Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

Project name: WIZARD

Team Members: William Fenno, Conner Mullen

Sponsor: Dr. Markus Zink

German Team Members: Leon Jaksch, Michael Dachender, Lisa Krug

Project Sponsor & Collaborators

- Sponsor:

  Professor Markus Zink

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- German Team Students:

  Machine Learning: Leon Jaksch

  High Voltage: Michael Dachender, Lisa Krug

Problem Statement

- Organic farming practices face significant challenges in controlling weeds within crop fields and need an ecological method of eliminating weeds with minimal time investment and labor use.

Solution Proposal

- Develop an autonomous robot system equipped with machine learning camera recognition and a targeted high voltage impulse zapper to effectively identify and eliminate weeds.

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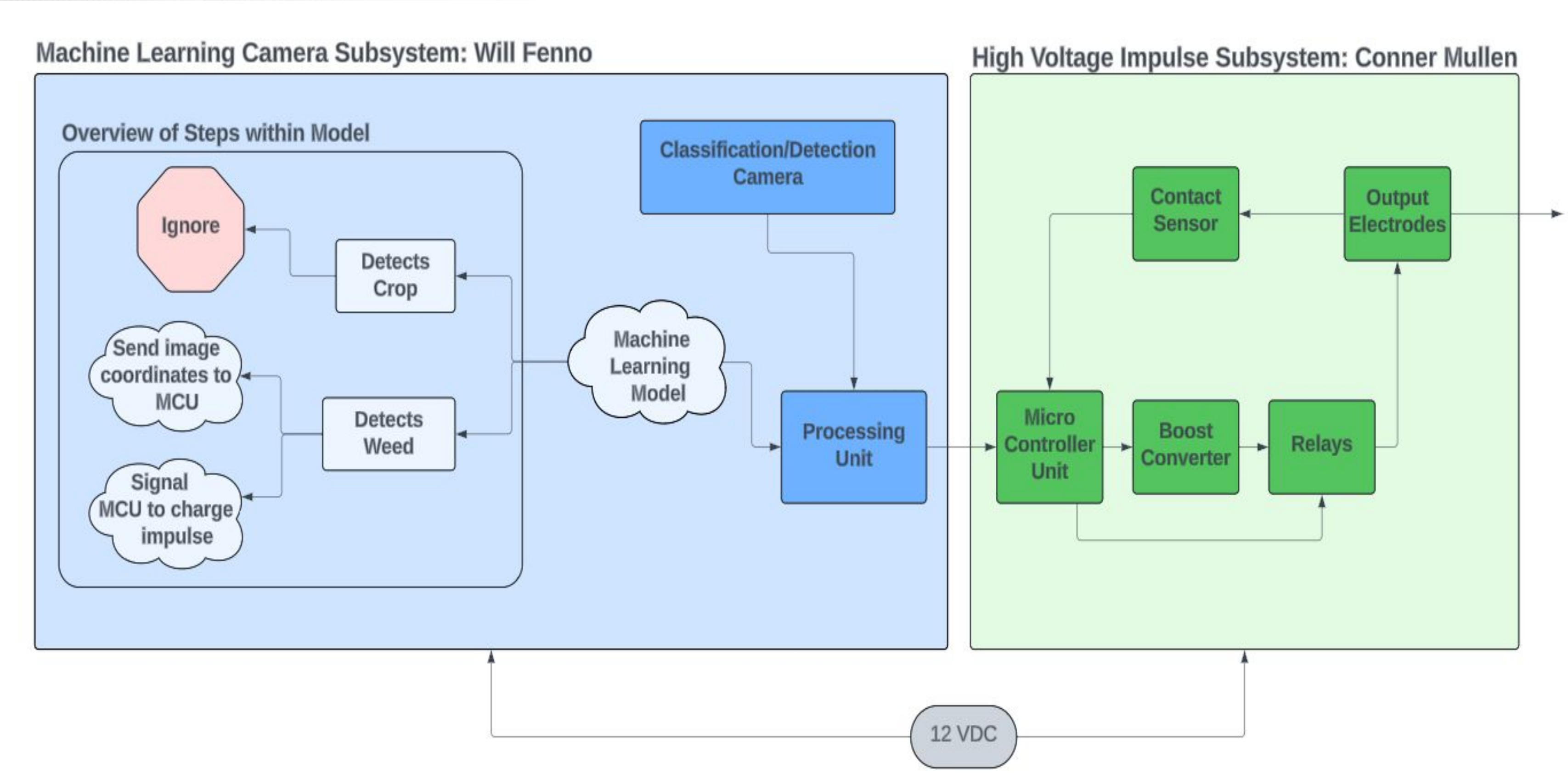
Diagram of Subsystems & Interface



ML Component Tradeoff Table

Processing Unit:

	Processor	VRAM/Memory	Power Consumption	AI Performance	Ease of Use	Operations
Nvidia Jetson Nano	Quad-core ARM Cortex-A57	4GB LPDDR4	5-10W (depending on load)	472 GFLOPS	JetPack SDK, strong AI development tools	AI applications, real-time object detection
Raspberry Pi 4	Quad-core Cortex-A72 (Pi 4) + Edge TPU	2GB, 4GB, or 8GB (depending on model)	5V (Pi 4) + low power for Coral	4 TOPS (with Coral USB Accelerator)	Requires TensorFlow Lite and Coral setup	General computing with added AI capability
Khadas VIM 3	Amlogic A311D (Hexa-core)	4GB LPDDR4	5-20W (depending on load)	5 TOPS (NPU)	Good, with Android and Linux support	AI-specific tasks
Odroid-N2+	Rockchip S922X (Hexa-core)	4GB LPDDR4	5-10W	3 TOPS (NPU)	Good, but less streamlined	General computing + AI tasks

ML Component Tradeoff Table

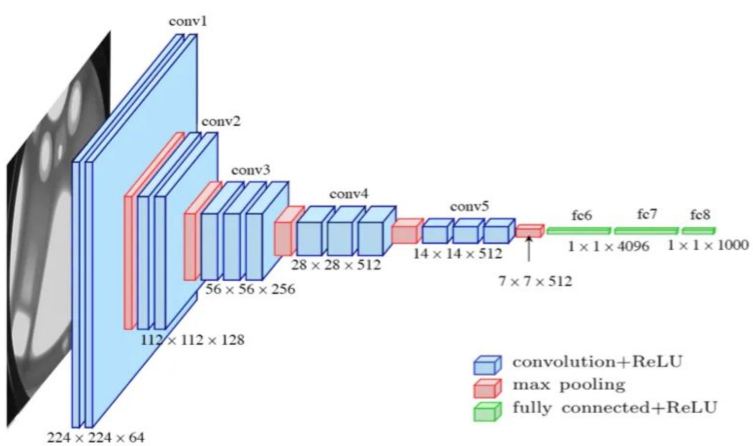
Camera:

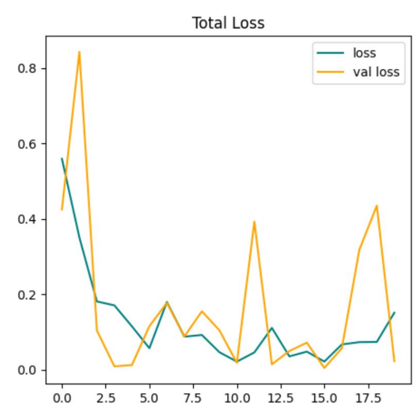
	Resolution	Frame Rate	Field of View (FOV)	Connection Interface	Use Cases
Raspberry Pi Camera Module V2	8 MP (3280 x 2464)	30 fps at 1080p, 60 fps at 720p	62.2° horizontal, 48.8° vertical	MIPI CSI	General-purpose use, outdoor projects
IMX219-83 Stereo Camera	8 MP (3280 x 2464)	1080p @ 30 fps	85° horizontal	MIPI CSI	Stereo depth vision
Sony IMX290	2 MP (1920 x 1080)	120 fps at 1080p	80° horizontal	MIPI CSI	Low-light applications
Leopard Imaging LI-IMX477	12.3 MP (4056 x 3040)	60 fps at 1080p	76° horizontal, 65° vertical	MIPI CSI	High-resolution imaging

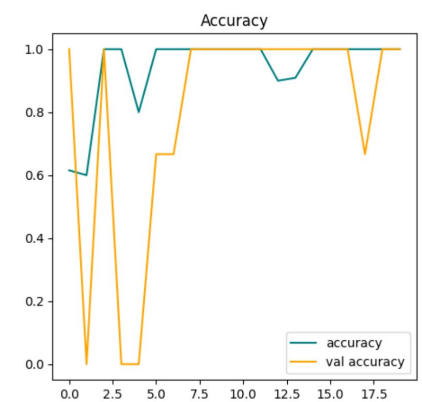
ML Camera Subsystem -

William Fenno

Accomplishments since the last presentation 40 hours	Ongoing progress/problems and plans until the next presentation
Finalized component selection. Added background images and labels to the dataset. Modified VGG16 architecture implementing classification and regression heads.	Ordering components. Still editing the model architecture to get better results. Total validation losses and accuracy are not very stable during training due to overfitting.







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High Voltage Generator

	Pros	Cons	Choice
Cockroft-Walton Generator	- Simple design - Multiplication, not addition - Each capacitor only holds 2x peak input voltage - Repeatable	- Requires alternating input; we are using DC power	Will Use This for Both Stages
DC-DC Boost Converter	- No need for DC-AC or AC-DC conversion	- Requires PWM signal - Needs multiple stages to reach viable voltage	Not Used for High Voltage
Op-Amp		- VCC sets upper limit for output	Not Viable

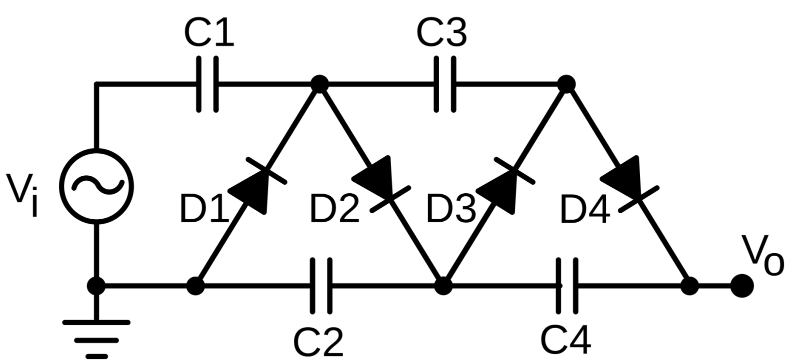
Alternating Voltage Source

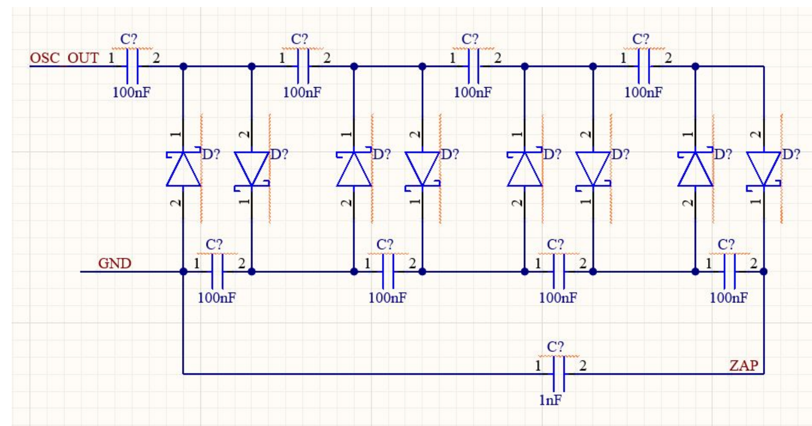
	Pros	Cons	Choice
555 Timer (NE555DR)	- Well documented - Necessary components are readily available - Full customization	- Maximum output current of 200mA - Cannot achieve perfect 50% duty cycle	Best Option
H-Bridge	- Well documented - Fairly simple to construct	- Requires external control signal - Dead time and short considerations	Alternative
Signal from Jetson	- Simple	- 2mA current limit	Not Viable

High Voltage Subsystem

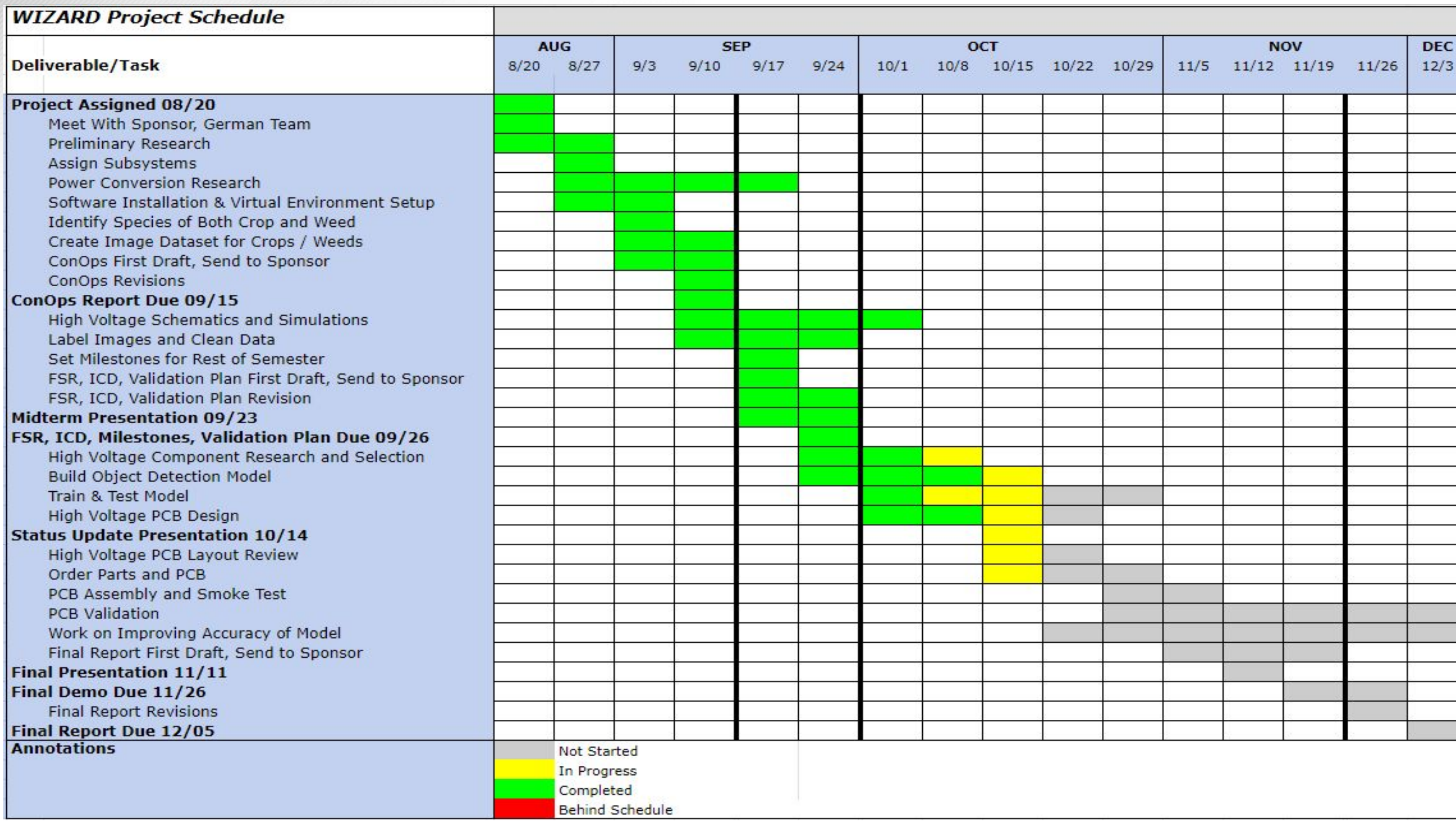
Conner Mullen

Accomplishments since the last presentation 25 hours	Ongoing progress/problems and plans until the next presentation
Crockroft-Walton Generator High Voltage Generation Schematics in Altium	Choose connectors for inputs and outputs Relays and Control Logic PCB Layout





Execution Plan



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Validation Plan

Paragraph #	Test Name	Success Criteria	Methodology	Status	Owner
3.2.1.1.	Capacitor Charge and Discharge Time	Time between start of charge up and end of discharge is less than 8 seconds	Measure voltage across output electrodes throughout a charge and discharge cycle, calculate time delta	UNTESTED	Conner Mullen
3.2.1.2.	Electrode Discharge Mode	Electrodes are only connected to high voltage output after contact is detected	With no contact: confirm that the voltage across electrodes is low With contact: confirm that indicator LED is on, and that the voltage across electrodes is high	UNTESTED	Conner Mullen
3.2.1.3.	False Positive Rate	FPR of less than 5% to prevent unintended crop damage	Conduct image classification test using a validation set with known crop and weed labels. Track the number of images where crops are incorrectly identified and calculate results	UNTESTED	Will Fenno
3.2.1.4.	False Negative Rate	FNR of less than 5% to prevent missed weeds	Conduct image classification test using a validation set with known crop and weed labels. Track the number of images where weedes are incorrectly identified and calculate results	UNTESTED	Will Fenno
3.2.1.5.	Camera Field of View	System detects objects at a range of 62.2 degrees horizontally and 48.8 degrees vertically	Measure the system's response to objects placed inside and outside the specified field of view	UNTESTED	Will Fenno
3.2.2.1.	Electrode Placement	Arcing does not occur across electrodes	Charge system to maximum voltage, visually confirm that no arc forms	UNTESTED	Conner Mullen
3.2.2.2.	Mounting	All components are secured properly	Visually inspect all connections to the robot or other platform, then attempt to move mounted components around to test strength of mounts	UNTESTED	Full Team
3.2.4.1.	Power Source	12V DC is converted to correct input voltages (after components are selected, exact values will be provided)	Before powering on: Perform continuity test for all 12V points Power on board with 12V DC source and test voltage at output of power converters	UNTESTED	Conner Mullen
3.2.4.2.	Inputs	All buttons/switches work as expected, as indicated by LEDs	Power system on, set to each combination and confirm that the proper LED indicators are on, and test for necessary continuities	UNTESTED	Conner Mullen
3.2.4.3.	Outputs	LEDs all light up under correct circumstances Energy discharges through electrodes (Germany)	Verify that proper LEDs light up under proper circumstances Charged capacitor is discharged following contact with target plant	UNTESTED	Conner Mullen
3.2.4.4.	Interface Between Processor and Electronics	I2C signal sent from processor is received by MCU, correct output is observed (specific output and input signals will be updated as we finalize designs)	Send I2C commands from processor to microcontrollers, verifying that every necessary function is initiated properly	UNTESTED	Full Team
3.2.5.1.	Temperature (Thermal Resistance)	System functions in complete range of temperatures (10C to 45C)	Low end of temperature range exists outside in Texas, high end will be created with temperature chamber	UNTESTED	Full Team
3.2.5.2.	External Contamination	Large particles are kept out of the electronics casing	Bombard empty casing with dirt, grass, and other particles; open casing and visually inspect inside	UNTESTED	Full Team
3.2.6.1.	Built-In Test (BIT)	The system will activate a red LED in the case of camera failure during the startup process	Intentionally simulate camera failure via disconnection to verify LED activation response	UNTESTED	Will Fenno
3.2.6.2.	Isolation and Recovery	In the case of a BIT fault, the system will be reset and restore normal operations	Conduct a reset test in response to a camera detection failure	UNTESTED	Will Fenno
Note	Specific values and signals will be included as we continue to develop and finalize our designs				

High Voltage Considerations

Capacitor Value Requirements:

- Availability (In Stock, Price)
- Charge Speed
- Amount of Energy Stored
- High Voltage Tolerance
- Choice: HVCC153Y6P102MEAX (1nF)

Diode Requirements

- Fast Switching
- Sufficient Reverse Voltage Tolerance
- Low Forward Voltage Drop
- Choice: SK520B Schottky Diode