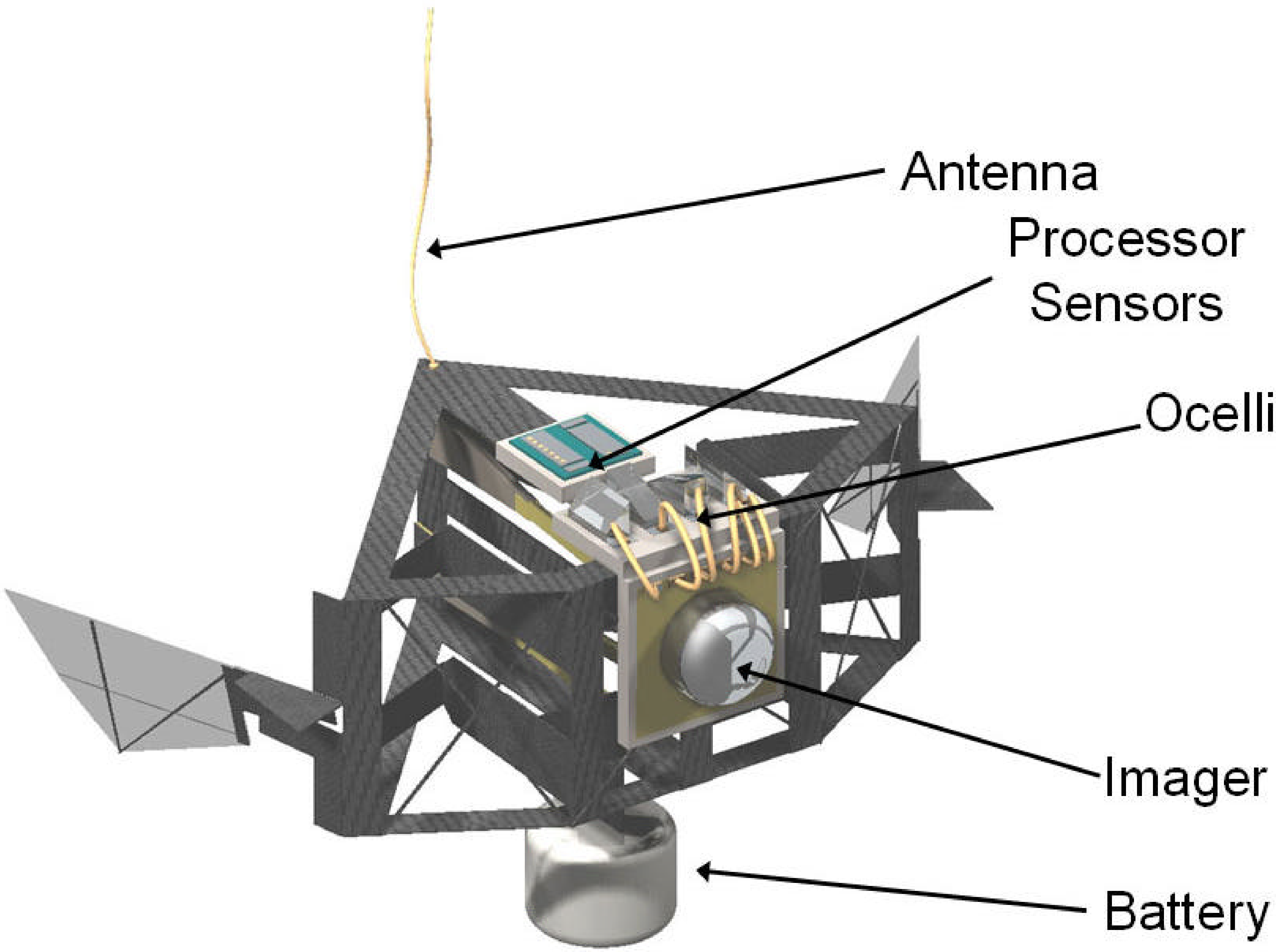
Vision Sensors for Entomologically-inspired Micro Aerial Vehicles

Dan Black, in collaboration with
Professor Reid Harrison


Antenna
Processor
Sensors
Ocelli
Imager
Battery

Insect Inspired

- Two kinds of vehicles:
  - Micro Hovering Aerial Vehicles (MHAVs)
    - ~50cm diameter
    - Larger, but smarter
  - Micromechanical Flying Insects (MFIs)
    - Very small, ~.1g
    - Smaller, able to accomplish specific, simple tasks
- Both need to be autonomous

Motivation

- It’s really cool.
- Building Clearing (points of entry, mapping)
- Situation Assessment (earthquakes, terrorism, etc.)
- Data Acquisition – Perch and Move
- Anything else the Government can come up with.

Who’s involved?

- University of California
- California Institute of Technology
- Stanford University
- Boston University
- University of Utah
  - Vision Sensors

Autonomous

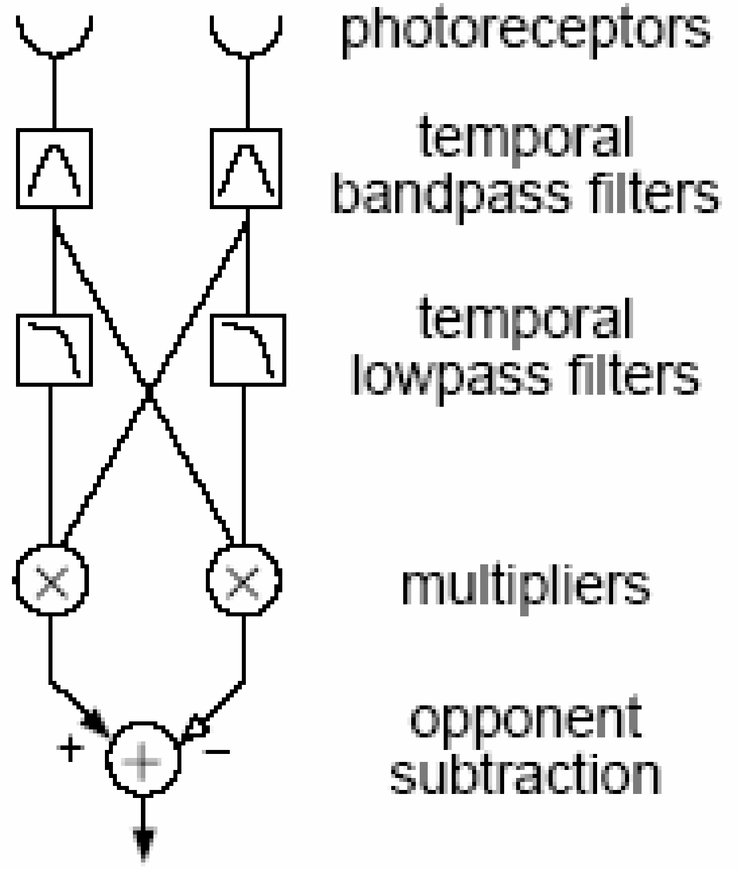
- Keeps itself upright
- Doesn't wander
- Compensates for wind currents, etc.
  - So user doesn't have to
- Doesn't run into walls, other objects (obstacle avoidance)

- All of these will depend on vision sensors

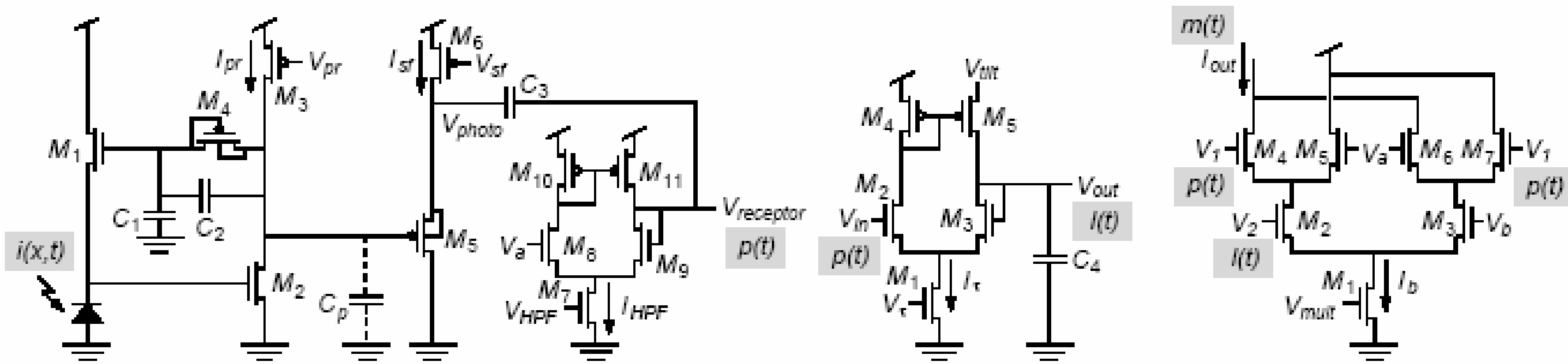
Version One: both dumb and smart

- Integrate CMOS imager and “smart” imager
  - Smart pixels already developed by Harrison
    - Gives directional information in x and y directions
    - Output is a differential current, for easy adding
  - “Dumb” CMOS imager in center with smart pixels on the outside

“Smart” Pixel


photoreceptors
temporal
bandpass filters
temporal
lowpass filters
multipliers
+
−
opponent
subtraction

“Smart” Pixel Details

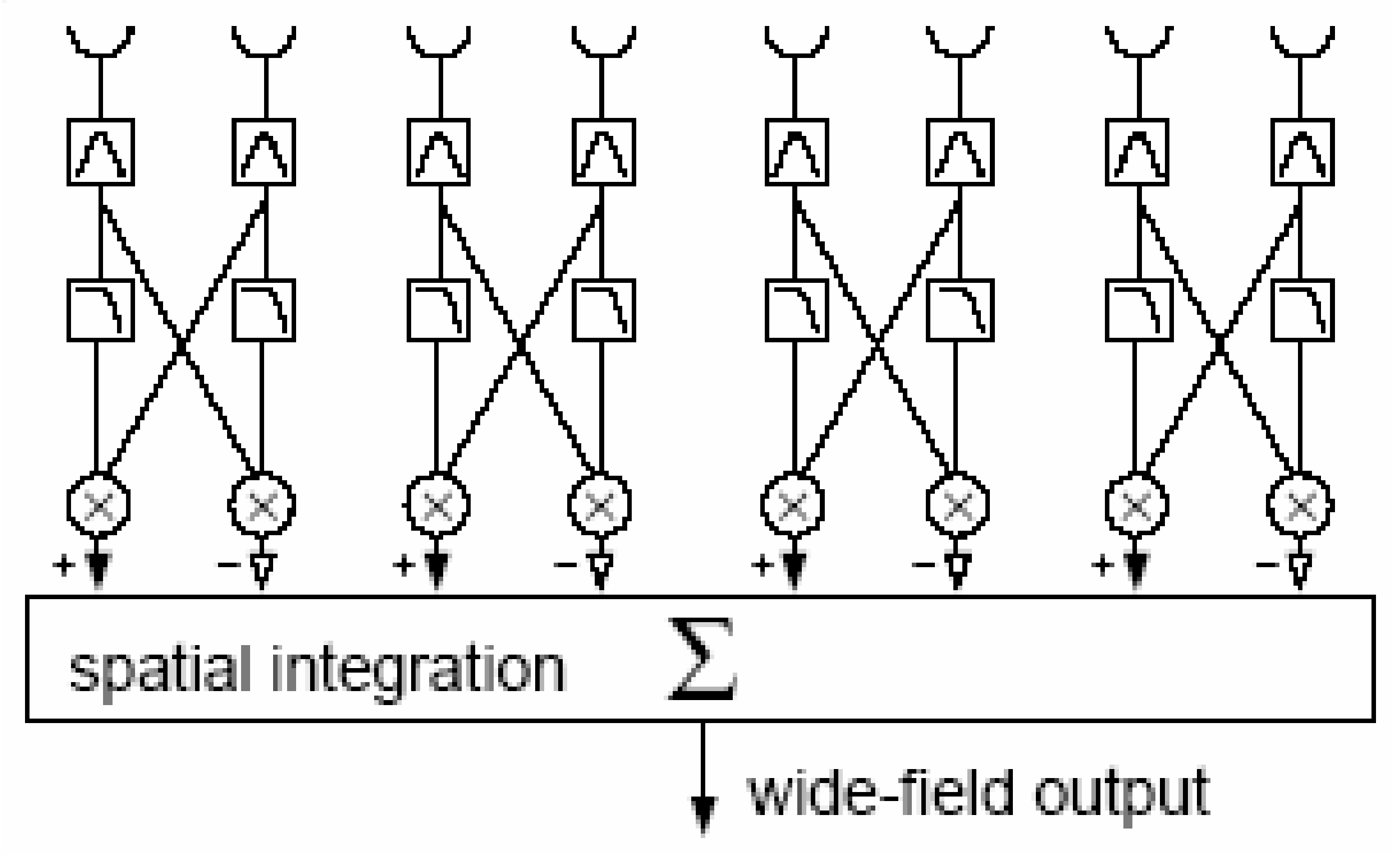


(a) Photoreceptor and Filtering

(b) Low-Pass Filter (Phase Lag)

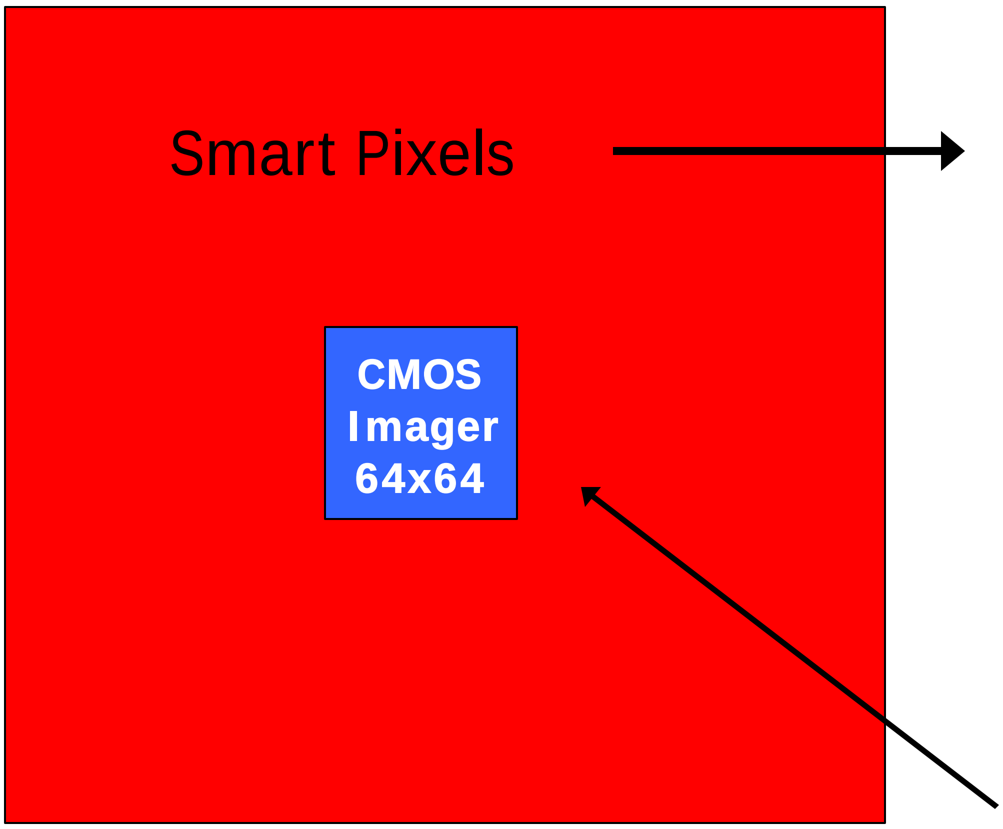
(c) Multiplier

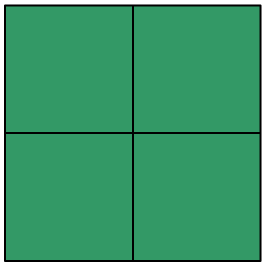
Combining Pixel Information



General Idea

Each pixel outputs both an x and y analog directional output.





These are combined for overall directional information.

CMOS Imager is a Separate System.

Testing

- Adjust design to output individual pixel information
- Develop Method of extracting this information
  - Microcontroller, external hardware
- Develop Matlab program for meaningful analysis
  - While waiting for chip to be fabricated

Integration

- Sensor must be integrated into MFI
  - Design with this in mind
  - Find out requirements, expected outputs
- Integration primarily at UC Berkeley
  - I will likely go there to help with integration

Communication Plan

- Meet with Dr. Harrison each week
  - Discuss Progress
  - Resolve Questions
  - More Often as necessary
- Presentations at milestones to Harrison and Grad Students
- Collaboration as needed with team members at other Universities

Official Milestones

Design V1 chip with optical flow and CMOS imager	**Y0.5**	**WP**
Benchtop testing of V1 chip	**Y1.0**	**proto**
Flight testing of V1 chip (at Berkeley, data collection	**Y1.5**	**WP**
Design of V2 sensor chip	**Y1.5**	**WP**
V2 sensor for integration with MFI	**Y2.0**	**proto**
V3 sensor design with roll/pitch/yaw detection+ocelli	**Y2.5**	**WP**
Benchtop testing of V3 chip	**Y3.0**	**proto**
V4 sensor design with collision avoidance	**Y4.0**	**proto**

Schedule Tasks

Tasks	Sep				Oct				Nov				Dec			
Learn Lab Tools																
Research Previous Work																
Preliminary Design																
Design Simulation																
Determine Testing Strategy																
Design Modifications																
VLSI Layout																
Submit for Fabrication																
Implement Testing Strategy																
Documentation																

Schedule Tasks (cont.)

Tasks	Jan				Feb				Mar				Apr			
Implement Testing Strategy																
Develop Analysis Tools																
Receive Fabricated Chip																
Test Chip and Analyze Performance																
Prepare for Thesis Presentation																
Present Senior Thesis																
Documentation																

Risks, Difficulties

- $$$ - No grant, no project
  - Backup plan involves neural recording
- Low power, small area
  - Layout will be a challenge
- Testing will be tough
- Simultaneous data for collision, flow, rotation info

Questions?