based on data modeling and trends. This data can come from numerous situations and subsets. Data is recorded and analyzed to teach and update software algorithms to react in certain ways based on recognized patterns. Machine learning can be achieved through various programming methodologies and techniques.

Machine Learning Overview
Applications can use Supervised and Unsupervised learning styles. Supervised learning gives the machine (learner) a set of previously known outcomes known as training data to understand and classify future data. During the training period, the application uses controlled inputs with corresponding outputs to allow the machine to learn based on correct examples. The machine will then generalize the training data to make educated predictions when presented with new or foreign data. Unsupervised learning does not provide the learner with training data and its task is to determine any underlying patterns in a dataset. Our project concentrates on the supervised learning method, using Support Vector Machine (SVM) techniques.

Support Vector Machine (SVM) is a method which focuses on binary scenarios. The method divides data into two classes, representing the binary decision the learner must determine. This technique creates what are known as support vectors. A support vector is data that is used to build and guide linear classifiers, also known as hyper-planes. The developed hyper-plane will separate the two classes denoting the binary decision taken by the learner. A visual example of this explanation is shown below. After the training period, the machine will be able to use the hyper-plane to make appropriate decisions based on the location of the support vectors.

Classes of Signals
Our project has three classes for signal detection: Detected, Missed, and False Alarm.
- Detected, when the signal has passed threshold and is within the expected boundaries.
- Missed, when the signal is not within range such as when threshold has not been met.
- False Alarm, when the signal is detected yet does not meet the specifications of a signal.

Hardware
We have done research on GPUs and have been able to run functions in parallel using multiple GPUs from multiple computing machines. Currently we have 7 machines with 2 Tesla C2050 cards per machine. The advantage of using this hardware is the ability to process in parallel, with large amounts of information in a short amount of time. In our project, this will help because we will be able to easily process extensive amounts of learning trials. This hardware would significantly reduce processing time for our decision-making process.

Possible Future Integrations
Our current program requires multiple functions and algorithms under the Support Vector Machine approach. Future integrations of our project can include, an optimized, parallel-performing environment using CUDA programming language. An increase in processing power and additional cognitive layers can simulate artificial intelligence, allowing the machine to make complex decisions and observations. Through the use of multiple GPUs and the CUDA language, these observations can be analyzed in parallel and allow faster decision making with more precision as well as tolerate large amounts of trials for learning. This implementation can be migrated to the medical field as a clinical decision support system, assisting physicians in patient diagnostics, tracking patient information and current trends in medicine.
Computer Engineering Program — Senior Design Project 2012
“Solar Powered Dual Temperature Controlled Enclosure with Automated Solar Tracker”

By Kevin Vo, Tsion Addisu and Jeff Poseley

Statement of Purpose
The purpose of this project is to apply computer science and electrical engineering based skills learned throughout our academic career to create a solar powered enclosure which utilizes the Peltier effect to provide refrigeration and heating methods to locations where traditional refrigerators would not operate.

What Is A Peltier Plate?
The Peltier plate is made up of an array of P-N junctions that are sandwiched in between two ceramic plates. When a current runs through the wire, one side of the plate becomes cold while the other side becomes hot. The temperature ranges from –40°C to 100°C depending on the ambient temperature, voltage, and specifications of the plate itself.

Implementing our design
We started with a minifridge as a basis for our enclosure, followed by mounting plexiglass shelves to hold the peltier chips, heatsinks, and provide a place to hide wiring. Our final design will feature two shelves, 4 heatsinks, and 2 zones (one hot and one cold).

During our testing we tried high end video card heatsinks, which worked for the hot side, but had issues when testing the cold side. This has to do with the design of the copper heatpipes of the high end coolers. Specifically, they utilize liquid or gas internally to transfer heat from the base to the fins. We used solid copper heatsinks for the cold side, and will be using low profile and low airflow fans for each.

The reason for low airflow fans is to keep the air moving, but still allow it to effectively transfer temperature from the heatsinks to the air. Also it changes the temperature of each compartment. When using high flow fans, the heatsinks changed to ambient temperature due to the surrounding air transferring its temperature to the heatsinks.

A microcontroller board is used to keep track of temperatures of each section, track dates, time, and report expired items, provide a locking mechanism, and control the rotation of the stepper motor. Possible additional features are temperature tracking, RFID tag integration, and tracking the status of remaining battery.

Solar Tracker
Our solar tracker went through several different design. The difficulty of designing a mechanical part with no real knowledge of how to do so presented challenges. Eventually we arrived at an A-frame design with a wooden support plate for the solar panel. In order to ensure the gear rotated the panel correctly the wooden frame was mounted to the central axis of the gear directly. Connecting that gear to the stepper motor will ensure that a lower torque motor can be used, lowering the price of the overall design.

However, we learned once we had built everything that the motor required a driver circuit, which we would have to include as well. The battery connects to the solar panel through a controller panel that ensures the battery is not charged beyond its limits. The battery is then connected to the rest of our system using the standard 12 volt DC outputs to the peltier plates, fans, and microcontroller board.

Peltier Effect — By passing current through two dissimilar electrical conductors, heat is either emitted or absorbed at the junction of the materials.
High-Performance Computing (HPC) for Accelerated and Secure Health Information Exchanges and Electronic Medical Record Collection

Accelerating Data Retrieval and Operations Using GPGPU Techniques on a CUDA framework

CPU vs GPU

CPU
- Central Processing Unit
- Carries out instructions of a computer program
- Perform basic arithmetical, logical, and input/output operations
- Consists of three components:
  - Arithmetic Logic Unit – does arithmetical and logical functions
  - Control Unit – extracts instructions, decodes and executes them
  - Memory – store data

GPU
- Graphic Processing Unit
- Used to rapidly manipulate and alter memory so fast that it can build images in a frame buffer for output to a display
- Multiple cores allow the GPU to execute functions much faster

What is CUDA?
- Compute Unified Device Architecture
- Parallel computing architecture developed by Nvidia for graphics processing
- Similar to C computer programming language
- Useful for parallel programming
- Handling multiple or repeating functions simultaneously
- Functions control done on GPU devices or kernel

What is PostGreSQL?
- Object-relational database management system
- Objects, classes and inheritance are directly supported in database schemas and in query language
- The data resides in the database and is manipulated collectively with queries in a query descriptive language
- Used for transactional enterprise applications
- Generally used for independent companies and self-funding communities

What We Have So Far
- GPU Accelerated Key Retrieval
- Sorting
  - Bubble Sort
  - Radix Sort
  - Selection Sort
- Addition of columns and rows
- Pattern Recognition
- PostGreSQL Interface
- Timing

Performance
- The following are execution times for our main PostGreSQL function on the device with 409600 elements. The dimensions for our database is 100 x ~5000 elements.
  - GPU key search time: 0.199 milliseconds
  - GPU radix sort time: 13.76 milliseconds
  - GPU sum column time: 1.917 milliseconds
  - GPU sum row time: 1.208 milliseconds
  - GPU sequential pattern search time: 7.592 milliseconds

The following are execution times for PostGreSQL functions without using GPU devices.
  - Import time: 600 milliseconds
  - Creating PostGreSQL database: 16 milliseconds
  - Join: 112 milliseconds

In conclusion with the results above, PostGreSQL functions using GPU devices are far superior due to the fact that it takes less time to carry out each function.

Applications
- Patient Health Records
- Customer Records
- Inventory