Eckart Kramer and Jürgen Schwarz, Potsdam-Bornim

Requirements for Future Operation Scenarios on Autonomous Field Robots

Nowadays large, high-capacity machines are available for field work in agriculture. Experiences with site-specific management show that the distribution accuracy of plant protectives is often not satisfactory. Field robots are a very promising approach for more precision in agriculture and for relieving farmers of record keeping and verification responsibilities. Field robots must carry out their tasks economically and reliably and must be user-friendly. General requirements for operating autonomous field robots are presented and a concrete operation scenario for weed mapping is illustrated more closely as an example.

Dr.-Ing. Eckart Kramer und Jürgen Schwarz are scientific staff members at the Institute of Agricultural Engineering Bornim (ATB), Max-Eyth-Allee 100, D-14469 Potsdam; e mail: *ekramer@atb-potsdam.de; jschwarz@atb-potsdam.de*

Keywords

Autonomous, field robots, requirements

Literature

Literature references can be called up under LT 04517 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

An autonomous (field) robot (AR) is characterised by its capacity to deal effectively with a given operation environment where local spatial and temporal dynamic variation may occur unpredictably. To react to this variation, the AR is generating its own rules and decisions (self-law making) and acts accordingly. This kind of behaviour would be significantly beyond just a self-regulating of measuring and execution tasks [1].

A „fully" autonomous behaviour of robots has only been realised in laboratory conditions so far. Due to the present available „artificial intelligence" and sensor equipment, dynamic variations of the environment can be perceived in a rather limited extend so far. Hence, essential routines are usually completely programmed and adjusted to the predominant constraints [2].

Requirements for autonomous field robots

The safety of an autonomous system towards their environment but also towards itself constitutes a particular challenge for development and design. For this reason current experimental systems as well as coming AR shall be operated in a semi-autonomous mode under human supervision. That would be required to gather operational experience for both safe operation and required legal conditions [3]. Current evolutions of control and surveillance systems aim at dropping the supervisory effort as to enable control of several (instead of one) robots by one human. Different approaches such as master-slave-systems [4] or systems with decentral remote supervision [5, 6, 7] are under development. In the latter case, there is a computer in the farm office that is permanently connected with the AR by radio and thus enabling supervision and intervention in control as well as exchange of data and images.

After the implementation of high-capacity machines for site-specific farming autonomous field robots are expected to enable a further scale-reduction process that may lead to the possibility of individual plant care systems called Phytotechnology [8]. On the other hand, AR should enable a much faster supply of data and information for the increasingly knowledge-based decision-making in farming. Both economic and environmental aspects could be stronger considered for to-date farm management [9, 10], on the other hand record keeping and verification management could be simplified by carrying out of on-field monitoring tasks in line with an immediate data processing by robots [3, 11]. Moreover, autonomous systems should be user-friendly designed for operation, attendance and supervision because farmers usually cannot afford to employ a robotics specialist. The robots should be capable of self programming and life-time online learning, of navigating continuously for long periods, and should adapt themselves to any environmental or robot kinematics [4, 12].

Finally, AR shall work economically without causing additional costs for the executed operations. Appropriate operation scenarios have to be identified for this.

Operation scenarios for autonomous field robots

From the technical and economic view autonomous machines shall grab the farmers attention if they achieve at least the performance parameters of current machinery at similar specific costs, and carry out additional tasks such as for management assistance. This can be achieved by less-capacity AR if a larger time frame is available for certain farm operations which enable work round the day at a slower performance rate [3, 11].

Against this background, robotics evolution shall „unfortunately" not result in an universal robot that carries out any work from tillage to harvest. Development will tend to rather specialised field robots for certain operation which distinguish from each other, both in concept and construction. Largely modular concepts should be aimed for this to a large extend to reuse certain sub-systems such as data communication or traction drives in several AR.

Weed control [13, 14, 15, 16, 17] as well as selective harvest of fruits and vegetables [18, 19, 20] are discussed intensively in the literature as promising application areas.

Although a high performance level has been obtained for a number of essential subsystems, no commercially spread (semi) autonomous system has been reported so far [21].

Additional tasks that should be taken over by AR may be addressed in crop monitoring or in data collection and processing for future record-keeping and management verification.

Manifold substantial approaches emerge from the report duties of various quality programs as well as from recent European legislation such as for proofing good agricultural practice [22, 23], traceability or cross compliance [24]. cross compliance is linking direct support schemes with the compliance of regulations for good agricultural and environmental condition of farmland, for production, and management. An extended article on the obligations of farmers to production supporting documents is planned for issue 1/2005.

The example of weed control

Recognising and combating individual weed plants by hoeing or spraying are in the focus of both the farmers and the research community. If an AR would be outfitted with a sensor system for the early (cotyledon) stage recognition [17, 25], it could eliminate weeds before a certain occupancy threshold is exceeded. Thereby a less-capacity AR could perform a periodical weed control at the same acreage than conventional machines, due to the larger time slot available. Moreover it is expected that for a spraying configuration, the use of herbicides could be reduced by up to 75% [26], and even by up to 92% under particularly favourable conditions [17].

If one looks at the size of such recent R&D models and prototypes of AR it maybe expected that a system ready for commercial use would be in the size of a smaller portal tractor with a power of approx. 15 kW. Due to its lower weight such a system would cause less soil compaction. There are assumptions that up to 70% of the present energy demand which is caused by tillage operations could be saved in the case of a complete replacement of current heavy machines by smaller and light-weight systems [8].

Besides the weed control, AR would perform the required timely and site-specific recording of related information on the taken actions. If herbicides are sprayed, the system would record the site-referenced product applications including crop name, location, date, productís active ingredient(s), applied quantity, legally set preharvest interval and cumulated weed density.

By way of its repeatedly scouting on the pre-set acreage, the AR may perform additional tasks such as control, recording and simultaneous combating of pests or the control of hazardous contamination by e.g. unauthorised waste disposal.

With regard to cross compliance regulations [24], AR contribute to „maintain the farmland in a good agricultural and environmental condition“ as undesired vegetation is prevented, the use of plant protection products is slashed, and soil structure is saved.

On the basis of such a demand-oriented approach, a concept of a „virtual“ modular autonomous field robot for weed control should be developed in an integrated and comprehensive manner, by an interdisciplinary team where farmers are strongly involved. Assignment, farm size, and available time-slots are a few of the basic data for the definition of system specifications for the manifold sub systems of such a robot. In this way, the need for further developments can be identified as well. It is appreciated that at the present state-of-the-art, a prototype of an autonomous field robot can be realised in the medium term by a competent team that is adequately outfitted. A substantial input is expected from automotive engineering, industrial robotics, space travel as well as medical technology why these domains are to be stronger sensitised for that agricultural topic at present [3, 7, 20].

Currently, the concept of a „Mobile Autonomous Sensing and Acting System“ (MASAS) for data capturing in rural areas is under development at the Institute of Agricultural Engineering Bornim (ATB) [7], see *Fig. 1*. The basic system is made up of a remote control station (Leitstand), and a mobile platform (Field Scout), with in-between exchange and processing of commands and information by use of navigation and communication satellites. The research prototype aims at developing and testing of sub systems for certain basic functions such as data and image capturing (sensing), bi-directional wireless data and command transfer, as well as for conducting limited acting at low energy and substance level (acting). Both the modular concept and current stage of the research prototype shall be explained more in detail in the next issue.

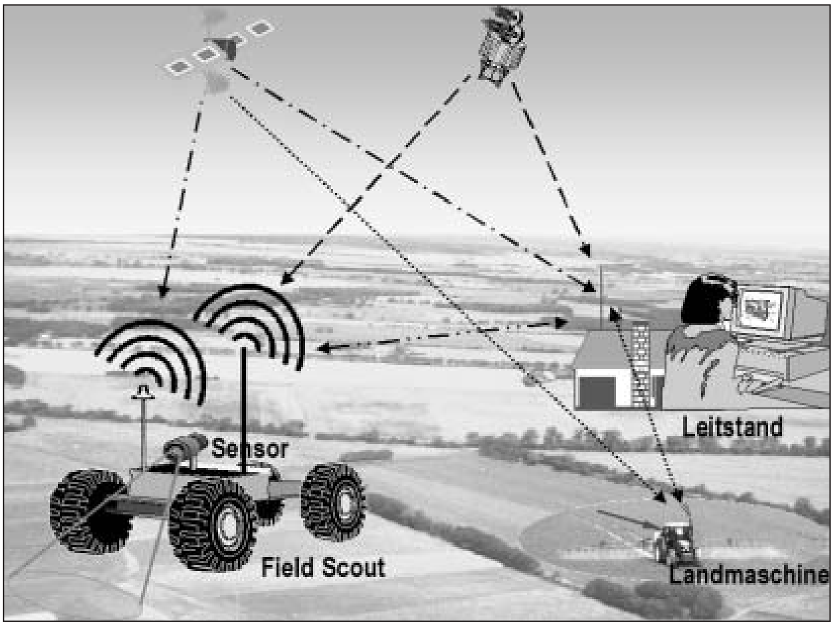

Fig. 1: The MASAS concept for information supply in rural areas