# Autonomous RC Racecar

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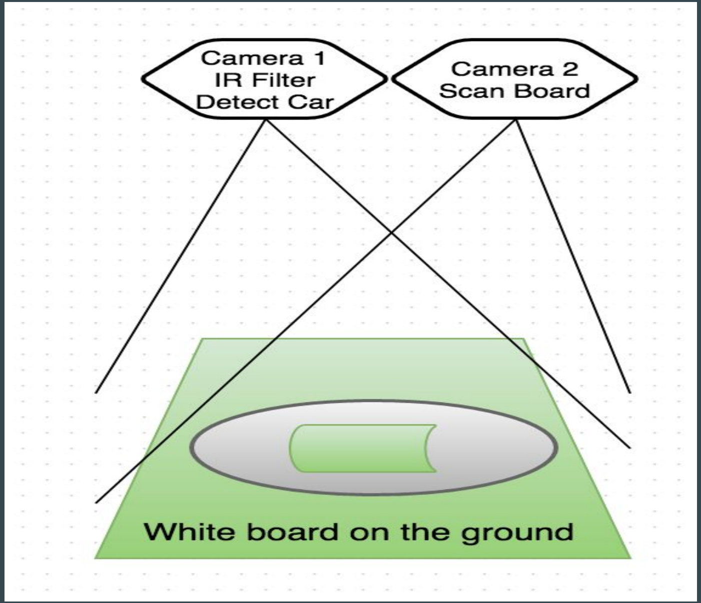
# Overview of Project

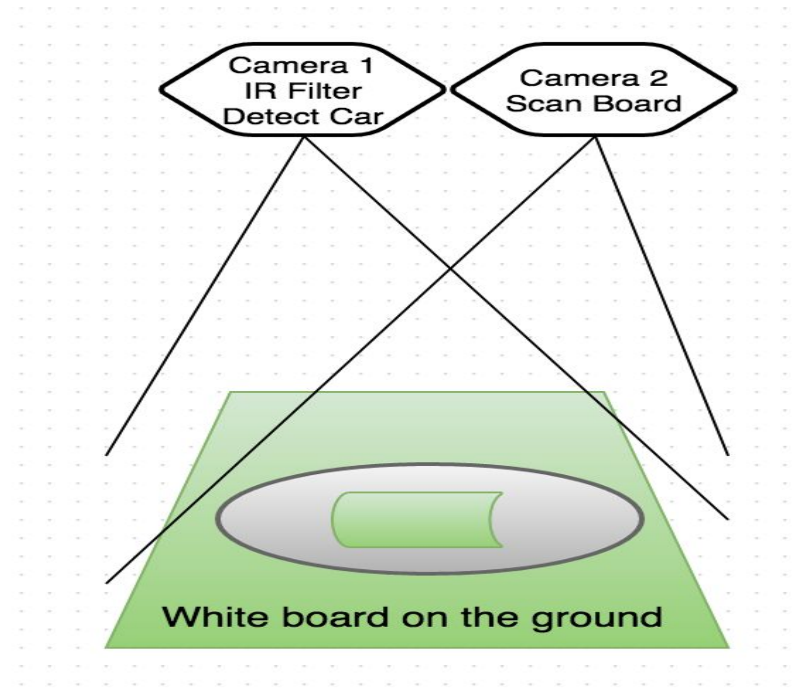
- Build an autonomous RC race car to drive on *any* track.
- Draw a map on a whiteboard and have the car drive the track automatically.



# Motivation

- Interest in using advanced peripherals for the FPGA
- Sought a project that was suited to FPGA’s purposes
- Popularity of driverless cars, Stanford’s Shelley Autonomous Car
- … because racecar!

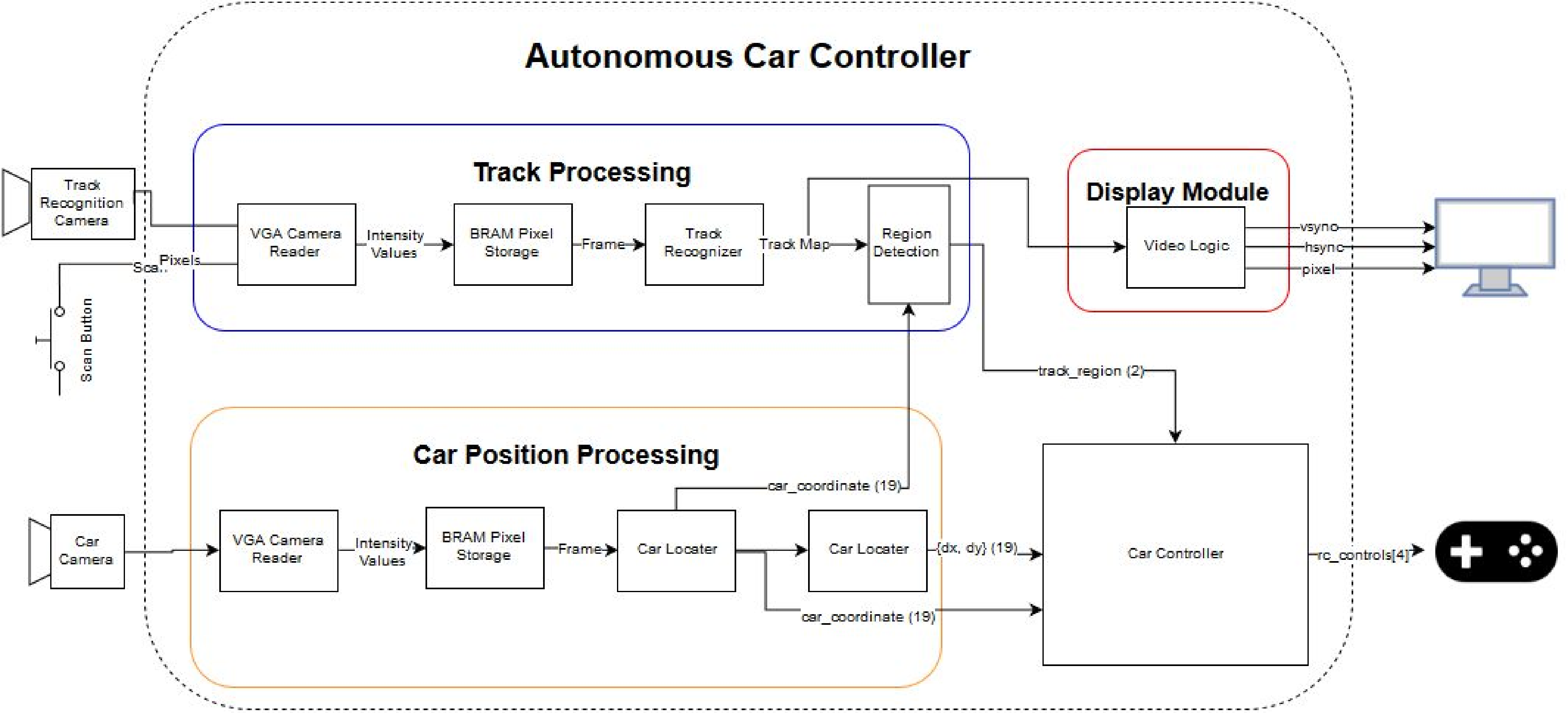
# Physical Set up



- Used car with IR led, and Camera with IR filter to detect car position (Camera 1)

- Camera 2 to process the track

# Autonomous Car Controller



## Track Processing

Track Recognition Camera

Scan Button

Sca..

Pixels

VGA Camera Reader

Intensity Values

BRAM Pixel Storage

Frame

Track Recognizer

Track Map

Region Detection

## Display Module

Video Logic

vsync

hsync

pixel

track_region (2)

## Car Position Processing

Car Camera

VGA Camera Reader

Intensity Values

BRAM Pixel Storage

Frame

Car Locater

car_coordinate (19)

Car Locater

{dx, dy} (19)

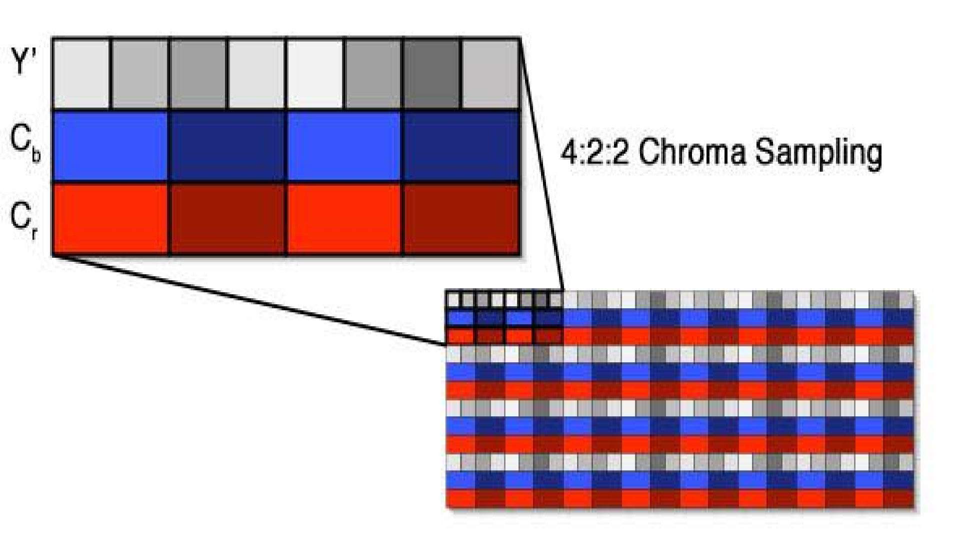
car_coordinate (19)

Car Controller

rc_controls[4]

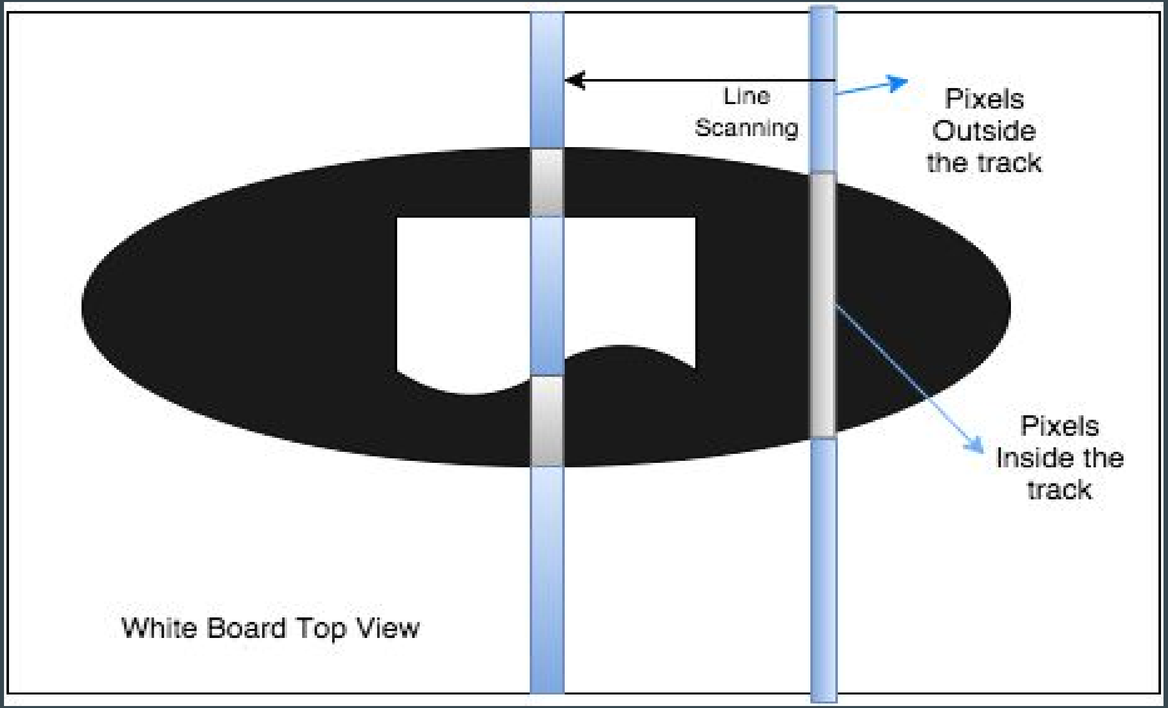
# Paper Track Processing

- YUV 4:2: 2 Format is used



- Converts picture into grayscale using Y information
- Classify each pixel as a part of track or not
- Identify regions of the track: Outside the track, track, inside track

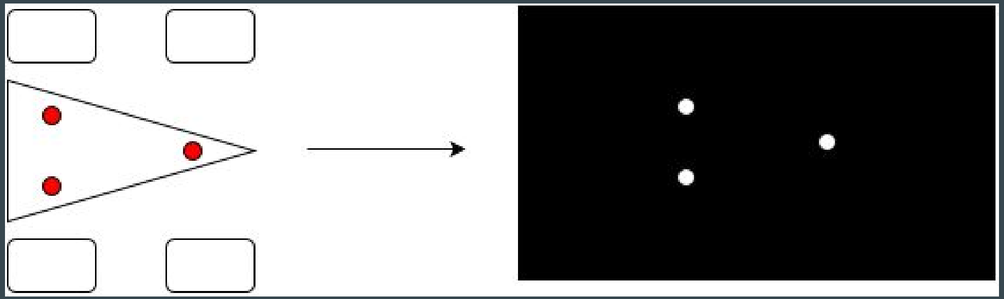
# Example Track (Track is closed loop)



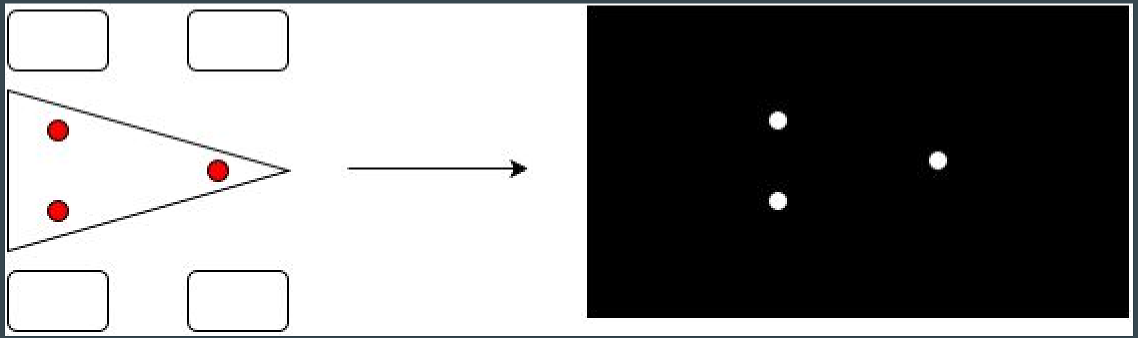
- Line scan algorithm will be used to classify pixels as boundary, outside the track, and inside the track
- Assumes that track is fully closed inside the whiteboard area. (No track edge can be in whiteboard area)

# Car Position Processing

- Car controller requires visual feedback
- LED’s on roof of car to identify position and heading
- Use camera with IR band-pass filter to make center of mass determination easier
- Special considerations:
  - Speed
    - High video FPS, fast algorithms to locate car
    - Asynchronous with video FPS
  - Accuracy



# Car Position Processing



Center of mass calculation for each blob:

- Thresholding
- Calculation of mean x and y coordinates for “blobs” of adjacent white pixels

# Car Controller

Two primary purposes:

- Determine corrective actions to stay on track
- Send proper commands to RC car

# Car Controller - Turning Control

Car Controller will receive the region of the map it is currently in and will be if it’s movement continues

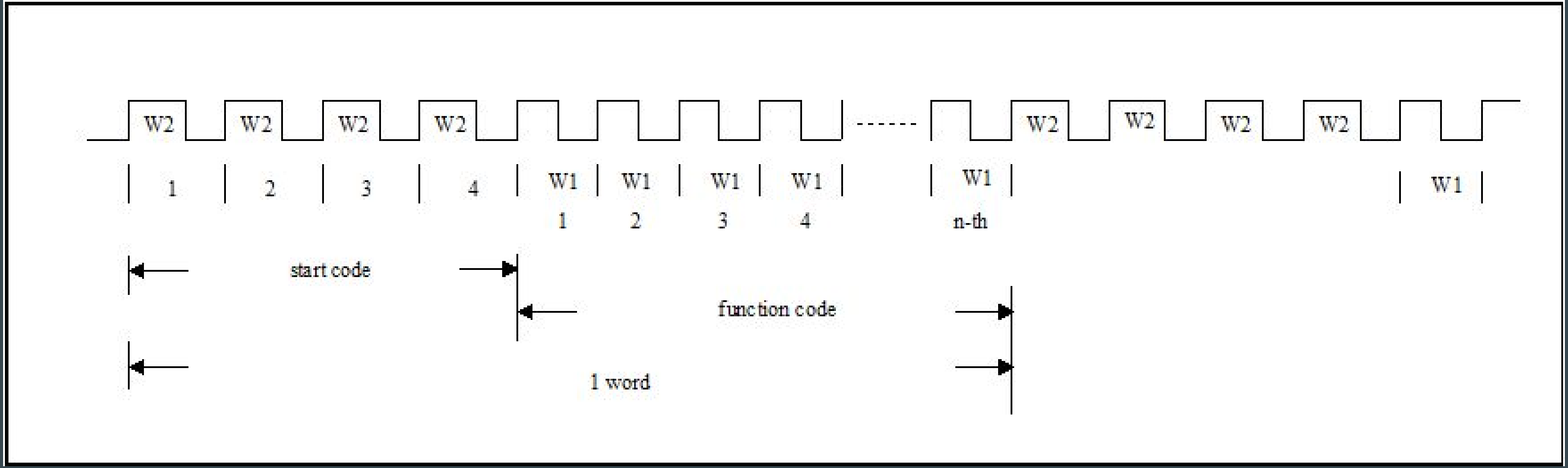
Current scheme doesn’t require current position but potentially could if eventually required

| Current Car Region | Predicted Car Region | Desired Command |
|---|---|---|
| Outer Track | Outer Track | Right |
| Outer Track | Track | Foward |
| Outer Track | Inner Track | Left |
| Track | Outer Track | Right |
| Track | Track | Foward |
| Track | Inner Track | Left |
| Inner Track | Outer Track | Right |
| Inner Track | Track | Foward |
| Inner Track | Inner Track | Left |

# Car Controller - Sending RC commands

Cheap and lazy transmission scheme, different number of W1 27MHz pulses

10 pulses = Forward
28 pulses = Forward + Left
64 pulses = Right

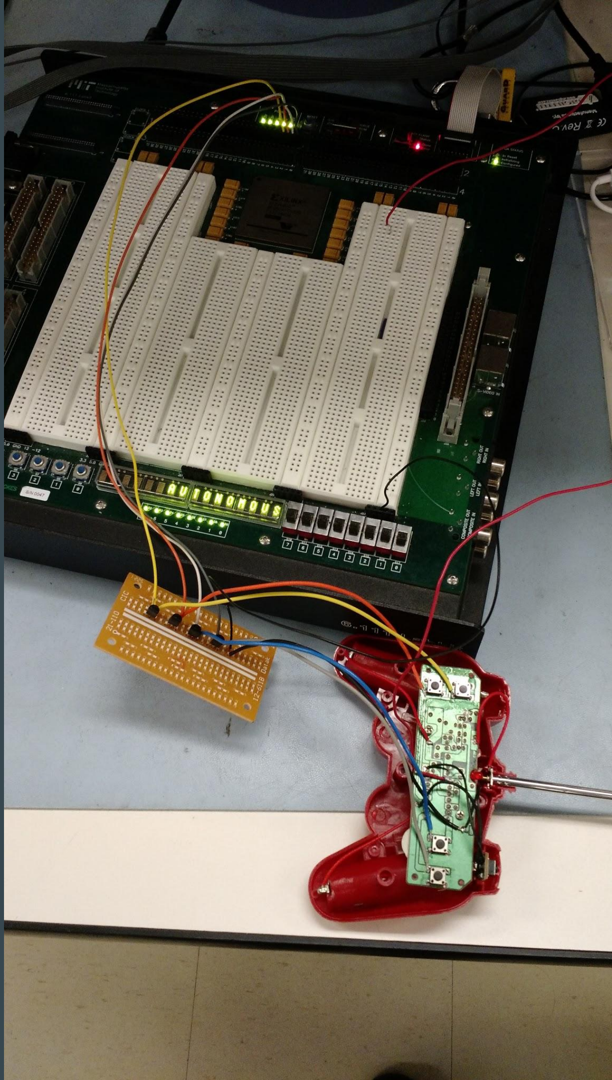


# Car Controller - Sending RC commands

Current implementation, FET's are used in parallel with the normal buttons.

Fast to implement but lacks precision

May be able to hijack RF circuitry to gain more precision



# Timeline

| Week/Members | 11/2/2015 | 11/9/2015 | 11/16/2015 | 11/23/2015 | 11/30/2015 | 12/7/2015 |
|---|---|---|---|---|---|---|
| **All** | **Rough Proposal Draft** | **Project Design presentation** | **Revised Proposal, Project Checklist** | **Thanksgiving week** | Buffer week | Done |
| Battushig | Recognize track, generate track in memory | Recognize track, generate track in memory | Integration | Testing | | |
| David | Get car under control from FPGA | Given heading and position, control loops | Integration | Testing | | |
| Kevin | Identify car position, heading. Basic mapping of camera space to map space | Identify car position, heading. Basic mapping of camera space to map space | Integration | Testing | | |

# Stretch Goals

- Gamify
  - Player vs. computer
  - Checkpoints
- Lap timing
- Optimize car control for speed

# Summary of Key Challenges

- Paper Track Processing
  - Detection of track boundaries and assigning regions to track map in memory
- Car Position Processing
  - Finding center of masses of white “blobs” as seen by VGA camera with IR bandpass filter
- Car Control
  - Smooth and fast control of car
  - Working around serial communication protocol of RC car

# Let’s go racing!

Questions?