

Ground and Aerial Robots for Agricultural Production: Opportunities and Challenges

Ground robots or unmanned ground vehicles (UGVs) and aerial robots or unmanned aerial systems (UASs) are used in both row-crops and specialty crops. Robotic manipulators (robotic arms) on the other hand are primarily used in dairy, specialty crop, and greenhouse applications.

Automation has the potential to not only augment current production practices through optimization of crop inputs, but also serves as a disruptive technology that has the potential to change the farming paradigm by reverting to more scale neutral technologies and perhaps Farming-as-a-Service.

- Researchers are developing robotic prototypes for row crop field applications such as autonomous weed management, seeding, and plant phenotyping. This is analogous to a tractor being used for multiple field operations such as planting, tillage, and grain haulage.



While UGVs are aimed at automating both production activities and sensing processes, UASs are used primarily for sensing applications so far.

- Weed, pest, and disease infestation resulting in observable changes in row crop color or physical structure can readily be observed with consumer-grade UASs equipped with standard cameras.
- A more advanced, but less common, use for UASs is to estimate production parameters using image-based remote sensing. Visible, multispectral, or thermal cameras deployed on multi-rotor or fixed-wing UASs are used to collect a series of images along prescribed flight paths at high spatial resolutions (1–10 cm per pixel).

The adoption of advanced technologies and machines in farming specialty crops including tree fruit orchards has been minimal

- Some of the challenges to successful adoption include lack of desired speed, accuracy, and robustness as well as high cost of the technology.
- To take the full benefit of automation and robotic technologies in specialty crop farming, all labor-intensive operations need to be automated so that there is a uniform, long-term employment in farming rather than seasonal peaks of hard-working laborers.

Robots or automated systems currently used in the dairy industry include automatic milking systems (AMS), feeding systems, teat sprayers, calf feeders, hoofbaths, and manure handling among others.

- Research is ongoing on devices that monitor gait and locomotion, rumination, and breathing, among others, which will overall help dairy farmers understand the complex dynamics of the milking environment and how it can be improved

Robotics in poultry and swine production is currently under development, and there is currently a fair amount of potential for automation within these animal systems, which is mainly focused on the feeding of animals, and the processing of products (meat and eggs).

- A “boar bot” is a widely used robotic application in swine industry. This is either a cart or a small vehicle that can hold a boar or its leash. The boar bot drives around animals for nose-to-nose contact during heat checking and breeding of sows.
- In poultry systems, robots are being investigated in the broiler industry and the buildings for layer hens housed on bedded floor. Robots are designed to pick up any eggs laid on the floor, monitor environmental conditions at the bird level, turn over the litter, and spray disinfectants.

Machine vision and AI technologies are key enabling technologies for the advancement of ground and aerial robots.

- When a ground or aerial robot passes through the field, or interacts with livestock, it uses machine vision and AI to identify key attributes of the crop and the livestock, respectively.
- Google's TensorFlow (<https://www.tensorflow.org/>) is an excellent example of an open source tool that offers some of the most advanced machine learning and vision tools.

Many rural areas and particularly remote farm fields do not have wireless infrastructure, so data transmission is limited to small data packets at times when machines are in range of cell towers or farm-based networks.

Ground and aerial robots also provide an opportunity to attract new generation into farming, which, otherwise, is expected to face a crucial challenge in the future as the current generation of farmers retires.

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