Sensing technology

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Factsheet about integrated weed management

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Introduction

Sensing technology can be used together with other precision agriculture techniques to adequately detect and terminate weeds at site-specific locations. Technological innovations in the areas of sensors together with nanotechnology, computer hardware, autonomous vehicles and robots have helped to advance precision agriculture rapidly in the last decade[1]. Monitoring and evaluation are cross cutting activities that take place during the entire crop rotation and throughout the growing season. Sensing technologies such as drones, support these activities and help famers not only to optimise weeding measures by sensing the location and weed infestation level but also to evaluate the success rate of previously applied measures[2].

Equipment

Sensing technologies vary from quite advanced systems that include the entire process from data collection until site-specific herbicide spraying, to relatively simple techniques that give insight in the locations and development of weeds. The main sensing technologies used in precision agriculture and for weed management specifically are:

- Mobile Terrestrial Unmanned Vehicles systems (UTV);
- Mobile Aerial Unmanned Vehicles systems (UAV, e.g. drones. UAV's have a shorter monitoring time and better control in the presence of obstacles, compared to UTV's);
- Sensors attached to tractors or other farm equipment. The most important types used for weeds identification are mainly categorised into three classes:
    - Red, Green, Blue (RGB) / Visible (VIS) sensors.
    - Multispectral sensors.
    - Hyperspectral sensors.

UAV's are often the primary choice for precise in situ remote sensing thanks to their affordability, versatility and user-friendliness. Depending on the sensing tool used and the survey aim, additional equipment may be required for analyses of the data, eventually combined with a decision support system (DSS).

For an over overview and details of the most common commercial cameras and sensors applicable in weed management you can have a look at 'Drone and sensor technology for sustainable weed management: a review[1] and 'Using Remote Sensing and an Unmanned Aerial System for Weed Management in Agricultural Crops: A Review'[3].

Applicability and efficacy

Sensing technologies that are mounted to the tractor can help in weed management by detecting the rows or directing the hoes. UAV's are ideal to identify weed patches by collecting photographic material of many hectares within a few minutes. Research on ways to integrate data collected from sensors on UAV's, ground sensors and other data sources for better management of punctual field operations is ongoing. Although UAV's differ from the territorial coverage provided by satellites, they offer a spatial and temporal resolution that other systems do not. Advantages of UAV's are:

- A higher resolution compared to other systems.
- Investment costs are compensated by the repeatability of flights (increasing the frequency of datasets)
- Collect easily deployable data in real time.
- Can be used for surveys of areas with high hazard levels or which are difficult to reach.
- Allows operators to collect data, regardless of weather conditions, including cloudy weather while other systems like satellites are troubled[4].

1| Esposito, M., Crimaldi, M., Cirillo, V., Sarghini, F. and Maggio, A., 2021. Drone and sensor technology for sustainable weed management: a review. Chemical and Biological Technologies in Agriculture, 8(1).

2| Riemens, M., Sønderskov, M., Moonen, A., Storkey, J. and Kudsk, P., 2022. An Integrated Weed Management framework: A pan-European perspective. European Journal of Agronomy, 133, p.126443.

3| Roslim, M.H.M.; Juraimi, A.S.; Che'Ya, N.N.; Sulaiman, N.; Manaf, M.N.H.A.; Ramli, Z.; Motmainna, M. Using Remote Sensing and an Unmanned Aerial System forWeed Management in Agricultural Crops: A Review. Agronomy 2021, 11, 1809. https://doi.org/10.3390/agronomy11091809

4| Esposito, M., Crimaldi, M., Cirillo, V., Sarghini, F. and Maggio, A., 2021. Drone and sensor technology for sustainable weed management: a review. Chemical and Biological Technologies in Agriculture, 8(1).

The data and locations of weed patches, collected by sensors can either be used to see where weed patches occur and whether it is time to take control measures, or they can be followed-up with control measures directly at the field, e.g. by robots. Although this is still in its infancy for most crops, the technology of robots for weed management is developed far enough for practice; experts estimate that with existing robot platforms already some practical applications are possible. With weed mapping software, the field can be divided into management zones, with a customised management plan for each zone, thus reducing herbicide use. Elements of location-specific weed management with weed detection are ready for practice, but system application is under development.

Costs

The costs of sensing technology highly depend on the high-tech level, that varies greatly. Costs of herbicide use or other management can be reduced thanks to local-specific weed management. In general sensing technologies require quite high investments.

However, RGB cameras are commonly used and available sensors in weed detection and their costs are low compared to other sensors. Little training is required to master the techniques for taking the photographs and analysing the images, while maintenance costs remain low as well. RGB sensors can be integrated with an UAV, what makes them efficient and useful for multiple purposes in field management, including biomass estimation, identification of plant stress and field mapping[5].

Core results

- New technologies are able to discern single weed species in open fields[6].
- Esposito et al. (2021)[1] and Roslim et al. (2021)[3] give an overview of the most common commercial cameras and sensors applicable in weed management.

Extra information

See *https://iwmpraise.eu/publications/* for all crop diversification strategies and their definitions, and check out the inspiration sheet:

- Prototype of camera controlled-guided post-emergence inter-row cultivator

5| *Roslim, M.H.M.; Juraimi, A.S.; Che'Ya, N.N.; Sulaiman, N.; Manaf, M.N.H.A.; Ramli, Z.; Motmainna, M. Using Remote Sensing and an Unmanned Aerial System forWeed Management in Agricultural Crops: A Review. Agronomy 2021, 11, 1809. https://doi.org/10.3390/agronomy11091809*

6| *Lottes, P.; Khanna, R.; Pfeifer, J.; Siegwart, R.; Stachniss, C.; UAV-based crop and weed classification for smart farming. Proc IEEE Int Conf Robot Autom. 2017.*
Pantazi, X-E; Moshou, D.; Bravo, C. Active learning system for weed species recognition based on hyperspectral sensing. Biosyst Eng. 2016; 146: 193–202.
Sanders, J.T.; Everman, W.J.; Austin, R.; Roberson, G.T.; Richardson, R.J. Weed species differentiation using spectral reflectance land image classification. ProcSPIE. 2019.

Figure 1 | The Garford robocrop is an in-row weeder that locates individual crop plants based on video image analysis.

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