PORTFOLIO

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Outline

Design

Manufacturing

Firmware

Software

Integration

Pedal Box

Stirling Engine

Dashboard

Object Recognition

Cube Thrower

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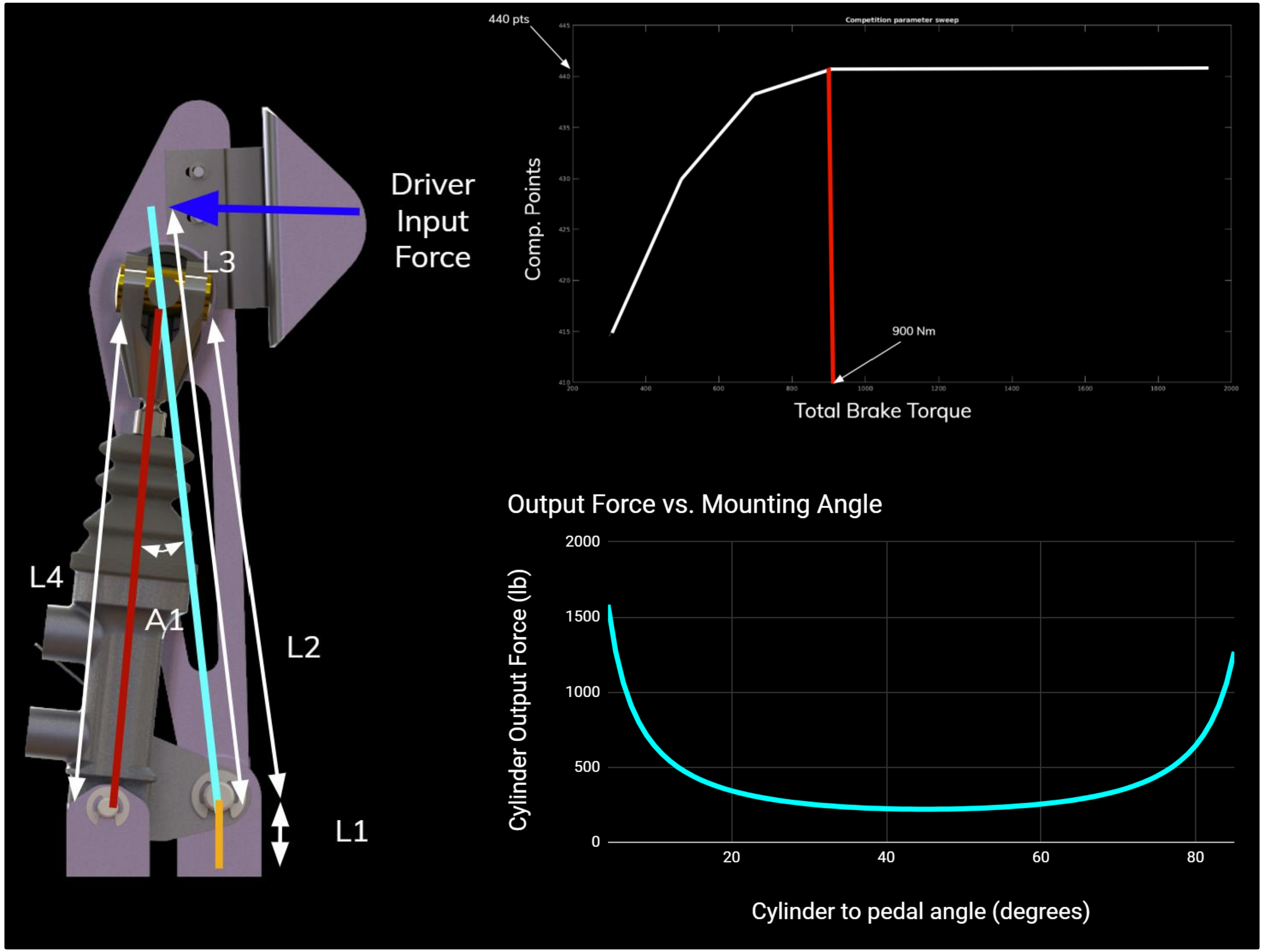
Design Criteria

Pedal box for a FSAE Electric Racecar

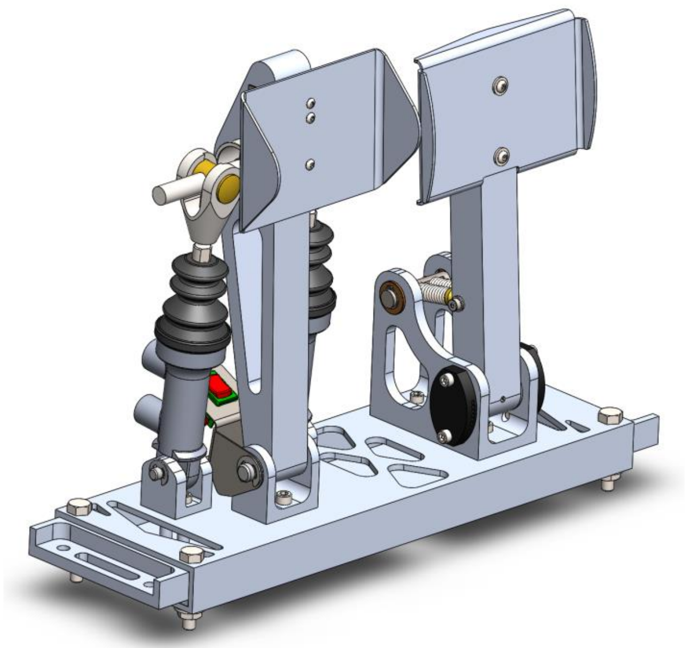
- Target 900 Nm (663.81 ftlb) rotor torque from tire model simulations
- Pedal actuation needs to be measured to actuate regenerative braking
- Must have small footprint to fit in impact exclusion zone



Vertical cylinder orientation maximizes output force within Packaging requirements

Design Optimization

- Design optimized for maximum braking force
  - Selection of sintered steel pads for highest μ avg of .55 (CP4226D27-RX)
  - Smallest MC bore diameter possible with 70% F/R braking to maximize line pressure
  - Largest caliper bore diameter and effective rotor radius within packaging constraints (CP4226-2S0)



Driver foce on pedal	**95 lb**	
MC Output Force	**541.32 lb**	
	Front	**Rear**
Balance Bar Bias	0.6	0.400
Master Cylinder Force	324.79 lb	216.53 lb
Master Cylinder Bore Diameter	0.55 in	0.70 in
Master Cylinder Piston Area	0.24 in^2	0.38 in^2
Master Cylinder Output Pressure	1367.06 psi	562.63 psi
Line Pressure	**1367.06 psi**	**562.63 psi**
Caliper Piston Diameter	1.00 in	1.00 in
Caliper Piston Area	1.566 in^2	1.566 in^2
Clamping Force on rotor	2140.14 lb	880.80 lb
Rotor-pad CoF	0.55	0.55
Friction Force on Rotor	**1177.08 lb**	**484.44 lb**
Number of calipers on axle	2	2
Effective Rotor Radius	3.34 in	3.34 in
Rotor Braking Torque	3931.43 in*lb	1618.04 in*lb
Tire Diameter	15.50 in	15.50 in
Tire Radius	7.75 in	7.75 in
Tire Longitudinal Force	**507.28 lb**	**208.78 lb**
Front Rear braking ratio	**0.71**	

Preliminary Testing Data and Sensors

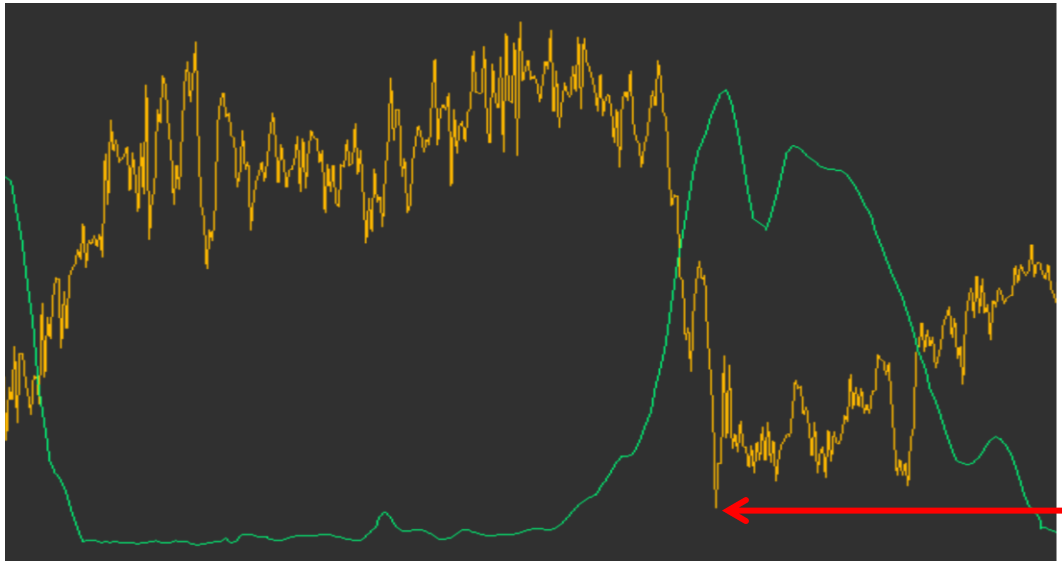
Initial testing of partial retrofit with 30-0 mph stops

= X acceleration (m/s^2)

= Driver input force (lb)

Peak deceleration 13.5 m/s^2

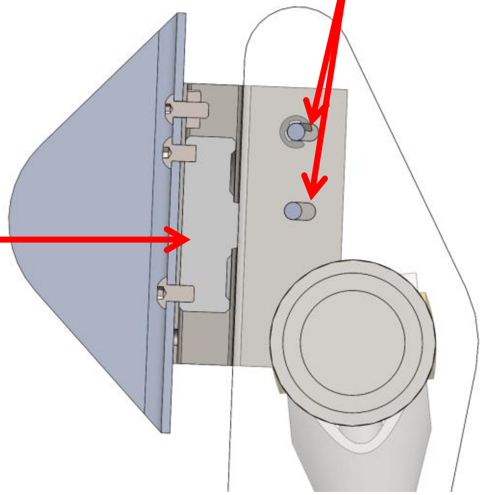
240 lb driver input



- Sensor suite used to measure braking forces
  - Pedal load cell mounted with zero force members
  - Line pressure sensors measure front/rear bias
- Hydraulic braking sensors used to calculate regen torque per corner

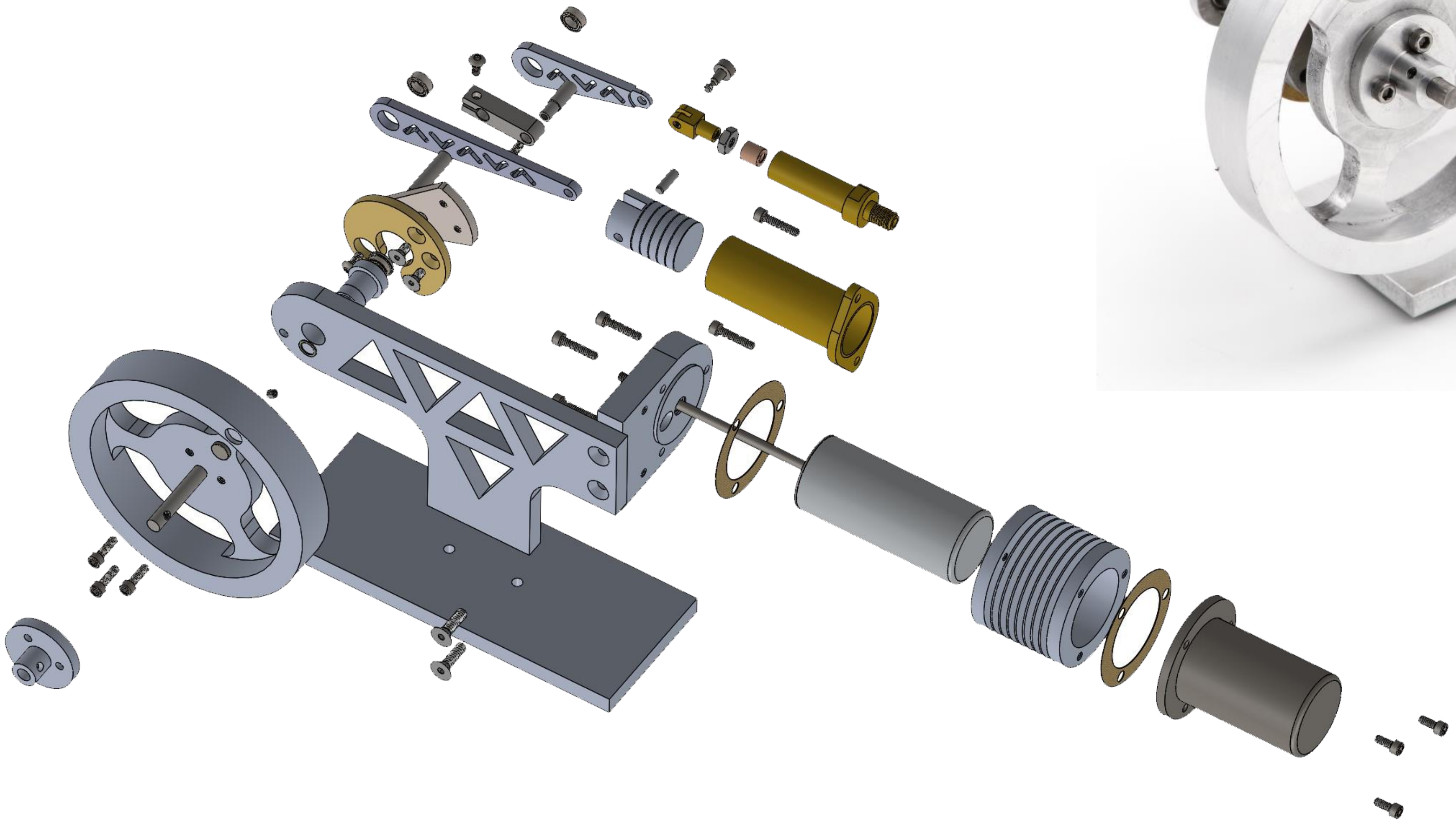
Zero force mounting pins

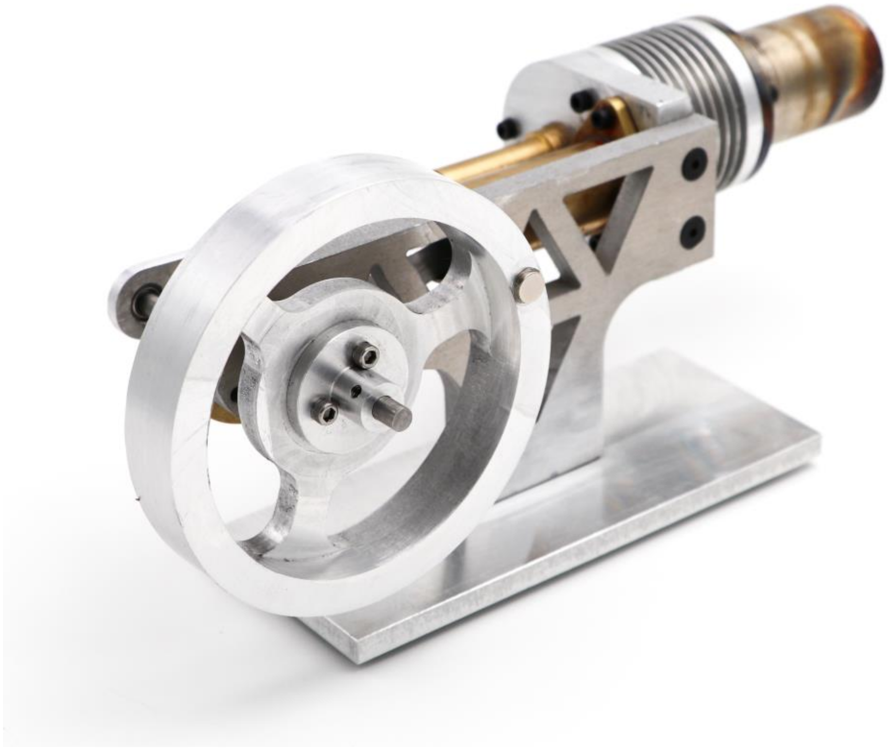
Load cell



Gamma Type Sterling Engine

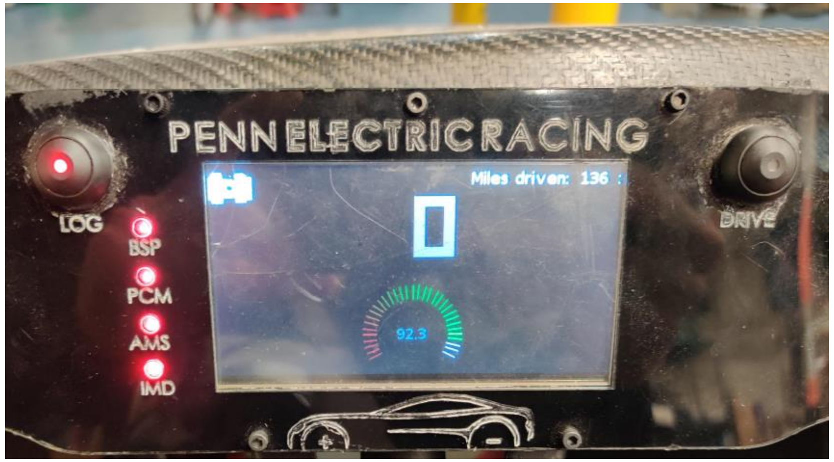
- Machined 19 parts with manual milling, lathe and CNC toolpaths
- Engine spun at over 1800 rpm

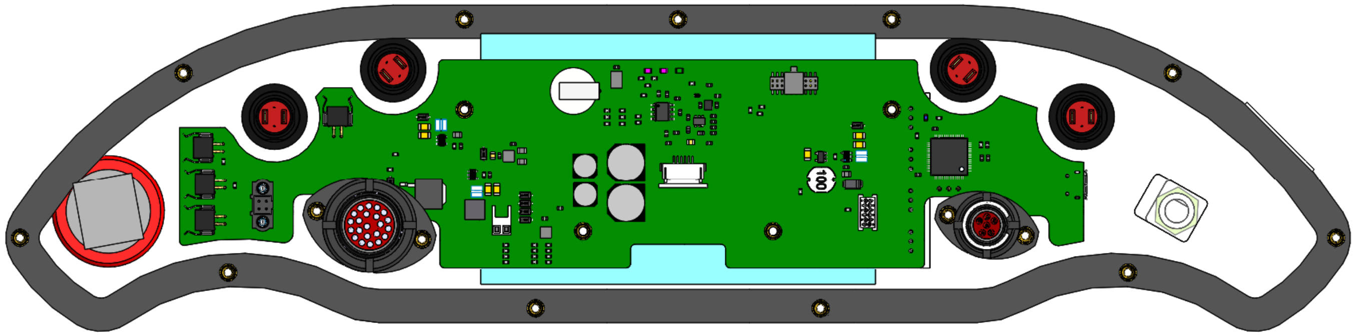


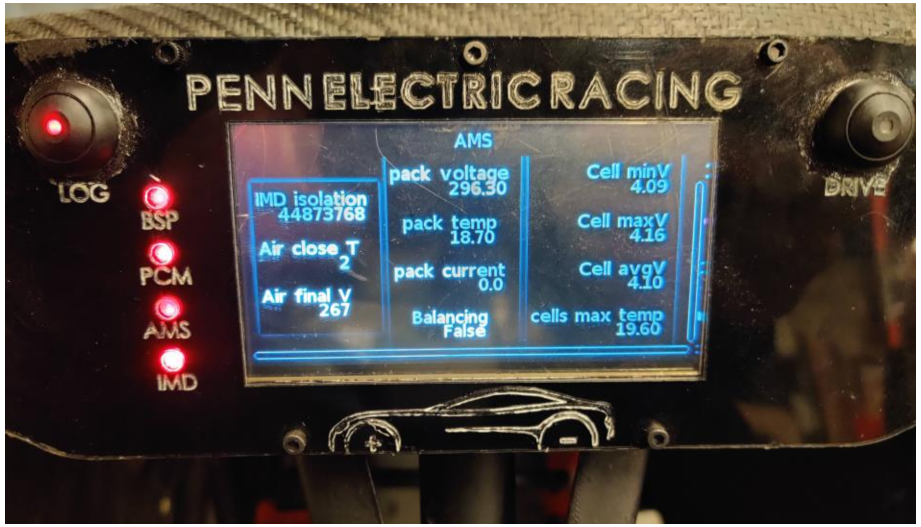


Dashboard

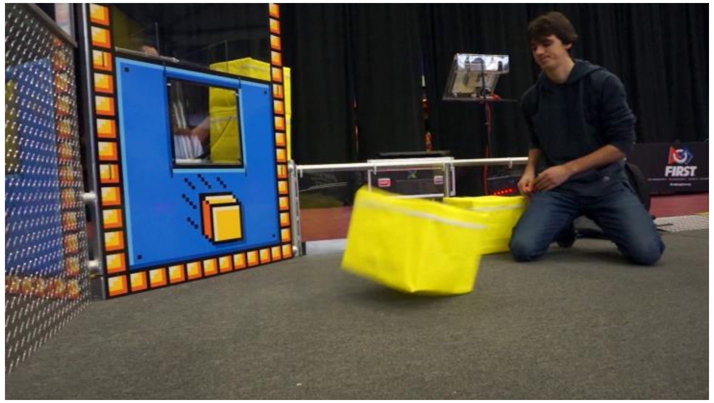
- Bare metal GUI implementation backed by LittlevGL
  - Enhanced driver performance with pace meter and energy meter
- Enables instantaneous debugging
  - Displays all vehicle soft faults, hard faults and critical information
  - Reduced debugging time from minutes to seconds



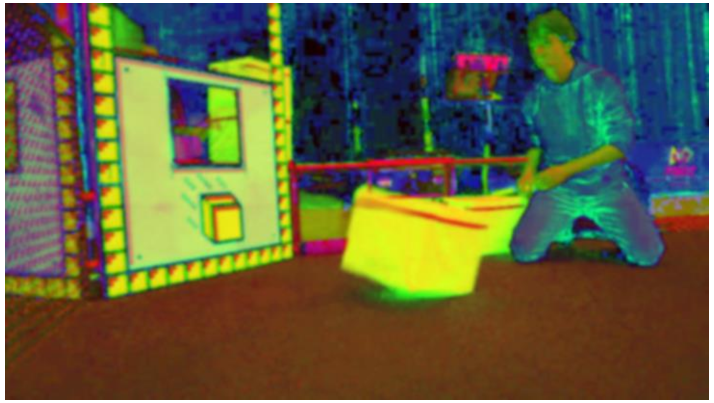




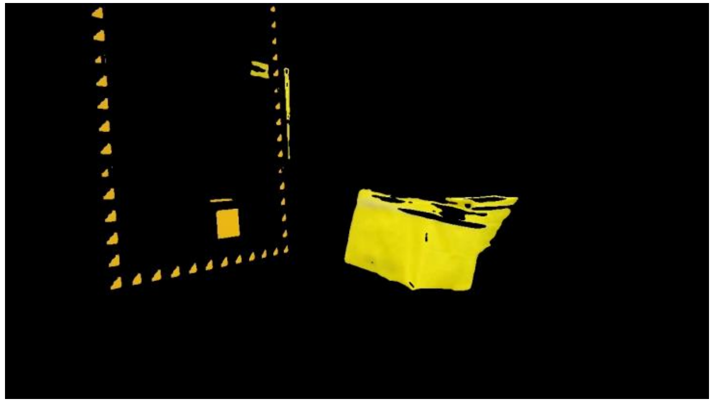
FRC Vision Based Autonomous guidance



Original frame

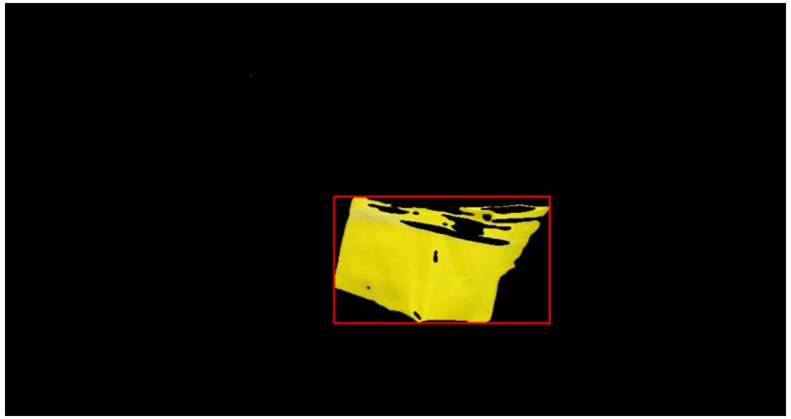


HSV color space and gaussian blur to close loose geometry



Contour masking - dynamically adjusted to lighting conditions

- 60 fps on a Jetson Tx1 co-processor with OpenCV
  - Position tracking performed with integration of onboard accelerometer
  - Cube and target zone positions mapped into 2d space
  - Linear path planner from cubes to scoring zones
- Integrated with powered cube thrower
  - Detection, grabbing and throwing a cube onto target zone



Stray contour removal, object bounding and centroid calculation

Powered Cube Thrower

- Automatic cube intake and hold
- Designed, manufactured, and tested
  - Aluminum MIG welded frame
  - PID angle controler - Java
- Throws 5lb object over 15ft
  - Ingestion, aim and launch in under 3 seconds