Bakker, T.; Asselt, C.J. van; Bontsema J.; Müller, J.; Straten, G. van, 2007. RTK-DGPS based path following with a Robotic Platform. In: VDI-MEG. Proceedings of the Land Technik AgEng 2007. Hannover, Germany pp. 183-184.

AUTONOMOUS NAVIGATION IN A SUGAR BEET FIELD WITH A ROBOT

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In organic farming there is a need for weeding robots that can replace manual weeding. The required labour for hand weeding is expensive and often di±cult to obtain. In 1998 in the Netherlands on average 73 hours hand weeding were spend on one hectare of sugar beet.

This abstract considers autonomous RTK-DGPS based navigation in a field with a robotic platform using the field and headland boundaries and row locations as a-priori information. The vehicle used for the experiments is a specially designed robotic platform for performing autonomous weed control [1]. The platform is four-wheel steered and four-wheel driven. A diesel engine powers the wheels via a hydraulic transmission. The robot uses RTK-DGPS to measure both its position and its orientation. From this position the robot contour, the centre of the robot frame and the actuator position are calculated.

To start the autonomous navigation in a field the robot is first manually located along the entrance of a row at one side of the field. The robot is then set in autonomous mode and starts path following with its vehicle control system consisting of two levels [2]. The high level control determines wheel angle setpoints and wheel speed setpoints from the deviation from the path and the error in orientation. At low level, controllers are used to realize the wheel angles and wheel speeds determined by the high level control. Each wheel angle is controlled by a P controller combined with a Smith predictor to compensate for a time delay in the hydraulic transmission. The deviation and the orientation error of the robot from a path are determined by a specially designed orthogonal projection on the path using the measured actuator orientation and position. The orthogonal projection is designed to calculate the deviation and the orientation error relative to a line of positions y(x).

Figure 1 – The robotic platform

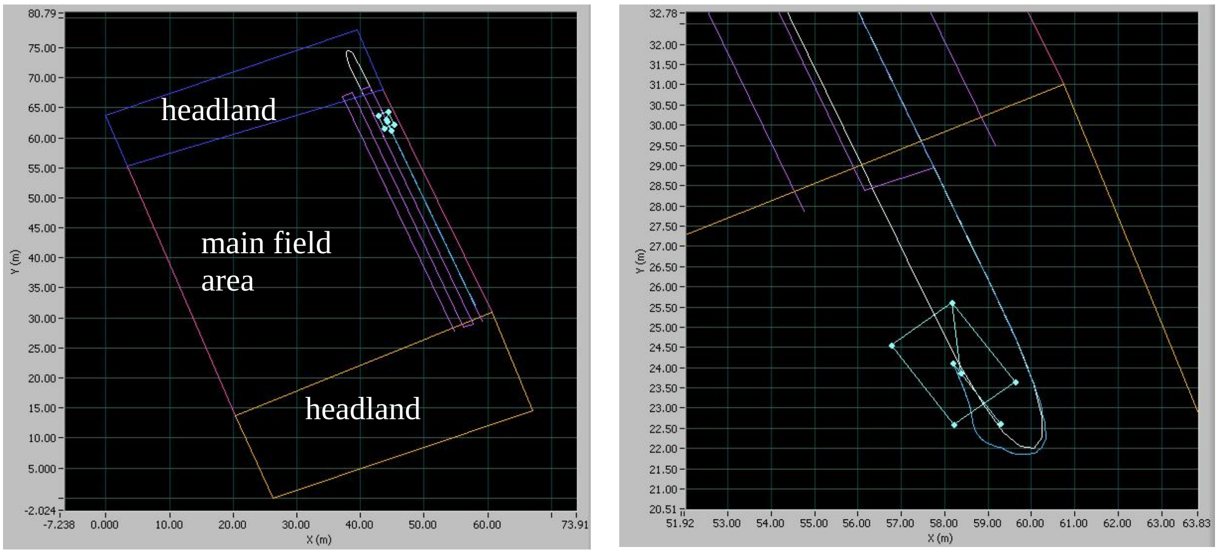

Figure 2 – Simulation results of autonomous navigation in a field

Before navigation over the field first the polygons of the headland boundaries and the boundary of the main field area are established. During navigating in the field, the point in polygon algorithm constantly tells if the actuator position is entering the main field area or if the front of the robot is entering a field headland using a point in polygon algorithm [3]. Also the robot constantly determines if its contour is located in one of the polygons. Any time the robot contour is not in the main field area polygon and not in one of the headland polygons, the robot is outside the field and is stopped immediately.

While driving along the rows in the main field area the robot continually measures its position and orientation and its distance to the headland. If the distance of the robot to the headland is less than 3 meters, the robot plans a route in the headland to a position one working width apart from the first row, which is close to the start of the next rows to be followed. The route is made by a spline function. The robot starts to follow the headland path when the robot front positions enter the headland. It changes to follow the crop row again when the actuator position enters the main field area.

The field navigation system was simulated and then tested in practice. Results (see figure 2) show that it is possible to navigate in a field autonomously. The control method using a high and low level control shows a good performance and the control parameters are easy to tune.

References

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