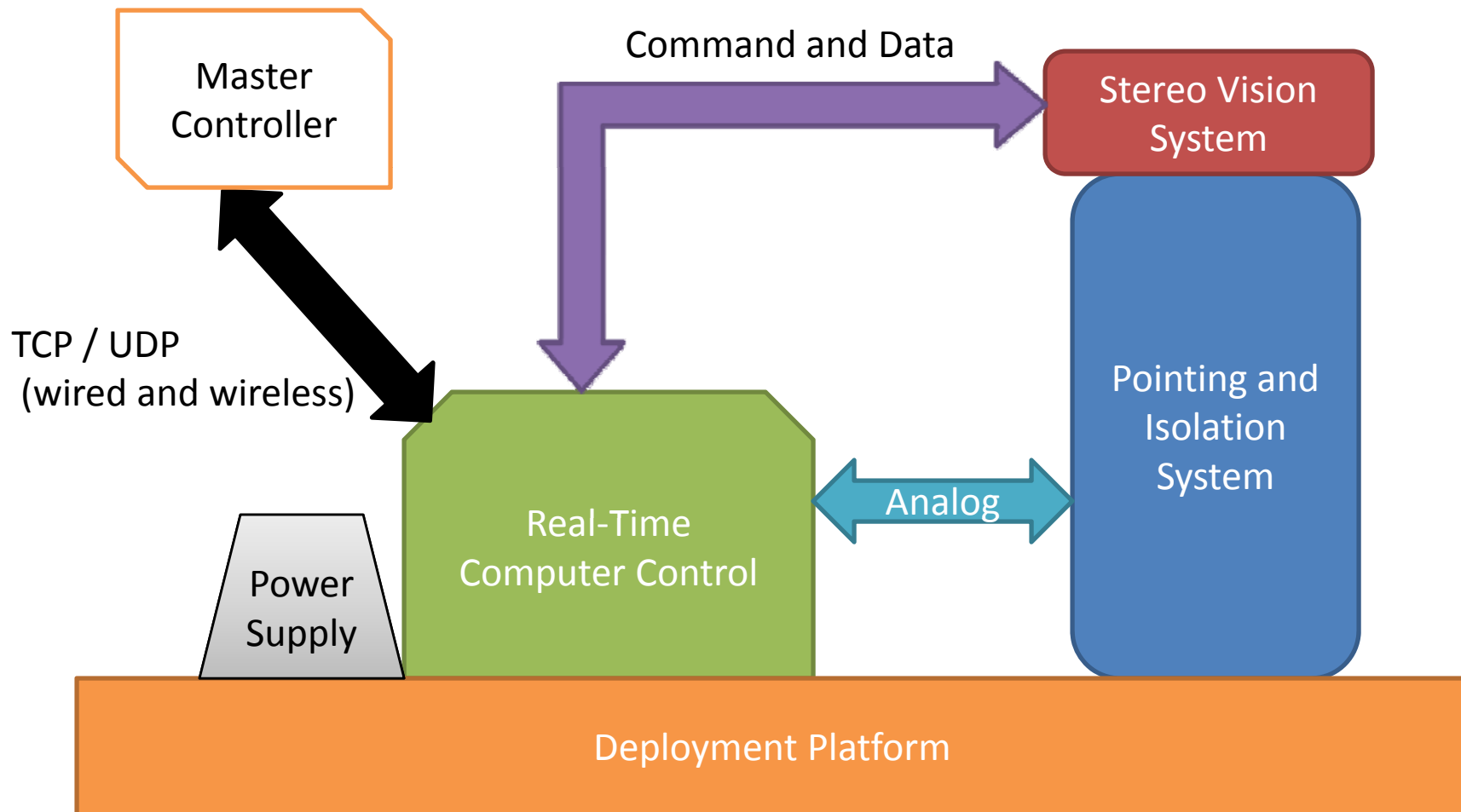


# Real-Time Flame Recognition and Understanding Using a Mobile, High Performance, Stereoscopic Vision System

J. Hamann, J. McInroy, F. Jafari,  
C. Wright, J. O'Brien, S. Morton

University of Wyoming

# Fire Fighter System Block Diagram



# Vision Tasks for a Firefighting Robot

- Situation awareness
  - Overall awareness of the fire and local environment
    - CCD camera(s), possible fly eye sensors, computer based pattern recognition algorithms
- Flame-front detection, tracking, and prediction
  - Stereo vision (3D vision) via CCD cameras and computer, stabilized for platform motion
    - Visible and/or IR
    - Rejection of base disturbances due to a moving platform
- Obstacle avoidance
  - Dynamic avoidance of gross objects, debris, and drops
    - Stereo vision and possible fly eye sensors
- Self-preservation
  - 360-deg low resolution visible/thermal imaging

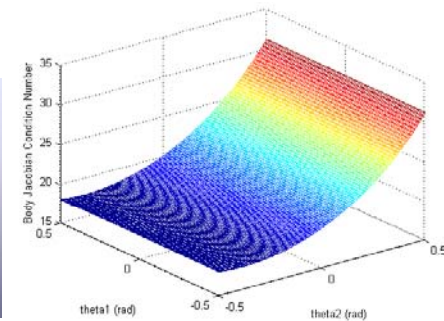
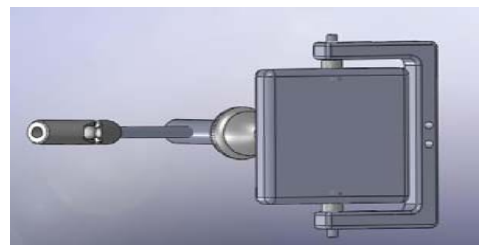
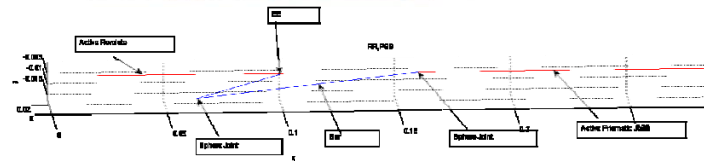
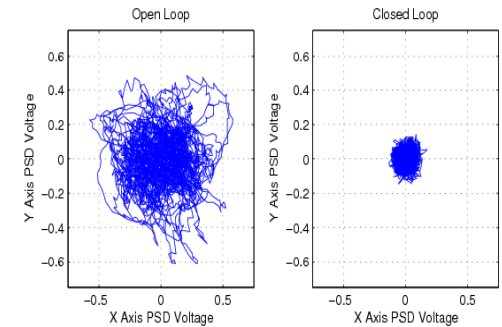
# Vision Tasks for a Firefighting Robot

- Combustion analysis
  - Multispectral sensors coupled with computer database to assess types of combusting material
- Nearby combustible materials assessment
  - Similar to above, but for materials nearby combustion zones
- High-level thermal imaging (very hot targets)
  - Assists in localizing centers of combustion, helps with flame-front tasks
- Low-level thermal imaging (less hot targets)
  - Assists in indentifying embers and potential re-ignition sites

# UW Parallel Kinematic Machine Development

## Evolutionary Jitter Reduction Hardware: From Phase 1 to the Automated Firefighter

- Phase 1
  - 4-leg, high performance PKM
  - Will be used in nested actuation experiments
- Phase 2
  - Small, lightweight and high performance 2-axis PKMs
- Automated Firefighter
  - Cooperative PKMs evolved from results of previous phases for high dynamic range optical tracking on a mobile platform



# Fire Fighter System Quick Summary (Page 1 of 2)

## Master Controller

- Development system (Win XP & all development and analysis tools)
- Supervisory control (“joystick” command mode available and image capture/view)
- World Net’d and local system connection
  - Three TCP I/Os (two wired, one wireless)
- Ample local storage
  - Multiple downloadable system configurations
  - Archives of system measurements
- Two generational possibilities (Desktop in prototype, Laptop in final test)

## Real-Time Computer Control

- NI Card-Cage with Two Versions Possible...
  - Lab prototype in VXI
  - Rugged deployment version in RIO
- Real-Time Operating System
- TCP capable both wired and wireless
- Analog I/O for sensors and actuators on “robot”
  - Simultaneous sampling at least 9 channels
  - Minimum of 6 voltage DAC output channels
- Digital/Protocol I/O for vision system communication
- Stand-alone and supervisory modes available (“joystick-like” open-loop) control
- Ultimately implements JAUS protocol at TCP interface with Master.

# Fire Fighter System Quick Summary (Page 2 of 2)

## Stereo Vision System

- NI Compact Vision System Controller
- Two Cameras (third port available, if needed)
- Multiple modes of operation
  - Grab and upload image(s) from any camera on command
  - Pre-process stereo images and sequences to reduce data before upload

## Pointing and Isolation System

- Mechanical manipulator with sensors for feedback control
  - Two “Eye” actuator assemblies for parallel 2x(2-axis) rotation
    - Amplifiers for actuation power levels
  - Neck tilt/pan actuators
  - Force and accelerometer sensors (6+3)
    - Bias and low-level signal amplifiers for interfacing back to NI A/Ds

## Power Supply

- Deployment platform compatible power conversion (AC prototype, battery test)

## Deployment Platform

- Varies: bench-top and wheeled cart in prototype, Army vehicle in final test