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Robot Localization for FIRST Robotics

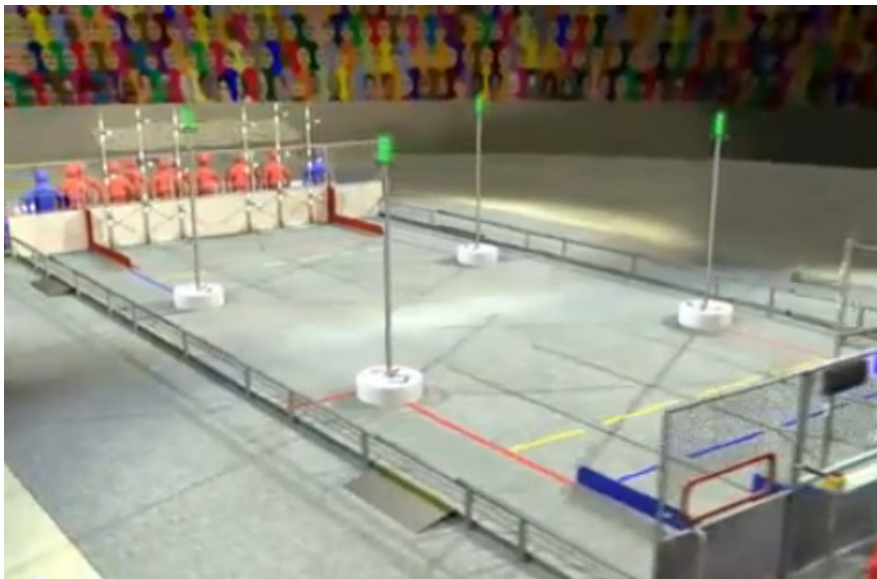


Overview

- Introduce FIRST Robotics
- Explain project goal
- System overview
- Explain key system components
- Show demonstration and findings
- Questions

FIRST Robotics

- Large international competition between high school teams.
- Students are given six weeks to build a robot that can operate autonomously and under wireless direction.
- FIRST Robotics Competition game type changes yearly and they are always looking for new ways to make it interesting.

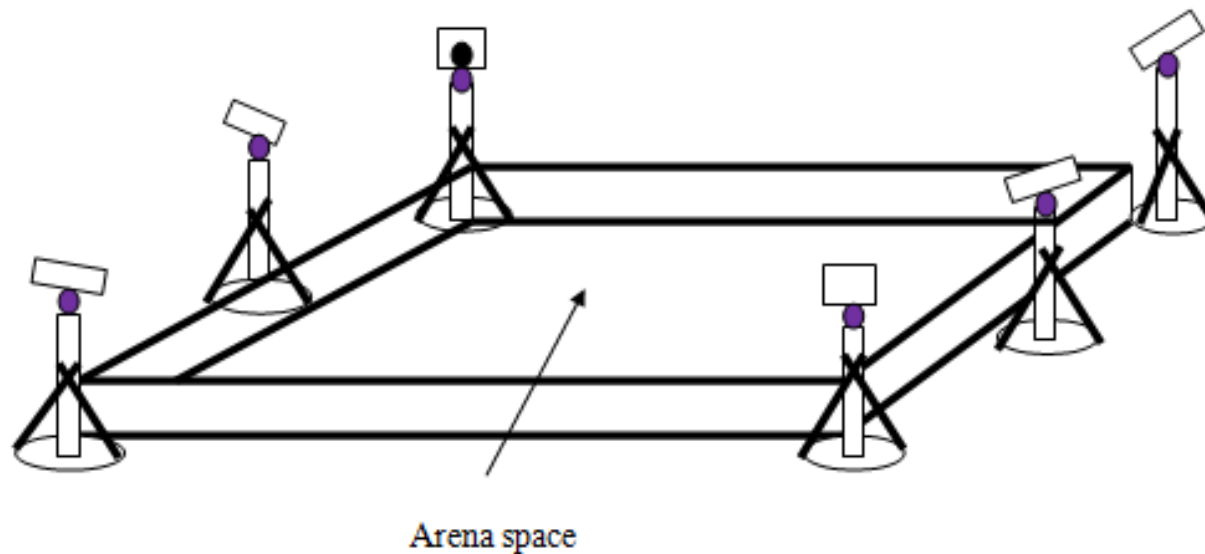


System Requirements

- Provide FIRST robots their own (x, y) coordinates during the competitions
- Identify the robots as individuals
- Provide the best accuracy possible while maintaining low cost and practicality
- Quick and easy system setup
- At least 5 updates per second

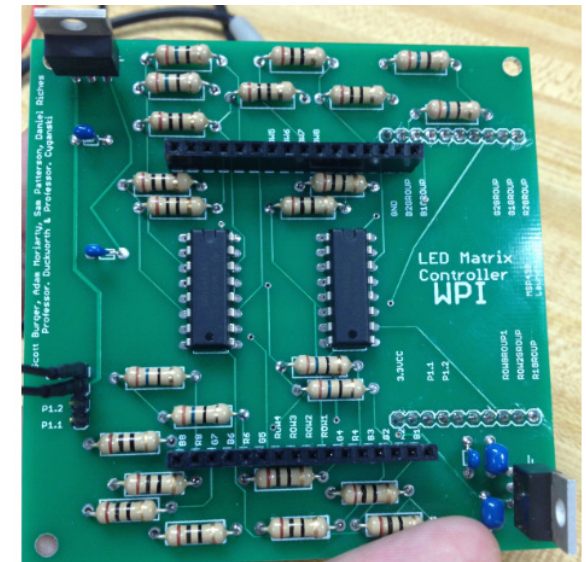
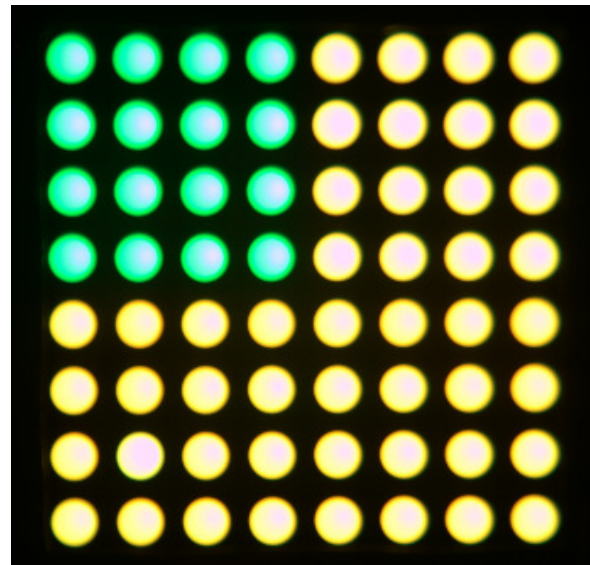
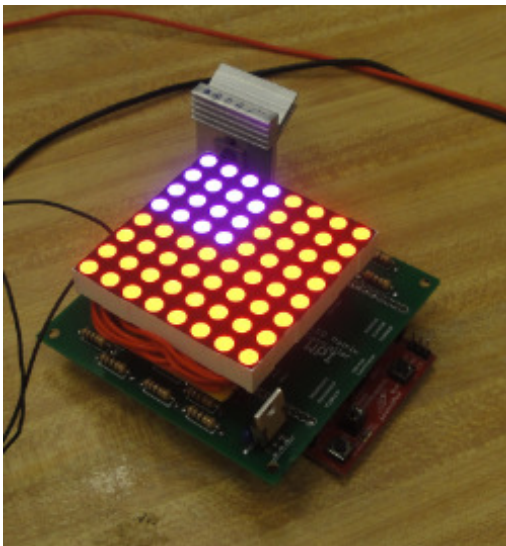
System Scope

- Full system includes six cameras that watch the arena from the sidelines.
- Information from the scene is used to locate and identify the robots, and then send them their coordinates during the competition.

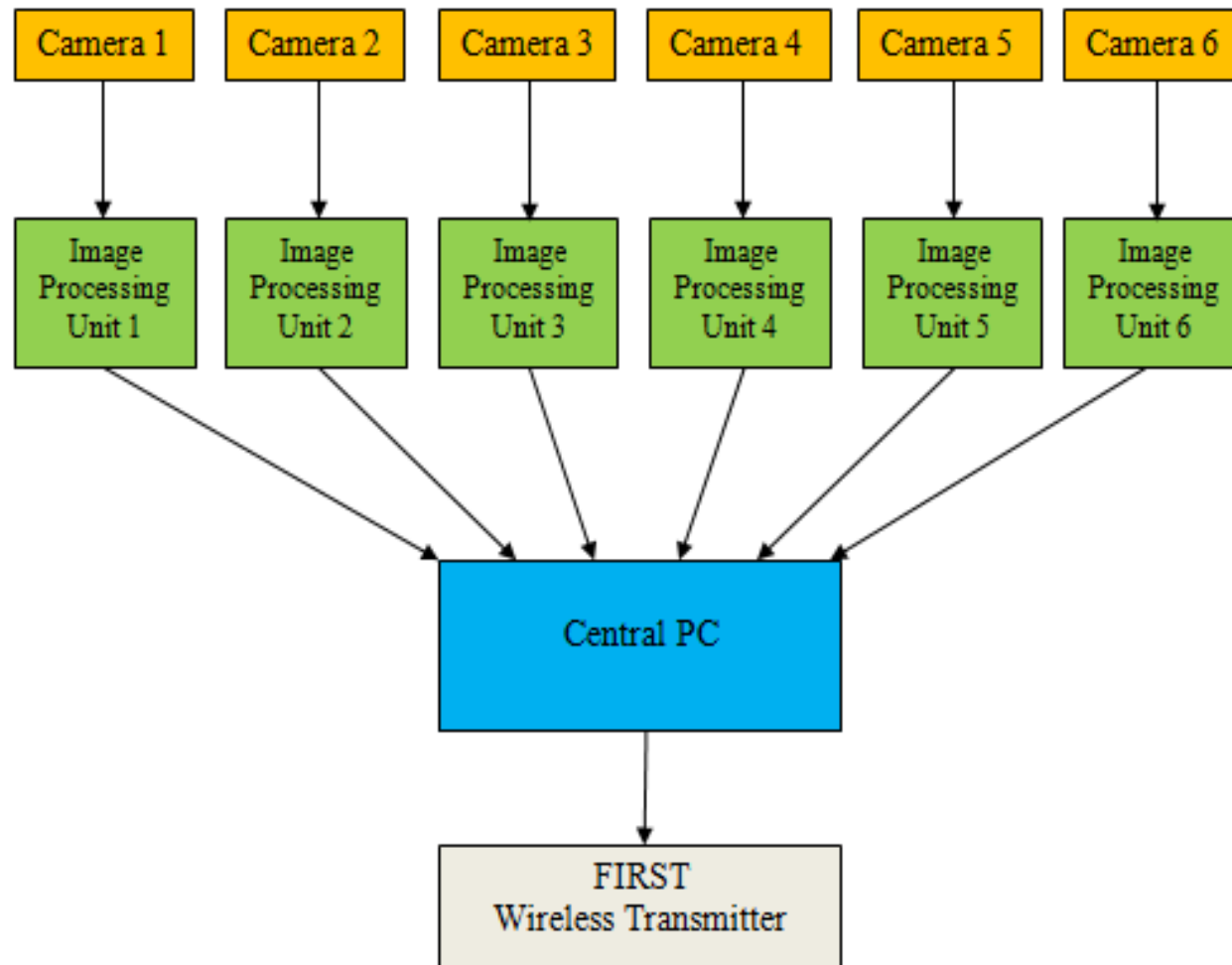


LED Beacons

- Need some kind of marker attached to the robots for consistency
- LED Matrix with programmable patterns
- Design allows for 12 unique patterns, twice the number currently needed

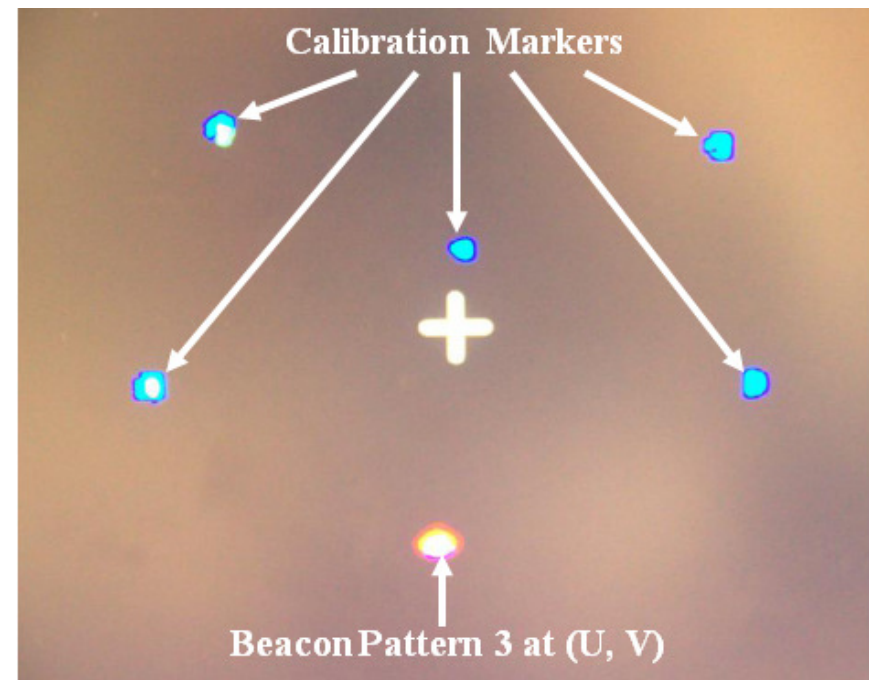
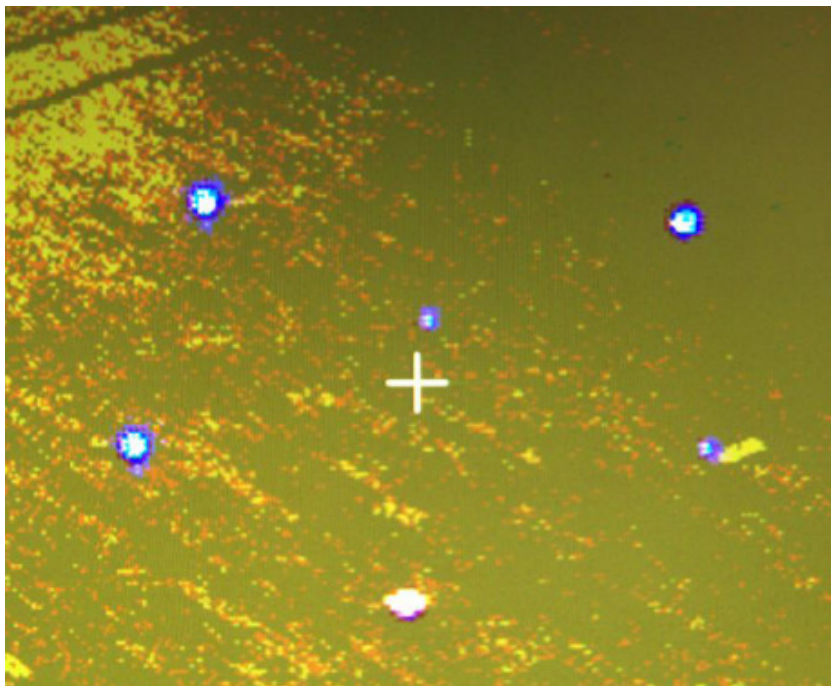


System Hierarchy



Embedded System Goals

- Capture images
- Identify calibration markers and LED beacons
- Send pixel coordinates to the PC
- Pipelined data path for real-time processing capability



Embedded System Operations

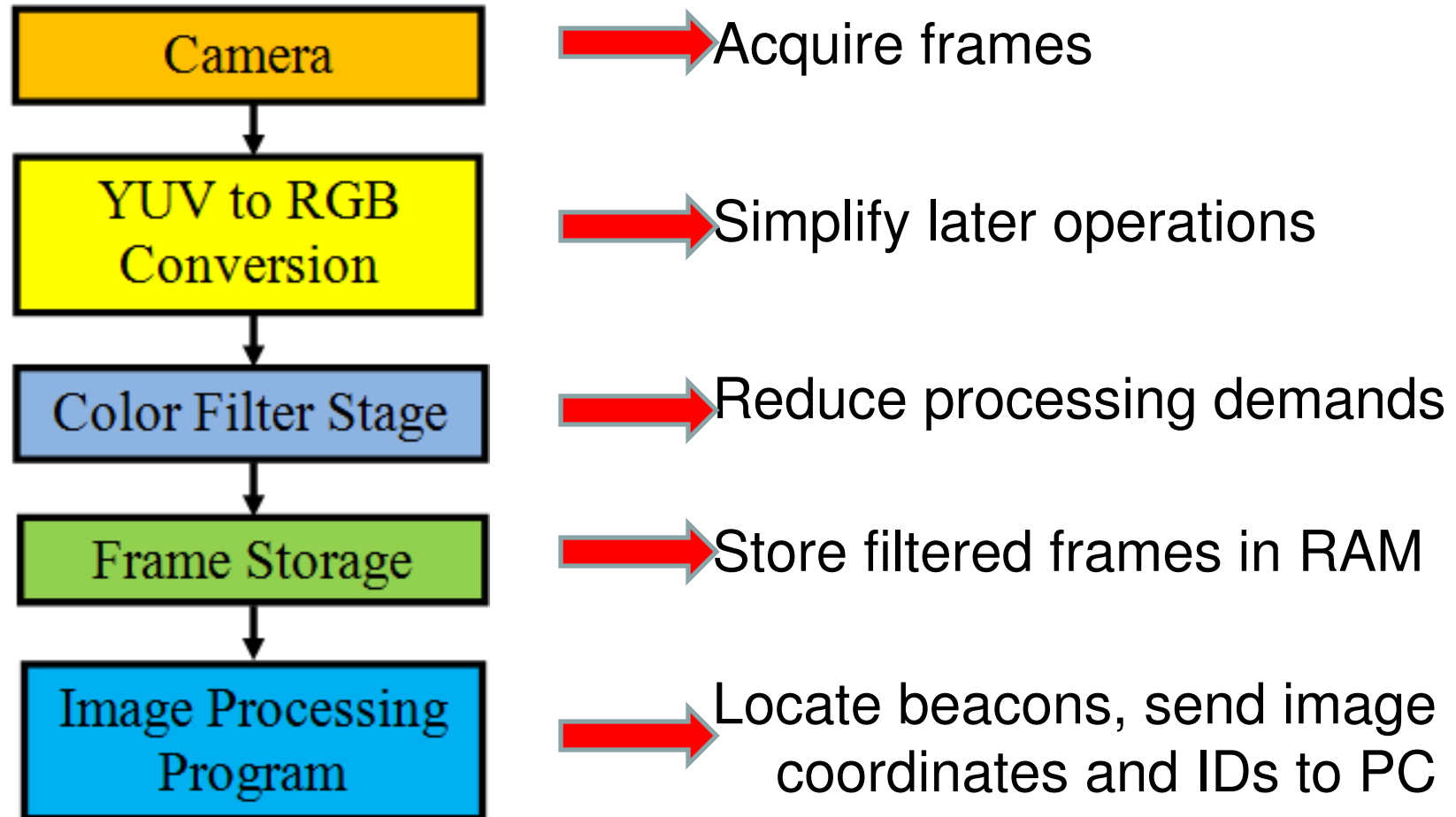
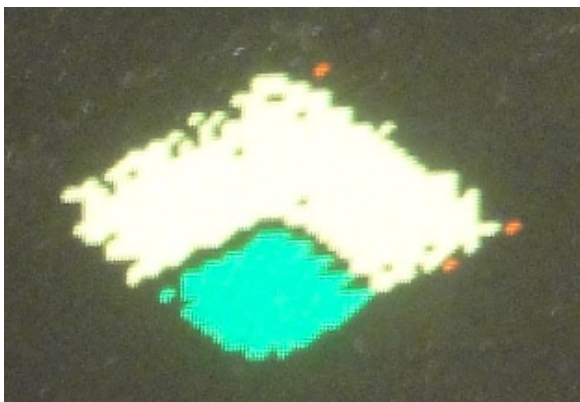


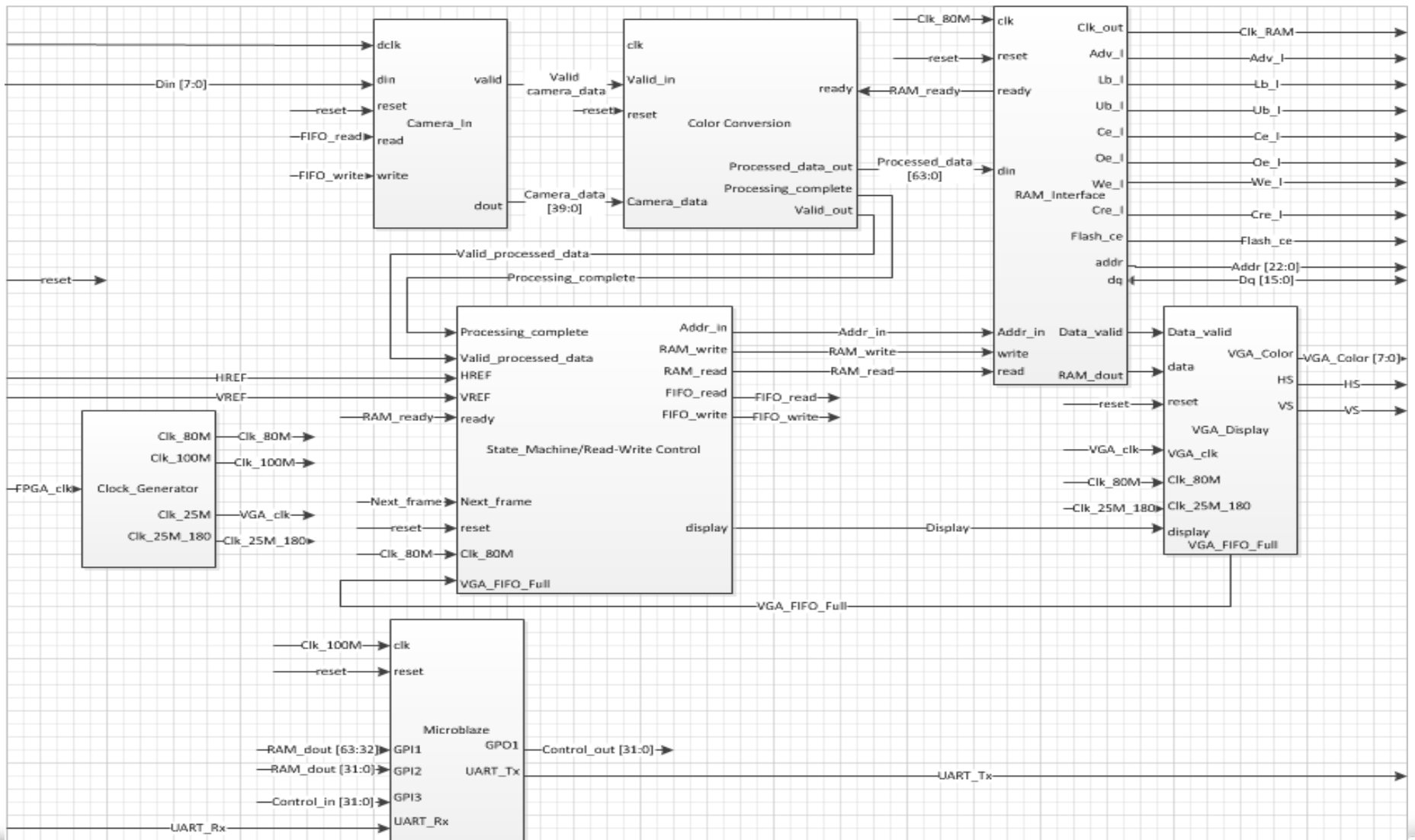
Image Processing

- Microblaze processor searches image for colored patches and uses relative proximities to identify beacon pattern
- Each beacon pattern has a unique ID code
- Sends pixel coordinates along with corresponding IDs to PC



```
Initialization Complete  
Send All The Data  
NumBeacons: 0 Big Color: 65532, Small Color: 28, ID: 5  
Passed  
Number of Beacons Properly Identified: 1  
X = 292, Y = 278, ID: 5  
All Data Sent  
FINAL MAXMARKER: 2
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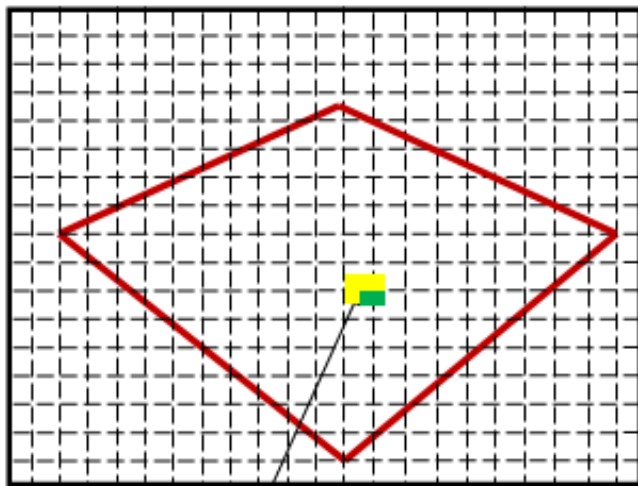
Embedded System Block Diagram



Physical Coordinate Reconstruction

- Combine data from the 6 cameras
- Uses principles of stereo-vision
- Extra information helps reduce errors

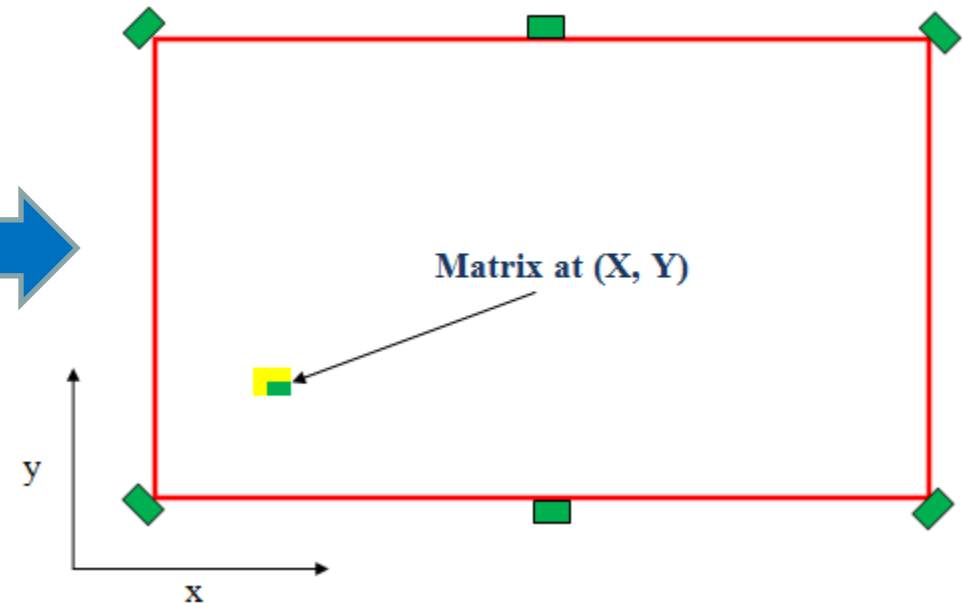
Image Plane Representation



Matrix at (U, V)

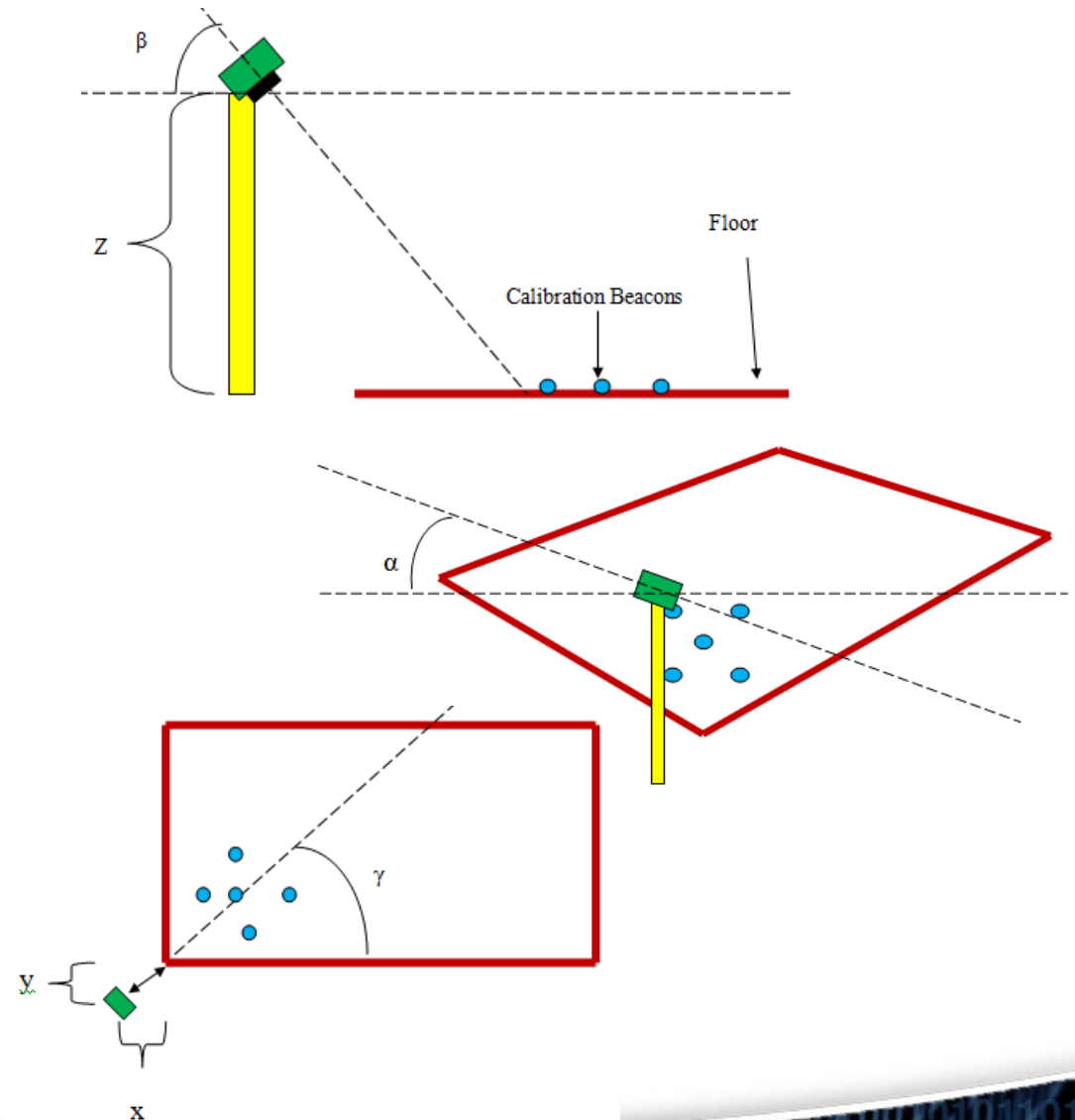


Overhead View Representation



Calibration

- Determines pose of the camera based on images of known calibration markers
- Allow easy setup for FIRST organizers
- No precision alignment required



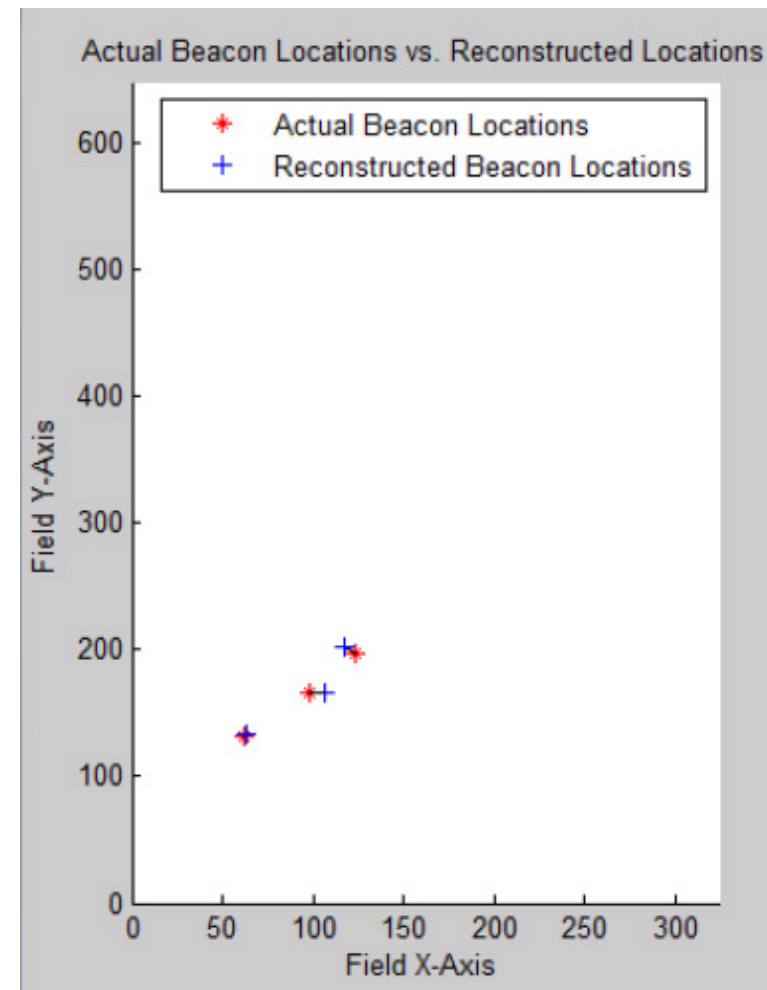
Prototype Demonstration

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Results and Conclusions

- Successfully located and identified beacons with good accuracy
- Maximum error 8 inches, minimum 2 inches
- Test successful using 3 cameras as well as just 2
- Real-time operation supported



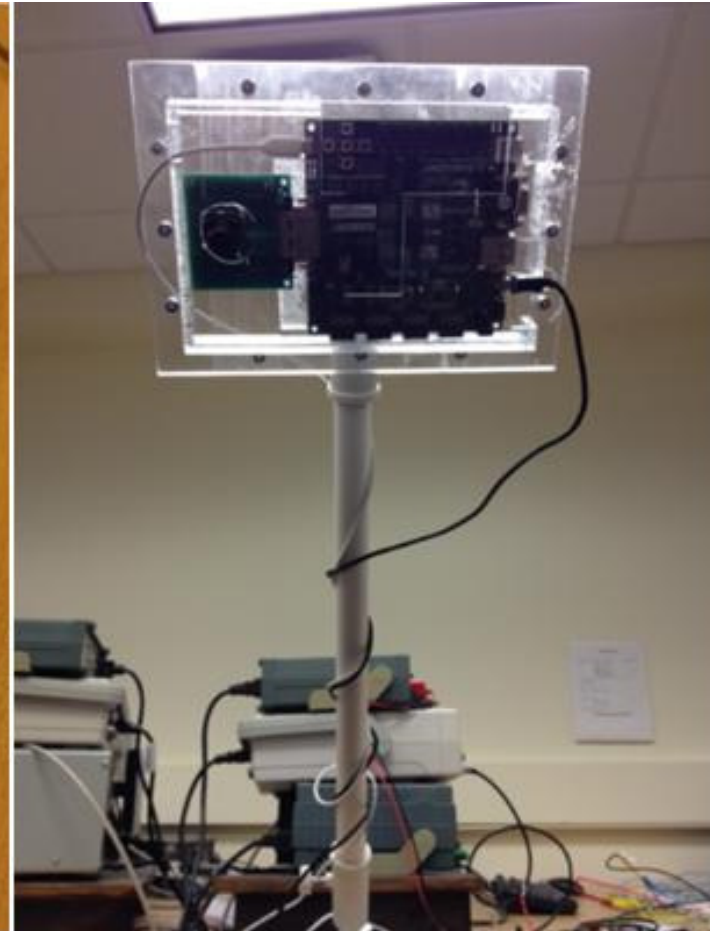
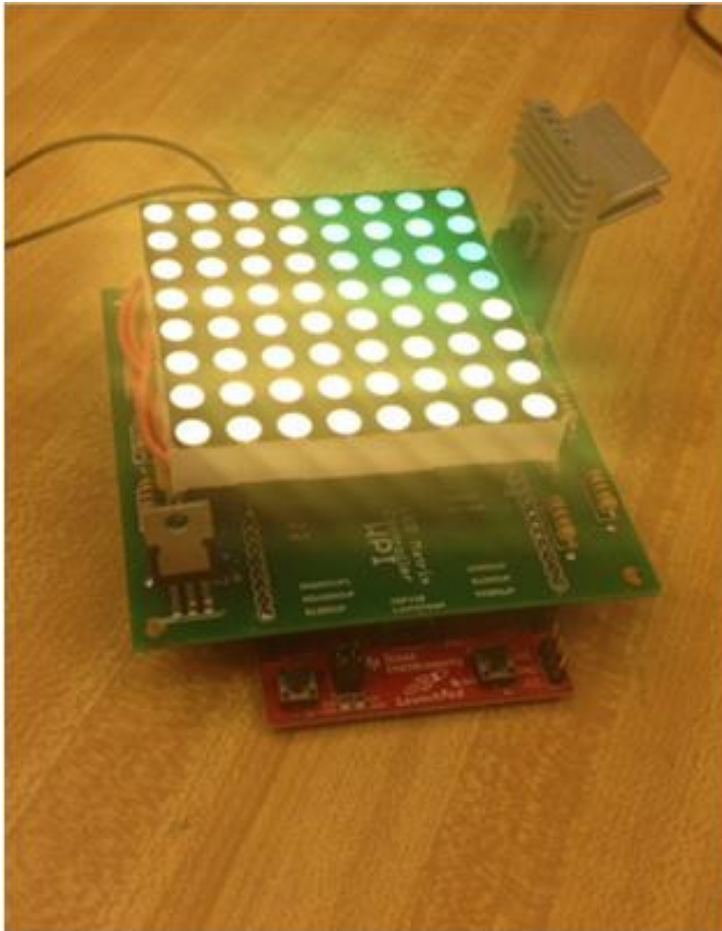
Future Work

- Prototype is capable of real-time operation with minor changes
- Replicate the hardware for six camera system
- New lens with wider angles
- Larger beacon design

Acknowledgements

- Professor Cyganski
- Professor Duckworth
- Professor Miller
- Technician Bob Boisse
- Kevin Arruda

Questions



Works Consulted

- (1) www.usfirst.org
- (2) www.wpi.edu
- (3) http://www.youtube.com/watch?v=93Tygo0_O5c
- (4) <http://www.firstinmichigan.org/>