Masterthesis

at Schneider Electric in Marktheidfeld, Germany

General information

Today's packaging machines cover a wide range of products in pharmaceutical, cosmetic, home care, food, beverage, dairy, tissue and paper etc. Their main task is to automate steps that happen over an over again in the packaging process in a fast and reliable way. Using state of the art technology, for example 1000 dish washer detergents can be wrapped in only one minute. This figure could move up to 2000 wrapped candies per minute, which means that the paper travels at a speed of 3 m/s.

To accomplish these goals a packaging machine distributes the control task across several components. The servomotors house the motor feedback controller along with sensors and their signal processing. The motion/logic control generates the reference values for the motor controllers; this functionality can range from pure feedforward and logics to a complex MIMO structure involving feedback from other sensors and coupling of different axis.

Schneider Electric supplies these components to machine makers, including hardware, platform and application software. While machine makers cannot change that much within the servomotors' controller, they usually programme the motion controller using an application software with given technology functions.

Master's theses usually touch at least one of the following areas:

- Modelling,
- Identification, parameter estimation and validation,
- Fault detection,
- Controller design, both linear and nonlinear.

Models are based on data that are collected in the laboratory or a complete machine (often both). Following the same philosophy, controllers are designed based on the developed models or on already existing ones. Followed by a validation process based on simulation, controllers will be tested in the machine or a lab setup directly.

Students of electrical engineering or computer science programmes, as well as students of mechatronics or applied mathematics programmes are mostly welcome to work on a thesis at Schneider Electric in Marktheidenfeld.

In order to complete these works successfully, a strong background in control engineering is required: this includes a basic course in control (covering modelling and control of linear systems), possibly courses on control theory, some lab-experience using Matlab/Simulink and related tools and basic programming skills in C++ or IEC 61131 type of languages (the latter is not necessary to know in advance, since this can be learned). Depending on the problem in particular, some familiarity with commissioning issues and electronics (basic wiring, taking measurements) is useful. However, there is an opportunity to learn these technicalities "on the job".

The development department in Marktheidenfeld consists of some 100 engineers dealing with machine functionality development, software, hardware, robotics, functional safety and testing.

Applications shall include a cover letter with statement of interests and name of a reference person at the university, copy of university courses and apprenticeships done so far, including credit points, marks etc.

About Schneider Electric

As a global specialist in energy management with operations in more than 100 countries, Schneider Electric offers integrated solutions across multiple market segments, including leadership positions in Utilities & Infrastructures, Industries & Machine Manufacturers, Non-residential Buildings, Data Centres & Networks and in Residential. Focused on making energy safe, reliable, efficient, productive and green, the Group's 150,000 plus employees achieved sales of 24 billion euros in 2013, through an active commitment to help individuals and organizations make the most of their energy.

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Masterthesis

Fault detection schemes for a servo motor

Students of Electrical Engineering, Mechatronics, Computer Science or Mathematics

What finally will create movement in a machine, is a drive and motor. The drive houses feedback control algorithms and sensors to measure e.g. motor's position and currents and will control the motor using a power stage. The drive will receive reference inputs from the controller, which in turn will co-ordinate all drives in the machine.

Obviously, motor and drive play a very central role from the pure functional point of view: when motor or control algorithm work incorrectly, the machine will respond with a poor tracking behaviour. Reasons for an incorrectly working control algorithm may be wrong input signals, such as the current motor angle, provided by the respective sensor. Therefore this position signal has to be continuosly monitored.

The generic scheme used for this monitoring is shown in Fig.1.

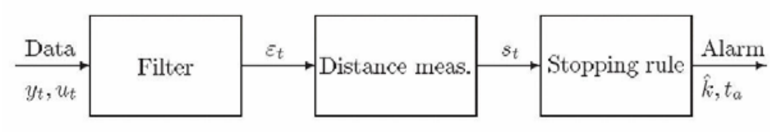

Fig.1: generic change detection scheme using filtering, distance measure and stopping rule, copy of [1, Fig.1.11].

In most cases, the filter, or model based monitoring function estimates the signal *y(t)* in question from independent signals and compares to the sensed one. For example, the measured position of the motor in the system is compared to an estimated one, computed with an observer using the motor's currents and voltages. The output is the the difference between sensed an estimated signal, the residuum *ε(t)*. The question now is to how to deal with the size of the residuum. Is it really big enough to alert a malfunction, or has it been big enough for a sufficient time? These are the jobs of the stopping rule and the distance measure respectively [1]. So far, some investigations and benchmarks have been done, both in simulation and on the testbench [2]. We would like to continue them in the following directions:

- Inestigate a wider range of motors, driver, encoder and combinations thereof.
- Investigate adaptive thresholding and multi-model approaches: in case of monitoring a sensor signal, a second source of information could be taken into account. This could be viewed as a multimodel approach to change detection and the interplay between these two information shall be investigated. Of particular interest would be strategies when one of the models is not valid.
- Explicite failure modelling [5].
- In some cases, the filter is designed as a (extended) Kalman filter, that could be integrated within the distance measure and stopping rule [1, chap 8.10)]. The existing filters have to be reviewed with respect to fault models before that.

Although the approach will follow [3-5] quite closely, it should be noted that the results there have been derived in a different context, which is

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automotive. Aspects, that will make the carry-over quite challenging incluse, but are not limited to: approach must work with a wide variations of motors, sensors, drives (while automotive has a fixed equipment). External load is generally not know, as well as environmental conditions (e.g. ranging from cold & dry when cutting cheese over clean in pharmaceutical to warm and dry in tabacco packaging).

The work will obviously need a lot of data collection both on the test bench and possibly in real machines. After having built the algorithms it is necessary to validate the structure, the parameters and the associated uncertainies by measurement data.

Area/Background Modeling, Parameter estimation/Identification, Fault detection, Programming (Matlab, Simulink), Experiments at testbench.

Interested? Then we are looking forward to receiving your application:

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References

[1] Gustafsson, F.: Adaptive filtering and change detection. John Wiley & Sons Ltd, 2000.

[2] Usman, Z: Motor Modeling And Sensor Monitoring For Safety Applications. Master’s thesis, Dept of EE, Paderborn University, Germany, December 2014

[3] Malinen, S. AFS change detection using signal estimation. Master’s thesis, Dept of Electrical Engineering, Linköping University, Linköping, Sweden, Apr. 2005.

[4] Malinen, S., C. Lundquist and W. Reinelt. Fault detection of a steering wheel angle sensor in an active steering system. In Preprints of the IFAC Symposium SAFEPROCESS, pp. 547–552. Beijing, China, Aug. 2006.

[5] Reinelt, W. and C. Lundquist. Observer based sensor monitoring in an active front steering system using explicit sensor failure modeling. In Proc. of the 16th IFAC World Congress. Prague, Czech Republic, July 2005.

Masterthesis

Designated safety functions for machinery

Students of Electrical Engineering, Mechatronics, Computer Science or Mathematics

What finally will create movement in a machine, is a drive and a motor. The drive houses feedback control algorithms and sensors to measure e.g. motor's position and currents and will control the motor using a power stage. The drive will receive reference inputs from the controller, which in turn will co-ordinate all drives in the machine. Obviously, motor and drive play a very central role from the pure functional point of view: when motor or control algorithm work incorrectly, the machine will respond with a poor tracking behaviour. Reasons for an incorrectly working control algorithm may be wrong input signals, such as the motor position, provided by the sensor.

When it comes to safety related applications, a motion profile that is deemed to be safe is run by the system just sketched. This is monitored by a separate safety system, which would shut down the motion system in case of unintended behaviour.

This "monitoring" is called a "designated safety function" in international safety standards [1]. For example functions like "safety limited speed" are defined. This function basically compares the present speed of the drive and to a given threshold. Once exceeding this threshold, it calles a fall-back state, which is very often to switch off the system. Although very simple conceptually, quite a few challenges can be observed, especially in the context of robustness: not to raise false alarms when being "a little bit" above threshold and/or only for short time; accuracy of signal vs. accuracy of threshold; transient behaviour between detection and switch off; quality of diagnostics at low speeds.

The task would be to model and implement a selection of the designated functions as listed in [1], followed by assessment of accuracy and robustness on a testbench.

The work will obviously need a lot of data collection both on the test bench and possibly in real machines. After having built the algorithms it is necessary to validate the structure, the parameters and the associated uncertainies by measurement data.

Area/Background Modeling, Parameter estimation/Identification, Fault detection, Programming (Matlab, Simulink), Experiments at testbench.

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References

[1] IEC 61800-5-2. Adjustable speed electrical power drive systems – Part 5-2: Safety requirements –Functional. First edition 2007-07.

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