Traffic Stop Watchdog

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Initial Project Document

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Project Narrative

Law enforcement personnel work in a highly reactive environment that demands focus and attention to avoid life-threatening situations. The ability to rapidly respond to changes in law enforcement scenarios is imperative, and any lack of situational awareness and information capture in these critical moments inevitably leads to obfuscation of events in the ensuing judicial review. Recent events have shown that for the safety of both law enforcement personnel and the public, higher precision information is needed in this line of work.

The "Traffic Stop Watchdog" project is a design proposal to fill a current gap in the information recorded during interactions between police officers and citizens during traffic stops or other exchanges within the vicinity of a police cruiser. Current systems like body-mounted cameras and dashcams often leave much of the scene out of view or out of focus while lacking support for live data communication. This project aims to develop a vehicle-mounted information system that utilizes AI to track a moving target on camera while providing support for a wireless audio recognition device that can be carried by an officer.

Driving the overall requirements for this system are the factors associated with its use. To be vehicle mounted, the design must be lightweight and compact with a strong enough chassis to withstand vibration and acceleration. The camera electronics must be powered off a standard car battery, consuming as little current as possible when the vehicle is off so as to not drain it. The audio recognition device should be a low-power device embedded in a small form factor design so as to avoid weighing down the user. Wireless communication between the devices in the system should maintain a minimum range of at least 500 ft, preferably greater.

By utilizing machine vision algorithms, the system should be capable of resolving more important information in a scene than current cameras. The onboard camera will track the law enforcement officer so as to record only the information vital to the scenario. 360 degrees of rotation and high placement on the vehicle will allow tracking in all directions. To maintain track of a fast moving target, the system will need high responsiveness and an accurate control loop keeping the camera centered. This will necessitate a blend of precision electromechanical design as well as robust software development.

Software Requirements

- Trained object detection model for police officers
- Low response times on image inferences (< 500ms)
- Camera footage recorded (32 GB max storage)
- Keyword recognition for microphone
- ZigBee Radio communication system (500 feet range)
- Accurate camera response movements
- Quick and effective officer-system interface

Hardware Requirements

- 360 degree pan angle, 180 degree tilt angle
- <1 degree angular resolution on both axes
- Weight of camera & mount < 7 lb
- 30-60 FPS at 1440 x 1080
- Low Power Consumption (< 1.5 A @ 12V)
- Low Battery Power Consumption (<200mA on 3.6V LiPo)
- Fast target acquisition
- Environmental feedback (Thermal Monitoring; Over-Voltage, Over-Current Circuitry; Telemetry Logging)

House of Quality Diagram

One of the toughest challenges coming from the customer requirements is getting a fast enough image detection model to both accurately and quickly pinpoint the officer's location on each image. Lower quality images being fed to the model will lead to faster inference times, but lessen the effectiveness of the recorded footage. The camera motion must also be swift enough to not lose sight of the officer, but smooth enough to not blur the incoming images too much.

Table 1

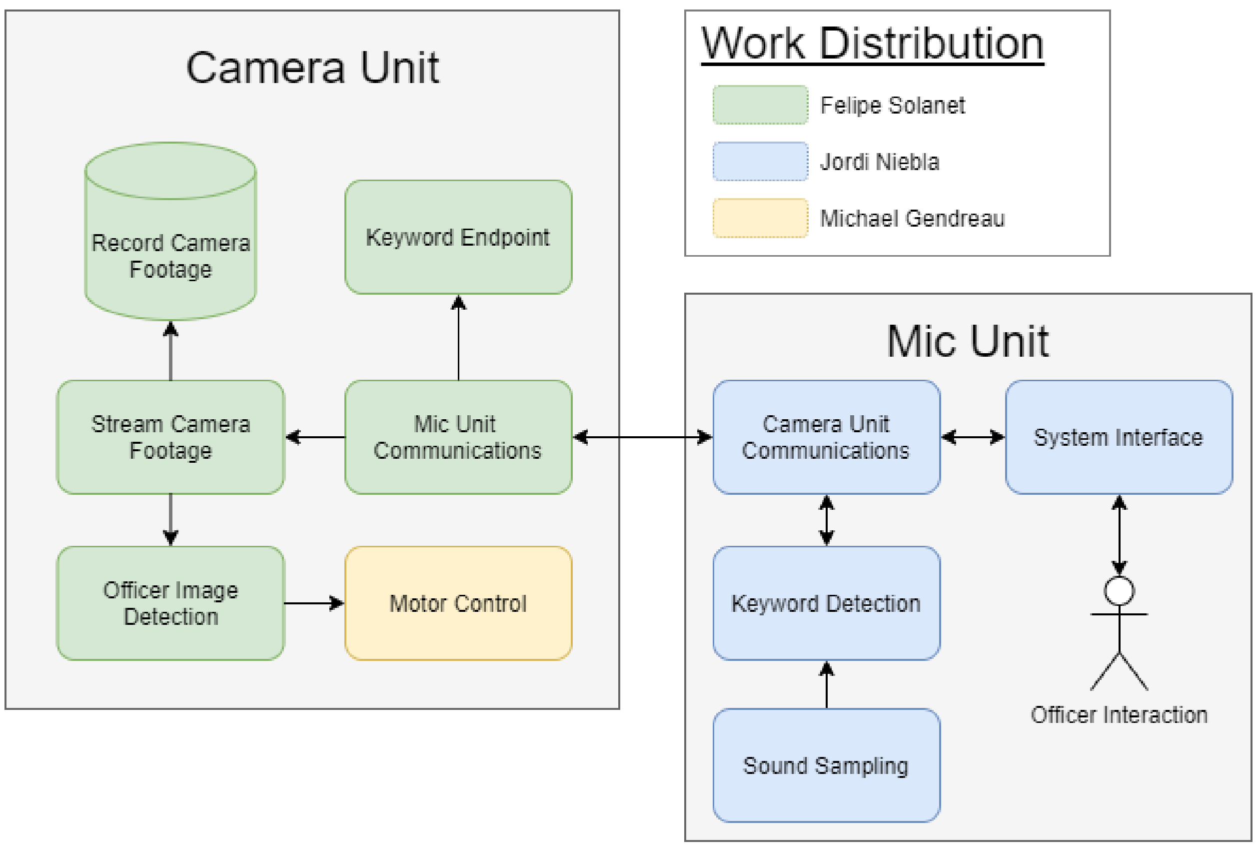
			Engineering Requirements						
			Power Supply	**Camera Response Time**	**Time To Implement**	**Device Communication**	**Dimensions**	**Weight**	**Cost**
			+	-	-	+	-	-	-
Business Requirements	**Officer Footage**	+		↓↓	↑↑				↑
	User Friendly	+			↑	↑	↓↓	↓↓	
	Durable	+	↓		↑↑		↑	↑	↑↑
	Install Ease	+	↓			↓	↓	↓	
	System Integration	+	↑		↑	↑↑	↓	↓	↑
	Cost	-	↑		↓	↑	↓	↓	↑↑
			12V Car Battery	**< 500 ms**	**< Two Weeks**	**> 500 feet range**	**Within 12 x 24 x 12 (LWH)**	**< 7 Lbs**	**< $1200**
			Engineering Targets						

Legend	
+	Positive Polarity
-	Negative Polarity
↑	Positive Correlation
↓	Negative Correlation
↑↑	Strong Positive Correlation
↓↓	Strong Negative Correlation

Software Block Diagram

The officer will use the handheld microphone device to activate and interact with the system. At which point the camera unit will start recording footage and searching for the officer. Once found, the camera will work with the motors to follow the officer. In parallel, the microphone device will be sampling for keywords to send to the endpoint in the camera unit. Once finished, the officer can use the microphone device to shut deactivate the system and stop the camera recording.

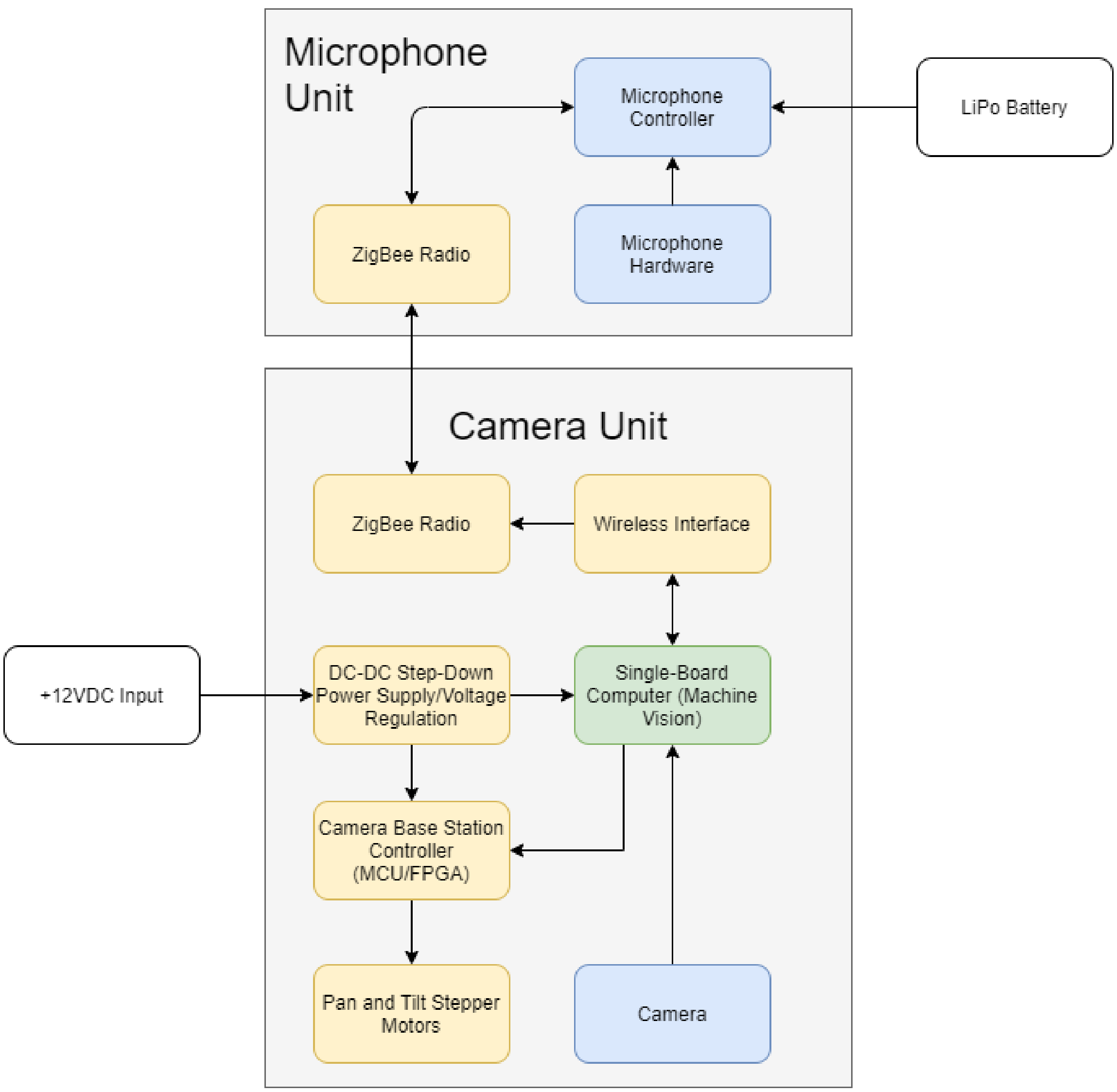
Figure 1



Hardware Block Diagram

Work on the hardware is split between two main groups: the camera assembly and the microphone unit. The camera assembly entails designing and building a two-axis pan and tilt mount for a camera, and integrating the driver electronics and power distribution within a vehicle-mountable form factor. The camera unit will require designing and assembling a small handheld device with a user interface to interact with components of the camera system. Work is divided primarily among Michael and Jordi on the hardware side of things.

Figure 2



Project Milestones

Table 2 shows the initial milestones set out for the project. Each milestone is intended to be achieved on or before the end of the designated week. These milestones also outline the sub-goals for the development, integration, and testing process.

Table 2

Milestone	Achieve by End of Week (SD1 & SD2)
Overall system design	Week 4 (9/14 - 9/18)
Microphone interaction with MCU	Week 5 (9/21 - 9/25)
Pan & Tilt mount design	Week 8(10/12 - 10/16)
Initial trained object detection model	Week 10 (10/26 - 10/30)
Camera library integration	Week 13 (11/16 - 11/20)
Device communication implementation	Week 15 (11/30 - 12/4)
PCB Testing	Week 22 (1/18) - Until Needed
Full software integration	Week 23 (2/22 - 2/26)

Estimated Project Budget

As shown in table 3, the budget for our project is about $1000. As of now, there are no sponsors for our project. Therefore, the total cost will be split between the three team members. The table below shows the higher priced components of our project, with shipping and taxes included. The “Miscellaneous” section in Table 3 includes two police officer outfits that will be used to train the FireFly DL camera for the machine vision process. This brings the total estimated cost of the project to about $765. With the $1000 budget, there is $235 leftover for any extra expenses or malfunctions.

Table 3

Major Components	Estimated Price
Mechanical Components	$160
FireFly DL Camera	$320
ODROID-XU4 (SBC)	$80
PCB and Components	$100
Voice Recognition Module	$40
Zigbee Radio	$25
Miscellaneous	$40
Total	$765