Obstacle Detection for Autonomous Vehicles in Agriculture

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Precision agriculture is an important technology which can help make agricultural production more sustainable by applying the right kind of inputs, at the right place and at the right time. This 3R concept almost certainly entails more passes through the crop, while driving slower (in order to apply the input at the right place). High labour costs can be avoided by deploying autonomous vehicles. Examples of such autonomous vehicles are the Intelligent Autonomous Weeder [1], a robot to detect and control broad-leaved dock [2], a pesticide applicator for strawberry fields (see Figure 1), and an autonomous golf course mower [3]. These vehicles use GPS to follow a pre-defined path. The broad-leaved dock uses additional sensing to detect and control weeds. The autonomous golf course mower is currently the only one which halts when it senses an obstacle.

Safety of autonomous vehicles in agriculture is obviously important, but has received less attention to date than issues such as navigation, efficient paths, detection of crop condition, and development of actuators which are suitable for autonomous operation. Development of a safety system for autonomous vehicles in agriculture is complicated as the outdoor agricultural environment is often heterogeneous: the soil surface may be rutted, crop rows may curve or run together, and crop plants have variable size and shape even in one field. Detection of obstacles and especially of people is more difficult against this variable background than it would be, e.g., on a factory floor.

Experiments will be conducted in spring and summer 2012 to assess the usefulness for obstacle detection of several kinds of sensors, in several agricultural environments. Sensors included are laser scanners, ultrasonic sensors, a time-of-flight camera, and colour and infrared cameras. Environments included are a strawberry field and an apple orchard. Experiments will be conducted with various kinds of obstacles: for example, a spade left in the field; a child (or crouching adult); an adult standing in the field or among trees; machinery such as irrigation equipment left in the field; a fence; but also bunches of weeds, tall grass, and overhanging branches (in the orchard) that are obstacle-like but need not be avoided by an autonomous vehicle. Experiments will be conducted with a tractor which is driven through the field or orchard.

Figure 1. Autonomous tractor used to apply pesticides in strawberry fields. At present, the only safety feature of this tractor is the front-mounted bar with emergency stop buttons at either end.

Analysis of the data will focus first on individual sensors. Data from each sensor will be filtered to derive stable signals from which the presence of obstacles may be detected. While literature suggests that this approach will give good results, we hypothesize that even better detection of obstacles can be achieved by including knowledge about the semi-structured agricultural environment. Therefore we will explicitly model the environment in a second step of the analysis. In the strawberry field, the strawberry beds, individual plants, and the tractor path are modelled; in the orchard, trees are modelled individually when they are growing separately, or as a "wall" when they are growing very close together. Model parameters include height and width of strawberry plants, and height and shape parameters of the trees. Model parameters will be estimated online with a particle filter. For each kind of sensor deployed, a physical model will be used to describe formation of the signal, and a likelihood function will be developed to relate belief to signal. Data from two or more sensors can be used to update the particle filter. With a clear estimate of what the environment looks like when it is free of obstacles, it is expected that obstacles -deviations from the environment- can be detected with high accuracy.

References

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