Machine vision systems for robotic weed sensing in field environments

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Robotic sensing systems for weed control are required to be developed that are compatible with current commercial farm operations, while also having potential to be integrated with autonomous weeding platforms in the future, to realise weed control cost savings in both the short and long term. Commercially available weed detection sensors in Australia are designed for 'green-from-brown' situations and are not capable of discriminating between weeds and crop when they are growing next to each other. Weeds growing in-crop are presently controlled by tillage operations, manual spot spraying, costly selective herbicides or over-reliance on chemicals in herbicide-tolerant crop.

Practical requirements for robotic weed sensing in commercial conditions are cost-effective and robust weed sensors, real-time weed detection at commercial groundspeeds, low calibration requirements, and operation in daylight and in typical crop growth stages. The National Centre for Engineering Agriculture, a research centre within the University of Southern Queensland, has developed a range of camera-based technologies for detecting weeds in-crop for site-specific herbicide application. These systems have been developed for the grains, sugarcane, cotton and horticulture industries in projects since 2007, for ground-based vehicles and more recently in application to machine vision sensors on aerial drones.

Low-cost consumer-style colour cameras have been demonstrated to extract plant size, and leaf shape and texture, using deterministic algorithms to discriminate weed from crop. A system developed for the sugar industry discriminated the leaves of Guinea grass (a grass weed) growing amongst sugarcane (a grass crop) and achieved a weed hit rate of 85% with less than 1% overspray onto crop, in a trial in which Guinea grass was automatically detected and spot-sprayed in real-time from a tractor. Enhanced discrimination was achieved through the addition of plant height segmentation using colour/depth sensing in the pyrethrum industry. Novel methods for operation in daylight without a shade hood, and real-time processing whilst travelling at up to 15–20 km h^{-1}, have been developed. Subsequently, weed detection systems from ground-based vehicles, suitable for 'green-from-green' commercial field conditions in major cropping industries, are currently undergoing commercialisation.

Aerial drone imagery provides the potential benefits of rapidly generating a weed map for a field without requiring multiple weed detection sensors to be mounted on a boom sprayer. A trial using conventional aerial drone imagery techniques demonstrated rapid quantification of the extent of weed populations in a fallow field. The technique is also potentially applicable to monitoring of plant species populations in various landscapes and for generating areas of interest for scouting on-foot. Current research for broadacre cropping is developing technologies for an automated and real-time workflow for drone flight to prescription map generation and green-from-green spot spray operation.

Keywords Spot spray, colour cameras, image analysis, prescription map, drones.