Vision-based Vibrator Calibration

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1. Introduction

Vibratory feeders are commonly used in the manufacturing industry to align and feed various types of parts into machines. The primary types of feeders are circular and linear. The main parts are the feeder bowl and the drive unit. The bowl is equipped with traps that ensure the parts are all oriented in the same way. The movement of parts happens by vibrating the bowl feeder.

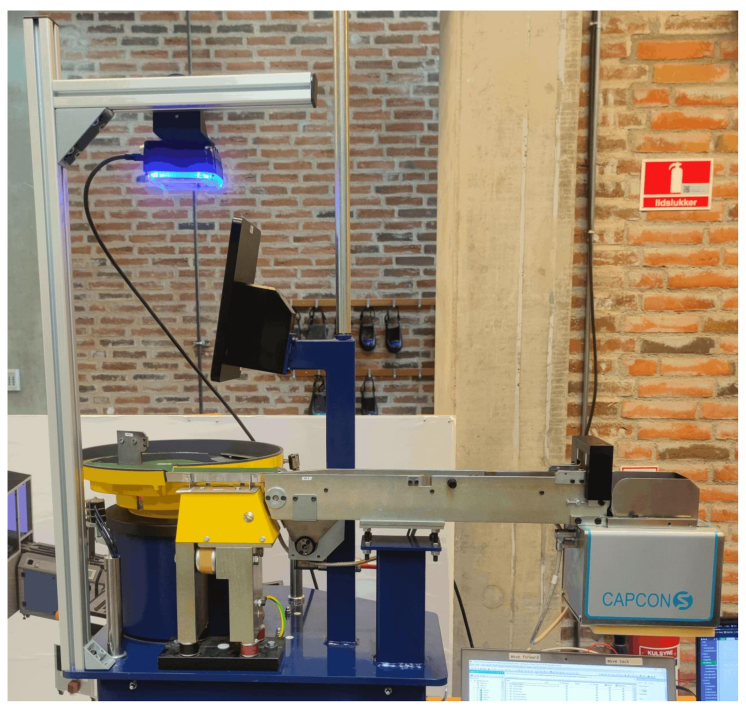

Figure 1: Vibrator bowl feeder setup

Since the mechanical properties of the feeders can change over time or depend on what parts are being fed, they require calibration to ensure a good and stable feeding speed and optimal power consumption. Thereby, the frequency of the vibrations should be close to the system's resonant frequency.

Currently, there are two main ways of calibrating the vibrators; using accelerometers that are temporarily placed to measure the performance and calibrate or using a sticker that is inspected while the vibrator is working to determine its amplitude. Both ways are manual and not continuous. The project's goal is to use cameras to determine the peak frequency of the system.

2. Method

The gathered information from B&R and the plausible options that was evaluated led to consider these five possible solutions: unsynchronized, phase shift, line scanner, long exposure, and synchronized method.

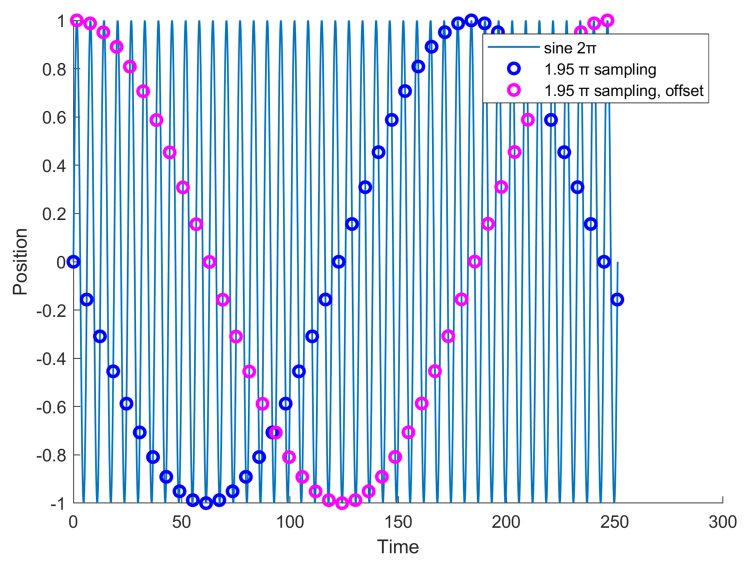

Figure 2: Synchronized method plot

The synchronized method has the highest scalability and flexibility potential out of the tested methods. It can be modified on higher frequency vibrators or cameras with a longer processing time.

The synchronized method utilize the PLC time to take the pictures. The pictures will be taken at the last picture time + period + increment. This results in repeatable sampling resolution even if the frequency of the vibration changes. If the number of pictures taken is set until the total increment equals the period, then the full-wave with high and low peaks will be captured. A simulated plot showing the results can be seen in the figure above. The plot shows that the sampling frequency would always change to be the same relative to the period in this method. The offset sampling illustrates that the method works regardless of the starting phase, which is not determined.

3. Testing and Results

The synchronized method was tested for different aspects. First, a power frequency test was conducted to determine if the method could detect the amplitude at different power levels. The resulting graph can be seen in figure 3. As the individual data points are marked with circles the graph also illustrates how the time-saving sweep is done.

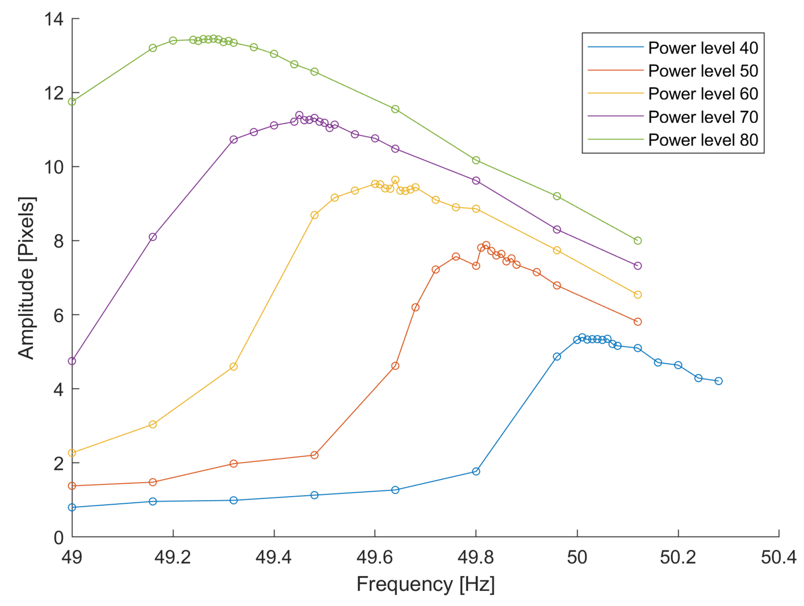

Figure 3: Line plot of frequency and power sweep

Next, a test was conducted to optimize the time taken for a single frequency sweep. This led to a decrease in run time to 89 s from 157 s. If the offset is changed from 125 µs to 250 µs half the amount of pictures will be taken, increasing the speed at the cost of resolution. The result comparison between the two offsets can be seen in figure 4. The standard deviation in the found peak frequency was 0.0066 Hz for the 125 µs offset and 0.0101 Hz for the 250 µs offset.

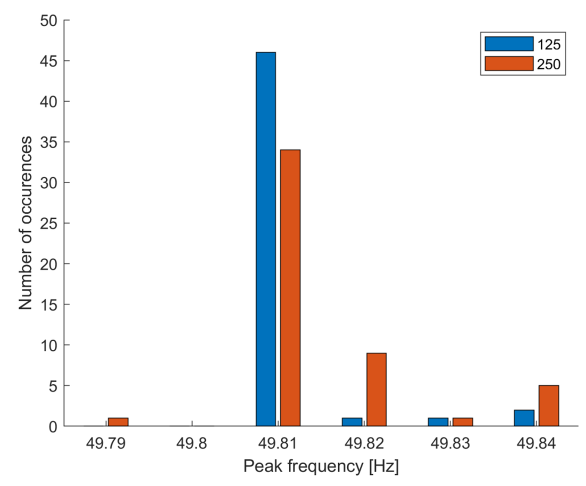

Figure 4: Bar graph showing the distribution of results for the 125 µs and 250 µs offset

Afterward, a test on the camera resolution was done. It was determined that the method still works with higher and lower resolutions. The lower resolution doubled the standard deviation; however, it only increased to 0.0118 Hz.

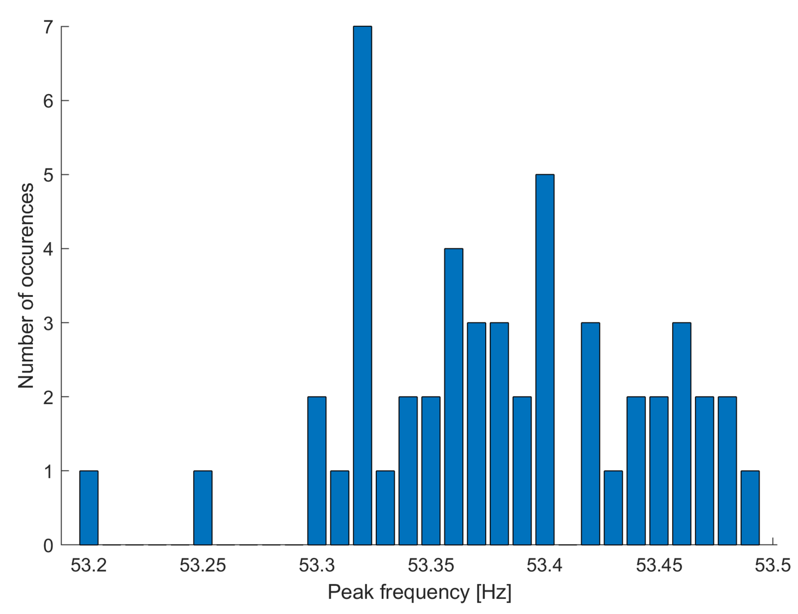

Figure 5: The results of a 50 frequency sweeps at power 50%

Lastly, a test was conducted to determine if the synchronized method would also work on the linear vibrator. In figure 5 it is possible to see the frequency for the maximum amplitude for 50 sweeps done at one power level. The standard deviation in the found frequency is 0.0632 Hz.

4. Conclusion

After extensive testing, the Synchronized method was able to successfully calibrate vibrator bowl feeder within ±0.1 Hz and therefore matched the requirement from B&R Automation. The method was proven to be highly scalable and adaptable, which would translate into a straightforward implementation when introduced into a production line.

Acknowledgement

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