Robot Localization for FIRST Robotics

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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

Camera 1 → Image Processing Unit 1
Camera 2 → Image Processing Unit 2
Camera 3 → Image Processing Unit 3
Camera 4 → Image Processing Unit 4
Camera 5 → Image Processing Unit 5
Camera 6 → Image Processing Unit 6

Central PC

FIRST Wireless Transmitter
Embedded System Hardware
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

1. **Camera**
   - Acquire frames

2. **YUV to RGB Conversion**
   - Simplify later operations

3. **Color Filter Stage**
   - Reduce processing demands

4. **Frame Storage**
   - Store filtered frames in RAM

5. **Image Processing Program**
   - Locate beacons, send image coordinates and IDs to PC
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
Physical Coordinate Reconstruction

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