Wireless and autonomous Agriculture Documentation System

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LaSeKo Project

The basic idea of this project was to develop and evaluate a system to control position and condition of mobile working machines, containers and accessory equipment in the construction industry. Due to a regulation of the European Union, the product liability law for food, the development of a documentation system for the entire harvesting process is obligatory. [1]

Based on a mobile electronic system the LaSeKo consortium is developing a technical approach to connect independent network devices and machines for the collection of process data, control and diagnostic purposes. The main item of the system is a private area network (PAN) module controlled by a microcontroller. On the basis of IEEE 802.15.4 wireless standard, the network is able to autonomously establish a network. The communication units (LaSeKo-Box) act independently, and comprise different interfaces e.g. CAN interface, a GPS receiver and, if required, an additionally fitted GPRS port for data transfer via Internet. All combines and tractors will be equipped with a communication unit (LaSeKo-Box). In addition to the technical details of the LaSeKo-Box, this paper shall give an overview of possible applications of such a system.

The wireless data transfer can be used for a universal agricultural documentation system. Site specific harvest data as well as other crop data can be transmitted from the LaSeKo-Box of the combine harvester to the LaSeKo-Box of the transport vehicle while transferring the crop. This procedure is shown in figure 1. Thus, the transport vehicle hand over of all information about the crop, e.g. its geographical growth position, the harvest quality, the harvesting time etc. This data can then be transferred to the following crop processing stages, setting up a complete information chain, ending with the consumer as final destination. As a big advantage the crop does not need to be fitted with RFID grain during the harvesting process [7]. However, drawbacks might be the size of the considered crop batches and the potential mixing of different packages in the crop elevator, impeding clear retracement.

By collecting data it is possible to visualize and simulate the harvesting process in farm office. As a result, human and machine resources may be used more efficiently. Furthermore it is possible to save the data in field record systems and to implement the autonomous documentation for cross compliance. Besides data can be transferred between other software programs according to the agro-XML standard [4].

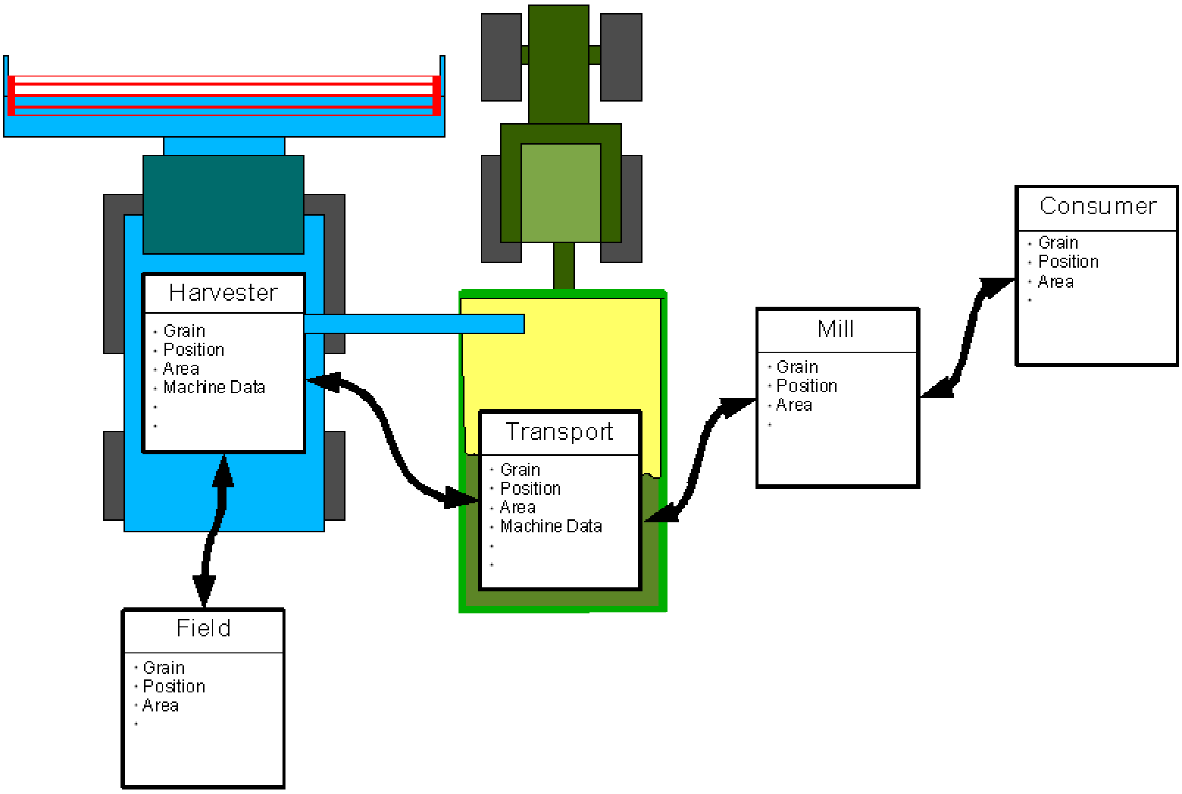

Fig. 1. Process chain of grain harvesting

The LaSeKo project is funded by the German Federal Ministry of Food, Agriculture and Consumer Protection. Project partners are the universities Universität Karlsruhe (TH), TU Dresden and TU Berlin plus the companies LogicWay, SimPlan, Arkade and John Deere AMS Europe. Among these partners the project-tasks are distributed as follows: The project coordination as well as the software development for the LaSeKo communication-unit (LaSeKo-box) is carried out by the researchers of

TU Berlin. The hardware, speaking of the communication-box itself, is developed and produced by the LogicWay company. John Deere AMS Europe provides an interface to enable the communication between the proprietary combine bus system and the LaSeKo-box. At Universität Karlsruhe (TH) scientists are determining the possibilities to predict failure of components based on the gathered data. SimPlan and Arcade are developing the master control station and the required central and local databases. Furthermore, SimPlan is in charge of the development of the tools to visualize and simulate the harvesting process. Field testing on John Deere combines is carried out by TU Dresden in close cooperation with John Deere AMS Europe.

LaSeKo-Box Interfaces

Figure 2 depicts the block diagram of the LaSeKo-Box with interfaces. The AP7000, a 32-Bit processor manufactured by Atmel, was chosen as microcontroller. The operating system is a Linux to control the running processes. By using additional software modules, is it also possible to easily implement real-time applications. AVR32Studio 2.1. serves as the integrated development environment (IDE) to write and cross-compile the applications.

For the radio interfaces the Atmel AT81RF231 serves as an IEEE 802.15.4 standard compliant chip. With a theoretical data rate of 250 kbauds, it can handle data volumes up to 50 Mbyte per day. But since only machine data needs to be transferred, the installed transmission capacity is sufficient. The chosen radio standard is free of provider charges and the costs of implementation are low. [6]

The communication box receives the position data from the Sirf III GPS chipset. This data string does not only contain the position but also a time stamp which can be used for cluster synchronization. At the same time, the box receives information about the GPS signal’s intensity and the number of satellites within reach. These data are analyzed and marked for comparison.

The communication-box uses the CAN interfaces to collect data of the connected machine, being able to recognize and forward the machine status. In most applications, the communication is done via SAE J1939 standard for Diesel aggregates or via the ISOBUS according to ISO 11783 for tractors and agricultural machineries. On the one hand the LaSeKo-box collects crop data, e.g. quantity, quality, moisture. On the other hand it works as diagnostic device, analyzing important data such as maintenance intervals, speed, operating hours or error massages. With the help of these data, the farm office is always aware of the current condition of the machine. [3]

The collected data is buffered on an SD card. In addition, it is possible to identify a machine user by the SD card. Furthermore all data packages have a time stamp, thus it is always possible to retrieve the latest data. The data is decoded and compared.

Via the GPRS/UMTS/EDGE module, it is possible to sent the data of the machine directly from the LaSeKo box to the farm office. This is done by a provider and is subject to a data transmission charges. As an estimated average transmitting time of 30 minutes for a data package via the crop transportation vehicles is presumed, only time critical data shall be transferred via GPRS/UMTS/EDGE.

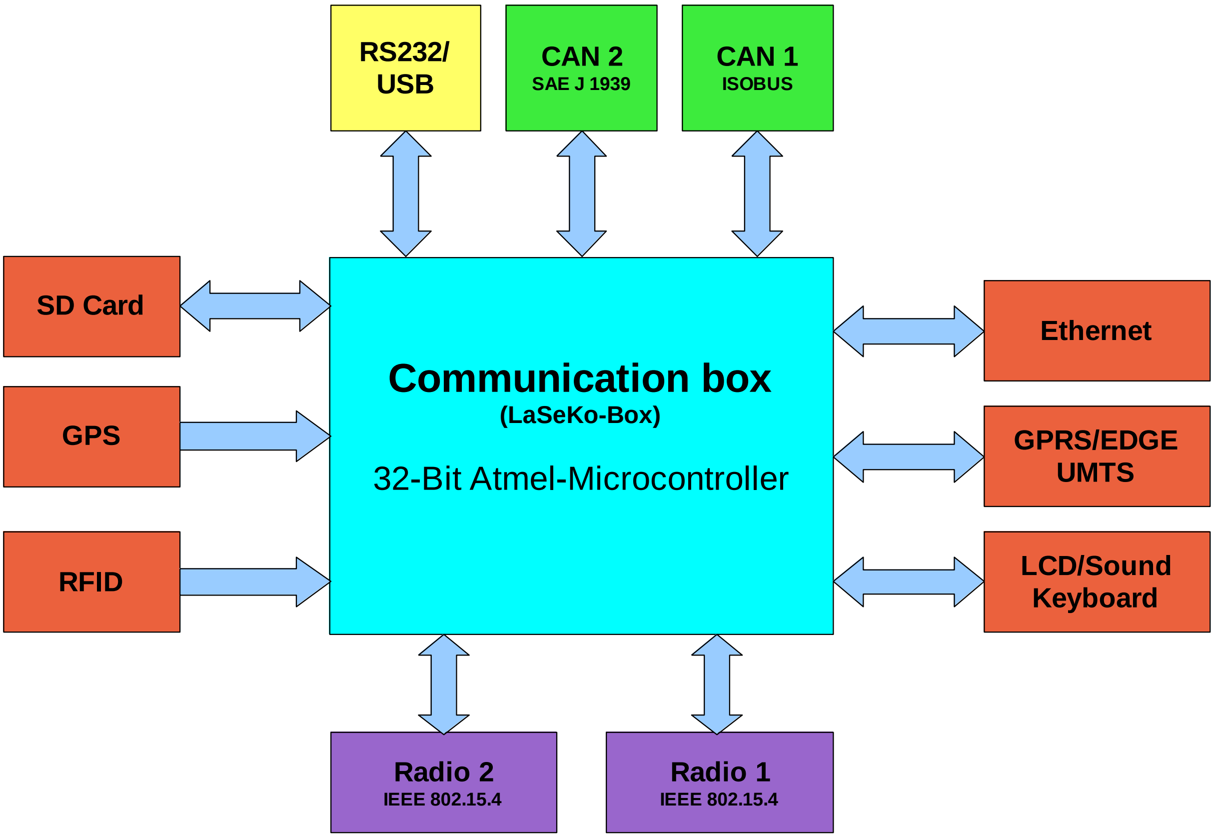

Fig. 2. Block diagram of communication box (LaSeKo-Box) with interfaces

With the RFID interface it is possible to identify a machine driver to enable accurate accounting of working hours and machine handling times. With RS232/USB-interfaces additional sensors or memory may be controlled.

To establish the communication between the database and the radio network a communication box is installed on the farm and connected via Ethernet. Additionally a WLAN interface has been developed to connect the LaSeKo box on the machines with a notebook. This is a big benefit in the development phase because the machine does not have to be stopped to broadcast data and to reconfigure the setup online.

The LaSeKo system is autonomous, thus no man-machine interface is required. Nevertheless, to realize a flexible system, LCD/Sound/Keyboard interfaces are integrated.

Network and System configuration

The transmission power and thereby the radio range of the single radio modules are limited. Therefore data has to be carried by the crop transportation vehicles. The data transmission between the working machines and the central file server is displayed in figure 3. This figure points out the process of the data transport from a combine to the fileserver. Process data, i.e. position, moisture, etc. is handed over simultaneously to the transfer of the grain. Hence the vehicle or equipment to which the data has been transferred, in this case a tractor with two trailers, keeps the information about its load and carries it to the silo. The vehicle furthermore records its route, error messages and fuel consumption during the transport and assigns the information to the process data. The whole data is passed to the central fileserver and allows later backtracking of the harvest.

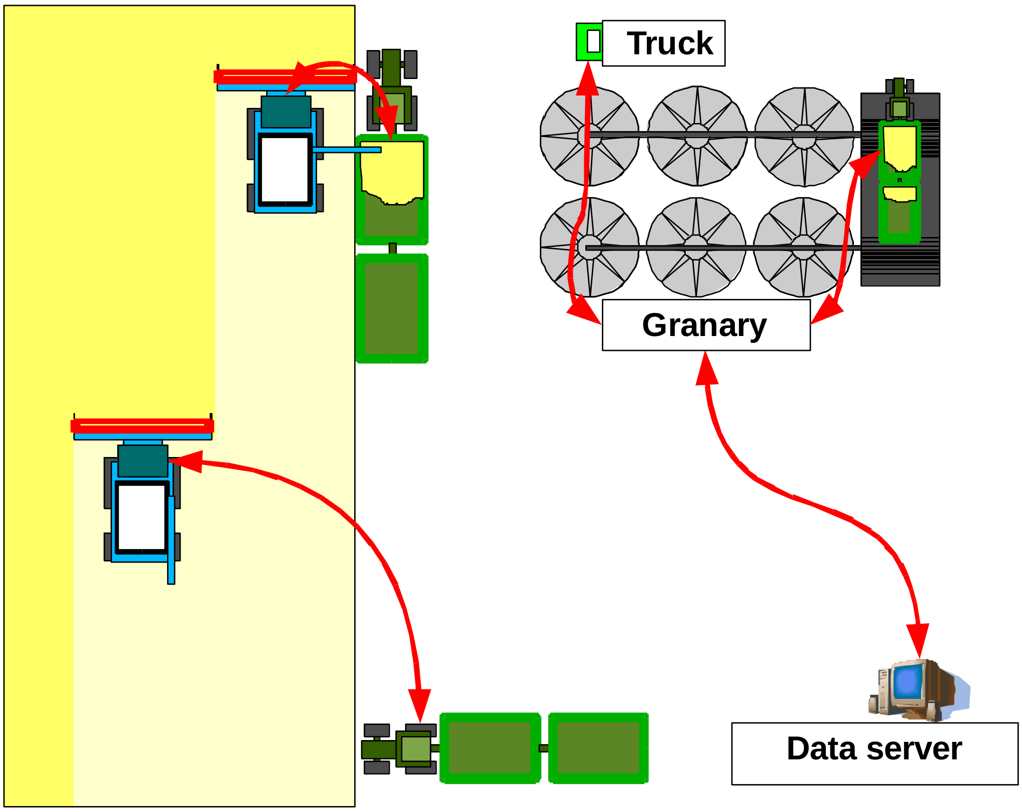

Fig 3: Data transport from combine to data server

Furthermore figure 3 shows the problems that might occur during the radio transfer of data packages. There has to be a fail-save data communication. In case of a third vehicle coming within range of the radio network, the data could be passed to the wrong device, concluding in an inaccurate assignment of the particular crop batch to the trailer.

Process Simulation

In this project the cumulated machine-data is visualized and the considered process is modeled in a simulation. The developed simulation can therefore be used to optimize the process. Due to the offline data-acquisition via a storage medium, the simulation is not real-time capable. Nevertheless, the obtained process- and machine data enable the user to accomplish a process analysis and a working time-documentation. Afterwards the vulnerability may be eliminated through a parameter variation in the simulation. The results are the optimized parameters to adjust the real process. [5]

Machine diagnostic

The LaSeKo-box gathers process- and machine data. The monitoring of this machine data, accompanied by selected sensor data, may be used to predict the failure of components. Through the data transmission via the LaSeKo-boxes, a remote maintenance becomes feasible.

Besides from the optimized machine-maintenance, the output of the LaSeKo project provides a development tool for machinery manufacturers. Furthermore it depicts a step towards the setup of a knowledge database about the workload of agricultural machinery, which is a profound objective of the researchers of the Institute for Mobile Machines at the Universität Karlsruhe (TH). The scientific approach to the subject is to initially develop a general methodology, valid for various types of mobile machinery, followed by the programming of the algorithms to handle the incoming machine data on the LaSeKo-box. Finally the usability of the system will be validated during a harvesting campaign on exemplary selected datasets.

Application

With a flexible mobile radio system are applications in construction industry possible for example road construction. In the asphalt plant, the relevant data for the according load is delivered automatically this could be for example temperature, amount and mixing ratio. The truck carries the asphalt and the data to the construction site and the street paver, who can optimize the production process with the help of the delivered data. The street paver passes the process specific data to the behind driving rolls. These can optimize the rolling (milling) process with the help of information such as temperature, place, mixing ratio and point in time. Furthermore the rolls mark the already rolled areas and communicate this to the other rolls. This way a too often rolled or even an unrolled area is avoided. Figure 4 depicts this application.

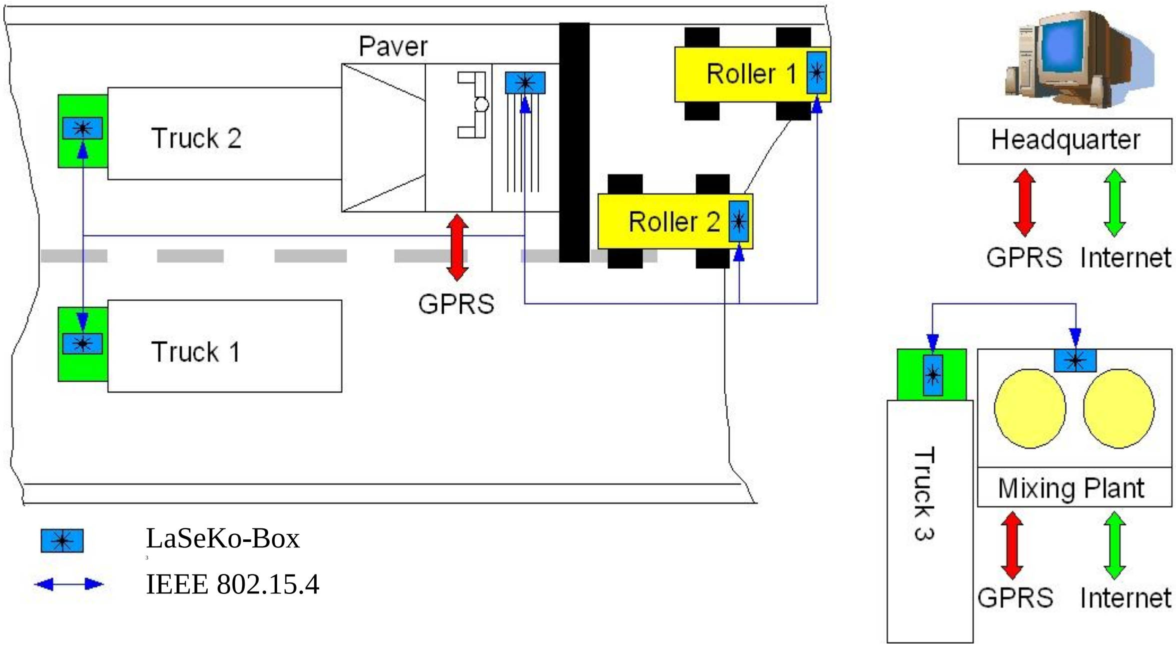

Fig. 4. Application road construction

Conclusions

This system allows the controlling and documentation of the entire harvesting process, visualizing and preparing data for farmers and Contractors. In the context of machine diagnostic the system may be used to implement a remote maintenance concept. The benefits of the LaSeKo communication system are its low costs of implementation and that it is free of transmittance charges for providers.

For a reliable and secure data transmission between mobile working machines and a data server, new data handling mechanisms have to be developed. These mechanisms have to consider the particular agricultural applications, constraints and conditions.

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