

## **NARRATIVE - PROGRAM OVERVIEW**

My overarching research objective is to advance innovations in agricultural machinery through the application of automation, specifically improving their ability to adapt to inherent spatial and temporal field variability. I have performed investigations into 1) the design of hybrid powertrains to better adapt to the time-varying nature of agricultural power loads, 2) statistical and mathematical representations of these power loads during standard equipment operations, 3) optimized routing of fleets of agricultural vehicles, and 4) automation of sprayers to provide location-specific application of chemicals.

### **Hybrid and Electric Powertrains**

I have continued my work with hybrid powertrains. After developing and testing a hybrid powertrain for use on an autonomous tractor, the powertrain was modified for space constraints to fit within the standard battery box in an electric forklift. This work has attracted the attention of various industrial partners (Clark Material Handling – CMH, Crown industries, Zapi Controllers, Kubota Engines and Curtis instruments) who have provided materials, engineering effort and technical support to this project. This area of research has resulted in a refereed journal article, multiple meeting presentations at ASABE conferences and an invited presentation at the Electrical and Hybrid Vehicle Technology Conference. It also provided the preliminary data needed to win a Sustainability Challenge Grant to investigate the potential to replace non-renewable energy (diesel for tractors and grid electricity to operate equipment) with solar power on diversified organic farms. For this program, the tractor has been converted to an electric-only powertrain, and a charger installed on the Horticulture Research Farm. A 10 kW solar system is designed, ordered and will soon be built on the Horticulture Research Farm.

### **Optimized Routing for Fleets of Agricultural Vehicles**

My research in optimized routing has focused on improving the efficiency of routes of agricultural vehicles working together as a fleet to complete field tasks. The challenge of routing multiple agricultural vehicles in a field is part of a class of problems recognized by computer scientists as NP-Hard and thus computationally intractable. Route optimization has required developing a method of transforming the field work problem into the more standard Vehicle Routing Problem recognized by computer scientists and developing heuristics and metaheuristics algorithm to produce optimized solutions. This work has been supported by a KSEF grant. It has produced multiple conference presentations and a manuscript is in review.

### **Location Specific Spraying**

Chemical application needs vary spatially within a field, and meeting these spatial needs requires application control at the individual nozzle level, which is currently not available. I developed a nozzle-level flow sensor based on optical cross-correlation. I also tested and created algorithms to use a nozzle-level optical sensor to determine the concentration of chemical agent in the carrier fluid as it is discharged through the nozzle. Both of these efforts resulted in refereed journal articles.

### **Apps**

A wet grain delivery app has been developed to assist producers in determining the best delivery location for wet grain as they harvest it in the field. With Sam McNeill and Jordan Shockley, Assistant Extension Professor in Agriculture Economics, a spreadsheet was developed and published as an Extension Publication that considers grain prices, moisture discount schedules and hauling costs for various

elevators in Kentucky based on location. The app version of this tool is under further development, which has been supported by a grant from the Kentucky Soybean Promotion Board. After in-field testing and revisions, it will be published to producers in popular app stores. A journal article on this development was published in the Journal of Extension and reviewers commented that it was an excellent direction for future of Extension. Additionally, location accuracy is an issue that often appears when attempting to use apps for agricultural production decision making so my team conducted tests to determine accuracy and error characteristics of these devices. This research is important and impactful enough that the popular farm magazine *Successful Farmer* ran a story about the results of the research. It also produced a refereed journal article.

**Service**

I have served as the BAE Student Branch advisor for the past three years (ending in August 2015) and have focused on ensuring that the BAE Student Branch engages students with our department. With this position, I have responsibility for our department’s E-Day exhibits. Our exhibits have continued to be some of the most crowded in the entire college. I have utilized my experience with apps in outreach efforts. My app Continuing Professional Development sessions at ASABE meetings have remained popular for 4 years now, and I have turned over teaching of these sessions to others in the past year. I also provided a similar to class to 4-Her’s at the 2015 and 2016 Kentucky 4-H Teen Conferences. Within ASABE, I have served as an officer and chair of technical committees and am Chair of the Information Technology, Sensors & Controls (ITSC) Technical Community (formally IET). In the past two years, I have served on two USDA SBIR Phase I panels and one USDA SBIR Phase II review panel.

**EDUCATION AND TRAINING**

Oklahoma State University	Biosystems Engineering	B.S.	2005
Oklahoma State University	Biosystems Engineering	M.S.	2007
Kansas State University	Biological and Agricultural Engineering	Ph.D.	2012

**PROFESSIONAL EXPERIENCE**

**Assistant Professor** 2012-present

Biosystems and Agricultural Engineering, University of Kentucky, Lexington, Kentucky

- Conduct research and teach in the area of machinery systems and automation

**National Science Foundation GK-12 Fellow** 2010-2012

Biological and Agricultural Engineering, Kansas State University, Manhattan, Kansas

- Collaborate with a seventh grade science teacher and a high school agricultural science teacher to develop and teach lessons/activities to deepen student understanding of sensors.

**Systems Engineer** 2008- 2009

The Charles Machine Works, Inc. (Ditch Witch), Perry, Oklahoma

- Designed electrical systems (schematics, wiring harnesses, and electrical components) on 10 different machine models.

## RESEARCH

### Refereed Publications (2015-2016)

- Seyyedhasani, H., **Dvorak, J.** (2016). Using the Vehicle Routing Problem to Reduce Field Completion Times with Multiple Machines. *Submitted to Computers and Electronics in Agriculture*. In Press.
  - Rounsaville, J., **Dvorak, J.**, Stombaugh, T. (2016). Methods for Calculating Relative Cross-Track Error for ASABE/ISO 12188-2 from Discrete Measurements. *Transactions of the ASABE*. In Press.
  - Seyyedhasani, H., **Dvorak, J.**, Sama, M., & Stombaugh, T. (2016). Technical Note: Mobile device-based location services accuracy. *Applied Engineering in Agriculture*. 32(5). In Press.
  - **Dvorak, J.**, Stombaugh, T., & Wan, Y. (2016). Nozzle Sensor for In-System Chemical Concentration Monitoring. *Transactions of the ASABE*. 59 (5). In Press.
  - Jackson, J. & **Dvorak, J.** (2016). Hybrid Diesel-Electric Drivetrain for Small Agricultural Field Machines. *Transactions of the ASABE*. 59 (5). In Press
  - **Dvorak, Joseph**, Stone, Marvin, & Self, Kelvin. (2016) Object Detection for Agricultural and Construction Environments using an Ultrasonic Sensor. *Journal of Agricultural Safety and Health*. 22(2): 107-119. (doi: 10.13031/jash.22.11260).
  - **Dvorak, J.**, Dvorak, T., & Neel, S. (2016). Utilizing Wii technology to teach acceleration to middle school students. *Transactions of the ASABE*. 59(2): 387-395. (doi: 10.13031/trans.59.11349)
  - **Dvorak, Joseph**, McNeill, Sam & Hardy, Clint. (2016). Wet Grain Delivery Advice: A Previously Impossible Extension Challenge Solved Through Apps. *Journal of Extension [On-line]*. 54 (2). Article 2IAW1. Available at <https://joe.org/joe/2016april/iw1.php>.
    - Reviewer Comments: “This is one of the **best manuscripts** I have ever reviewed for JOE [*Journal of Extension*]... Kudos to the authors for a great project and a well written paper.”
  - **Dvorak, J.S.** & Bryant, L.E. (2015). An optical sprayer nozzle flow rate sensor. *Transactions of the ASABE*. 58(2): 251-259. (doi: 10.13031/trans.58.10765)\*\*\*
- \*\*\* Awarded an ASABE superior paper award at ASABE’s 2016 Annual International Meeting.
- Zhang, N., **Dvorak, J. S.**, & Zhang, Y. (2013). A Correlation-Based Optical Flowmeter for Enclosed Flows. *Transactions of the ASABE*. 56(6): 1511-1522. (doi: 10.13031/trans.56.10052)
  - **Dvorak, J. S.**, Franke-Dvorak, T. C., & Price, R. R. (2012). “Apps” – An innovative way to share extension knowledge. *Journal of Extension [On-line]*. 50(6) Article 6IAW2. Available at <http://www.joe.org/joe/2012december/iw2.php>.

### Publications under review

- **Dvorak, J.**, Zhang, N., (submitted 2015). Open channel velocity sensor geometry design using computational fluid dynamics. *Submitted to International Journal of Agricultural and Biological Engineering*. In final revision.

## **FUNDS RECEIVED**

### Extramural

- USDA-NIFA: Alfalfa and Forage Research Program (as PI): LIDAR and photogrammetry to map alfalfa yield and quality using Unmanned Aircraft Systems. \$250,000. 2016-2019. (with Michael Sama, Josh Jackson, Michael Montross, Ben Goff, Jessica Williamson).
- Kentucky Soybean Promotion Board (as PI): Wet Soybean Delivery Advice App. \$13,945. 1 year: 2016-2017. (with Sam McNeill and Jordan Shockley).
- Kentucky Science & Engineering Foundation (as PI): Efficient Routing with Multiple Vehicles for Agricultural Area Coverage Tasks. \$30,000. 1 year: 2016-2017. (with Michael Sama).
- 2015 USDA Agriculture and Food Research Initiative Foundational Program (as Co-PI, Michael Sama PI): Development Of A CAN-Based Data Management And Decision Support System For Optimal Equipment And Harvest Timing From Grain Harvest To Storage. \$500,000. 2015-2018. (with Michael Sama, Michael Montross, Tyler Mark and Sam McNeill)
- Stombaugh, T., **Dvorak, J.** (as Co-PI, Tim Stombaugh PI): Control and Monitoring of Sprayer Output. 2013-2014. \$265,000. CNH. August 2013-December 2014

### Internal

- 2015 UK Sustainability Challenge Grant: Solar Powered Tractor. (\$25,000). 1 year project in calendar year 2016. (with Don Colliver and Mark Williams)
- Spring 2015 Education Abroad UK Sponsored Program Development Grant. (\$2000). Award in support of developing an education abroad version of BAE 305.
- 2014 UK eLearning Innovation Initiative (eLII) (\$4000). Award in support of development of blended and hybrid teaching.

### Other - Hatch Projects

- Dvorak, J.S. 2013-2016. W2009 Integrated Systems Research and Development in Automation and Sensors for Sustainability of Specialty Crops. Multi-state Project.

## **GRADUATE STUDENT ADVISING**

### *Major Professor*

- Joseph Jackson. MSc. Biosystems and Agricultural Engineering. Graduation Date: August, 2015. Thesis Topic: Efficiency of Hybrid-Electric Tractors for Agricultural Production.
- Hasan Seyyedhasani. Ph.D. Biosystems and Agricultural Engineering. Expected Graduation Date: December, 2016 (co-advisor)
- Joseph Rounsaville. Ph.D. Biosystems and Agricultural Engineering. Expected Graduation Date: August, 2017 (co-advisor)

*Committees:* I am serving or have served on 3 graduate student committees.

## **VISITING SCHOLARS**

- Anderson Ravanny de Andrade Gomes. Brazil Scientific Mobility Program at the University of Kentucky, Sandwich Doctorate. July 2015 – June 2016. Investigated planter seeding rate accuracy under various equipment and field conditions.

- Anaira Noia de Souza. Brazil Scientific Mobility Program – Undergraduate. May 2015 – August 2015. Testing of an optical sprayer concentration sensor.

### **UNDERGRADUATE RESEARCH PROJECTS**

I have lead 5 undergraduates on research projects. Two of these students were invited to present at the 2014 National Conference on Undergraduate Research (April 3-5, 2014).

### **EXTENSION AND OUTREACH**

#### Extension Publications

- Jordan Shockley, Sam McNeill, **Joe Dvorak**. (2016). Grain Hauling Decision Guide. AEC 2016-11.

#### Extension/Outreach Presentations and Popular Press Publications

- 2016 Kentucky Fruit and Vegetable Conference. *The Future: Autonomous Tractors*. Presentation on the opportunities for advanced autonomous systems in horticulture.
- Organized the Biosystems and Agricultural Engineering exhibits at UK's E-Day (2014-2016).
- Precision in Practice. *Successful Farming*. April 2015. Research on the location accuracy of common mobile devices featured in a nationwide farm industry magazine.
- Field Day for Market Growers: Mechanization for Organic Vegetable Production. June 9, 2015. Presented research and demonstrated concept vehicle for future possibilities with electric vehicle powertrains and autonomous operation for market growers.
- Kentucky Farm Bureau Energy Committee. September 23, 2014. *Electrical Energy for Agriculture Machinery*. Invited presentation on the future of agricultural machinery energy sources. 25-30 attendees.
- 2014 Kentucky Cooperative Extension Professional Development Conference. February 26, 2014. *Creating an Android App*. Presentation on basics of app development and how to make simple apps. 140 attendees.
- Boyd County. Introduction to GPS and location apps. February 2013.
- Fulton County Field Day. Helped Teach GPS and precision farming to high school students in the area. August 2012.

### **SERVICE**

#### Departmental

Undergraduate Curriculum Committee Chair 2013-2016

ASABE Student Branch Advisor 2013-2016

#### University/State

2015 KY 4-H Teen Conference. June 9 and 10. Taught "There's an App for That" Workshop on Android App Development. 27 participants.

2016 KY 4-H Teen Conference. June 14 and 15. Taught "There's an App for That" Workshop on Android App Development. 31 participants.

#### Involvement in University Research Groups

- Member of Unmanned Systems Research Consortium (USRC)

#### National Committees

I am an officer on 4 ASABE technical committees, including chair of the Information Technology, Sensors and Controls technical community.

ASABE Professional Development Seminars Taught

**Developing Agricultural Applications for Handheld Mobile Devices.** Offered at:

2012 ASABE Annual International Meeting  
2013 ASABE Annual International Meeting  
2014 ASABE Annual International Meeting  
2015 ASABE's Agricultural Equipment Technology Conference  
2015 ASABE Annual International Meeting

Manuscript Review

I have reviewed for:

Transactions of the ASABE  
Journal of Agricultural Safety and Health  
Applied Engineering in Agriculture  
Biosystems Engineering  
Computers and Electronics in Agriculture  
International Journal of Agricultural and Biological Engineering

Proposal Review Panels

I have served on:

4 separate USDA review panels.

Peer-Reviewed Conference Presentations

- Franke-Dvorak, T. C., & **Dvorak, J. S.** (2016). Extension agents' use of smartphones and apps as a means to educate clientele. Southern Rural Sociological Association (SRSA) Annual Conference, San Antonio, Texas, February 7-8, 2016.

Conference Presentations

- **Dvorak, J.** & Seyyedhasani, Hasan. Simple Field Logistics Simulation Comparing Field Efficiencies and Field Capacities between Larger and Smaller Equipment. Poster Presentation. 2016 ASABE Annual International Meeting, Orlando, Florida. July 17-20, 2016.
- Seyyedhasani, H. & **Dvorak, J.** Comparison of traditional path assignment for multiple vehicles with computer generated one in agricultural field context. 2016 ASABE Annual International Meeting, Orlando, Florida. July 17-20, 2016.
- Turner, A., Montross, M., **Dvorak, J.**, Sama, M.P. Tracking Grain Trucks Using a Fleet Management System. 2016 ASABE Annual International Meeting, Orlando, Florida. July 17-20, 2016.
- Rounsaville, J. & **Dvorak, J.** System Power requirements for a Fully Electric Drivetrain in Ag. 2016 ASABE Annual International Meeting, Orlando, Florida. July 17-20, 2016.
- **Dvorak, J.S.** Electrical Energy for Agricultural Machinery. Oral Presentation. 2015 Electric & Hybrid Vehicle Technology Conference. Novi, Michigan. September 15-17, 2015

- **Dvorak, J.S.**, Rounsaville, J. RAFiE - The 30HP Autonomous Tractor. Oral Presentation. 2015 ASABE Annual International Meeting, New Orleans, LA. July 26-29, 2015.
- **Dvorak, J.S.** Application testing of an optical individual sprayer nozzle agent concentration sensor. Oral Presentation. 2015 ASABE Annual International Meeting, New Orleans, LA. July 26-29, 2015.
- Seyyedhasani, H., **Dvorak, J.S.** Optimal Path Planning Using NSGA II. Oral Presentation. 2015 ASABE Annual International Meeting, New Orleans, LA. July 26-29, 2015.
- **Dvorak, J.S.**, Seyyedhasani, H. Testing of Tablet-Based GPS Systems. Oral Presentation. 2014 ASABE Annual International Meeting, Montreal, QC, Canada. July 12-17, 2014.
- **Dvorak, J.S.**, Dvorak, T.C., Neel, S. Utilizing Wii Technology to Teach Acceleration. Oral presentation. 2013 ASABE Annual International Meeting, Kansas City, MO. July 21- July 24, 2013.
- **Dvorak, J.S.**, Byrant, L. Optical Sprayer Nozzle Discharge Sensor. Poster presentation. 2013 ASABE Annual International Meeting, Kansas City, MO. July 21- July 24, 2013.
- **Dvorak, J.S.** Framework for Distributed Control of a Fleet of Agricultural Field Robots. Oral presentation. 2013 ASABE Annual International Meeting, Kansas City, MO. July 21- July 24, 2013.
- **Dvorak, J. S.**, Zhang, N. Improvements to an Optical Fluid Velocity Sensor. Oral presentation. 2012 ASABE Annual International Meeting, Dallas, TX. July 29-August 1, 2012.