Autonomous robot for harvesting apples

Figure 1: The autonomously operating harvest assistant Aurora (Source: Hochschule 21)

CANopen measurement and sensor solutions from Siko are not only found in industrial applications. Currently, the company supports an agricultural research and development project for an autonomously operating harvesting vehicle in fruit orchards with rotary encoders from its range for mobile machines.

Aurora (autonomous orchard assistant altes land) is a small autonomous vehicle which in future will move independently around fruit orchards and detect full fruit boxes, pick them up, and take them to a defined unloading point. The robot eases the burden on harvest workers and allows them to concentrate on more challenging tasks. Technology and automation should increasingly help to avoid monotonous, tiring activities, and is set to make the job of fruit growers significantly easier. The idea for the project comes from practice: fruit farmer Johann Schröder from Jork in the "Altes Land" region south-west of Hamburg asked Hochschule 21 in Buxtehude for help in developing an autonomously operating vehicle of this sort. The project was launched in collaboration with the agricultural equipment manufacturer PWH from Jork in February 2020. The demand for technical support is high among fruit orchard owners and the project is therefore intended to turn into a market-ready, profitable product in the medium term. The concrete objective of the project, however, was to deliver a functioning prototype by January 2023 in the first instance,

which will demonstrate its practical feasibility. The project is funded through the ZIM funding program of the Federal Ministry for Economics.

Second milestone: robot drives autonomously

The project is currently in the last third of the planning stage, having achieved its second milestone: the robot can already operate largely autonomously in an orchard. Work is still being carried out on avoiding collisions and detecting the ground conditions, to avoid getting the wheels stuck in muddy ground, for example, or drifting off course into a ditch. Milestone number three will then be actually to pick up a box and transport it.

A development project of this sort always poses particular challenges, starting with coordination of the interests of various fruit farms, which often have very different harvesting processes, through problems with the infrastructure, such as a stable cell phone standard so that ▷

Figure 2: The Aurora harvest assistant will navigate through the rows of trees in an apple orchard and detect and pick up fruit boxes and transport them to a defined unloading point autonomously in future (Source: Hochschule 21)

the robot can receive GPS data and communicate with the operator, to practical difficulties in day-to-day outdoor operation (weather conditions, snow, rain, sunshine, ground conditions).

Rotary encoder for tough environmental conditions

Sensors that carry out various measuring tasks are needed for a vehicle that operates autonomously. Measurement and sensor specialist Siko was called in to work on the steering angle detection and positioning of the box holders. With many years of experience in mobile machines and agricultural machine technology, Siko was able to contribute its expertise to the planning phase and ultimately came up with two suitable rotary encoder types that support these important functions. One of them supports CANopen. Alexander Kammann, research assistant at Hochschule 21, appreciates the work of the SIko experts: "We were pleasantly surprised by the willingness of Siko to support future-oriented projects and how committed they were in offering their advice. In the beginning, we were not even sure what requirements we actually had of the sensors. We worked all this out and defined it together."

First of all, potential sensors must be extremely robust and resilient in the face of tough outdoor conditions (mud, dust, rain, strong sunshine, unevenness in the ground). Components in the Pure.Mobile range of sensor modules from Siko are particularly suitable for use in mobile machines under harsh environmental conditions. A couple of the products in this range support CANopen, CANopen Safety, or J1939.

A double wheel is fitted to the back of the vehicle, which can rotate and thus control the steering. The steering angle is recorded, processed, and sent to the controller by the CANopen WV5800M magnetic rotary encoder. This is a multiturn rotary encoder by means of which even multiple rotations can be detected absolutely. If the power supply is interrupted, because the batteries are flat for ▷
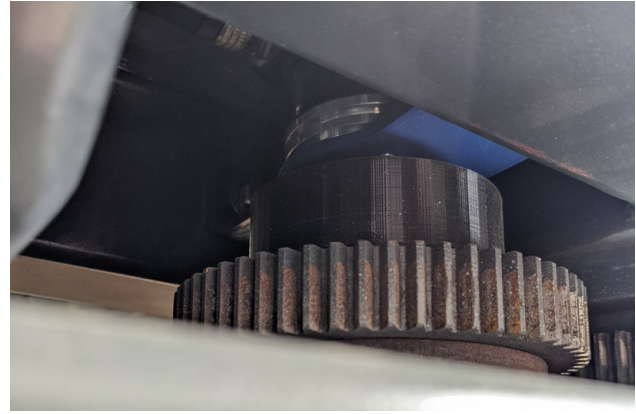
Figure 3 + Figure 4: Important details of the steering: The CANopen WV5800M multiturn rotary encoder records the steering angle so that the vehicle can follow its defined path (Source: Hochschule 21)

example, the steering angle previously set is still present. Without an absolute encoder, this would incorrectly be set as the zero degrees angle when the vehicle is started up again. The magnetic measurement principle meets the requirements of robustness and resilience. The high precision and reliability of the rotary encoder also impressed the team, meaning that the vehicle always adjusts its steering angle so that it keeps to its defined path – without failures or unacceptable deviation from tolerances. In order to increase safety in interaction with the people working in the orchard still further, the WV58MR safety variant (CANopen Safety) of the rotary encoder with redundant position detection will be used for future vehicles to reliably prevent failures. In the development phase, the focus was initially on technical feasibility, so that the rotary encoder without the safety standard was adequate. The plus point of the Siko models: the two rotary encoders are identical in design, so that no mechanical adjustments need to be made to the application when swapping them. A CANopen interface was required for the steering angle detection system so that as many standard electronic components as possible can be used, replaced quickly, and integrated into the system bus.

Details of the CANopen WV5800M/WV58MR magnetic rotary encoders

The WV5800M rotary encoder is a magnetic absolute rotary encoder with solid shaft, which has been specially developed for use in mobile machines. It is available optionally with a CANopen or J1939 interface and records the absolute travel information.

The WV58MR rotary encoder is a magnetic safety rotary encoder with redundant position detection, also custom-designed for use in mobile machines. It can be employed in safety-critical applications up to Performance Level PLd. It provides an optional redundant CANopen or CANopen Safety interface.

Both encoders can be parameterized and read out via the CAN interface using the CANopen protocol. For diagnostic purposes there are 3 LEDs in the encoders (yellow, red, green), which indicate error or status information for diagnostic purposes (CiA 303). The encoders support the following CAN in Automation (CiA) specifications: CiA 301, CiA 303 Part 3, CiA 305, and CiA 406.

The safety variant additionally supports CANopen Safety (EN 50325-5).

◆ CiA 301 CANopen application layer and communication profile specifies the CANopen application layer. This includes the data types, encoding rules and object dictionary objects as well as the CANopen communication services and protocols. In addition, this specification specifies the CANopen network management services and protocols. This specification specifies the CANopen communication profile, e.g. the physical layer, the predefined communication object identifier connection set, and the content of the Emergency, Timestamp, and Sync communication objects.

◆ CiA 303-3 device and network design – Part 3: CANopen indicators. This recommendation describes the communication-related indicators. Additional application-related indicators are either described in the appropriate device profile or are manufacturer-specific.

◆ CiA 305 CANopen layer setting services (LSS) and protocols specifies the layer setting services (LSS) and protocols for CANopen. These services and protocols are used to inquire or to change the settings of three parameters of the physical layer, data link layer, and application layer on a CANopen device with LSS server capability by a CANopen device with LSS manager capability via the CAN network.
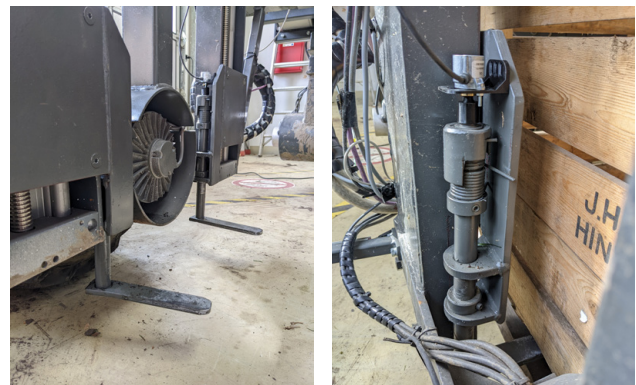

Figure 5 + Figure 6: The position of the box holders, the so-called flippers, is detected by the robust AH25S miniature rotary encoder (the rotary encoder is located at the top of the structure) (Source: Hochschule 21)

◆ CiA 406 CANopen device profile for encoders specifies the communication and application parameters for different types of linear and rotary encoders such as incremental and absolute, normal, and high resolution, single and multi-sensor (linear only) encoders. The document provides also operating principles of the encoders and specifies encoder output process values such as position, speed, acceleration and jerk. The document specifies also encoder CAM parameters. This document also specifies CANopen Safety parameters such as Safety position and Safety speed for encoders with CANopen Safety functionality (see EN 50325-5).

CAN Newsletter Online

The CAN Newsletter Online already reported on further CANopen sensors from Siko:
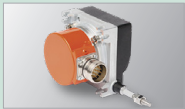
SPS 2021
Sensor family for mobile machines

The wire-actuated encoders of the Pure. Mobile family from Siko (Germany) measure position, speed, and inclination due to an integrated single-axis inclination sensor.

Read on

SPS Connect 2020
Sensors and actuators for harsh environments

Siko introduced several devices at the SPS Connect 2020 digital fair. The AP10 position indicator, AG03/1 actuator, IKM360R inclinometer, and WH5800M encoder are connectible via CANopen.

Read on

Machine on wheels
Siko and STW cooperate regarding sensors

The two companies have agreed on a strategic partnership with the aim of further opening up the market for mobile machinery. This includes joint developments of sensors.

Read on

Position sensor
Wire-actuated encoder for 12-m measuring length

The SG121 wire-actuated encoder from Siko is suitable for measuring lengths up to 12 m. It comes with an installation depth of 70 mm x 8 5mm x 105 mm and supports CANopen, J1939, and CANopen Safety interfaces.
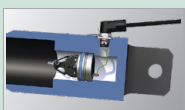
Read on

For hydraulic cylinders
Position sensor with +105 °C temperature range

Siko updated its SGH10 position sensor. The product has been certified by the German Federal Motor Transport Authority in accordance with UN ECE R10 and now has E1 certification for road vehicles.

Read on

CAN Newsletter magazine
Encoders for hydraulic and telescopic cylinders

Draw-wire sensors based on rotary encoders have some advantages compared to other solutions. Matthias Roth, Siko's Industry Manager Mobile Automation explains them on the example of the SGH series.

Read on

cd

Position sensors for the "flippers"

Figure 7: The AH25S, WV5800M, and WV58MR encoders described in the article (Source: Siko)

The second Siko rotary encoder (not CANopen capable) used in the project is the AH25S. It is a single turn rotary encoder which monitors the position of the box holders, the so-called flippers. The filled fruit box is picked up at four points by one flipper for each. When the robot moves over the box and the spring-loaded holders touch it, the flippers swivel to the side, then open automatically and are then located under the four corners of the box for pick-up. In order to be able to transport the box safely, the position of each flipper must be known: has it really swiveled back or has it jammed? Are all four flippers under the box to ensure that it is picked up correctly? The space is very restricted, so a miniature rotary encoder was required which could be used directly without a special holder. An analog encoder is adequate here, as the data is less critical than that provided by the steering angle sensor.

A harvesting tool with real added value

Many little cogs have to interlock in a development project of this sort to turn a vague idea into a technically perfect product, which in future can be used with a balanced cost-benefit ratio in numerous orchards. In order to offer farms genuine added value, the intention is to use Aurora for other maintenance work, too, such as mulching and mowing or as support for planting new trees. Effective use virtually throughout the year is therefore possible and is not just restricted to harvest time. ◀

Source

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