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Data Management System for Teleservice Applications in Mobile Machinery

Teleservice systems offer great potential in improving the maintenance and task management of mobile working machines. Within those systems, data management is of particular importance. Intelligent data pre-processing in the machine contributes to the demand oriented transfer of only relevant data. Also, access to relevant information in the teleservice back-end can be improved as well. Suitable data reduction algorithms can reduce the amount of data, especially if it is necessary to transfer the signal developing over a certain period of time. With such an algorithm the amount of data can be massively reduced and the compressed data are still a good approximation of the original signal developing.

Especially in agriculture when producing our food, the operators of mobile machines are under very great cost pressure. For the sake of competitiveness, the machines used are becoming more and more efficient. Since these very complex machines can generally be used only seasonally during a few days per year, the demands regarding operation and maintenance management are very high. Under the above-described circumstances, downtime generally also results in high costs. This in particular applies, if an efficient logistic chain is linked to the machine, which is common in many harvesting processes. In addition, quality losses may occur if optimal harvesting times cannot be kept due to machine failure, e.g.

So-called teleservice-systems are intended to allow failures to be diagnosed quickly and efficiently so that failures can be repaired as fast as possible. In addition, the demand-oriented transmission of machine and process data is intended to increase output and to enable the machine to be maintained depending on its condition so that failures can be avoided.

The basis is the automated collection and transmission of the relevant machine and process data. For the early detection of failures and the timely initiation of maintenance measures, the data must be analyzed and evaluated intelligently. With this in mind, it becomes clear that the data management shown in *Figure 1* is of crucial importance within a teleservice-system.

The Collaborative Project DAMIT

The goal of the research project DAMIT is the development of such a data management system. This project is being carried out by the Institute of Agricultural Machinery and Fluid Power (ILF) in cooperation with the two agricultural machinery manufacturers Claas and Grimme as well as with the company LINEAS Project Services. Since May 2006, this project, which has a planned duration of three years, has been supported financially by the Federal Ministry of Education and Research (BMBF).

The core points of the research project include the development of:

- maintenance strategies for exemplary subassemblies (ILF in cooperation with Claas and Grimme)
- techniques for the reduction of the data

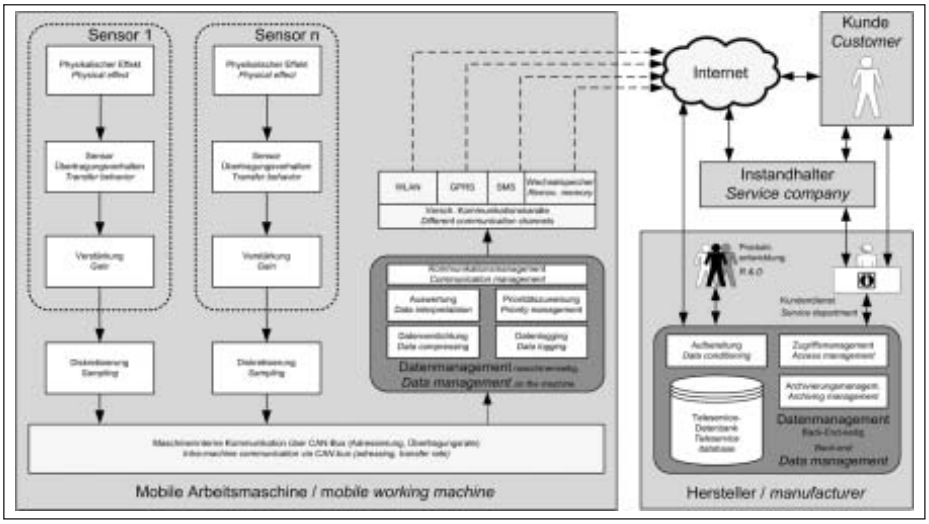

Fig. 1: The data management is of major importance within a teleservice system

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Data management, teleservice, maintenance strategy, data reduction

quantities to be transmitted (ILF)
- methods for the optimization of communication and archiving (LINEAS)
- process models for the logistic chain "sugar-beet" and a service workshop (Grimme and Claas).

Below, initial results of the research carried out at the ILF since the beginning of the project are presented.

Maintenance Strategies

Teleservice can facilitate the implementation of condition-oriented maintenance strategies in mobile machines or is even a prerequisite for them to be realized. Since a condition-oriented strategy is not appropriate for all subassemblies, it was necessary to carry out an analysis in cooperation with the industrial enterprises involved in order to find out for which subassemblies such a maintenance strategy can be implemented efficiently in the medium run. In order to be able to compare different subassemblies, criteria were defined and evaluated. For the later course of the project, four subassemblies were chosen based on this analysis.

As an example of a mechanical subassembly, the feeder house chains of a combine were chosen. Length measurement at the pre-tensioning unit of the chains on both sides allows conclusions about chain wear to be drawn relatively easily. The rupture of a chain can entail severe damage to the combine, which leads to high repair costs and long downtime of the entire machine. However, the expenses for preventive chain replacement are also not insignificant. Therefore, condition-dependent maintenance seems particularly sensible here.

As a second example, the air filter of the combustion engine was selected. Today, the air filter is generally cleaned daily as part of regular combine maintenance regardless of its actual loading condition, which leads to wear on the filter tissue and thus to a reduction of the total service life of the filter. Since information about the rotational speed and the power utilization of the engine are available via the CAN bus and their measurement does not require any additional sensors, the remaining service life of the air filter is intended to be determined with the aid of a differential pressure sensor and intelligent evaluation. The resulting possibility of condition-dependent air filter servicing allows maintenance times to be minimized and the service life of the air filter to be better exploited.

On a sugar-beet harvester, the hydraulic oil is monitored by an oil multi-sensor. The goal of this sensor monitoring is to change the oil not after set maintenance intervals, but just before it reaches its wear limit. Since the sensor is still at the test stage, oil samples are taken parallel to the sensor measurements and examined as a reference at the laboratory.

As the fourth subassembly, a hydraulic cleaning roller drive of a sugar-beet harvester was chosen. If the soil contains large numbers of stones, they may lead to roller obstruction. These obstructions can be diagnosed relatively easily with the aid of pressure sensors at the roller drive. These examinations are intended to show whether the frequency of stone obstruction allows conclusions about wear on the cleaning units to be drawn.

Data Reduction Methods

Some applications of teleservice-systems may require that not just individual incidents or frequencies, but entire temporal courses of different process parameters are transmitted to the central service office. This may be the course of the rotational speed of a functional unit or of the diesel engine of the mobile machine. Especially if the measurement parameters are scanned at high frequency, the data volume is not insignificant and may lead to high transmission costs along with transmission problems if narrow-band data connections are used.

As part of the project, methods were developed and examined at the ILF, which provide a reduction of the data volume to be transmitted without significantly impairing the relevance and the information content of the data. As an example, *Figure 2* shows initial development results. In order to reduce the quantity of data, not every scanned measurement value is transmitted. Instead, transmission is restricted to a mean value which is formed based on a certain number of measurement values. If three consecutive measurement values are merged in one transmission (block size 3), the data quantity required for the course of signals shown can already be reduced by 51%, while the compressed set of data still reflects the relevant course of the original measurement values. If block size is increased, the quantity of data can be reduced even more, but the relevant course of the measurement values gets lost. In order to address this problem, an algorithm was developed, which allows the data quantity to be reduced even more while preserving the information content of the compressed set of data. For this purpose, conditions were defined, which lead to a recalculation of the mean value (e.g. a sudden, significant alteration of the measurement value, etc.). The result of the reduction is shown in the lower part of *Figure 2*. With regard to the information content, it is comparable with the signal course shown in the top part of *Figure 2*. As compared with the original data, however, the required storage space was able to be reduced by 76%. Thus, the data need only approximately 50% of the storage space required for a fixed block size. An important condition for the development of the data reduction methods shown is the on-line capability of the algorithms. This means that the data must be able to be processed as it is transmitted by the CAN bus without any knowledge about the future course of the signals. The adaptation of just a few parameters also enables the reduction algorithms to be applied to other measurement values.

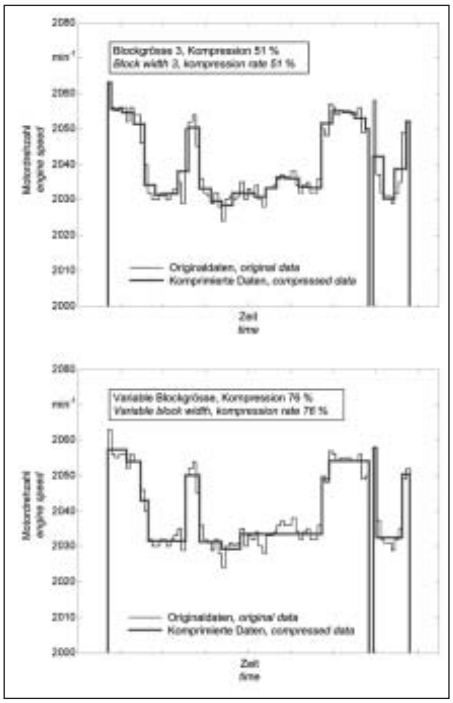

Fig. 2: Comparing different data reduction methods

Summary

The improvement of the maintenance management of mobile machines by means of teleservice-systems requires functional data management on the machine and in the teleservice-backend. Exemplary subassemblies of different mobile machines were chosen for which the implementation of a condition-dependent maintenance strategy will be examined in the future course of the project. Thanks to suitable data reduction methods, the data volume to be transmitted can be reduced significantly without any loss of important information.