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Data compression methods in telematics applications on mobile machines

Nowadays self propelled agricultural machines get more and more often integrated in telematics systems. So a wireless exchange of information with a central database or other machines that are involved in the actual working process is enabled. To reduce the amount of data that has to be transferred, suitable compression methods had to be developed because especially in rural areas, where the operation of agricultural machines usually takes place, the infrastructure for wireless communication is often not that powerful and still very expensive as well. The compression results that can be achieved with the developed algorithms show that in most cases savings from more than 90 % can be realised without loosing significant information from the original data.

Keywords
Data compression, telematics, relevance criteria, storage space

Abstract
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At the Institute of Agricultural Machinery and Fluid Power of the Technical University of Braunschweig (ILF), current research is addressing the development of a data management system for remote service in mobile machines. These studies are being carried out as part of a so-called collaborative research project with the financial support of the Federal Ministry of Education and Research and the participation of the companies Claas, Grimme, and Eck*cellent IT as industrial partners.

Goals

An internet connection allows different mobile machines (e.g. agricultural machinery) to exchange data with a central back-end server. This back-end server can be accessed via internet by different persons involved (e.g. the machine operator, the maintainer, or the manufacturer). Hence, this is a telematics system characterized by the networking of several computers with the aid of a communication system, which combines them into one computer system.

As part of this data management system, methods are being developed at the ILF which allow the quantity of data on the machine to be reduced before communication without losing important information. This is necessary because the mobile use of the machines requires communication via wireless media (generally mobile communication networks), which sometimes have rather small useable bandwidths (at least in rural regions) and are still relatively expensive.

Fundamentals of data compression

Data compression is defined as a modification of the digital form of representation of a given quantity of data with the objective of reducing the required storage space and/or increasing transmission speed. The data compression rate is defined as the quotient of the quantity of the original and the compressed data [1]. Thus, the data compression rate increases as the quantity of data is compressed more and more. If the quantity of data grows during compression because an unsuitable compression method has been chosen, data compression rates may even be smaller than one. The saved quantity of data is often termed compression gain. If the size of this data quantity saved by means of compression is correlated with the original data quantity and multiplied by 100, the result shows the savings in the form of a percentage value.

In principle, two different kinds of data compression can be distinguished, namely lossless and lossy compression.

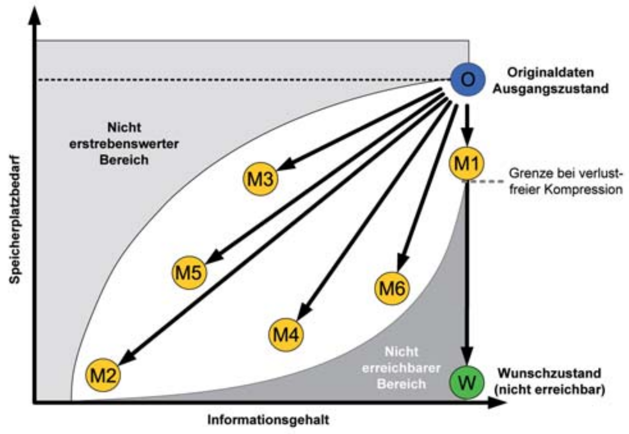
The characteristic of lossless methods of data compression is that all information of the original data can be perfectly reconstructed from the compression results. This means that during lossless compression only the redundancies in a given quantity of data are eliminated. However, this is also the reason why the compression gain which can be achieved with the aid of lossless methods is limited. This method of compression is used in particular in applications where a loss of information cannot be tolerated. Examples of such cases are the transmission of booking data in banks or generally the compression of text data. If lossy data compression methods are applied, it is impossible to reconstruct the original data perfectly because these methods not only eliminate the redundancies contained in the original data quantity, but also irrelevant data. In contrast to lossless compression, the compression gain which can be achieved by means of lossy compression is not limited. However, high compression rates and high compression gains can only be achieved at the expense of a reduced information content. Figure 1 illustrates the comparison between the original data and the compression result with regard to the information content and the required storage space for different compression methods. In addition, the fundamental limits of data compression methods are shown. A very well known method of lossy data compression is the conversion of audio files into the MP3 format. During compression, those parts are filtered out of the original data quantity which cannot be perceived by the human ear and are therefore irrelevant for the human listener.

Two examples of applications

At the ILF, several data compression methods were developed and tested in practical trials on an experimental tractor in field use. The modes of operation of these methods are explained below using two examples. The first method allows measurement values which may dynamically change over time to be compressed. This method was exemplarily applied to the engine speed of the experimental tractor. Figure 2 shows part of the measured original course of the signal and the corresponding compression result. The compression method applied was lossy, which means that the quantity of irrelevant data in the original data set was reduced.

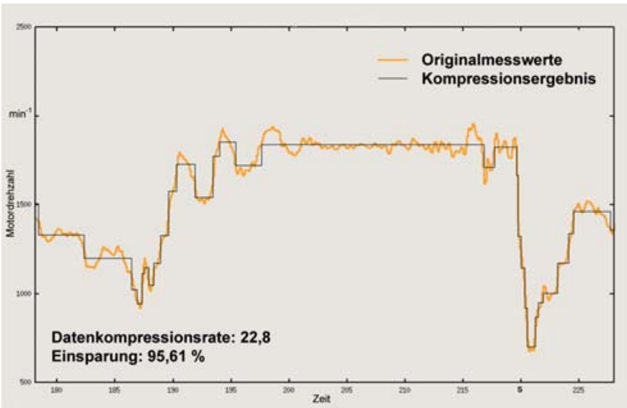
The computer-based elimination of irrelevant data requires that clearly defined mathematical criteria for irrelevance and relevance must be found, which can serve as the basis for an algorithm. For the compression of a temporarily variable measurement value, e.g. the engine speed, the minimum deviation of the original course of the signal from the currently calculated average value has proven to be a suitable relevance criterion in preliminary tests. This means that the average of the newly registered measurement values is determined until the newly calculated mean value at least deviates by a predefined value from the course of the measurement value at one point. When this is the case, the information is relevant, and the previous mean value is saved together with the start-time of the signal averaging. Afterwards, the calculation of the average value begins again at the current time with the current measurement value.

Fig. 1



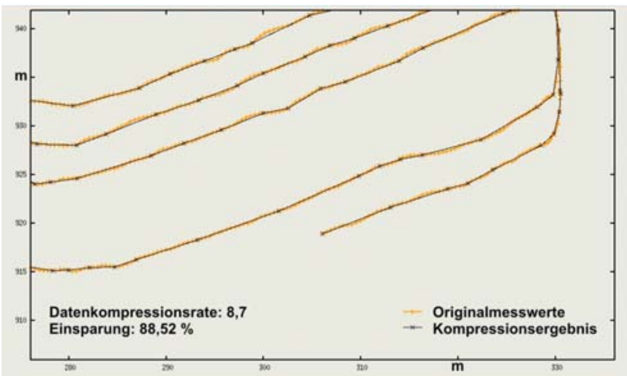
Qualitative comparison of different compression methods

Fig. 2



Compression of engine speed data of a tractor

Fig. 3



Compression of position data of a tractor while working in the field

Another example is a method which serves to compress position information determined by the GPS receiver of the experimental tractor during field use. Here, the compression result should also contain only relevant information. However, the necessary relevance criteria are more diverse than in the first example. Figure 3 shows the result of position data compression.

Newly measured positions are disregarded until the omission of a position value would lead to an excessively large deviation of the compression result from the original measurement values. The compression result is the linear connection of all successive position values which are considered relevant. The relevance criteria upon which the algorithm is based are maximum permissible lateral deviation, a maximum permissible change of direction, as well as maximum permissible longitudinal deviation. In addition, successive points which do not have a defined minimum distance from one another are considered irrelevant and disregarded. Therefore, successive position values which are recorded when the machine remains stationary are not recorded repeatedly.

Both presented methods do not require the intermediate storage of entire sequences of measurement values and therefore need only very little storage space on the mobile computer. The data can be processed in the order in which they arrive from the CAN bus. In addition, the developed compression methods can be applied to other measurement values and other machines. Since configuration is possible, the compression result can be very easily adapted to the individual application by varying the parameters. Thus, it is possible to set a higher compression rate during road rides and greater precision for the compression of position information during field use, for example.

Summary

It was shown that the use of suitable data compression methods in telematics applications makes it possible in some cases to save more than 90% of the data quantity to be transmitted without the loss of significant information. The developed compression methods can run on-line and need only very little computing performance and storage space in the information-processing unit on the machine. The variation of a few parameters enables the mode of operation of the compression methods and, hence, the quality of the compression result to be influenced. The application of such methods is interesting in particular on agricultural machinery because mobile communication networks are often the only possibility of wireless communication in rural areas. There, however, these networks often have only very small useable bandwidths, and data transmission is currently still very expensive. All in all, data compression in telematics applications is an important element of data management.

Literature

Books are identified by ●

[1.] ● Brockhaus Naturwissenschaft und Technik, Definition Datenkompression

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