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***Ground and Aerial Robots for Agricultural Production:
Opportunities and Challenges***

November 17, 2020 Webinar Questions and Answers

Panelists: Santosh Pitla, Tami Brown-Brandl, Dennis R. Buckmaster, Todd J. Janzen, Michael Sama, and Scott Shearer.

Are there any robotic platforms for soil testing? In particular Indigo Ag is interested in SOC, and Bulk Density estimations.

DB: rogoag.com is one robotic soil sampling company.

You mentioned there is very little data showing an economic benefit, does that imply there is data but the majority of which does not suggest an economic benefit, or that there is insufficient economic cost/benefit analysis as of yet?

MS: Most of the work relates to the development of the underlying technology.

DB: Combo—tough to show benefit of any tech early in development.

How are students at the universities represented on this panel helping prepare future agricultural workers to effectively use/manage these evolving technologies?

DB: Continuous refinement of curricula; improving knowledge in data pipeline is a part; new opportunities for graduates of ASM type programs and let's hope our universities are adjusting quickly—and 2-year ag tech degrees of increasing importance, too.

Is USDA funding work on use of robots? Are organic farmers more or less interested—any studies on economic impact for organic growers?

SS: AI may alter how we view GMO/organic production - Blue River.

Where are we in terms of Precision Application and the use of Robots and Machine Vision? Especially for areas other than herbicide use. For example, do we have technologies to spray only on certain parts of the plant/trees/vines? Who in the Academia or Research is leading in this area?

SS: OSU/ARS has developed Smart Spray Applied technology for ornamentals/tree crops.

DB: Seems vision technologies to determine where there is nothing to spray are developed, Dalhousie University work a few years ago.



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Are there examples of ground and aerial systems interfacing together, perhaps for applications in combined imaging/pest verification and management?

DB: Requires interoperability still needing improvement at this time—certainly work in progress.

How long until you think autonomous robots will be common place in row crop production?

DB: Growing slowly over coming years, not likely common for a decade—just one prediction.

Battery life seems to be one of the primary limitations for at least UAS implementation for many—are you aware of new developments that will help with this issue?

MS: Fixed wing systems are approaching 2-3 hours of flight time, multi-rotor systems are approaching 1 hour.

How is a lack of regulatory framework around autonomy affective development?

TJ: We have a 50 state regulatory system. Any new introduction into the US marketplace has to comply with each applicable state.

How do you see the issues around end-user trust being resolved considering the "black-box" nature of the AI algorithms (e.g. CNNs, DNN etc.) used for operation?

SS: Yes, this has prompted XAI...

For analyzing fields for crop stress with drones, is the analysis done on the drone or is the drone more video feed to a larger ground computer to do the analysis?

DB: Generally, in cloud, but may be moving more to the edge; as of today, very little on vehicle.

Is there hope that FAA will move to allow more aerial options?

MS: Yes, it's been a slow process but steady progress is being made.

What areas of opportunity are being considered where ag robotics can aide in environmentally sustainable practices?



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DB: Often environmentally sustainability directly aligns with reducing cost and improving efficiency of the farm. Robotics (even pre-robotic automation) can reduce inputs. They also allow the opportunity to be more flexible with operations timing, etc.

Any work on using UAS to herd livestock?

MS: Some work at UK, primarily looking at cattle response to UAS to induce movement.

What research has been done in use of UASs for livestock management?

MS: Cattle tracking, biometric measurements, physiological and behavioral response to drones.

What is the farmer's adoption rate of these technologies in the US?

<https://ag.purdue.edu/digital-ag-resources/wp-content/uploads/2020/03/2019-CropLife-Purdue-Precision-Survey-Report-4-Mar-2020-1.pdf>

<https://access.onlinelibrary.wiley.com/doi/full/10.2134/agronj2018.12.0779>

What do you anticipate will come in terms of regulatory control when these are used for food production?

DB: I would hope regulatory control mimics that of human-powered work. While there is opportunity for "more data", to require it will be unfair to those not yet using robots.

Do you foresee the FAA allowing fully autonomous abilities?

MS: Probably not in the near future, some incremental levels of autonomy will be feasible through waivers.

Is there a system using ear tags that indicate heat stress in livestock for hilly and grass feed beef? How frequently do they need to be scanned to be effective?

DB: I don't know about scanning frequency, but the tech is now available to send that via LoRaWAN pretty energy-cost-effectively.

What are the challenges of mounting thermal sensor on robots for monitoring micro climate (Especially temp and RH) in row cropping? If it is doable it would be revolutionary for irrigation scheduling of specialty crops.



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DB: Very likely hyperspectral imaging can also lend insights and that is a rapidly growing technology.

When using the aerial sprayers in small holder farmers field surrounded by fields of other farmers. The spray in one farm land may be detrimental for the others, the chances of drifting of the ionic nanoparticles could be higher. How is this drifting to non-target area avoided?

TJ: In many US states, pesticide application requires a licensed applicator or someone with some training. The same standard will apply to a UAS or AGV operator of an unmanned vehicle.

What does the regulatory landscape look like 5 years from now for UAS application? Is there hope that this area will be freed up to allow more US innovation and investment?

TJ: That is difficult to answer. It all depends on the FAA and how it responds to increased UAS presence in the skies. Also, it depends on how well the UAS industry performs and mitigates accidents with manned aircraft.

With respect to weed management, where do ground robots and UAVs fit? Do you see completely distinct tasks or working in collaboration?

DB: See previous question, too. Treating them as a coupled fleet is in the future. UAVs to scout, selectively apply small amounts, then ground robots in larger areas.

What is the best place to publish or release case study of checking and assessing the interest in autonomous ag systems?

DB: Crop Life Magazine does a study on technology adoption every couple years. I reckon publishing could be in discipline-crossing journals such as Computers and Electronics in Agriculture or in journals specific to engineering in agriculture such as Transactions of ASABE or Biosystems Engineering.