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Tablet-PC increases the machinery control

The increasing pressure of keeping costs down and the need for more accurate documentation is becoming a challenge for custom operators and agricultural producers. One central solution is composed of cross linking all work processes and information gathered on all machines in use. Operating systems, originally only laid out to control machine functions, continue to take over areas of assignment management, navigation and logistics. Modern tablet-PCs are easily able to take over any of these management duties at a reasonable price, and in addition offer a large number of extra functions.

Keywords
Operating systems, data management, ISOBUS, tablet PC, machine control, assignment management, iPad

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In the last twenty years, numerous developments in the topic area of 'precision farming' have been made. Adding upon the early conceptual ideas, practical systems have been developed in conjunction with research and development projects. Currently, these systems are more and more incorporated under the term 'smart farming' [1]. In contrast to an entirely individual machine operation, the focus lies on the orientation towards basic agricultural processes. For this, the information technology connection of steering and documentation tasks is a prerequisite which is increasingly provided by the ISOBUS (Standard: ISO 11783). However, in contrast to the intensively held technical discussion is the actual market penetration of 'smart farming' products in the wider range still dissatisfactory.

The existing entry barriers are numerous. They range from inadequate compatibility and too complicated handling to too high costs. Furthermore, the heterogenic requirements, e.g. those of a large-scale fruit crop producer using mostly their own equipment in comparison to those of a medium-sized contractor in a region with small-scale acreages, are difficult to compensate in one system. While the wide implementation into practice has not taken place yet, the topic of 'smart farming' has a high potential for innovation. This is, among other things, fueled by the rapid development of consumer electronics. Likewise, this simultaneously leads to higher expectations amongst the users [2]. This raises a latent trade-off between a high innovation rate and the necessary standardization.

Against this background, the company Kotte Landtechnik GmbH & Co KG and the Labor für Landtechnik und mobile Arbeitsmaschinen of the University of Applied Science Osnabrück as well as further partners have initiated a project named 'SmartControl for iPad' (SCI), in which a standard Tablet-PC (iPad) takes the assignment and data management for liquid manure trailers over. In comparison to the existing solutions such as the iPhone-App Herakles [3], the Tablet-PC was additionally connected to the CAN-bus of the machine control via WLAN. With this, the Tablet-PC is also able to visualize portions of the machine control and tap machine data for the management functions. The main motivation for the project SCI can be summarized as follows:

- The iPad provides the user with a familiar UI (user interface) from the consumer electronics.
- In comparison to standard machine terminals, the iPad has cost benefits (development effort/production costs).
- Besides the SCI-App, the iPad provides the user with many 'free of charge' additional functions (e-mail, internet etc.).

Taking into account the existing experiences concerning the conception of apps in the agricultural field [4] as well as the extensive development activities of programming of machine controls, even in safety-relevant applications [5], a direct machine control via the Tablet-PC was intentionally avoided when designing the 'SmartControl for iPad'.

System Description

SmartControl for iPad (SCI) is a software application for the iPad, which provides the user with assignment data for the dispersion of liquid manure and visualizes, saves and evaluates process data. **Figure 1** shows the basic structure of the SCI. Here, the iPad is connected to the machine control of the liquid manure trailer via WLAN. Optionally, data can be exchanged with the Farmpilot-portal from avarto Systems as a server (ISO-XML) using an internet connection via GSM or WLAN. In this case, the application of Farmpilot takes the whole assignment management over. Simultaneously, additional functions of Farmpilot such as 'navigation' or 'fleet management' can be used.

Fig. 1

Basic structure SmartControl for iPad (SCI)

In case no Farmpilot connection is available, all assignment data can be directly entered on the iPad. Either there is already stock data available or they are directly entered by the user. Hereby, the designation of the field is given using Geofence points. In the same way, entrance points to the fields, certain meeting points etc. are determined. **Figure 2** shows the map display of five sample assignments in the way it is seen on the iPad by the driver. On the screen's left-hand side, the corresponding task data is visible. In the upper row, the chosen allocation of the tractor, the liquid manure trailer and the driver is shown. Finished work tasks are saved locally and, if so desired, sent to the client or back to the Farmpilot-portal via email.

During the labor process, the driver can focus on main tasks, i.e. filling, transportation and dispersion of the liquid manure. Automatically, the WLAN interface of the machine control builds up a connection to the iPad. The data from the liquid manure trailer such as the operation mode (transportation on street, filling or dispersion), the driving speed, the dispersion rate and the working width are sent to the SCI application every 0.5 to 2 seconds. Here, the data is linked with the geoposition via the iPad's GPS receiver and a time stamp. As a result, the process of dispersing the liquid manure can be analyzed offline and optimized for future operations. **Figure 3** shows the display during the dispersion. Via the iPad, the driver receives the following information: driving speed, working width, remaining volume in the tank, remaining operating distance in meter and minutes as well as the amount of dispersed liquid manure in m3/min and in m3/ha. In addition to the amount of the dispersed liquid manure, the deviation from the desired value is shown.

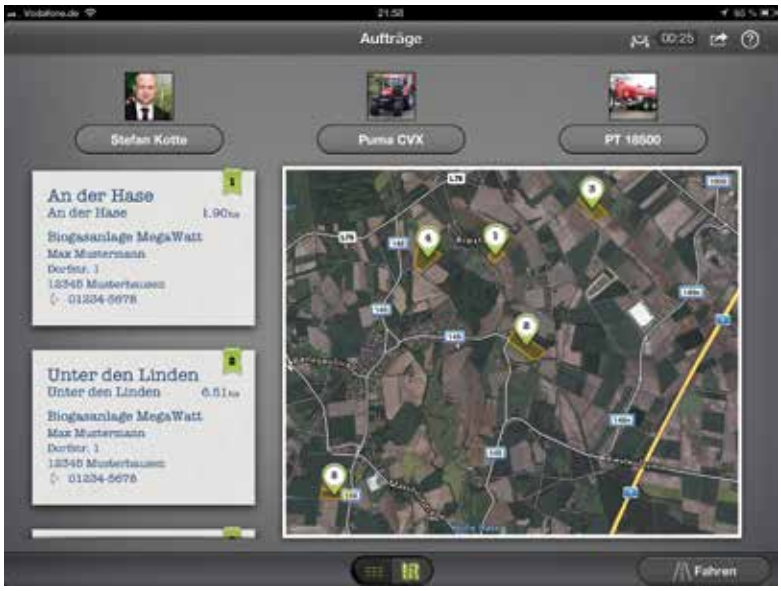
The operation of the SCI application is done with techniques that are typically used for Tablet-PCs (swiping, zooming, typing) and therefore, it is 'iPad-like' and intuitive. This also applies to all additional functions. For example, all operating instructions are deposited and, if needed, an error protocol with the information about the location can be sent to the manufacturer via email. Correspondingly, in case a repair is necessary, the immobilization time may be reduced. Further functions such as a rain radar or video-telephony via Facetime are also available.

Future Potentials

With the SCI project, a local solution for liquid manure trailers of one producer was developed. In particular, the connection of the iPad to the CAN-bus of the machine control was easy under these circumstances, since all bus devices (control units, joystick etc.) and their outputs are precisely known and not variable. The app development process and the initial positive user responses are encouraging. As a result, the project partners are planning to collaboratively develop subsequent generations of the SCI. Further, the developed local solution shall be placed on a broader basis to also make it usable for other tractor-equipment-combinations. The interfaces between the Tablet-PC and the CAN-bus of the machine control (SM) or the ISOBUS (SI) which are shown in **Figure 4** will be essential for this.

The development of a new interface between the Tablet-PC and optional CAN-bus systems of a machine control is in the 'ISOBUS era' certainly in need of an explanation. A direct connection between the Tablet-PC and the machine control, similar to today's SCI, is for smaller working equipment without ISOBUS and especially for second-hand machinery interesting, if they, for example, shall be integrated in a modern assignment management via Tablet-PC. On the basis of an interface (SM, **Figure 4**), machine manufacturers or service providers

Fig. 2

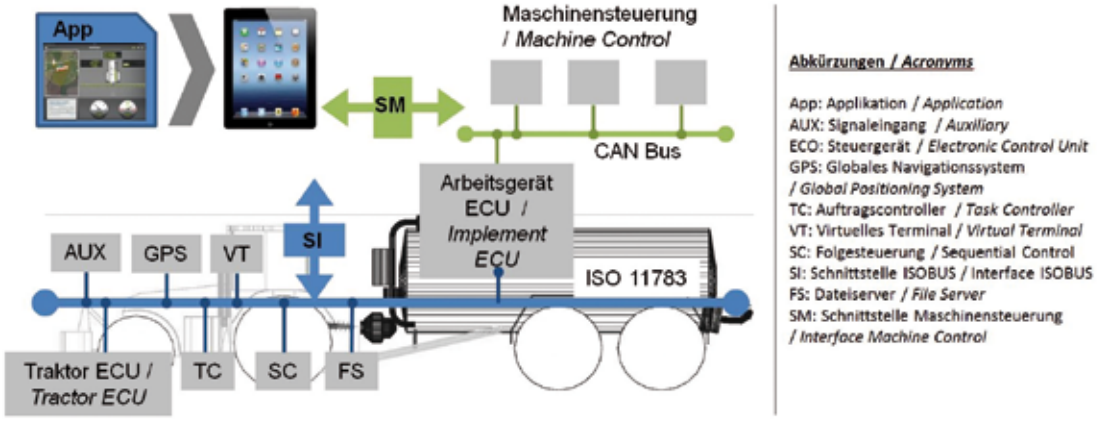


Example for tasks with the belonging fields

Fig. 3

Combined view of machine data, task data and map view during the spreading process

Fig. 4



Overview interfaces to the Tablet-PC

can develop simple apps for their products without difficulties. Depending on the installed or attached working equipment, the user selects the correspondent app and starts the working process. Exactly like in the basic idea of the ISOBUS, there will be only one 'terminal' for all working equipment if the Tablet-PC is used.

For ISOBUS-compatible working equipment, an interface (SI, **Figure 4**) between the Tablet-Pc and the ISOBUS is of interest. With this, Tablet-PCs could take over producer-independent additional functions with correspondent apps, comparable with the SCI introduced in this article. Also, a facilitation of the ISOBUS network could be possible. For example, simple functions of the task controller (TC) or the file server (FS) could be taken over by the Tablet-PC. However, from the present point of view, it will be difficult if the Tablet-PC shall take over self-steering assignments. With a view to the requirements on the functional safety (ISO 25119), a resilient clarification of the possible (in terms of permitted) functions is still missing. Therefore, it is questionable, if the probably quickly evolving desire of the user to exchange the cost-intensive virtual terminal (VT) with a Tablet-PC and a partly tedious loading of object pools with an opening of an operation app can be realized.

Conclusions

In the course of the process-oriented interconnection of agricultural machines, Tablet-PCs can take over the connection to assignment management systems. One initial producer-specific solution is shown by the development project SCI. The potential of a further developed system, consisting of a Tablet-PC (iOS or Android), an app-based software and established interfaces (SM, SI) as complementary modules for the machine control and cross-linking, is very large. For the technical and user-friendly implementation of this next generation of Tablet-machine-connections, apart from the technical development and programming, further questions concerning the functional safety need to be clarified.

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