Senior Design Proposal

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Smart Chemical Sensor/Alarm System

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Executive Summary

1.1 Overview

The goal of this project is to make a smart sensor system to detect CH4(Methane gas). This system is a combination of hardware and software and should be optimized for least amount of processing time. The application of this device lies in home appliance. Many housefires are caused by gas leak. This system will detect the leak and notify the user about it. This project has potential to save property from being burnt and save lives.

Product

The smart chemical sensor/alarm system includes a vapor sensor, temperature sensor, methane gas sensor, a microcontroller and a LED. It is fast since the computing is done in a microcontroller. The microcontroller is programmed in assembly language to make the runtime as fast as possible. The sensors will be interfaced with the microcontroller. When it senses the methane gas leaking, or an unattended stove, the system will immediate ring an alarm. The system is small, portable. It is recommended that it is implemented on a gas stove for the utmost performance. When gas leakage occurs, the system will send a signal to turn off the gas.

1.2 Competition

For the final working version of the system, there is no competition. In the market, currently there is not gas detector system for stove. However, a system does exist for electric stove. Given that gas stoves popular in terms of usage, the system has little competition.

1.3 Challenges

The challenge the team faces is communication between the sensors and microcontroller. It is very crucial the interfacing is done in perfection. Then comes the challenge of programming the microcontroller with assembly. To make the code as simple as possible for faster runtime.

1.4 Team Experience

The team is made with two seniors in Stony Brook University majoring in Computer Engineering. Both members have taken coursework on Embedded Systems and currently taking a graduate course on Modern Sensors. Both teammates have experience in programming microcontroller using assembly. The team have the knowledge required for the completion of the project and the team will apply the knowledge to complete the project.

2. Project Statement and Goals

The purpose of this project is to develop a smart sensor system as a home technology solution for home fire prevention. This sensor system is a safety device embedded in and around home stoves. The system can detect unattended stoves and gas leakages aiding in raising fire alarm when necessary. The system is small, low powered, low cost fire prevention technology; therefore, the goal is to have Realtime operating system supervising calibrations for transducers, data acquisition and processing. Technical goals in designing the system will require us to condition sensors output in communication with a microcontroller. Therefore, a sub-goal is to convert analog signals from sensors such as peso-electric into digital code. In simplicity, the overall system will act as an enhanced safety feature for existing home stoves.

According to the allocated time these following goals would be achieved and tested progressively.

Goals:

- Design a multi sensor system capable of detecting natural gas leakage and unattended cooking.
- Research about parts to be used in the system design.
- Research about competitions and current technology solution for the problem proposed.
- Test and verifications of proper communication among sub-systems in top level design.
- Consideration of alternatives solutions of proposed problem.

- Once working prototype is achieved, consider adding additional features to overall system to appeal the end user.
- Deploy and enhance safety features of existing systems in industry.
- Prevent house fire by proper use of our system in daily lives.

3. Background:

3.1 Overview:

According to article, “Home Cooking Fires” by Marty Ahrens, in data collected between 2012-2016, unattended cooking is the leading cause of house fire and primary death toll caused by fire (1). The average civilian fire death is about 500 and rising each year. The current technology is inadequate to in dealing with house fire hazards. In order to prevent house fire an evolution in home appliance technology needs to be undertaken. The smart needs to be low cost and efficient in order to make it available to as many homes as possible.

3.2 Current Standard:

There are many home safety and securities devices are available on market for consumers. However, only one such device deals with the fire preventions. It is age old technology, known as Fire Alarm. Although simple in concepts, technology in fire alarms have also evolved to quickly detect and notify end users in case of fire emergency. However, its non-smartness puts in the era of sea travel. There are mainly two type of smoke alarms Ionization and photo-electric smoke alarms (2). Although they use different technology to disturb the flow of current, hence raising alarms; the underlying concept of detection is same, which is to trigger on gathered smoke inside the detector. Depending on fire type (smoldering or flaming fire) it can take a while for smoke to be dense enough to be detected by the smoke alarms. Additionally, smoke alarms only use high pitch sound as medium of notification. In these days of IoT, other means of notification is faster and more reliable.

3.3 System Parts:

The underlying design challenges requires us to choose components that are practical, low powered and small. The system requires multiple sensors to work in an array and communicate with each other when necessary. Based on the specification of this project, a natural gas detector is essential. Since most home use CH4 (methane) as their main method of cooking gas; therefore, for natural gas detection we choose CH4 Gas Sensor Module. Second part of the project specification is to detect unattended gas stoves; which needs to be done in many stages. One formula to use a pressure sensor to detect presence of cooking ware on stove; in combinations with water vapor sensor and inferred heat sensor to detect human presence, it is possible to conclude if the stove is unattended or not. Part ICP-10111(pressure sensor) and water vapor sensor were chosen from Samsung to fulfill this requirement. Full lists of parts can be found in budget.

According to planned project timeline, more research time has been allocated in principle of ‘measure twice, cut once’. Therefore, future research may impact part selection and deliverables in similar ways. It would also allow us to dive into our competition tracking and keep up with industry standard technology.

4. Social, environmental and societal impact considerations:

As engineers we are tasks to solve problems in ethical manners which do not impact society in negative way. On positive note, our system will compensate for human errors in kitchen and help prevent house fire. The use of such technology will help us save billions of dollars' worth in property damage and our precious lives; which is priceless. It will help evolve current home safety equipment and make it smarter. This system can connect to our mobile devices which enables instant notification deliveries. The system is low powered, small and can be manufactured in on a single PCB, which has low to nonenvironmental effect. There are only positive social effects, since app for this system will always keep you connected with fire hazards drills. The app can also alarm the authorities in the case of emergencies, resulting is quick evacuation drill.

The potential negative effects need to be also under consideration in designing this project. Although, smartness of this device makes our lives safer, it also allows 3rd party members an opportunity interfere with communication between subsystems. Underlying structure of this device is to gather information from physical sensors and send notification to user phone and proper authorities. If signal is intercepted in mid-communication, potentially hackers can alter the transmitted message leading to no alarm or false alarms. This problem will be solved using software solution to encode the messages between selected channels. A concern regarding this project can be highlighted during data acquisition part, where user's data is collected through various sensors. User must agree to give system the permission to collect adequate data for flawless operations of the system. This concern can be address by being

transparent about how the total system works to the user. Overall the negative societal impact of this design project is minimal and will be continually be revised in predicting future problems.

5. Narrative:

5.1 Overview:

The goal of the design project undertaken is to research and formulate a feasible senior design idea at the end of Fall Semester, and finally materialize a working prototype in Spring Semester. For our project, we decided to build sensor system to detect gas leakage in home kitchen and perform periodic checks on unattended stoves. Details of the proposed solution is described below along with deliverables.

5.2 Proposed Solution:

In order to prevent home fires, we must solve human related errors such as unattended stoves or the event when user forget to turn off the stove. For each case we use different sensors to detect absent of human presences and other material inputs. The underlying structure for this system is simple and easy to follow. This system will collect data through sensors; process data in onboard microcontroller (Realtime OS); send data(notifications) to smartphone. In the first case, where our goal is to detected build up gas caused by user's error of not turning the stove off; we use a CH4 gas detector to sense build up of methane in air. This gas sensor can be calibrated to withhold a threshold level. When buildup of natural gas goes over threshold level user or authorities is immediately notified of unsafe amount of gas in air. This system also works simultaneously work with user's smartphone in a way that notifies user immediately when phone is out of certain range of stove and burner is still on. The second and slightly more complicated case of unattended stoves can be detected using data from pressure sensors. A pressor sensor such as piezoelectric sensor will be used under stove grate to detect presence of any object such as cooking pans or other cookware. Water vapor pressure senses water vapors in air will be

installed in the vents top of stoves. This will allow us to detect if the burner is causing chemical reactions (cooking) and change in air contents. Inferred camera continuously monitors presence of human like feature through body heat signature. Once all these data are available a decision can be made to see if burner is on when nobody is around the burner. For simplicity, microcontroller will process data and make these decisions in Realtime while user gets notifications of any mishaps.

Depending on sensors requirements, we can condition input and output of sensor data. We will need analog to digital converter to convert analog signal such given by pressure sensor to be feed to microcontroller system. Transducers might be used in such conditioning of signal data in order to establish a proper communication channel. During prototyping phase low cost sensors will be used without WIFI capabilities to ensure proper operation. However, final product will introduce WIFI modules to all sensing components since they reside far part in actual system. The microcontroller unit will have WIFI capabilities to connect to a cloud based software in transmitted present statues of working system.

6. Project tasks and roadmap to deliverables

The first task is to figure out the individual components of the project. These components include a microcontroller, breadboard, sensors, wiring, LED and gaseous stimulus. What comes next is picking out the specific sensors required for the project. Then we must figure out the interfacing. Multiple sensors will be sending data to the microcontroller. Processing the data is the next step. The communication between the sensors and the microcontroller is where potential risks lies. It can be mitigated by researching and how interfacing between sensors and microcontroller is done. An LED will light up if the sensors has detected gas leak and/or unattended stove.

7. Project Team

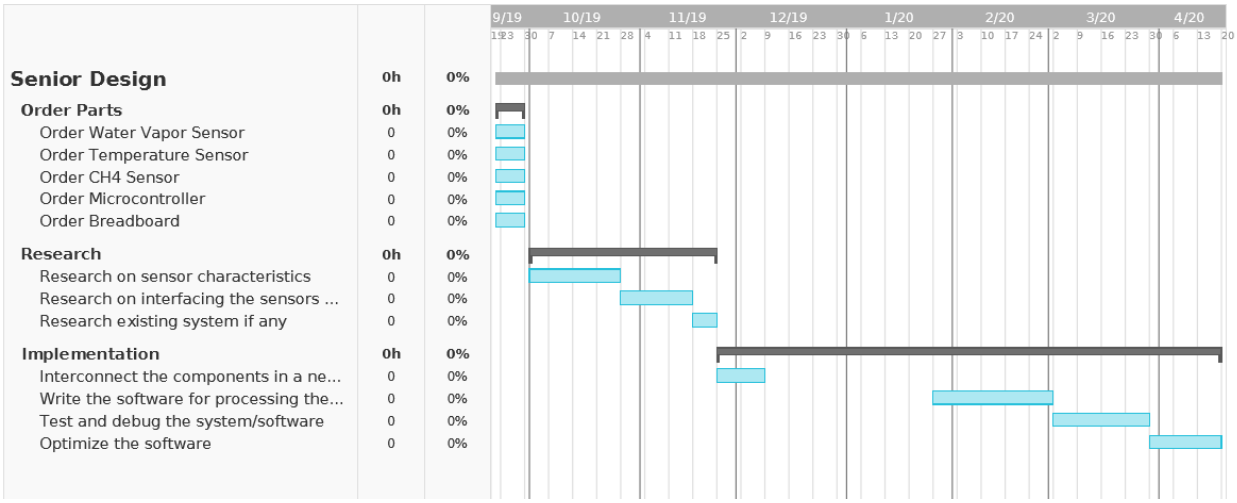
Asif Iqbal is pursuing a BE in Computer Engineering. He is enrolled in the accelerated program. Currently enrolled in a Modern Sensors graduate course, he will be responsible interfacing the microcontroller with the sensors, making sure that the data is from the sensor is getting to the microcontroller.

Roni Das is pursuing a BE in Computer Engineering. He is enrolled in the accelerated program. Currently taking a PCB design course and his expertise on embedded systems, he is tasked with making a custom PCB board for the system and design the software for microcontroller.

8. Project Timeline

Senior Design

Order Parts	**0%**		**Start**	**Due**	**Assigned**
Order Water Vapor Sensor	0%		Friday	Sep 27, 2019	
Order Temperature Sensor	0%		Friday	Sep 27, 2019	
Order CH4 Sensor	0%		Friday	Sep 27, 2019	
Order Microcontroller	0%		Friday	Sep 27, 2019	
Order Breadboard	0%		Friday	Sep 27, 2019	
Research	**0%**		**Start**	**Due**	**Assigned**
Research on sensor characteristics	0%		Oct 1, 2019	Oct 25, 2019	
Research on interfacing the sensors and the	0%		Oct 28, 2019	Nov 15, 2019	
Research existing system if any	0%		Nov 18, 2019	Nov 22, 2019	
Implementation	**0%**		**Start**	**Due**	**Assigned**
Interconnect the components in a	0%		Nov 25, 2019	Dec 6, 2019	
Write the software for processing the data	0%		Jan 27, 2020	Feb 28, 2020	
Test and debug the system/software	0%		Mar 2, 2020	Mar 27, 2020	
Optimize the software	0%		Mar 30, 2020	Apr 17, 2020	



9. Budget

Item	Supplier	Quantity	Unit Price
Water Vapor Sensor	Samsung	4	$19.99
ICP-10111	Semiconductor Store	4	$1.66
CH4 Gas Sensor Module	Active-Robots	4	$28.21
ESP32	Grid Connect	4	$6.43
WB-106-1+J	CircuitSpecialist	1	$17.26
Total			$242.42

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1. Ahrens, Marty. "Home Cooking Fires." *Nfpa.org*, 2018, www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/US-Fire-Problem/Fire-causes/2018-Home-Cooking-FIres--Report_FINAL.ashx. Date Accessed : 9/10/2019

2. Based, Online. "Ionization vs Photoelectric." *Ionization vs Photoelectric*, 2017, www.nfpa.org/Public-Education/Staying-safe/Safety-equipment/Smoke-alarms/Ionization-vs-photoelectric.Date Accessed : 9/10/2019

3. "Samsung Water Leak Sensor." *Best Buy*, www.bestbuy.com/site/samsung-water-leak-sensor/6265831.p?skuId=6265831&ref=212&loc=1&extStoreId=458&ds_rl=1266837&gclid=CjwKCAjwwvfrBRBIEiwA2nFiPdKjdTZEvFJlEQHpX6YiTEc-ov6KePNzZGxs2BiZmcrrQya21zE-jhoCzkkQAvD_BwE&gclsrc=aw.ds.

4. "ESP32-DevKitC ESP32 Module Development Kit." *Grid Connect*, www.gridconnect.com/products/esp-devkitc-esp32-module-development-kit?gclid=CjwKCAjwwvfrBRBIEiwA2nFiPSPkU8oijmgaZ-rEyin4uhir3fMao3TCTfFCh5WkcI2c5wluNH_fKxoCfj4QAvD_BwE.

Appendix A:

Team meeting is held with professor Leon every Friday at noon in the fall semester. There will be weekly meeting held in the spring semester too. Time and days for that will be determined in the beginning of Spring semester.