Building a dataset for AI-assisted detection of belt tension on a conveyer belt

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Abstract

A measurement setup based on an accelerometer, MEMS gyroscope and magnetometer was used to gather data on a conveyor belt to determine the tension of the belt. 100,000 data points are split into 10 measurement series with 10,000 data points each. Each data point consists of 9 time series of the 3 sensors with 3 axis each.

Data origin

The data was recorded as part of a project, which is involved in the condition monitoring of machines and Edge AI. For this application several sensors were chosen in conjunction with a dedicated measurement hardware, data processing workflow and AI-assisted evaluation approaches. The goal is the development of an easy-to-use workflow for predictive maintenance and provide references on the required sensors, sensor placement in the machines, and required computational power of the edge device.

Measurement setup

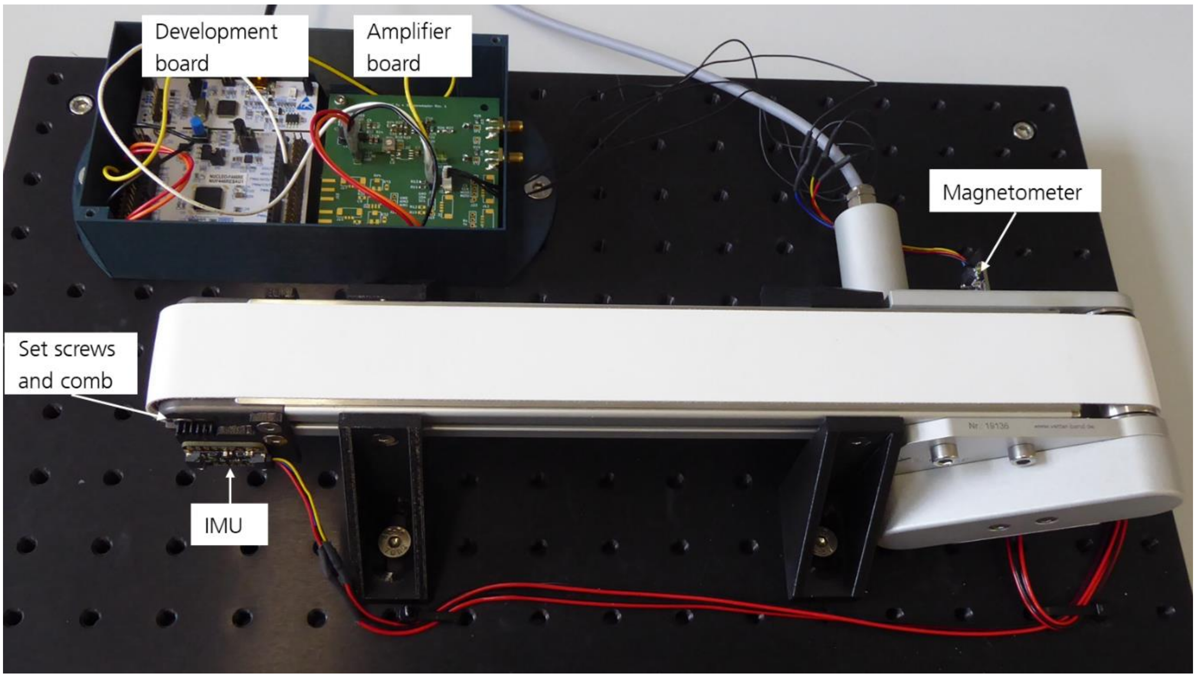

Figure 1: The used measurement setup.

A conveyor belt (Vetter Kleinförderbänder GmbH, BK-20-40-1-300-20) is equipped with an inertial measurement unit (IMU) and magnetometer (Figure 1). The IMU is a STMicroelectronics LSM6DSOX, which is mounted via a 3D-printed adapter next to the pulley of the belt. The magnetometer is a STMicroelectronics LIS3MDL, which is mounted near the motor of the belt. The data is sampled by a development board (STMicroelectronics NUCLEO-F446RE) and send via the integrated virtual serial port to a PC to store the data. The amplifier board serves as adapter between the microcontroller on the development board and the sensors via an I2C interface. This board also contains analog amplifiers for other sensors, which are not included in this setup.

The IMU includes an accelerometer, which measures lateral movements, and gyroscope, which measures rotational movements, each in 3 different directions. This gives information about vibrations caused at the pulley.

The magnetometer is used to measure the magnetic field of the motor. This gives information about the current. This measurement technique has been chosen to stay in line with the retrofitting aspect of the project. The approach does not require to modify the cables of the motor.

The configuration of the sensors is shown in Table 1. Data sampling is done in parallel between the IMU and magnetometer. This process is shown in Figure 2. Each measurement pass creates a data buffer with time series data from a timespan of 100ms. Each of the sensors, accelerometer, MEMS gyroscope, and magnetometer operate on 3 axes, resulting to 9 sets of time series per measurement point.

Table 1: Sampling parameters of the sensors.

Sensor	Range	Sampling rate	Number of samples
Accelerometer	±4g	3,333Hz	333
MEMS gyroscope	±500dps	3,333Hz	333
Magnetometer	±8 gauss	1,000Hz	100

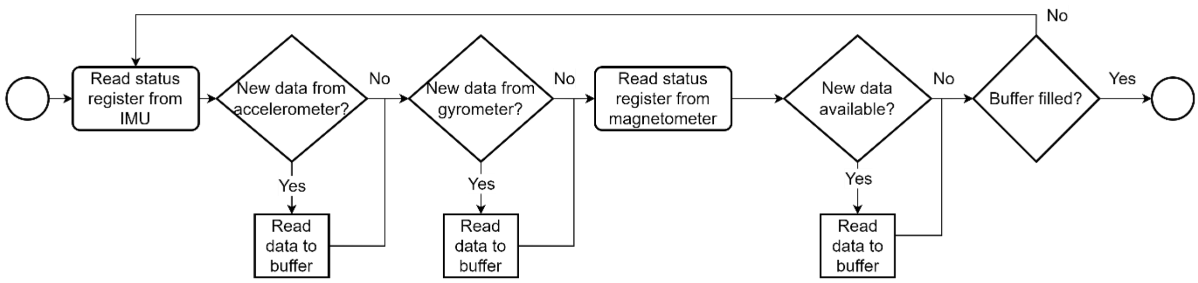

Figure 2: Process of data sampling from the sensors.

Measurement process

The tension of the belt can be set using set screws at the pulley. To mark defined positions for repeated measurements, there is a comb-like structure attached to the adapter for the IMU. It has fingers at a 1mm interval. There is a screw and markings on each side of the belt. The following positions have been defined:

- 3: Low tension. The belt does not move continuously and gets stuck due to the low tension.
- 4: Low tension. The belt runs continuously without getting stuck.
- 5: Good tension. At this position the belt runs smoothly without increased strain on the motor.

- 6: Good tension. The current consumption of the motor is slightly increased, i.e. there is a higher strain on the bearings of the system.
- 7: High tension. The current consumption of the motor and strain on the system is increased further.

The current measurement for the setup phase was done by the laboratory power supply used to supply the conveyor belt.

Each of the 10 measurement series were obtained by the following sequence:

1. Perform 10,000 measurements while the belt is not active.
2. Set tension to the lowest level (3).
3. Start the belt and fine-tune the tension, so that there is no misalignment.
4. Perform 10,000 measurements.
5. Increase the tension by 1 level and repeat steps 3 and 4 until tension level 7.

Since the data acquisition is split into 10 different datasets, which were acquired over several weeks, we can assume to include a variance of the noise in the measured data and environmental influences, such as temperature and humidity.

One should consider that the high tension applied during the measurements can stress and wear out the belt. The lower tension levels should be similar over all measurement series. Higher tension levels could be regarded as a lower tension level for later measurements, as the belt already wore out.

Data format

The software that safes the data to a file on the PC is realized in python. The data format is HDF5. As HDF5 is a structured data format, there are several Pandas data frames in each file.

Each HDF file contains the following dataset: 'L3_R3', 'L4_R4', 'L5_R5', 'L6_R6', 'L7_R7', and 'background'. The numbers indicate the tension level where L and R are left and right, respectively. Meaning that the tension was the same on both set screws and there is no misalignment in the belt for all measurements. The first dataset also contains test measurements for misalignments, but this was not continued for now.

The Pandas data frames can be easily loaded with the read_hdf function such as in this example, where the dataset L4_R4 is loaded from the first measurement series:

```
>>> import pandas
>>> df = pandas.read_hdf('Conveyor_Belt_1.hd5', 'L4_R4')
```

The variable *df* now contains the time series data from 10,000 measurements where the tension was set to level 4:

```
>>> df.columns
Index(['AccX', 'AccY', 'AccZ', 'GyrX', 'GyrY', 'GyrZ', 'MagX', 'MagY',
'MagZ'], dtype='object')
```

The 9 columns of the data frame represent the data of the accelerometer (Acc), gyrometer (Gyr) and magnetometer (Mag) in the X, Y, and Z direction respectively.

Current work on the data

Currently, there are no publications based on the data.

The data has been processed in different ways and neuronal networks as well as machine learning models have been trained to detect the tension of the belt. The current work focuses on implementing an embedded AI on the microcontroller on the development board to perform the inference and give feedback of the current state of the tension. This could be used in systems to assist an operator to set the optimal tension. In a next step, the dataset may be expanded to measurements with misaligned belts to automatically detect anomalies in big conveyor belt systems.