DOI 10.5162/SMSI2020/P2.4

Multifunctional Stick-Slip Sensor

Klemens Gintner[1], Michael Weber[1], Bernhard Beck[1]
[1] University of Applied Sciences Karlsruhe, Faculty MMT, Moltkestr. 30, 76133 Karlsruhe, Germany,
klemens.gintner@hs-karlsruhe.de

Summary:
A new type of stick-slip sensor is presented. The signals of a pressure sensor and an acceleration sensor are advantageously used to evaluate the quality of a gripping process. The motion profile of the gripper and also the minimum mass of the gripped object can be determined at the same time. Such a sensor can be used, for example, in robotics or in prosthetics (hand prostheses).

Keywords: Stick-slip sensor, additional information, grip quality assessment

Motivation: Evaluation of gripping process

The evaluation of a gripping process is important in many applications, e.g. in robotics, because the handling of objects must be evaluated or carried out correctly. This is also the case with hand prostheses, which should allow a secure grip.

Description of the New Sensor System

It is a sensor system on a gripper - e.g. thumb on a hand prosthesis or a gripper on a robot arm. An acceleration sensor with at least one axis (better two or even three axes) is required to detect the relative movement (= slipping due to the tangential force $\underline{F}_{T,X}$ in x-direction) between the sensor and the object to be gripped. The acceleration sensor is located in a conical base body, which can oscillate tangentially in x-direction to the holding force $\underline{F}_{N,Z}$ parallel to the z-axis when an object slips through ("elastically" mounted) - see Figures 1, 2 and 3.

The corresponding (oscillation) frequency depends, among other things, on the geometry of the base body and the frequency is typically above 120 Hz (see Fig. 5). By suitable frequency-selective evaluation using low-pass and high-pass filters, slipping of an object to be gripped can be detected at the resonant frequency of the base body.

An example of the evaluation algorithm of the acceleration signals to detect slipping is shown in Figure 4. The given values are to be understood as an example.

The evaluation also allows the movement of the gripper to be detected, as the corresponding frequency range is significantly lower than the resonance frequency of the base body (usually higher than 120 Hz). Thus, for example, the movement of the gripper can be detected and, if necessary, better controlled.

With the help of a pressure sensor at the point of contact of the base body, the holding force in z-direction can be determined, which also allows conclusions to be drawn about the minimum mass of the object to be gripped. All this enables further plausibility checks to be carried out so that slippage can be detected even better. Further details can be found in [1].

The three-dimensional acceleration can also be used to determine the orientation of the object to be gripped (e.g. the direction of the acceleration due to gravity). If an additional rotation rate sensor (yaw rate sensor) is used, the trajectory of the gripper can be followed even better.

The following sensors were used for the first measurements:

Force or pressure sensor: QTC (Quantum Tunnelling Composite) single-point sensor QTC SP200-05 from Peratech [2] and three-axis acceleration sensor: LIS344ALH from ST [3].

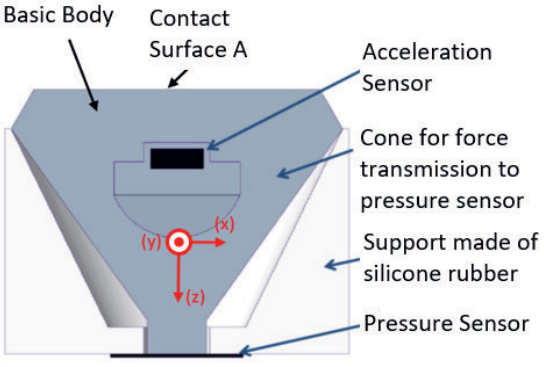

Fig. 1: Sectional view of the sensor

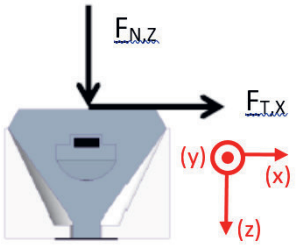

Fig. 2: Forces on basic body: Here: Normal force $\underline{F}_{N,Z}$ and tangential force $\underline{F}_{T,X}$

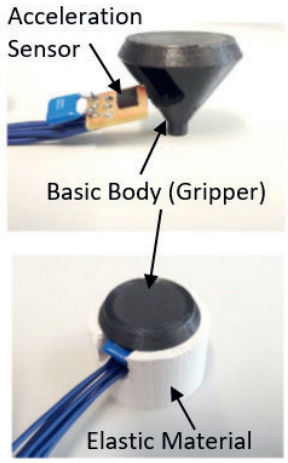

Fig. 3: Images of the sensor above: circuit board and acceleration sensor below: with silicone rubber (elastic material)

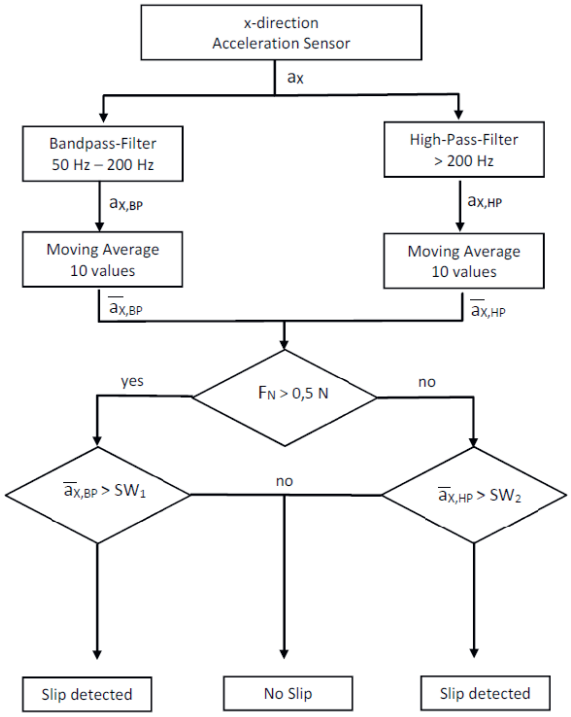

Fig. 4: Example of an evaluation algorithm for the detection of slippage

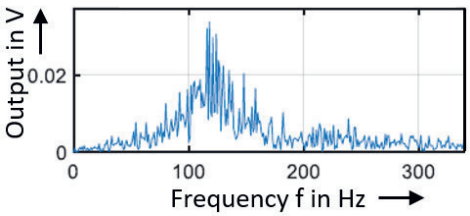

Fig. 5: Output of acceleration sensor a_X in Volt as a function of frequency f in Hertz

Conclusion

By data fusion of different sensors (force and acceleration sensors), both the force for gripping and a relative movement between gripper and object (slipping) can be detected and evaluated. Additionally, it is possible to detect the movement of the gripper and to estimate the minimum mass of the object to be gripped. A patent application has already been filed.

References

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