Affordable telematics system for recording and monitoring operational data in crop farming

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Abstract.
The aim of this research was to create an affordable telematics system for agricultural tractors for enhancing existing data logging capabilities. This system enables real-time transmission of operational data from the tractor's CAN bus to a server for storage, monitoring, and further analysis. By leveraging standardized communication protocols like ISO 11783 and J1939, operational data such as fuel consumption and engine load can be easily monitored. The system was built around a Raspberry Pi 3B+ mini-computer which interfaces with the tractor's CAN bus via a CAN shield and records bus data. The precise location is recorded with a GPS-RTK2 receiver attached to the computer. Open-source programming tools, including Node-RED, were employed to manage data transmission and create a user interface for data monitoring. Data was stored in a MySQL database on a remote server, transmitted securely via 4G LAN connection. Field tests conducted at the Viikki Research Farm of University of Helsinki, during the 2023 growing season, involved monitoring two tractors performing various tasks, including silage harvesting with a forage wagon and a baler, as well as mowing hay. The server hosted the database and user interface, allowing real-time monitoring of recorded data such as fuel consumption, driving speed, engine speed, power, and tractor's location. The implemented system successfully collected data from multiple tractor tasks during silage harvesting, with easy retrieval and analysis facilitated by decoded CAN messages. Real-time monitoring via the user interface ensured seamless operation. The CAN bus's ease of use makes it beneficial for continuous-time analysis. The recorded operational data can be utilized in decision making of crop farming and for model development purposes when developing new concepts for agricultural vehicles and machinery. Additional sensors can be easily connected to the telematics system as the open-source interface provides multiple options for sensor measurements.

Keywords.
CAN bus, Node-RED, operational data, secure network, telematics

Introduction

Modern production buildings and farm machinery continuously produce information that can be leveraged not only for planning and managing farm production but also for developing more sustainable and energy-efficient food production systems (Backman et al., 2019). Increasing use of automation technologies in farming has significantly expanded the volume of data generated from field operations (Paraforos et al., 2017). For instance, modern agricultural tractors generate standardized operational data, which is currently used primarily for tractor and implement control (Boland et al., 2021). Additionally, various farming implements can continuously collect and generate data on field conditions, crops, and other sources (Steinberger et al., 2009). In this context, data security has emerged as a crucial element that must be carefully considered during system development. Ensuring data security is particularly important when transferring data wirelessly from tractors to servers (Nikander et al., 2020).

There is a growing interest in enhancing productivity through the optimization of production inputs rather than merely focusing on economies of scale (Pitla et al., 2014). As the production capacity of agricultural machines increases, optimizing production inputs has become essential for both farm productivity and environmental sustainability (Paraforos et al., 2017). Employing advanced technological methods in farming, often referred to as precision farming, allows for the optimization of inputs such as fertilizers, herbicides, and pesticides.

Methods

The measurement system used in this research was built using a Raspberry Pi 3B+ single-board computer. This device was selected for its compact size, affordability, and easy compatibility with add-ons and open-source programs. The mini-computer was equipped with a CAN measurement board (RSP-PICAN2), enabling connection to the tractor's CAN bus. The recorded data, along with location information, was transmitted to the server via a secure 4G LAN connection. For network connectivity, a Tosibox 175 remote connection device was installed on the tractor, allowing for the creation of a secure local network connection to the server. The Raspberry Pi was connected to the Tosibox device via WiFi, and the Tosibox device was powered from the tractor's 12-volt power outlet. The process data read from the CAN bus was sent to a database server located in the laboratory building at the University of Helsinki. A Linux-operated computer was used as the server machine to store the measured data.

Open programming tools were utilized for developing the measurement and data transmission system. Data collection and transmission were managed using Node-RED, which also facilitated the creation of a user interface for the measurement system. The data was stored in a MySQL database on the server machine and transmitted in real-time to the database server. The data logging process involved collecting information, which was then processed and transferred to the database via Node-RED. The data source was a Python program that read and decoded CAN bus messages. The decoded CAN messages, formatted as JSON strings, were forwarded to a JSON node to be converted into JSON objects. Subsequently, a timestamp and other variables were added to the messages using a function node. Since each message from the CAN bus contained only part of the parameters, information from different messages was combined into a single JSON object using a join-node, ensuring that each message sent to the server included all the measured information. Message transmission was regulated to a frequency of 10 Hz using a rate limit node.

Results

The main results of this research were the developed measurement system and secure data storing approach. The measured data represent additional results which were used to evaluate the measurement system operational performance. Dataset measured from one field when operating the forage wagon is presented in Figure 1. Overall, it was concluded that the recorded data had very good quality and the system operated as planned. The computational power of the mini-computer was quite limited therefore it should be upgraded to a newer version when more data is being recorded.

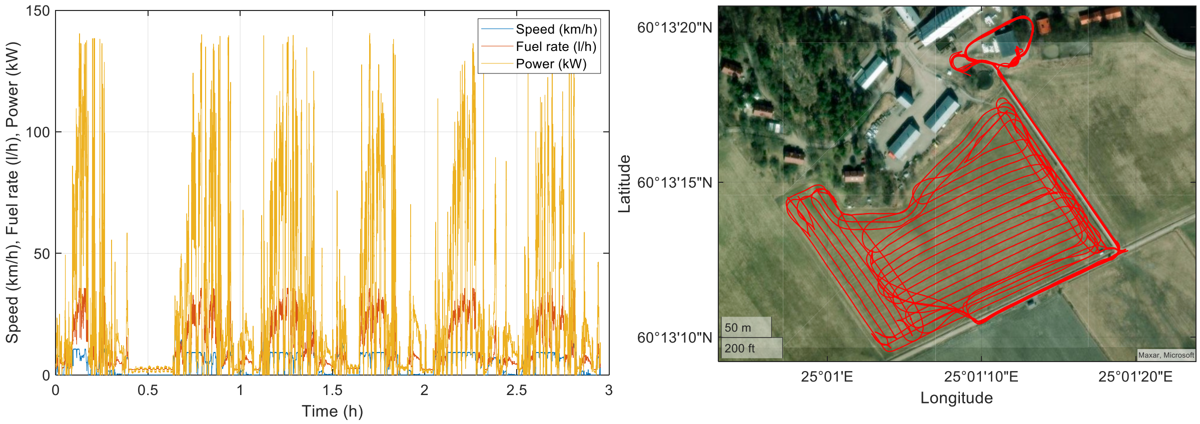

Fig 1. Measured data and trajectory of forage wagon usage in a field.

Summary

Measured data from agricultural field operation can be used for wide variety of purposes in crop production. Measurement and instrumentation technologies have been developed rapidly during the last decades providing economically affordable and secure methods for recording and storing the operational data from agricultural tractors and farm implements. This type of data can be used among others for operational management, preventive maintenance, yield variation assessment, and economical analysis of farm crop production. The developed measurement system can be easily extended with additional sensors acquiring data from crops and conditions as well as from the farm implements. Furthermore, the operational data can be used as reference and input data for modeling and simulation of agricultural operations.

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