Autonomation of the self propelled mower Profihopper based on intelligent landmarks

MSc. **W. Niehaus,** MSc. **M. Urra Saco,** MSc. **K.-U. Wegner,** Dipl.-Ing. (FH) **A. Linz,** MSc. **M.Thiel,** Prof.Dr. **A. Ruckelshausen**, University of Applied Sciences, Osnabrück/Germany; Dr. **J. Marquering**, Dr. **B. Scheufler**, AMAZONEN-Werke H.Dreyer GmbH & Co. KG, Hasbergen-Gaste/Germany; Dipl.-Ing. **T. Pfisterer**, AMAZONE Machines Agricoles S.A., Forbach/France

Abstract

The autonomation of a commercially available self-propelled agricultural machine (AMZONE Profihopper) has been realized. Moreover, intelligent landmarks have been developed, where a rotating laser line is placed on the robot and the detecting optoelectronic landmarks include a wireless communication to the robot. First tests of the system have been performed. Future applications are the autonomous design-based area machining or crop care.

1. Introduction

Due to innovations in electronics and software development activities in the field of automation of agricultural machines has strongly increased. While for larger (harvesting) machines driver assistance systems have already been implemented in products, complete autonomous machines are still in the stage of research [1]. There is a strong impact to agricultural engineering arising from competitions such as the Field Robot Event [2]. Moreover, the authors recently proposed the concept of an autonomous robot for the application “weed control”, where a new vehicle platform is under development [3]. While on one hand the small robots used in the Field Robot Event are more or less experimental setups and used for inspiration, very large machines – on the other hand - will probably not run autonomous in the near future because of reasons of assurance. As a consequence there is another option by making existing small self-propelled machines autonomous. If special limitations are given with respect to the application of such a vehicle, the autonomation could be a large step forward to gather practical experiences with functional field robots and to reach the market. Figure 1 illustrates the 3 different concepts of the authors for autonomous field robots: The field robots for the Field Robot Event (see left side, “Maizerati” [4]) are meant for the implementation and test of new technologies and concepts under real field conditions; in the centre the robotic platform WEEDY [3] is shown, which is a complete new design meant for an autonomous vehicle; on the right side the commercially available Profihopper is shown, where technology for autonomation has been implemented.

Fig. 1: Concepts for the development of autonomous field robots: Experimental apporach Field Robot Event (left side, field robot Maizerati [4]), new design of autonomous field robots (centre, autonomous robot WEEDY [3]), autonomation of existing vehicles (right, Profihopper)

2. Profihopper

In order to realize this idea the authors have used the AMAZONE Profihopper, a self-propelled mowing and scarifying system with a length of 2.67 m and a width of 1.48 m.

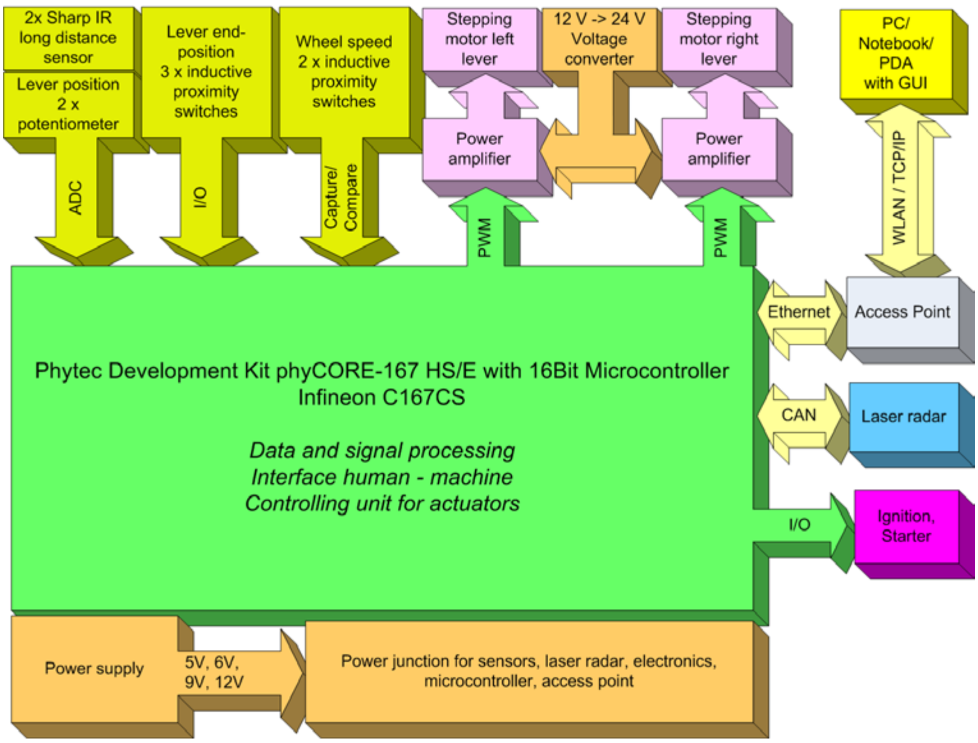


Fig. 2: Architecture of the technical components for the autonomation of the Profihopper.

In the first step several mechanical and electronic components have been implemented in order to establish the ability to control the Profihopper via software. The concept is modular designed and is based on embedded microcontroller technology as shown in figure 2 and table 1. As a result a remote control of the vehicle is possible, whereas a PC, a PDA or a mobile phone can be used for remote navigation (WLAN). Moreover the Profihopper can be started or stopped via these external devices and sensor data can be logged and stored as well. For terms of safety mechanical emergency buttons at the vehicle are implemented.

Table 1: Integrated components for autonomation

Component	Function
Embedded master microcontroller board	Data processing, algorithms, actuator control, data storage of sensor information and routes
Laser radar system (micro-controller, FM receiver, stepping motor, line laser, encoder)	Emits a rotating vertical laser line and receives the wireless message of laser light detecting active landmarks; calculation of the Profihopper position
Long distance sensors	Detecting obstacles in the direct environment
WLAN access point	Wireless communication between Profihopper and the Graphical User Interface (GUI)
Power supply with voltage converters	24 V for stepping motors; 5V, 6V, 9V and 12V for electronics
Power electronics and relays	Controller based engine ignition and motor starting operation
Buffer battery with power junction and plug for protection switches	Power supply for the electronics during the engine start procedure
Step motors with epicyclical gear and chain drive	Moving the steering levers
Inductive proximity switches	Detecting mechanical end positions of steering levers
Potentiometers	Determine steering lever positions between mechanical end positions
Inductive proximity switches	Determine wheel speed
Protection switches	Stops Profihopper engine and powers down the motors for steering levers, if only one switch was pressed

3. Intelligent landmarks

Since the application of the Profihopper is limited to restricted areas the authors developed intelligent landmarks for navigation, thereby being independent of a GPS signal. However, the Profihopper can be as well combined with a high resolution GPS system. The vehicle is equipped with a vertical laser line illumination, which rotates continuously. Each landmark consists of a horizontal sensor structure consisting of photo diodes, which are detecting the laser light. Two photo diodes are used to compensate the effect of daylight. After detecting laser light this information is transmitted (wireless), correlated and results in positioning information for the robot (see figure 3). The laser unit and a detection unit are shown in figure 4, the number of detection units is flexible.

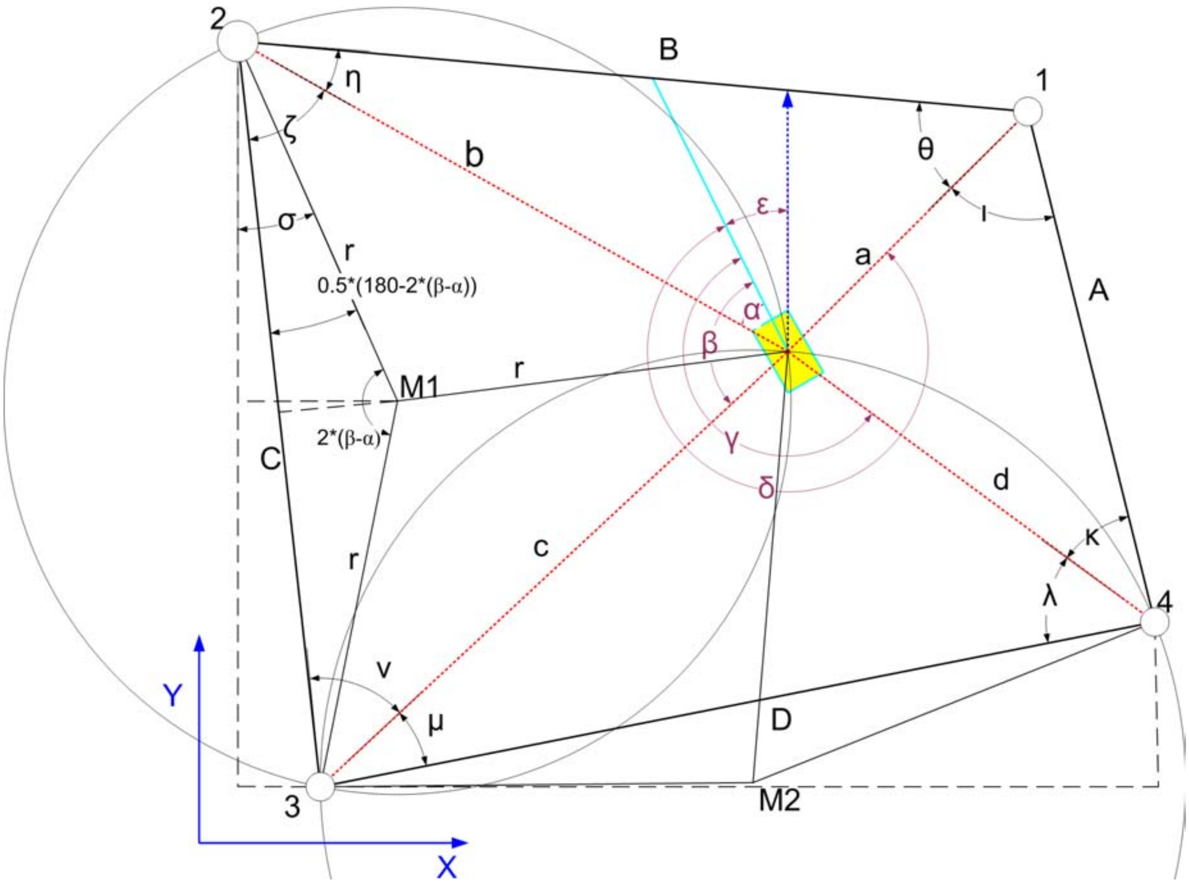
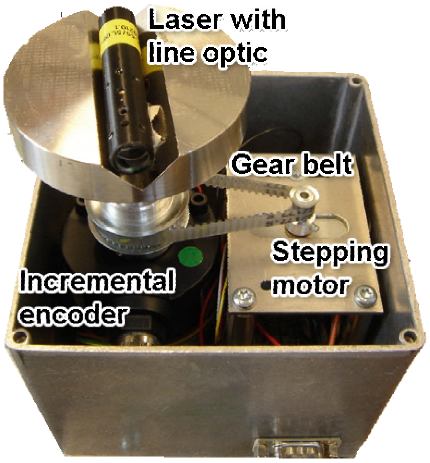


Fig. 3: Geometrical method to determine the position of the Profihopper based on given positions of the landmarks.



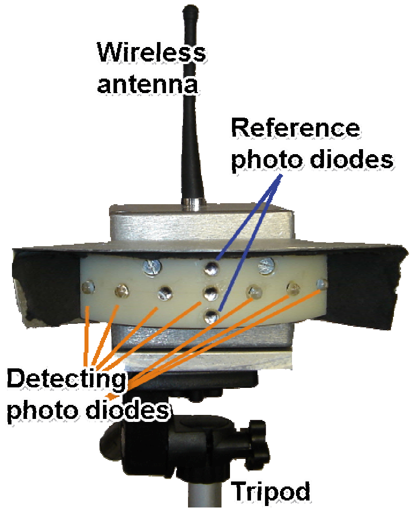


Fig. 4: Key components of the intelligent landmarks. Left side: The laser unit is placed on the robot, a rotating (vertical) laser line is generated by the unit. Right side: An active landmark is shown with the corresponding components for optoelectronic detection and wireless communication.

4. Results and conclusions

The Profihopper equipped with the above described technical equipment has been combined with the laser unit. First successful tests have been performed. Moreover a prototype of a routing system has been developed where routings can be implemented as well as documented (electronic documentation). Figure 5 shows the creation of tracks on a virtual environment, where data can be transferred to the real vehicle (Profihopper). A route consists of user-defined segments on which the cutting device is active. In addition the GUI includes a simulation option to test and optimise navigational algorithms. In the simulation positioning data from the Graphical User Interface (GUI) and steering commands from the microcontroller of the Profihopper are combined, whereas the data are exchanged via WLAN. Moreover, obstacles existing in real environment can be placed in the GUI. As a consequence the Profihopper avoids these areas and generates steering commands with use of virtual environments in different distances around. If the cutting device is active the current position is coloured white. The integration of obstacle information based on sensor measurements (as already realized in [4]) is planned. First applications, such as the preparation of advertising panels or landscape conservations, are planned.

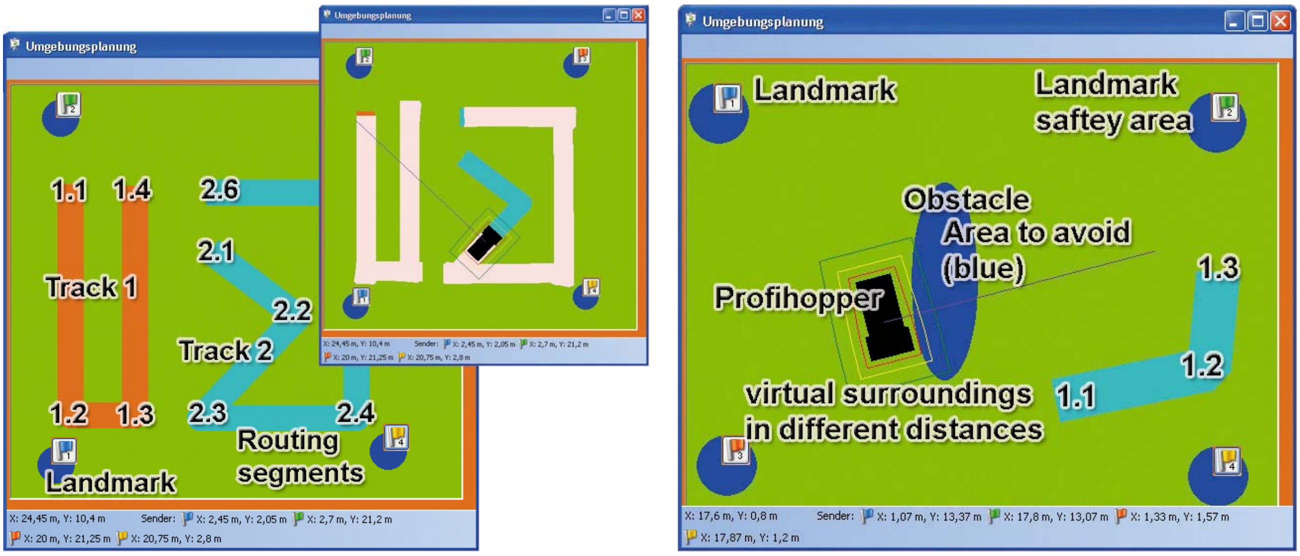


Fig. 5: GUI option to create a route on a virtual environment for the Profihopper (left). Simulation of the navigation for testing algorithms (right); the virtual Profihopper avoids the user defined obstacles (blue) on its way to the first routing point; positioning data of landmarks and the cursor are shown in the lower window bar.

[1] Pedersen, S.M.; Fountas,S.; Have, H.; Blackmore,B.S.: " Agricultural robots – system analysis and economic feasibility", Precision Agric (2006) 7:295–308.

[2] Mueller,J.; Walther, S.; Boettinger,S.; Ruckelshausen,A.; van Henten, E.J.: "Field Robot design contest – a showcase in Agricultural Engineering education", in: Kataokea T., Noguchi N., Murase H., editors. 3rd IFAC International Workshop on Bio-Robotics, Information Technology and Intelligent Control for Bioproduction Systems 9-10, September 2006, Sapporo, (Japan), p. 276-281.

[3] Ruckelshausen, A.; Klose R.; Linz, A.; Marquering, J.; Thiel, M.; Tölke, S.: "Autonome Roboter zur Unkrautbekämpfung"; Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz, Sonderheft XX, 173-180, 2006.

[4] Klose, R.; Klever, J.; Linz, A.; Niehaus, W.; Thiel, M.; Urra Saco, M.; Wegner, K.-U., Ruckelshausen, A.: "Sensor fusion based navigation of the autonomous field robot Maizerati"; Bornimer Agrartechnische Berichte, Heft 60, S. 56-62, 2007.