Vertically Integrated Projects (VIP) at Purdue University

ECE 279, 379, 479

James V. Krogmeier, Samuel P. Midkiff
School of Electrical and Computer Engineering
Purdue University
April 10, 2014
What are the goals of Purdue VIP?

- Enable undergraduate students to innovate in the context of design projects related to a faculty member’s research.
- Foster team-based research communities involving faculty, research staff, graduate students, and undergraduate students where all can experience:
  - Collaboration
  - Mutual respect
  - Communication
  - Shared responsibility
  - Teaching and learning
  - Leadership
- Provide opportunities for undergraduates to participate in research publication.
- Engage students in entrepreneurial activities.
VIP Goal: Transform Education via Team Projects, Mentoring, Entrepreneurial Activities

Umbrella VIP Course Structure

- **Facilities**
- **S&E**
- **Training**

**Typical VIP Team**
- Faculty and Staff
- Ph.D. and M.S. Students
- 5 to 10 Undergraduates

**Academic Research Projects / Companies / Customers**
- Research Problems
- Product Needs

**Students with Standard Background**

**Graduates Poised for Successful Careers**

**Publications**
**Prototypes/Demos**
**Intellectual Property**
Mixture of hardware and software experiences with real applications.

Weekly:
- Review meetings with faculty and grad student mentors
- Homework on background topics
- Oral project presentations

Oral midterm exams.

Poster session and call-out near semester mid-point.

Final project presentations and review.

Sponsor meetings, field trips, paper writing.
Lifecycle of “Typical” VIP Team Project

- Concept Development
- Hardware/Software Prototyping
- Experimental Data Collection
- Algorithm Development
- Analysis and Algorithm Refinement
- Refinement of Experimental Hardware/Software and Additional Data Collection
- Analysis and Publication
- Possible Generation of Related Concepts and New Teams
- Entrepreneurship????
Team Makeup:
- Teams size varies: number undergraduates 2 to 15, sophomores to seniors
- Mentors: 1 or more graduate students, faculty

Course Credit:
- 1 or 2 credits per semester
- Counts as laboratory and technical elective
- Senior design via course number borrowing

Team Selection: Team recruiting presentations first Wed of semester, students rank choices, teams formed over the weekend, kickoff in second week

Summer opportunities via hourly paid research, SURF, DURI
VIP Program Structure at Purdue (cont’d)

- **Resources:**
  - Two 25% TAs
  - About 2000 sq feet of laboratory, meeting, presentation space

- **Kurtenbach VIP Leadership Summer Scholarship**

- **Purdue Provost’s Fund**

- **Individual research projects fund some of the teams**
  - National Science Foundation
  - Industry: Hewlett-Packard, Proctor and Gamble, Aruba Networks, Motorola, Yelp, Individual farmers, Climate Corporation, etc.
VIP Faculty/Staff Team Leaders (24)

Matthew Swabey
Jim Krogmeier
David Love
Aaron Ault
Jim Garrison (AAE)
Dimitri Peroulis
Charles Bouman
M. Mattioli (IU-Law)
Yung-Hsiang Lu
Thomas Talavage
James Ogg (EAS)
Chih-Chun Wang
Jan Allebach
D. Buckmaster (ABE)
Mark Johnson
Samuel Midkiff
Vincent Drnevich (CE)

David Ebert
Matthew Swabey
Jim Krogmeier
David Love
Aaron Ault
Jim Garrison (AAE)
Dimitri Peroulis
Charles Bouman
M. Mattioli (IU-Law)
Yung-Hsiang Lu
Thomas Talavage
James Ogg (EAS)
Chih-Chun Wang
Jan Allebach
D. Buckmaster (ABE)

Mark Johnson
Samuel Midkiff
Vincent Drnevich (CE)

Ed Delp
Niklas Elmqvist
Eric Nauman (ME)
B. Robinson
M. Janis (IU-Law)
J. Sullivan (AAE)
VIP Projects for Spring 2014 (17 Teams, 86 Students)

- Technologies for Neuroimaging
- Autonomous Aerial Vehicle
- Image-Based Health Measurements
- EMC / Signal Integrity
- Software Defined Radio
- OpenATK
- Time Domain Reflectometry
- 3D Capture and Applications
- Visual and Data Analytics
- Electromagnetic Visualization Game
- High-Speed Electric Motorcycles
- Earth History Visualization
- Smart Phone
- Big (Imagery) Data
- Intellectual Property Team
- SoCET
- Wideband software defined radio for Remote Sensing with Signals of Opportunity
VIP Projects for Spring 2014 (17 Teams, 86 Students)

- Technologies for Neuroimaging
- Autonomous Aerial Vehicle
- Image-Based Health Measurements
- EMC / Signal Integrity
- Software Defined Radio
- OpenATK
- Time Domain Reflectometry
- 3D Capture and Applications
- Visual and Data Analytics
- Electromagnetic Visualization Game
- High-Speed Electric Motorcycles
- Earth History Visualization
- Smart Phone
- Big (Imagery) Data
- Intellectual Property Team
- SoCET
- Wideband software defined radio for Remote Sensing with Signals of Opportunity
Technologies for Neuroimaging

Prof. Thomas Talavage

Functional Magnetic Resonance Imaging (fMRI) is a powerful MRI technique for the study of the brain, allowing us to understand how we perceive and think about the world, and how we interact with it.

The goal of this team is to build devices that can augment (1) our ability to how we perceive and think about the world around us, and (2) virtual environments in which we may better probe how we interact with the world.
AR Drone

Instructors: Prof. Charles Bouman, Prof. Samuel Midkiff

**Goal:** Command the drone to complete various image processing based tasks using LabView

**Labview Toolkit**
- The Labview toolkit allows flexible control of the AR Drone
- There are Labview wrappers for open CV which allow precise image processing in flight
- Labview enables us to use any input method to control the drone
  - Xbox controller
  - Joystick
  - Autonomous Navigation

**Project Background**
- AR Drone is French made robotic flying product that can be controlled by Iphone/Ipad via a wifi connection.
- By using open source software, we can fly the AR Drone with a joystick.
- We use Labview as new programming platform instead of using C programming.
- We have been able to get the drone to track a ball using Labview.
- Currently on the 3rd semester using the LabView software to control the drone.

**Future goals**
- Use a 3G/4G network to connect to the drone from long distances.
- Get the drone to track faces using openCV facial recognition libraries.
- Explore ways of getting the drone to recognize multiple objects.

**Progress**
- Moved to LabView and the OpenCV platform instead of C programming for the robotic control.
- Created a basic flying platform with image processing to track a colored object in 3 dimensions.
- Derivative controlled feedback for pitch.
- Can track multiple colors including a user defined color and human skin color.
- Eliminated signal noise from mask and from bright lights that seemingly alter color of the object.
Earth History visualization
via Time-Scale Creator package ("time machine")

Time Scale Creator
Database coordinator: Jim Ogg
Software development: Adam Lugowski

TS-Creator is for you to create on-screen and downloadable charts of any portion of the geologic time scale with your choice of bio-, magneto-, chemo- and other events in Earth History. See HELP for Features.

Supported by:

Supported by:
ICS
CHRONOS
NSF
Purdue University

Other Support from:

ExxonMobil
Chevron
bp

www.tsccreator.org
(Made at Purdue; hosted here in Engineering)
Motivation

- New instrumentation for airborne remote sensing of ocean winds and roughness, soil moisture, and atmospheric temperature.

Research Goal

- Demonstrate coherent recording of GNSS signals from two antennas, using a highly stable frequency reference.

Project Objectives

- **DESIGN** a wide-band (20 MHz) multi-channel recording system for GNSS signals.
- **BUILD** flight box prototype using Universal Software Radio Peripheral (USRP) technology.
- **TEST** full system remote sensing capabilities.

Preferred Qualifications

- CAD
- Machine/Electronics Work
- Linux & Bash Scripting
- MATLAB
- USRP
- EE301

Technologies

- Software Defined Radio
- GNSS
High Speed Electric Motorcycles

Objective: Set national and international land speed records for small electric powered motorcycles
Open Ag ToolKit
Aaron Ault, James Krogmeier, Dennis Buckmaster

Open Source Apps
Cloud Platforms
Ag and Watersheds

OpenATK: http://openatk.com
ISOBlue: http://isoblue.org
Water Apps: http://waterapps.org
Open Ag ToolKit - Apps

This Semester:

Open Source Yield Monitor

Field Notebook

Planting

External Data Integration

New Platforms (iOS, HTML5)

65 psi = 38,000 lbs 72 psi = 42,000 lbs

Total Weight: 80,000 lbs
Open Ag ToolKit – ISOBlue/RTK GPS

ISOBlue: [http://isobluue.org](http://isobluue.org)

This Semester:
Cheap RTK GPS + 3G/4G Cape
Open Source Library
Yield Data from Real Harvesters
Open Ag ToolKit – ISOBlue/RTK GPS

ISOBlue: [http://isoblue.org](http://isoblue.org)

This Semester:
Cheap RTK GPS + 3G/4G Cape
New Initiative Involving OpenATK VIP Team: The Open Ag Data Alliance

The central guiding principle of OADA is that each farmer owns data generated or entered by the farmer, their employees, or by machines performing activities on their farm.
Data Today: The Downside of Prescription Planting
Data: The (Unfulfilled) Promise

- Cover Crops
- Deep Till vs. No-Till vs. Minimum Till
- Effect of Manure Management
- Effect of stover removal
- Fungicide response in a dry summer
- Stratego vs. Headline
- 22 oz/acre Glyphosate vs. 32 oz/acre
- Split Fungicide Applications
- Irrigation
- Seed spacing
- Down pressure
- Silage corn vs. BMR
- Insecticide
- Starter fertilizer rate
- 20% vs. 5% Refuge vs. RIB
- GPS-based fertilizer vs. constant rate
- Variable-rate population
- Variable-rate nitrogen
- Variable-rate population by soil type
- Foliar fertilizer
- Foliar fertilizer rates
- 30-inch vs. 15-inch bean rows
- New planter vs. old planter
- Disc vs. vertical tillage
- Fall vertical tillage
- Level7 solution buffer
- Crop oil additive
- Mycogen vs. Pioneer vs. Dekalb vs. Beck’s
- Quantifying standability yield effects
- Phantom Loss
- Replant after flooding
- Real effect of planting date
Data with OADA: A Better Prescription

Planting Scenario

- Frank's Combine with OEM A's Monitor
- Fertilizer Co-op
- OEM A's Cloud
- OEM B's Cloud
- OADA REST API
- Frank's Cloud of Choice
- Agronomist's Computer
- Rx Map
- Yield Data
- As-Applied Fertilizer Data
- Frank
- Frank's Planter
- RX Map
- Yield Data, Soil Tests, Seed Varieties, Fertilizer Data, Irrigator Outlines
- Local Agronomist
VIP at Purdue Plans for the Future

- Growth outside of the College of Engineering
  - Schools of Science, Agriculture
  - Brian Lamb School of Communication
  - Computer Science
  - Management and IP with Krannert and IU Law
- Team scheduling must be automated
- Creation of “Just-in-Time” curricula in support of project needs
- More entrepreneurial support and opportunities
- Creation of a journal for undergraduate research and development, yearly VIP research conf.
Thanks to Purdue VIP Sponsors