LED Pathfinder

Druck Green and André Walker

Motivation

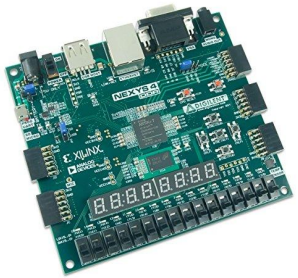
Gain experience working with different hardware peripherals

Wanted to make something interactive

Design Overview

Resources:

- RC Tank
- Nexys 4 FPGA
- OV7670 Camera
- 4 IR LEDS



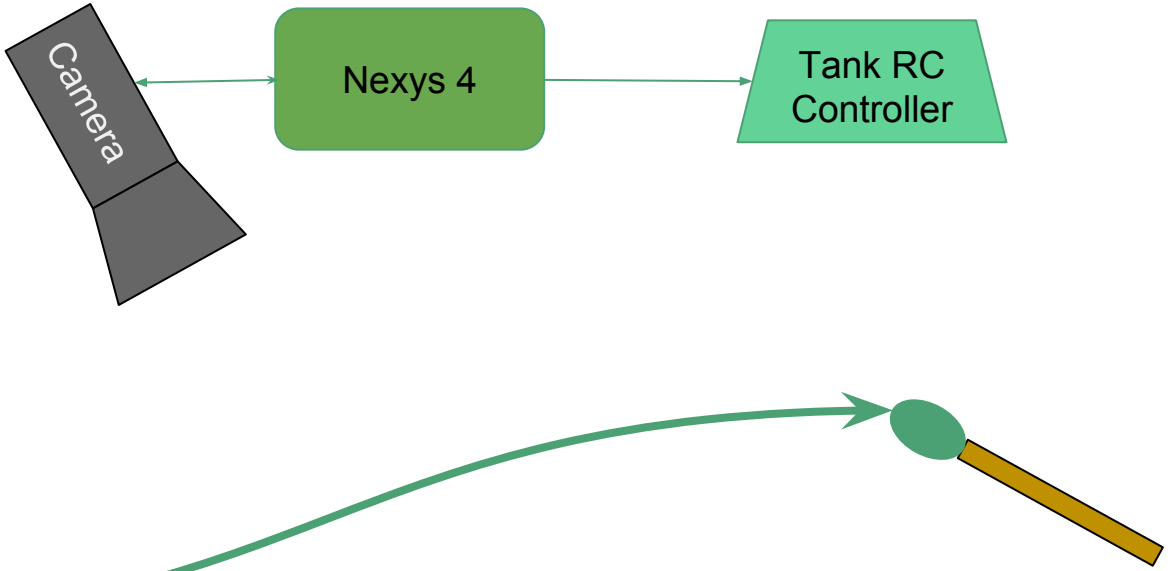
Store camera frame in BRAM

Process frame to pick out coordinates of tank/LED wand

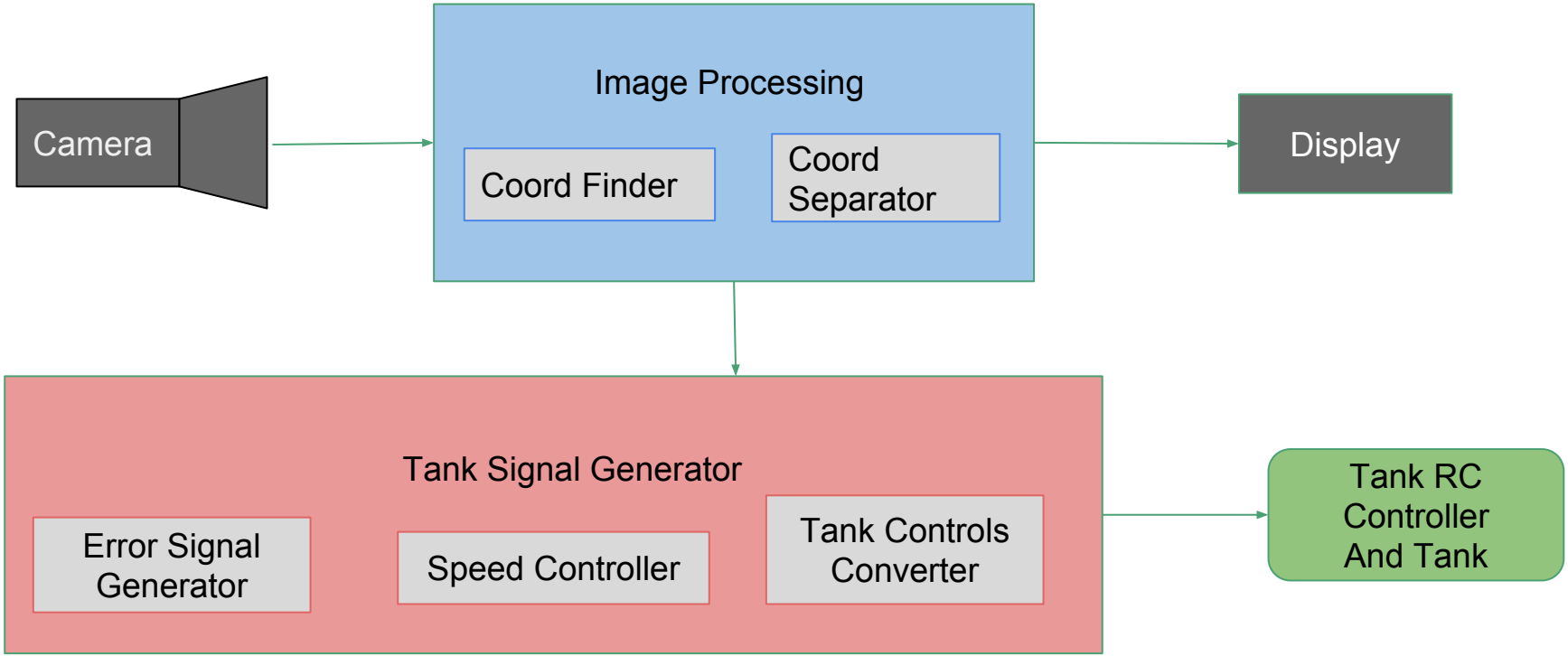
User draws a path with wand which is stored in BRAM

Compute control signals to make tank follow path

Setup



High-Level Block Diagram

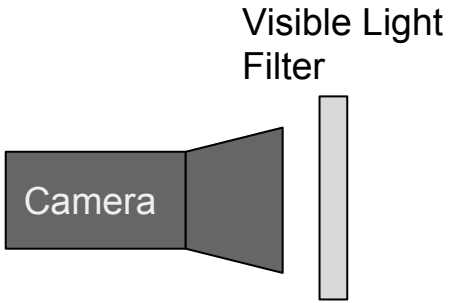


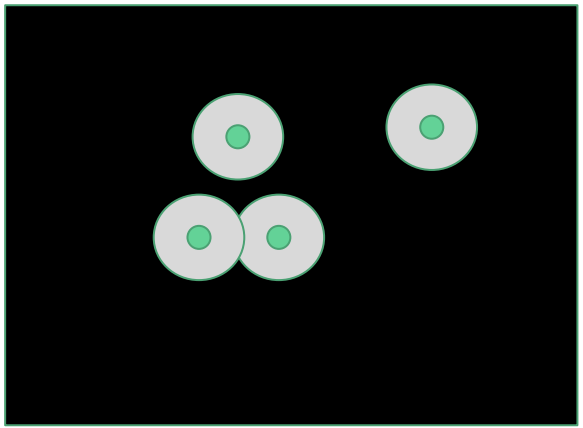
Coordinate-Finder

Filter a single video frame with a skeletonization convolution filter

Average to find LED center

Send the computed coordinates to the Coordinate-Separator





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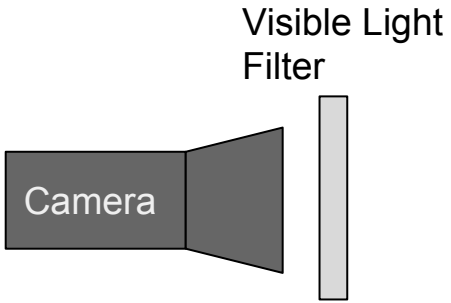

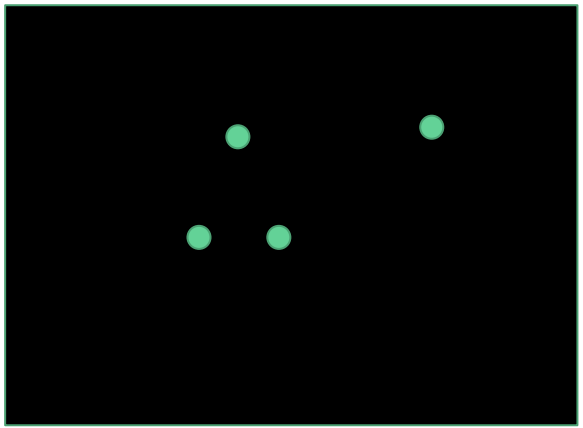

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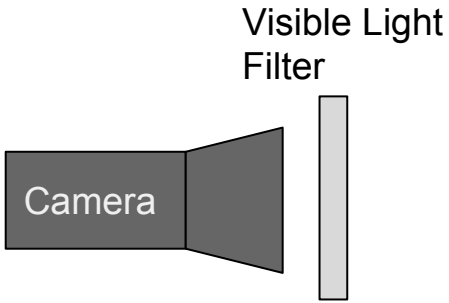
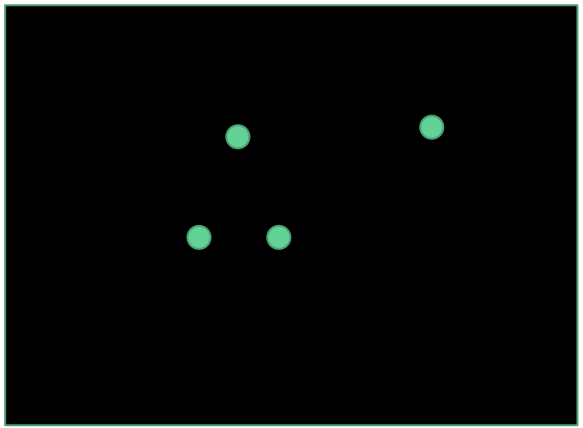


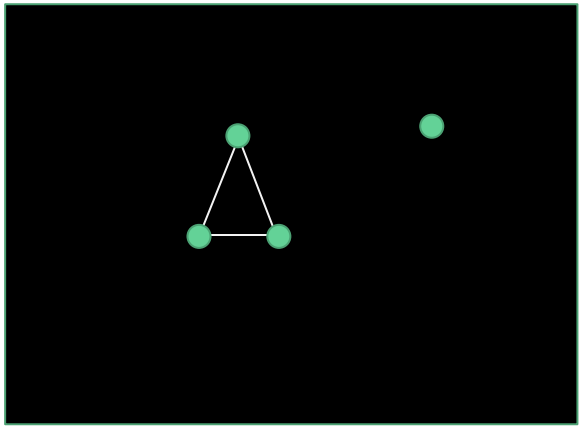


Coordinate Separator

Distinguishes between the Tank and Wand LEDs

Compare distances between sets of the four LEDs

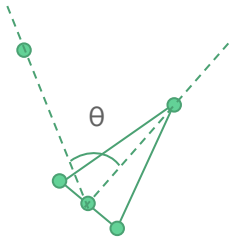
Find the combination that matches the isosceles triangle of LEDs on the tank



Error Signal Generator

Takes in coordinates of the tank LEDs and reads the next coordinate of the wand from BRAM.

Calculates midpoint of the back LEDs of the tank and uses that point as a reference to calculate the angle between the tank's orientation and the next point on the path.



Calculates the distance (in pixels) from the path to the front tank LED.

Speed Controller

Takes in the error measured in the angle and distance, and outputs the desired linear and angular speed of the tank.

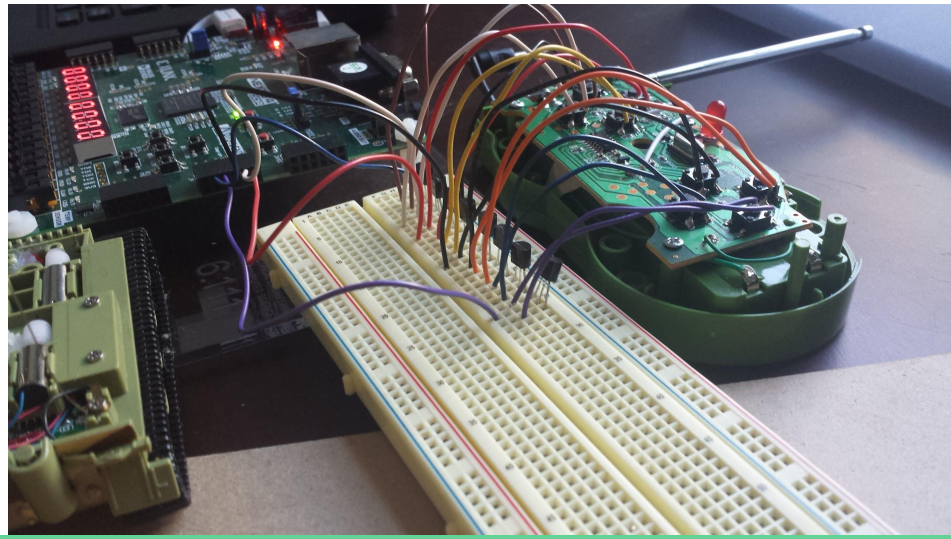
First pass of this module will be a simple proportional controller.

After the full system has been tested we will implement a proportional-integral controller for better performance.

Tank Controls Converter

Takes in desired speed values and outputs the appropriate PWM signal to NFETs, which have been placed in parallel with the buttons on the tank remote.

Minimum duty cycles which produce minimum and maximum tank movement is found via “guess-and-check.”



Timeline

Week of Oct. 30th - Andre - Camera Display, Druck - Car Control Converter

Week of Nov. 6th - Andre - Coordinate Finder , Druck - Speed Controller, Error Signal Generator

Week of Nov. 13th - Andre - Coordinate Separator, Druck - Integrate/Test Tank Signal Generator

Week of Nov. 20th - Andre - Integrate Top Level Module, Druck - Shape Recognition Module, Both - Debugging/Testing Whole System

Week of Nov. 27th - Andre - Overlay Path/Tank Sprites on Path, Druck - Implement Tricks Mode, PID Speed Controller, Both - Finish Testing/Debugging

Week of Dec. 4th - Both - More Testing/Debugging

Stretch Goals

Tricks mode

- Shape Recognition Module

Path planning mode

- User draws boundaries for tank and decides endpoint
- Tank finds its way to the endpoint without crossing boundaries

Use correlation to find tank position and direction

- Eliminates the need for mounted LED and IR filter

Questions?