IPRO 324

Enhancing the Functionality of Residential Garage Door Operators Using CCD Camera Technology

Sponsor: The Chamberlain Group, Inc.
Overview

- 3rd Iteration of IPRO 324

- 1st semester: showed how hardware and software could be integrated

- 2nd semester: documented various issues, recommended improvements
Goals

- Use CCD camera
- Develop software package
- Solve skewing, lighting, scaling, and processing speed issues
- Determine feasibility of product for commercial use
Today’s Presentation

- Hardware specification
- Software design and approach
- Project demonstration
- Conclusion
Hardware Specification
Parameters

- Problem Identification
- Possible Hardware Contribution
- Hardware Requirements
- Possible Hardware Configurations
- Hardware Selections
Problem Identification

- Previous IPRO Attempts
  - Camera - Web cam
  - Interface - USB Port

- Problems Encountered
  1) Lighting
  2) Scaling
  3) Skewing
  4) Processing Speed
Possible Hardware Contribution

- Image Quality
- Reduction in Processing Speed
- Address Lighting Issues
  - Filters
  - Inferred
Hardware Requirements

- No user adjustment.
- Wide depth (must focus up to 20ft).
- Camera resolution to cover 20ft (640x480 and better).
- Needs own illumination (ideally <1/2 Watts).
- Operation under extreme lighting conditions
Possible Hardware Configurations

- Acoustic Sensors
- Web cam
- Inferred Camera
- CCD Camera
Interface Selection

- Dazzle Digital Video Creator
- ADS USB Instant DVD
- Integral Flashpoint 3dx PCI Frame grabber
CCD Camera Advantages

- High Spatial resolution
- Higher Sensitivity (SN ratio)
- Lower Smear Ratio
- Wider Dynamic Range
Integral Flashpoint 3dx

- High Resolution
- Fast Image Acquisition
- Camera Control Interfaces
- Compatibility
Hardware Selections

- JVC 1/3 CCD
  - 1/3” interline transfer CCD
  - Electronic shutter
  - Auto IRIS
  - Built in back light compensation

- Integral Flashpoint 3dx
  - PCI video frame grabber
  - Programmable C++ Interface
Attacking Design Problems With Software
Problems

- Skewing
- Scaling
- Lighting Issues
- Running Independent of User Adjustments
Fix Skewing

1. Followed suggestion from previous IPRO

2. Circle – can be moved or rotated but still have same aspects.
Initial Approach: *Correlation*

- How past IPROs attacked the problem
- Comparison between all aspects of an image. Obstruction determined by a correlation coefficient
- Idea was that correlation would fix all issues
Initial Approach: *Correlation*

- **Problems:**
  - What would the threshold value be?
  - Small changes in the picture may not be noticed as much as change in light
  - Other objects in picture, but in front of pattern would give bad correlation
  - Could not get it to work
Final Answer

- Comparison of the perimeter and area of multiple objects

- Fix lighting issues
  - Convert gray scale image to black or white image
  - Threshold value used to determine whether gray value became white or black. Determined through testing
  - Matlab function Edge used to find displacements between colors

- Example
Example: Camera Images

No Obstruction

Obstruction
Example: Convert Black and White

No Obstruction  Obstruction
Example: Edge Detection

No Obstruction

Obstruction
Scaling & Running Independently

- Previous methods used cropped images
- Independently create circle in Matlab
- Compare created circle with Image
- Run a Loop comparing various circles
- No user or specific distance required prior to setup
Presentation

- Computer Simulation
  - C++ Interface created
    - Controls camera Image
    - Simulates operation of Garage Door
    - Calls Image Processing Engine
  - Event Log is created
Interface

Start Monitor

Capture Image

Save Image

If Still Closing

Start Matlab Application

Obstructed

Open Door

Terminate Monitor

Image Processing Engine

Start Matlab Application

Request Image

Load Image

Process Image

Convert to Black and White

Perform Edge Detection

Label Objects Found & Calculate Area and Perimeter

Create Circle 5 - 25 sizes

Compare Area and Perimeter of the Circle and the Objects

Add circles Created

Find 6 Patterns

Close Garage

Open Garage
Project
Demonstration
Conclusion
Issues Encountered

- Hardware driver compatibility
- Software integration difficulties
- Processing time of MATLAB engine
- Camera performance
Accomplishments

- C++ graphical interface effectively connected hardware to MATLAB
- MATLAB successful in pattern recognition, complex image processing
- Optics issues were resolved
- In-depth documentation of code, various issues encountered
Feasibility

- Main purpose of project: to determine feasibility of system for consumer use

- MATLAB algorithm too slow for practical use

- High cost of CCD camera, capture card
Future of project

- End of this project, The Chamberlain Group, Inc. has software and hardware
- Skilled programmers could translate MATLAB functions to C++ code
- Have recommended optics requirements, now wait for cheaper camera technology
Acknowledgements

- Ed Laird, The Chamberlain Group, Inc.
- Ana Lukic, Faculty MATLAB imaging expert
- Ross Johnson, leader of 1\textsuperscript{st} IPRO 324
- IPRO staff
- Philip Felber, Faculty Advisor