UCSD AUVSI

Unmanned Aerial System Team

Joshua Egbert
Shane Grant

Agenda

- Project background and history
- System design overview
  - Gimbal Stabilization
  - Target Recognition
- Lessons Learned
- Future Work
- Q&A

UCSD AUVSI Background

- Student Unmanned Aerial System (UAS) team
  - 10 undergraduates from electrical, computer, and aerospace engineering
  - Split into groups working on computer vision, user interaction, and onboard systems

AUVSI Student UAS Competition

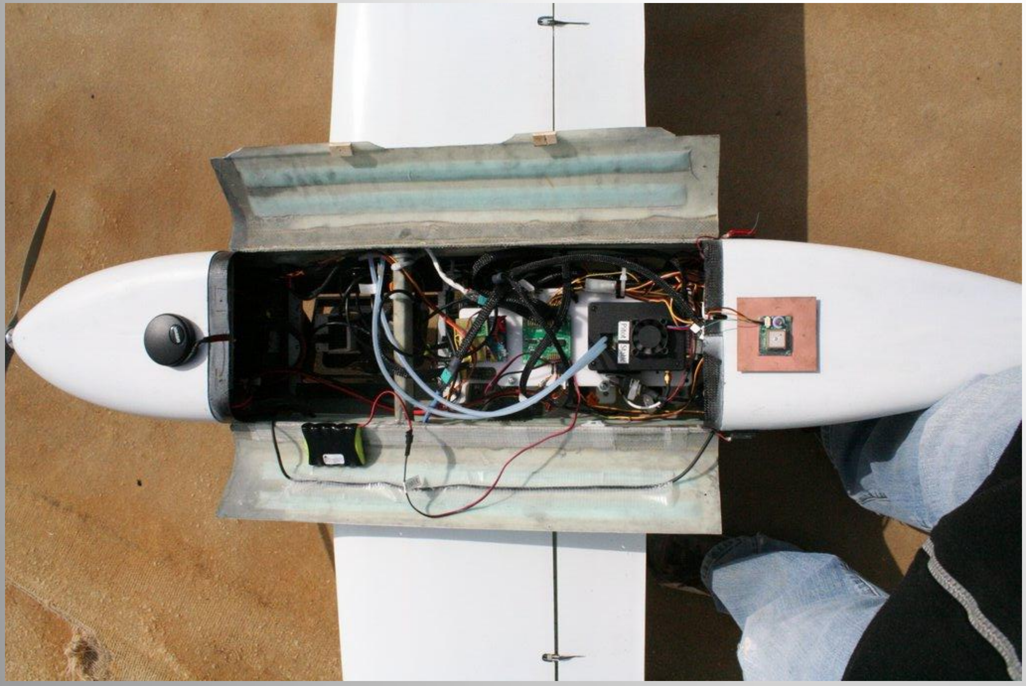
- Annual international competition
  - Put on by AUVSI seafarers chapter
  - Around 20 schools competing
  - $78,000 in prize money awarded last year
    - First place took $14,000
- Held at Webster Field, Maryland
  - June 16-22

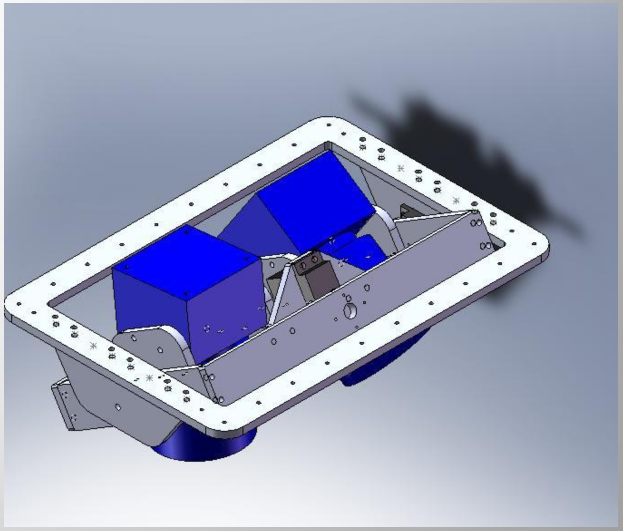
The Mission

- Perform a fully autonomous flight mission
- Navigate through a series of waypoints
- Locate and identify an unknown number of targets within a designated search area
- Re-task in flight to locate target outside of search area

Last Year's Approach

- Still cameras facing ground
- Image processing onboard

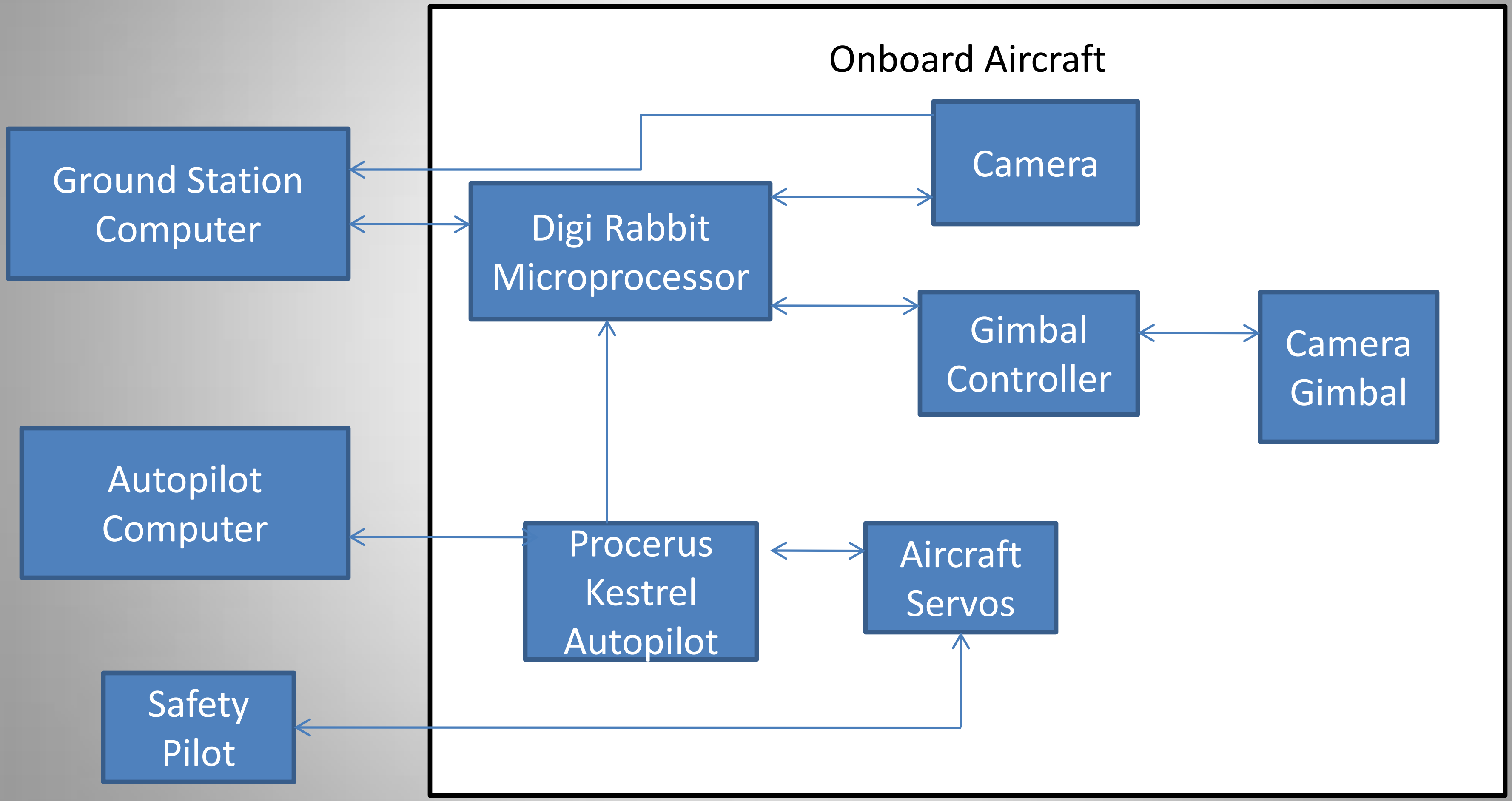




This Year's Approach

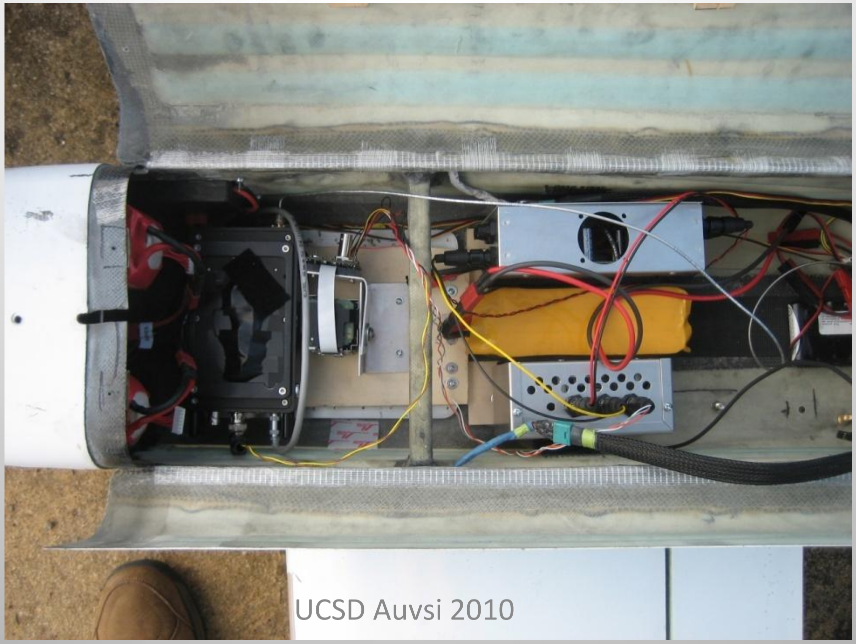
- System driven design
  - Model each subsection independently
- Geo-pointing gimbaled video camera
- Real time autonomous target detection and recognition

System Overview



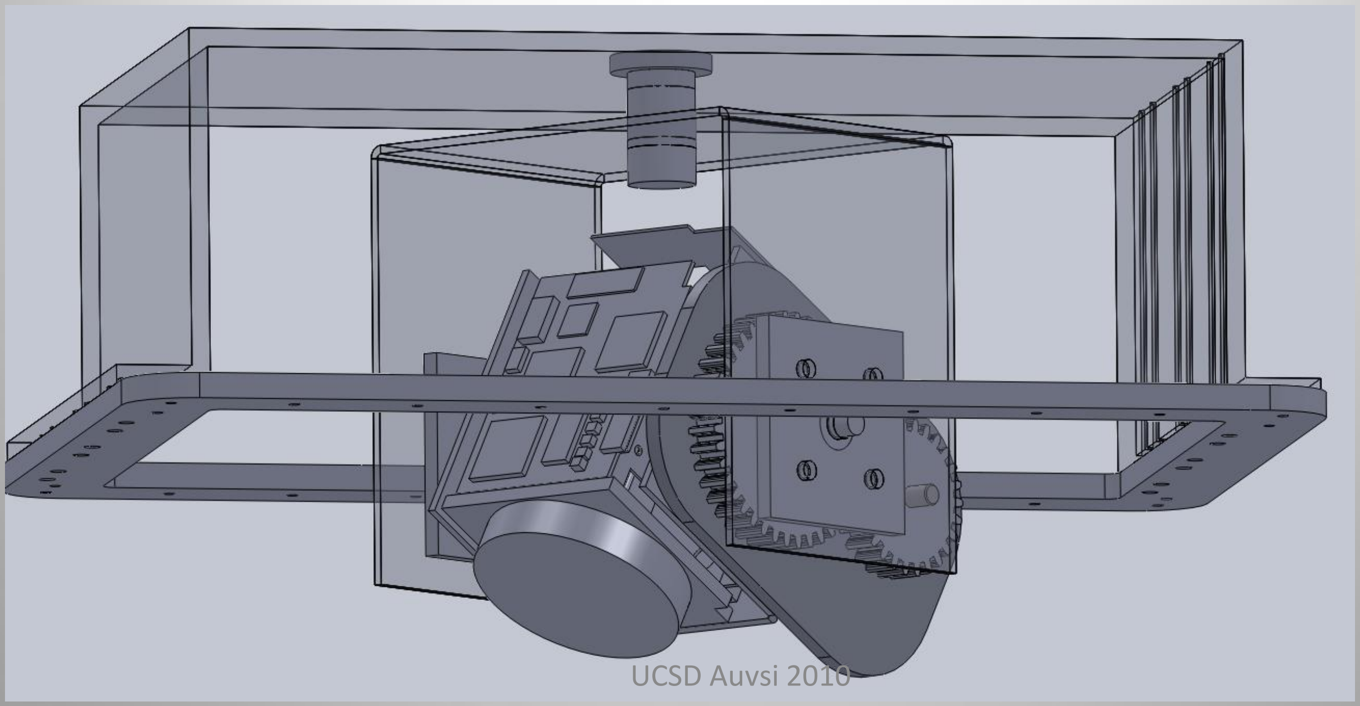
System Overview

- Subsystems are divided into independent units
  - Individual components can be easily replaced
  - Aircraft is more cleanly organized.



Geo-Pointing Gimbaled Camera

- Goal is to track a GPS point to 50ft accuracy.
- Accept either GPS position or position changes as inputs



Physical Gimbal Design

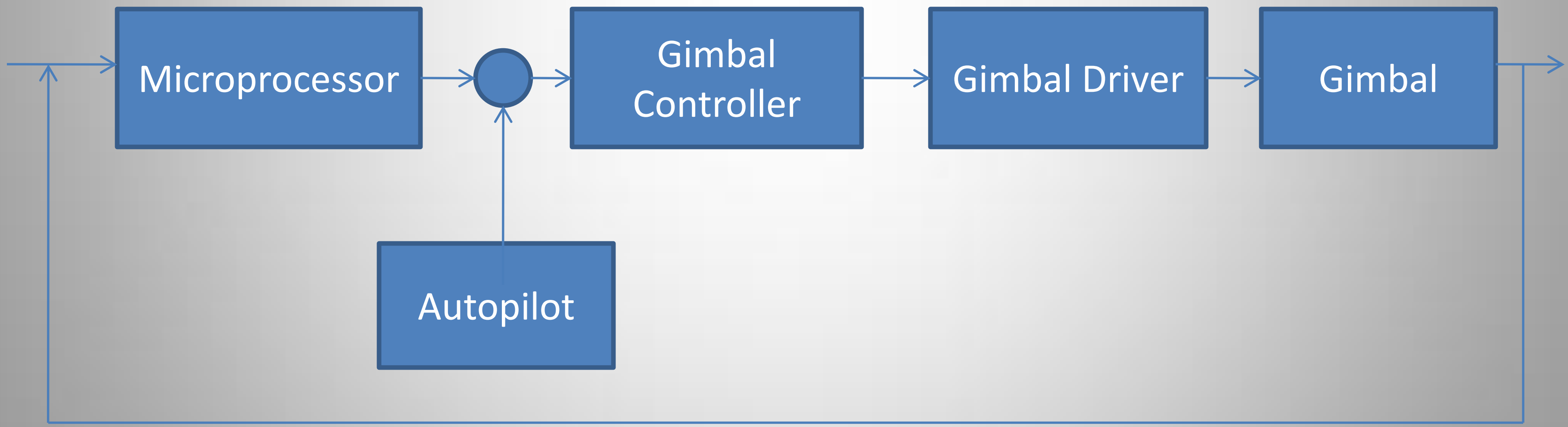
- Physical Design Requirements
  - 1 degree Pointing accuracy
  - 15 degree/s Tracking speed
  - 90 degrees of tilt
  - 360 degree continuous rotation
- Emulate real world gimbaled cameras.

Gimbal Model Validation using MATLAB

- Gimbal currently just out of the physical design phase, fabrication is almost complete.
- Next step will be model validation using MATLAB.

Control Law Development using SISO tool

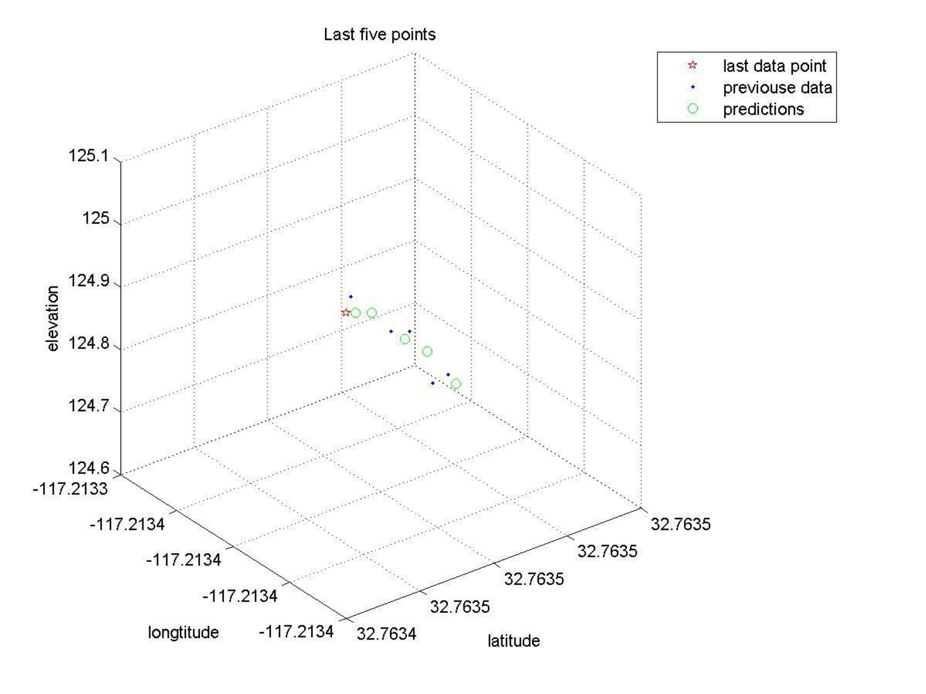
- Using gimbal model develop real time controller using the SISO tool function and other controls tools.

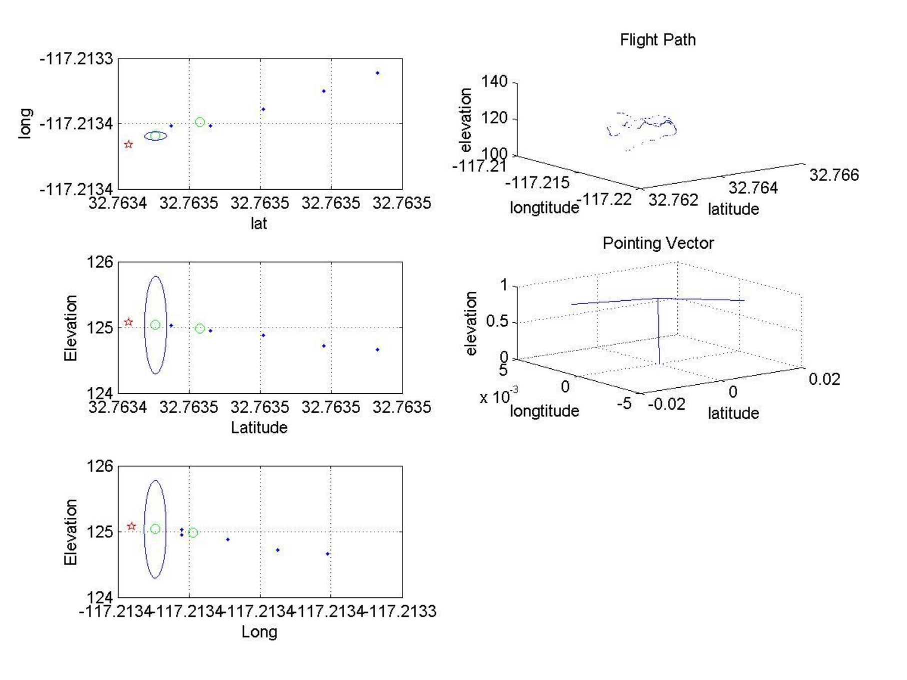


Path Prediction using MATLAB

- Developed using past flight data files
- Designed using built in MATLAB functions including the Kalman filter
- Goal is to increase gimbal response time and reduce error by using the predicted path of the airplane to augment the control law

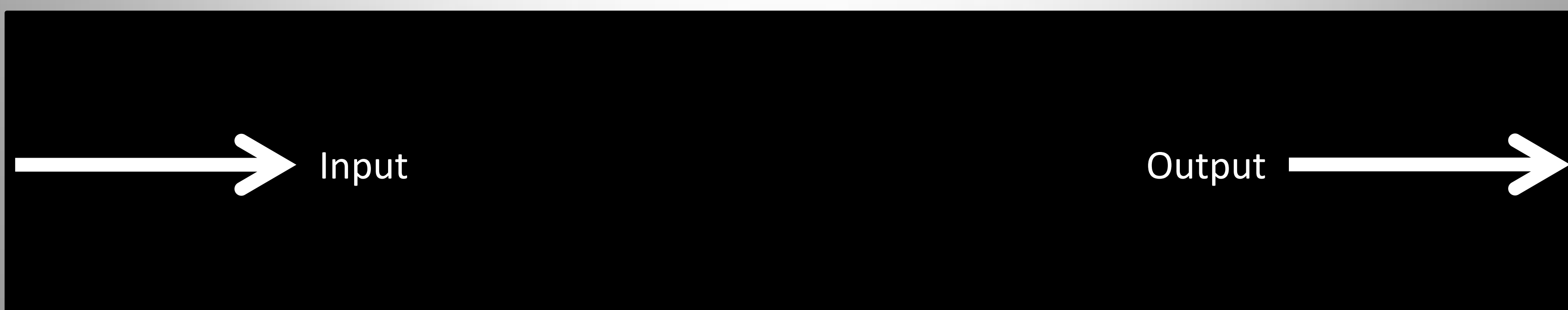
Path Prediction Results





Computer Vision Systems

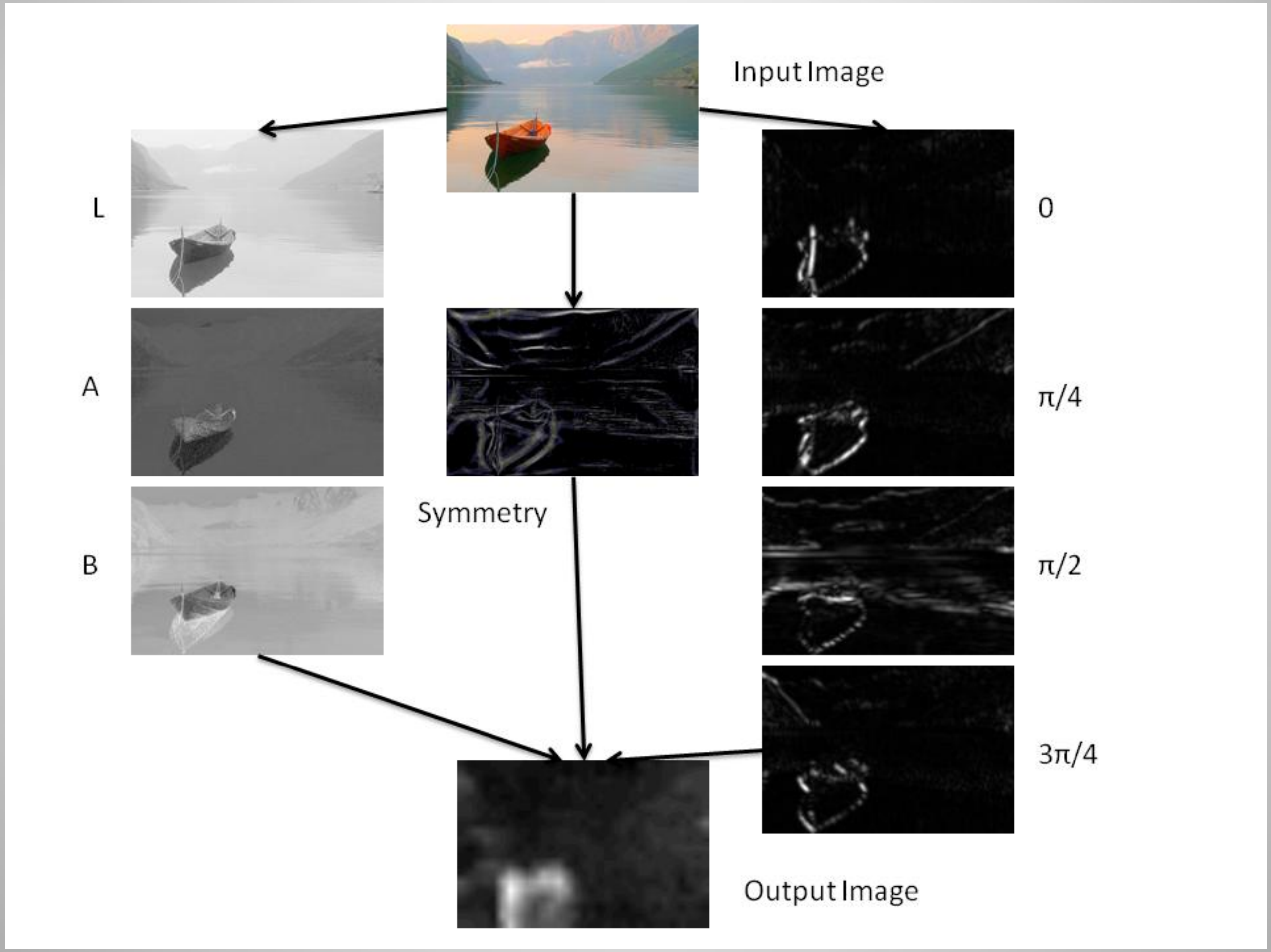
- The challenge:
  - Correctly geo-reference all imagery
  - Identify candidate regions for targets in real time
  - Analyze these regions to determine target parameters



Leveraging MATLAB

- The three vision challenges can be developed independently
- Developed and prototyped in MATLAB before implementing on specialized hardware: graphics processing units (GPUs)
  - Considerably faster to develop
  - Far easier to test
  - Vectorized code translates well to GPU

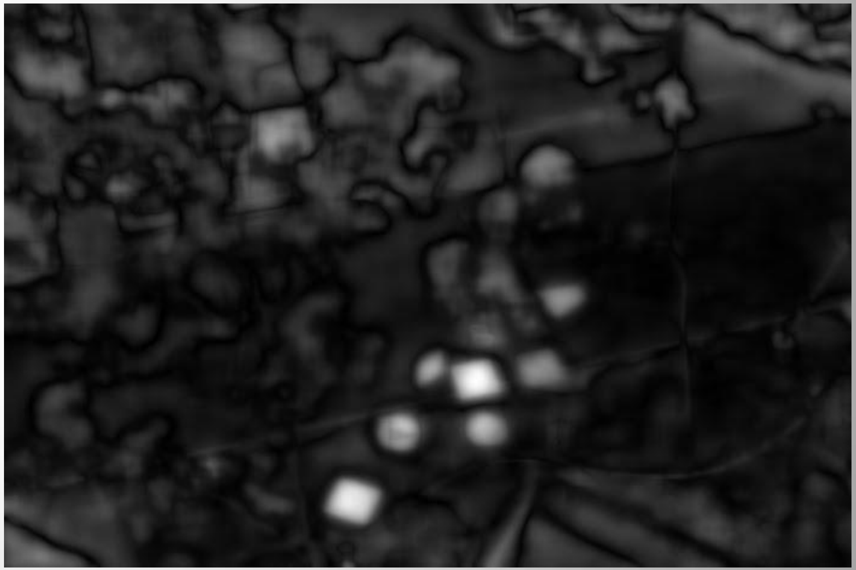
Candidate Region Selection



Saliency – A Model Independent Algorithm

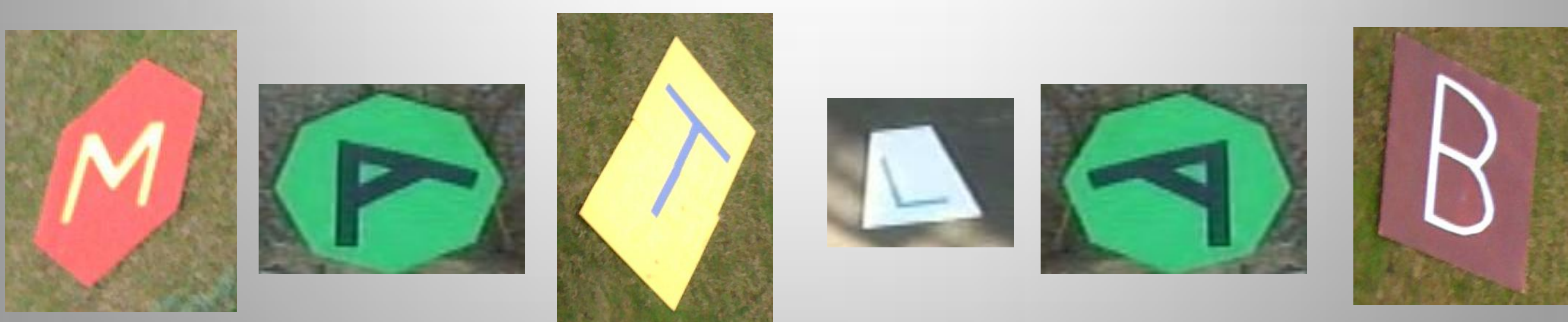
Input

Output



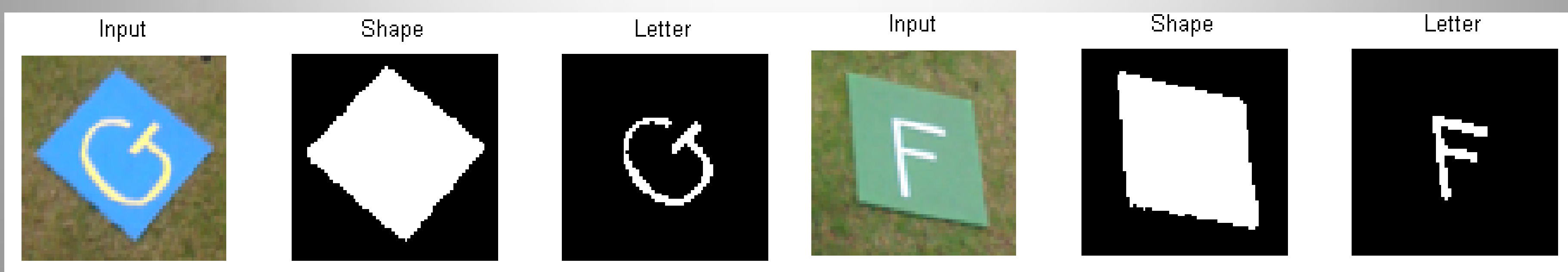
Target Recognition – A Model Dependent Algorithm

- Create model of targets we expect to encounter
  - Solid colored shapes with a solid colored alphanumeric character
- Some examples (letter choice purely random):



Target Recognition

- Utilize several Matlab toolboxes for recognition:
  - Image Processing – used in everything
  - Statistics – used during image segmentation
  - Wavelet – used to compute features in recognition



Lessons Learned

- The development of a full system layout and plan before doing any design greatly increased the complexity of the system we were able to design.
  - Past student projects were much less ambitious than we were here.
- Working on a primarily “aerospace” project with computer and electrical engineers allows for the development of much more robust systems.

Future Goals

- Future goal: Integrate target recognition with gimbal control with the goal of fully autonomous search.
- Field test gimbal system with and integrate with path prediction.
- Win competition!


UCSD
UCSD
UNIVERSITY OF CALIFORNIA SAN DIEGO
UCSD
UCSD
GENERAL ATOMICS
NASA
The MathWorks