HeatSeekr

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***Abstract* — As a high-level electrical and computer engineering project, HeatSeekr is a creative and practical fire extinguishing system to detect and exterminate the early stages of a fire. By utilizing WiFi alerts, line navigation, and advanced ultraviolet detection, HeatSeekr is able to autonomously become aware of a fire's presence, travel to a specified searching point of a room, and extinguish any flames in the area. By removing the human factor of a fire extinguisher, HeatSeekr attempts to make fires safer for humans and cause as little residual damage to other technology around the fire.**

***Index Terms* — Event detection, fires, master-slave, mobile robots, navigation, phototransistors, wireless sensor networks.**

I. INTRODUCTION

The HeatSeekr rover, and accompanying wireless probe, is a fire detection and extinguishing platform made to showcase how the integration of technology can add an additional active fire protection module to current fire response systems available today. HeatSeekr addresses the issues plaguing current fire response methodology, namely reacting to fires that have already grown beyond control. Such fires require extinguishing of entire rooms and floors which can cost hundreds of thousands of dollars in damage to sensitive equipment and other property, causing widespread panic and chaos in the process. By focusing on breaking the mentality of fire containment being on the scale of households and entire office buildings, HeatSeekr utilizes advanced ultraviolet spectrum radiation detectors and wireless communication networks to meet its goal through a balance of elegance and efficiency.

HeatSeekr itself incorporates several subsystems in its multiphase operation. The rover is a thirty pound, multilayer, tread-driven combination of the fire extinguishing system, navigation system, and "The Overlord" master processor. Each system is controlled by its own microprocessor, and performs tasks in parallel with other systems, allowing the rover to navigate a hallway and constantly monitor the area for fire emissions simultaneously. The microprocessors communicate through the master processor over I^2C and UART, allowing data to be exchanged between them and procedural decisions to be made.

II. SYSTEM COMPONENTS

HeatSeekr is best presented with a breakdown of each of the individual subsystems that are combined to create the final product. This section provides a semi-technical introduction to each of these subsystems.

A. Microcontrollers

The controlling network of HeatSeekr is run by four MSP430G2553 microprocessors from Texas Instruments. The MSP430 was chosen for its cheap, yet powerful computational abilities. Three dedicated MSP430 microprocessors were given to the remote wireless probe, navigation, and extinguishing subsystems. The fourth MSP430 was used as "The Overlord" master processor and was used to determine when to switch states based on each subsystem's output. The remote wireless probe commutates to the master microprocessor through UART, while the navigation and extinguishing microprocessors communicate through I^2C. Each microprocessor was programmed using Code Composer Studio.

B. Remote Wireless Probe

The remote wireless probe utilizes a RN-42 microchip, which is a Class 2 Bluetooth Module for communication. The remote probe has the Bluetooth slave module, while the Bluetooth master module is connected to "The Overlord" master processor on the rover. By consuming ultra low amount of power, a standard A23 alkaline battery is able to power the system. The probe's main responsibilities for HeatSeekr are to detect a fire and alert the rover to drive to its location by sending a command to the master processor to interrupt its sleep cycle from an idle state.

C. Navigation Subsystem

Once HeatSeekr has woken up from its idle state, it will begin transportation to the probe's location by use of a line follower. Utilizing three CNY70 reflective optical sensors underneath the main chassis of HeatSeekr, the reflection of IR light will be able to steer HeatSeekr to its destination. This array of CNY70s feeds into a comparator that outputs logic level Boolean responses for control over the drive motors. When the line is straight, the middle CNY70 will instruct the MSP430 to turn both motors on to drive in a straight path. If the right CNY70 turns on, indicating a right turn is needed, the MSP430 will instruct the left motor to turn on while the right motor stays off. Since HeatSeekr is driven through treads, operation of the inverse direction to turn is required for suitable steering. The drive motors that HeatSeekr uses are PGHM-02, which were chosen for their ability to move 388.85 oz/in of torque at 65 RPM with 12 Vdc.

D. Extinguishing Subsystem

The extinguishing subsystem uses an advanced ultraviolet sensitive transistor known as a UVTron, created by Hamamatsu, to detect fires. By utilizing a shroud to limit the UVTron's field of view, a detection range of twenty or more feet is allowed directly in front of HeatSeekr. At 12 V and 4 mA, it has a fast detection speed of one degree per second, and processes any ultraviolet light into a frequency counter. If enough ultraviolet light pulses are captures within a few milliseconds, then the extinguishing system will alert "The Overlord" master processor that a fire is present. A UVTron is present on the Remote Wireless Probe to detect the initial fire and summon the rover, and another UVTron is mounted on top of the rover to determine the exact location of a fire.

To control the direction the UVTron is steered at on the rover, a 39BYG302 stepper motor is used to control its direction. With a torque of 1 N/cm at 12 V and 0.32 A, this stepper motor is able to smoothly rotate in a large radius at 1.8° steps. This allows the UVTron to pinpoint a fire in any direction within the allowed radius. Once the fire has been detected, a TOPSFLO micro gear water pump is turned on and run through another 39BYG302 stepper motor connected above the UVTron to spray in that direction to extinguish any fires. To detect water levels, two screws have been inserted into the water tank and are being given 3.3 V. When there is water in the system, one screw will be at 3.3 V while the other is in series with a resistor to draw 0 V as the water reduces some voltage. When both screws are supplying the same voltage, water is known to be low.

III. System Concept

To understand how each subsystem interacts with each other and what pieces it can control, the complete block diagram is shown for the navigation subsystem, extinguishing subsystem, and wireless subsystem, as well as individual block diagrams for the subsystems.

As shown in Fig. 1 below, both the wireless and extinguishing microcontrollers control a fire detector that utilizes the UVTron to detect pulses of ultraviolet light. The master microcontroller has a LCD screen that is visible above the chassis, and is used to alert anyone viewing the rover what the current status HeatSeekr is in. HeatSeekr's status changes at four distinct stages: when the wireless probe alerts the rover of a fire, when the rover has arrived at its destination, when the fire has been put out, and when the water level is low.

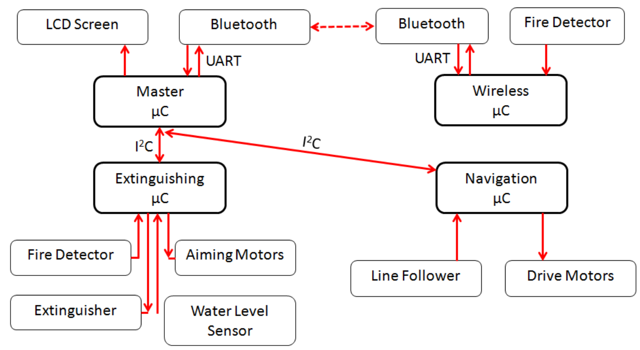


Fig. 1. Block diagram of HeatSeeker's subsystems.

As shown in Fig. 2 below, HeatSeekr's navigation subsystem centers on controlling two motors by checking the status of a CNY70 array which can output four conditions according to the current track configuration: both motors on, left motor on, right motor, or all stop.

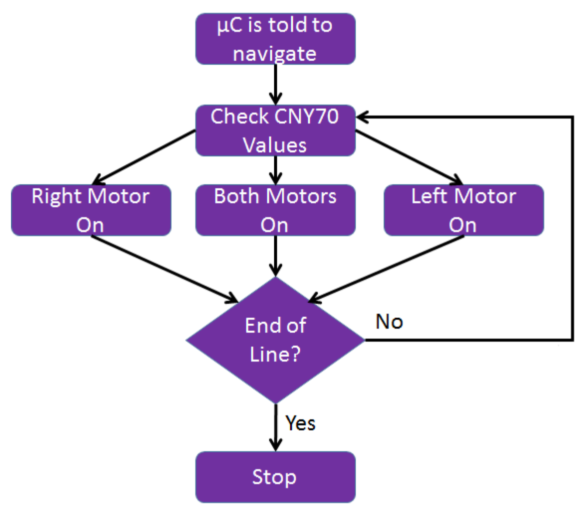


Fig. 2. Flowchart of the navigation subsystem.

The ability of the microcontroller to quickly switch between states is paramount in allowing a smooth line navigation that increases response time and lowers unneeded jarring of the water payload.

The extinguishing subsystem as flowcharted in Fig. 3 displays the interaction between the x-axis and y-axis stepper motors and the UVTron input to the microcontroller. The timing of the water pump is elucidated as well, with a state also including the firing algorithm consisting of modulating both stepper motors together.

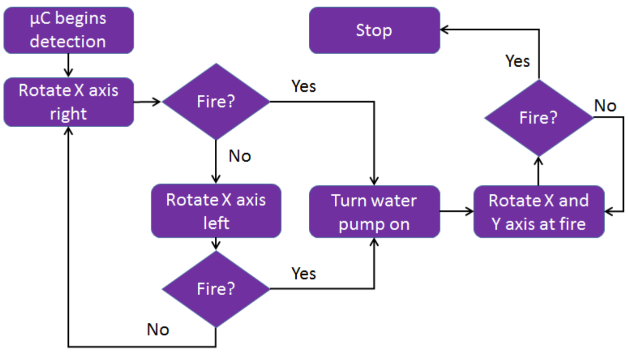


Fig. 3. Flowchart of the extinguishing subsystem.

The remote wireless probe subsystem significantly resembles the extinguishing subsystem, as it also incorporates the fire detection code, but instead of activating a pump relay, it begins a wireless connection with the rover and transmits the fire present status code, as displayed in Fig.4

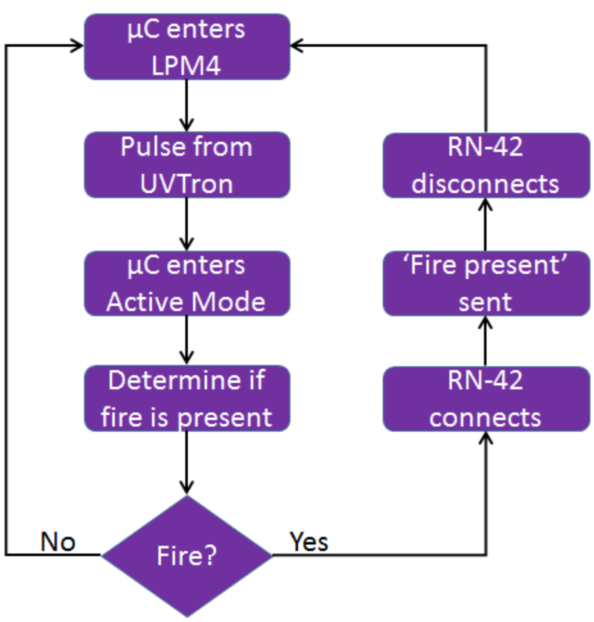


Fig. 4. Flowchart of the remote wireless probe.

Special attention should be placed on the LPM4 and active mode blocks in the chart that give insight into the various power saving measures undertaken in the remote wireless probe subsystem, due to UVTron support.

IV. Hardware Detail

Each of the major system components outlined in section II, System Components, will now be explained in technical detail. Including but not limited to: motor drivers, power, testing LEDs, circuit design.

A. Microcontrollers

The chosen microcontroller for HeatSeekr is the MSP430G2553. As an ultra-low power microcontroller, it is optimized to achieve extended battery life in portable applications. It was chosen for its ability to perform at low power levels and incredibly cheap price. As shown in Table 1 below, its parameters provide a modest power for minimal voltage supply and met all estimated requirements of HeatSeeker's specifications.

Frequency	16 MHZ
Flash	16 kB
SRAM	0.5 kB
GPIO	24
Timers-16-bit	2
Low supply voltage ranges	1.8 to 3.6 V
Active power consumption	230 µA
Standby mode consumption	0.5 µA

Table 1: MSP430G2553 specifications. [2]

The microcontroller comes in a DIP and TSSOP packages, which is able to accommodate either a 20 or 28 pin connection. For HeatSeekr's purposes, four MSP430G2553 microcontrollers were used for the navigation, extinguishing, remote wireless probe, and master processor. Of those systems, the master processor and extinguishing system required the 28 pin accommodations while the smaller remote probe and navigation system only needed the 20 pin accommodations. The master and slave system incorporated used I^2C to efficiently transfer data throughout the extinguishing and navigation systems. The remote wireless probe was designed to communicate back to the master controller through use of the Bluetooth communications through the use of the RN-42 microchip and UART data transfer.

B. UVTron

The chosen sensor for fire detection is the Hamamatsu UVTron Flame Sensor with C10807 driving board, an ultraviolet detector that is tuned to the specific emissions from flames. The C10807 driving board converts the output of the UVTron into a series of pulses that has a frequency dependant on the amount of incoming ultraviolet radiation. The UVTron was chosen due to its 16 foot fire detection range, its wide 120° x 120° field of view that can simultaneously be easily limited, and the low computational requirements of its implementation. The UVTron bulb's impressive field of view is characterized below in Fig. 5.

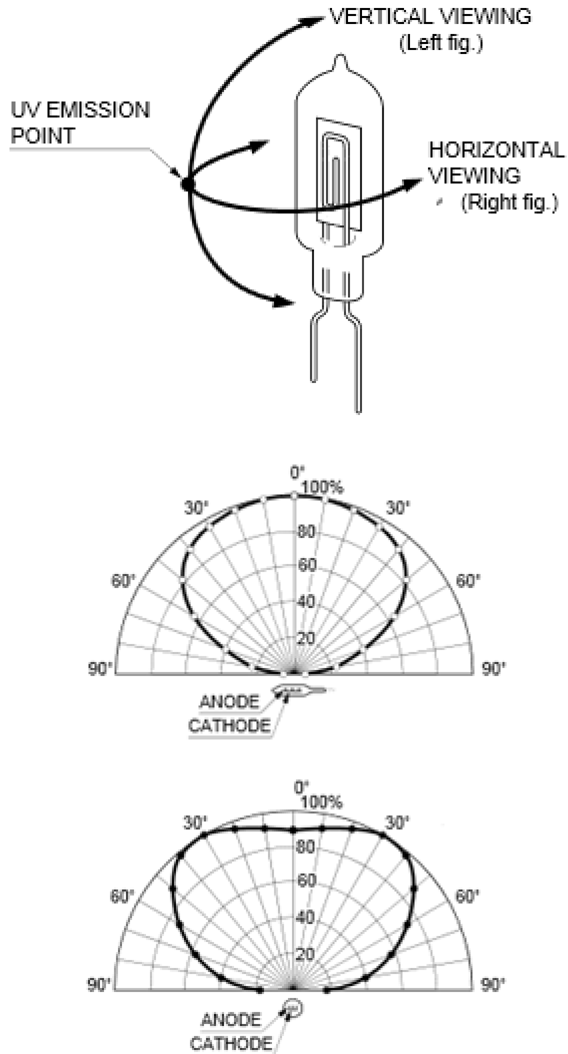


Fig. 5. Field of view for UVTron bulb divested of its C10807 board and shown in profile and top-down configurations. [1]

C. Water Pump

To extinguish the fire, a standard TOPSLFO Micro Gear Pump was used to launch water across the room. By creating a 12” by 6” by 6” water tank out of ultraviolet-resistant clear extruded acrylic sheets, a maximum volume of 7.079 L (1.87 gallons) of water can be stored for a fire. Once a fire has been detected, 12 V can be applied to the motor to supply a max flow of 2.5 L/M. By connecting the end of the water pump’s tubing to a nozzle and motor, aiming the flow of water is easily achieved to reach up to 25 feet.

D. Stepper Motors

To control the aiming capabilities of HeatSeekr, two 39BYG302 stepper motors are used for the X and Y axis control of the water tubing and UVTron fire detection device. By mounting the UVTron on top of the X axis motor, and the Y axis motor above the UVTron with the water tubing, HeatSeekr is able to detect a fire and extinguish it within 30 seconds of its arrival into an active room.

The NEMA 16 step motors, model 39BYG30, are small step motors with a step angle of 1.8° and 200 steps per revolution. With a small dimension of 0.98” by 0.511”, they easily fit onto the chassis while keeping a sleek appearance. Despite their small stature, they provide a moderate amount of torque at 1.0 N/cm. This torque has proved to easily carry the lightweight UVTron and shroud for detection. To run each step motor, a Texas Instruments DRV8811 stepper motor controller was used. The DRV8811 provides two H-bridge drivers and microstepping indexing logic to control each stepper motor.

E. Navigation Motors and Treads

In order to navigate to the fire, two PGHM-02 drive motors were chosen for their high torque values of 388.85 oz/in while still running at 12 V. Although the high torque came at a lowered speed of only 65 RPM, the lower speed was actually helpful as it reduced the acceleration’s effect on the carried water. If HeatSeekr moved too quickly, the sudden changes in speed at start and finish would cause the water to fluctuate greatly and cause excessive weight distribution and unbalance. To drive the PGHM-02 drive motors, a Texas Instruments L293DNE was used to control both motors.

F. Line Detection

The line follower hardware configuration for the rover consists of a three member array of the CNY70 reflective optical sensor with transistor output and the MSP430 microcontroller. The CNY70 reflective optical sensor is a four polar port package consisting of an infrared emitter and transistor, each comprising two of the four total ports. It should be noted that the emitter and transistor are, for all intents and purposes, separate circuits within the same package, and thus comprise two isolated nets. The infrared emitter is essentially a diode, and the transistor has collector and emitter ports, thus it is important to note the polarity of connections regarding these two elements. The diode requires 5V to run efficiently, and requires between

25 to 50 mA of current, thus 200 Ω resistors will be placed on a leg of each diode circuit, with the anode leg of the diode connected to the 5V power rail. The CNY70 emitter leg current outputs are fed through a resistor and the voltage is fed into a comparator where it is compared to a reference voltage and the logic level 1 or 0 output of the comparator is polled by the microcontroller.

G. Wireless System

The wireless system utilized the Roaming Networks RN-42 Class 2 Bluetooth module. This module required a minor configuration change for the master module; otherwise it was utilized entirely in its factory configuration. In this configuration, the module connects to the microcontroller via UART and is completely transparent to the microcontroller. Whatever is placed on the UART transmit buffer is sent out to the microcontroller, into the RN-42, and over the air to the other RN-42. Whatever data the RN-42 receives is placed on the microprocessor's UART receive buffer. The microprocessor's coding will then interprets the data in the buffer and determines if a fire has been detected and change status accordingly.

In order to effectively detect a fire, the remote wireless probe can be placed in a separate room from the rover given that the rover can still read a prepared line to the room. The remote probe will constantly be monitoring for a fire through the use of the Hamamatsu UVTron, the Roving Network RN-42, a MSP430-G2553, and a standard A23 alkaline battery. Because the entire probe runs on ultra low power, the small alkaline battery is able to support all these components without fear of being drained quickly.

H. Power Management

As HeatSeekr is a fully autonomous robot, the ability to supply enough power to all components is a crucial part to its success in extinguishing a fire. By utilizing three separate power rails, each system is able to be supported by one large battery that can be recharged during downtimes. The microcontrollers, water level sensor, line following sensors, and wireless module are all low consumption machines, so they are run on a 3.3 V rail with 0.5 mA, 0.3mA, 3mA, and 30mA (Tx) respectively. The stepper motor is run on a 5 V rail with 32 mA. The main draws of power from HeatSeekr are the drive motors, the UVTron, and the water pump. Each of these components runs on a 12 V rail with 80 mA, 4mA, and 40mA respectively. During testing, HeatSeekr has been noticed to run all individual parts without any pressure. The only time that a power management concern was raised was for when the extinguishing subsystem was running the water pump at full blast with both stepper motors moving in unison to create a large spread over the fire's location. Although the system is able to handle this scenario, this condition is utilizing almost all available energy from the chosen battery. Thankfully, this stage of fire extinguishing takes less than one minute, and the battery used for the HeatSeekr rover, as detailed below, is truly expansive in its 7800 mAh rating, ensuring that, while the system will be providing peak energy, the capacity should be sufficient.

I. Batteries

To power HeatSeekr, a Tenergy 22.2 V 7800 mAh Li-Po battery pack was chosen. Mounted inside the chassis near the motherboard, a physical switch is able to toggle between a recharge state, off state, and on state. Upon switching to the on state, the voltage is distributed through three rails with a Murata Power Solutions 78SR-3.3/2 3.3 volt switching regulator, a Murata Power Solutions 78SR-5/2 5 volt switching regulator, and a Innoline R-78c12-1.0 12 volt switching regulator. Additionally, a 12V A23 battery is used for the wireless probe, further reinforcing the need for severe power saving strategies for the probe as the A23 battery has a very limited capacity and is counted on to perform for the rover system to function.

V. SOFTWARE DETAIL

A. Microcontrollers w/ pin layout

The Master Processor interfaces with the RN-42 through bits 0-2 on Port 1. It acts as the I^2C Master and connects to the I^2C bus via bits 6 and 7 on Port 1. Finally, it interfaces with the 40 x 2 character HD44780 LCD via most of Port 2 as shown in Table 2 below.

Master Processor	
P1.0	RN-42 Status
P1.1	RN-42 UART Tx
P1.2	RN-42 UART Rx
P1.6	I^2C SCL
P1.7	I^2C SDA
P2.0	HD44780 RS
P2.1	HD44780 RW
P2.2	HD44780 EN
P2.4	HD44780 BIT4
P2.5	HD44780 BIT 5
P2.6	HD44780 BIT 6
P2.7	HD44780 BIT 7

Table 2: Master processor pin layout.

The Navigation Processor reads the state of the line following sensors from bits 0-2 on Port 1. It listens to the

I^2C bus as a slave using bits 6 and 7 on Port 1. Finally, it interfaces with the L293DNE motor driver via bits 0-5 on Port 2 as shown in Table 3 below.

Navigation Processor	
P1.0	Left sensor
P1.1	Center sensor
P1.2	Right sensor
P1.6	I^2C SCL
P1.7	I^2C SDA
P2.0	L293D 1-2EN
P2.1	L293D 1A
P2.2	L293D 2A
P2.3	L293D 3-4EN
P2.4	L293D 4A
P2.5	L293D 3A

Table 3: Navigational processor pin layout.

The Extinguishing Processor reads the state of the UVTron from bit 0 on Port 1. It reads the state of the water level sensor from bit 1 on Port 1. It controls the water pump relay from bit 3 on Port 1. It listens to the I^2C bus as a slave using bits 6 and 7 on Port 1. Finally, all of Port 2 is used to interface with both DRV-8811's as shown in Table 4.

Extinguishing Processor	
P1.0	UVTron
P1.1	Water level sensor
P1.2	Pump relay
P1.6	I^2C SCL
P1.7	I^2C SDA
P2.0	X Stepper EN
P2.1	X Stepper STEP
P2.2	X Stepper DIR
P2.3	X Stepper HOME
P2.4	Y Stepper EN
P2.5	Y Stepper STEP
P2.6	Y Stepper DIR
P2.7	Y Stepper HOME

Table 4: Extinguishing processor pin layout.

The Remote Processor interfaces with the RN-42 through bits 0-2 on Port 1. It reads the state of the UVTron from bit 3 on Port 3 as shown in Table 5.

Remote Processor	
P1.0	RN-42 Status
P1.1	RN-42 UART Tx
P1.2	RN-42 UART Rx
P2.3	UVTron

Table 5: Remote processor pin layout.

B. Flame Detection Algorithm

The UVTRON's C3704 board outputs a 10 ms width pulse output that corresponds to detected sources of ultraviolet radiation. The specifications for the sensor indicate that there is a background pulse allowance that must be accounted for in order to prevent false positives. Thus the flame sensor outputs a frequency varying signal whereby higher frequencies denote higher sources of ultraviolet radiation and lower frequencies indicate adjacent sources or simply background radiation.

The integration of the UVTRON and the MSP430 then relies on a method for counting the pulses emitted by the C10807 board and comparing the measured count to a predefined threshold. This is most readily accomplished by polling a GPIO pin on MSP430 at a higher sampling frequency than the on period of the square pulses.
From the experiments, it was determined that small flame sources roughly 1 meter from the UVTRON will result in signals of 10 pulses per second from the C10807 with an on time of 10 ms, as shown in Fig. 6.

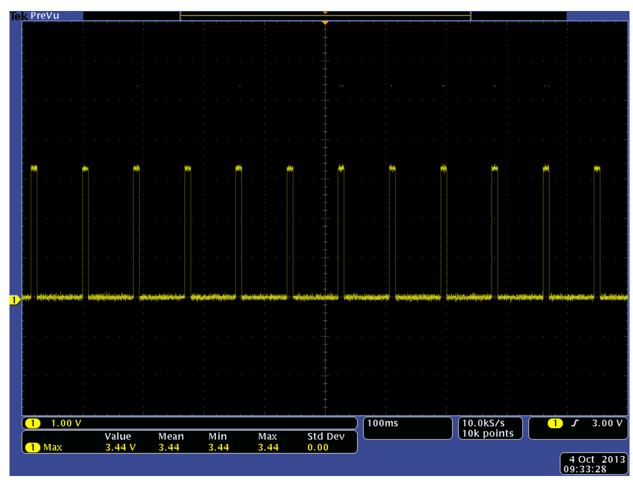


Fig. 6. Oscilloscope output waveform from C10807 from a fire.

By sampling the state of the input pin every 1 ms, pulses can be discerned, counted, and and used to determine the frequency of the C10807 output. By adjusting the shroud slit opening and measuring the frequency for a flame output, the threshold frequency can be determined for optimum aiming.

The design of the rover and its intended use require that the flame detector's field of view be swept horizontally through the environment to accurately guide the extinguishing hose. This is accomplished through the use of programmed loops that sweep through a range of horizontal values for the x-plane servo motor that occur while monitoring the frequency of the C10807 output signal. These sweeps will call functions in the MSP430 written to control the stepper motors as outlined previously. The functions deterministically manipulate the horizontal and vertical values such that a return to a predefined location is possible, ensuring that the sweeping sensor's location will be known.

C. Extinguishing Algorithm

The hose of the extinguisher will be mounted on the same servo driven platform as the UVTRON detector. This means that the x-radial position of the hose, for the purposes of extinguishing, is in line with the fire once the fire has been detected and the sensor stops scanning. The same loops used for scanning are used for the extinguishing algorithm, namely, the stepper motor controlling y-radial position will cycle through 90° of movement reflected by a function call to the stepper motor function for moving upwards 45° and then downwards 90°, and then upwards 90° again while the x-radial stepper motor will alternate between +/- 4.5° ten times for every one full y-alternation. A simplified illustration of this algorithm follows in Fig. 7, viewed behind the extinguisher.

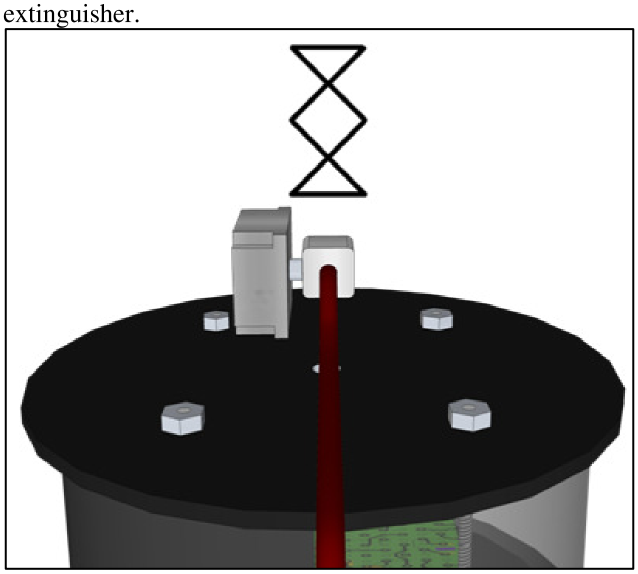


Fig. 7. Shortened firing algorithm rendering with y-stepper

Upon reaching the center of a room, the fire detector will sweep a near 360° radial distance. Upon positive identification of the flame, the sensor will cease the sweep and remain pointed at the fire. The fire extinguisher then is primed to begin the aforementioned algorithm, beginning the y-radial sweep with the stepper motor and then setting pin P1.3 to high and activating the relay, powering the MCP355 water pump. The MSP430 monitors the status of the UVTRON, and when the UVTRON particle detector no longer senses a flame, pin P1.3 will be reset and the extinguisher will cease at the zero degree mark of motion.

D. Line Follower Algorithm

The CNY70 reflective optical sensors that comprise the line detector's three member array connect to one input each of three comparators. The comparators will share a second leg with sets a reference voltage on which they can output a 3.3V that are polled by the MSP430 on three separate ports. When a CNY70 sensor is situated over a white surface, the voltage seen by a comparator from the transistor and over a resistor triggers the comparator and grounds a port in the MSP430 that has been pulled high by an internal resistor. The reference voltage by which the comparators trigger is modifiable through a shared pot.

A three member array will be defined in the code that will represent the status of each CNY70 sensor. The digital conversion by the comparators yield a binary 1 or 0, where 0 corresponds to the CNY70 sensor being situated over a black surface and a 1 corresponding to the CNY70 being situated over a white surface. The previously defined array will be loaded with the values for each sensor in order, with a sample value being 010, representing the line being situated at the exact center of the CNY70 sensor array. What will follow is an algorithm applied to each array, with the array value updating upon completion of the algorithm.

Whenever the center comparator is 1 and both left and right comparators are 0, both motors will turn on. The status of the left and right comparators are trigged on through an interrupt routine that immediately alternates right and left motors respectively, and if both left and right comparators have been triggered, the rover will come to a complete stop and the navigational microcontroller will report to the master upon being polled that it has reached the end stop of the line. It is important to note that the left and right motor separate enables are sometimes called even when the center comparator is high; this is by design and allows for sharper turns on the track.

E. Wireless System and Remote Sensor

After power on and initialization, the remote probe rests in a very low power standby mode. When a pulse is received from the UVTron, the processor wakes up and checks for more pulses to determine if a legitimate fire is present rather than the UVTron picking up a stray UV source. If the fire is determined to be legitimate, the local RN-42 is instructed to establish a connection to the remote RN-42. The remote probe then transmits the byte “0x0F’. Every 30 seconds, the probe re-evaluates the data from the UVTron to determine if a fire is still present. Once the UVTron stops alarming, the RN-42 transmits the byte “0x00” and then disconnects from the remote RN-42. Upon disconnect, the processor goes back into very low power mode, necessary again because of the high voltage low capacity battery used in the remote probe.

VI. Conclusion

The completed HeatSeekr platform represents the union of many diverse and intercommunicating systems representing many disciplines within electrical engineering. Unified under "The Overlord" master processor, the fire extinguishing and navigational systems have been engineered to quickly detect and extinguish a fire in an office environment. Through careful crafting of the required algorithms and the optimization of available processing power, the few weaknesses of the specific hardware choices have been overcome and even positively utilized in the resulting design. Successful derivation of the navigational algorithm and hardware has granted HeatSeekr deployability in a variety of residential, commercial, and industrial environment, enabling a possible future integration into the greater fire protection infrastructure. Supported by an expandable suite of wireless monitors, HeatSeekr can be used as a facility wide solution in conjunction with its expandable and modular track system. By effectively targeting the source of a fire, HeatSeekr has laid the foundation for a comprehensive, facility-wide fire protection strategy, enabling the possibility for pinpoint fire responses that will potentially save sensitive property that would otherwise be lost by less discriminating fire protection systems.

HeatSeekr represents a robust union of many engineering disciplines, and through methodical adherence to design and prototype plans, will easily transition to a high performance, working model. The unique challenges of integrating several complex systems has conferred a greater knowledge of the engineering process to every researcher involved in the creation of HeatSeekr.

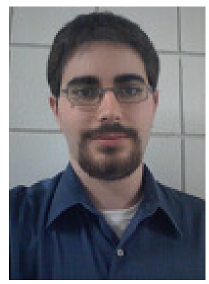
Acknowledgement

The authors wish to acknowledge the assistance and support of the following professors for dedicating their time and knowledge to HeatSeekr success: Dr. Sasan Fathpour, Dr. Michael Haralambous, Dr. Thomas Wu, and Dr. Samuel Richie.

Biography

Bernadeau Charles will be graduating from the University of Central Florida in fall 2013 with a Bachelor's of Science in Electrical Engineering. He plans to enter the work-force shortly after his graduation from the University of Central Florida and attain an MBA within the next year.

Matthew S. Erdelac is currently a senior at the University of Central Florida and will receive his Bachelor's of Science in Electrical Engineering in December of 2013. He has interned twice with Duke Energy – first at the Crystal River Unit 3 Nuclear Power Plant in Florida during the summer of 2012 and then at McGuire Nuclear Station in North Carolina during the summer of 2013. He intends to enter the workforce shortly after graduation with an emphasis on nuclear power generation.



Erik Ferreira will be graduating from the University of Central Florida in fall 2013 with a Bachelor's of science in Computer Engineering. He is currently working at LightPath technologies as a programming intern with a heavy emphasis on hardware and software upgrades. He plans to enter the work-force shortly after graduation with an emphasis on software development.

Armin Sadri will be graduating from the University of Central Florida in Spring of 2013 with a Bachelor's of Science in Electrical Engineering and a minor in Bioengineering. While at the University of Central Florida, he has worked towards gaining experience in the medical and engineering professions through shadowing with local physicians and interning with Advantor where he engaged in PLM practice and design, prototyping and analysis of electrical systems, and ECAD component design. He plans to continue his education in the field of Bioengineering, through either traditional graduate studies or a tertiary medical institution.

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