Masterthesis

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 140,000 plus employees achieved sales of 24 billion euros in 2012, through an active commitment to help individuals and organizations make the most of their energy.

Schneider Electric Automation GmbH

Schneider Electric Automation GmbH with its main office Marktheidenfeld/Germany is part of the Schneider Electric global Industry business. With its departments Machine Solutions and System Consistency, Schneider Electric Automation is globally responsible for developing and manufacturing hardware and software products for automation solutions in machines and plants. The international activities of the department Machine Solutions are managed in Marktheidenfeld.

Masterthesis

Modelling and parameter identification of a 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 and important role: 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. Since this monitoring function is model based, a good and accurate model of the motor is needed for implementing this functions, which is the key aspect of this work.

The task is to refine and improve the existing model of the motor. Starting off with a very simple model for the motor, parameters shall be identified and validated. One key aspect is to estimate a parameter uncertainty over the range of motors coming directly from the production line. All these motors fulfill the quality specs, but still behave differently from an input/output point of view. One topic is to map these uncertainties, arising from series production, to uncertainies associated with model parameters, so that a robust controller design can take care of them. Another issue is to build more sophisticated models (i.e. starting off with more detailed modelling and differential equation), estimate parameters and uncertainties as above, this time with a clear focus on fault detection and detection of abrupt parameter changes. This model will be used for design of additional functions or controllers that ensure a basic operation even when not having all signals available.

The work will obviously need a lot of modeling, followed by data collection both on the test bench and possibly in a machine. After having built the model it is necessary to validate the models, their parameters and the associated uncertainies by measurement data.

Area/Background. Modeling, Parameter estimation/Identification (linear and nonlinear), Programming (Matlab, Simulink), Experiments at test-bench.

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

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References

[1] Lundquist, C. and M. Rothstrand. Modelling and parameter identification of the mechanism and the synchronous motor of the active steering. Master's thesis, Dept of Machine and Vehicle Systems, Chalmers University of Technology, Göteborg, Sweden, May 2003.

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Masterthesis

Model based monitoring of 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 task is to develop a monitoring function that estimates the motor position based on independent signals. Several approaches could implemented such as extended Kalman filters, simple parity equations etc. Although the approach will follow [1,2,3] quite closely, it should be noted that the results there have been derived in a different context, which is 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). Particlar issues that could also be addressed are initialisation, offsets, abrupt change of sensor signals (due to short-cuts, communication time-outs etc), sensor drifts, etc.

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

Area/Background. Modeling, Parameter estimation/Identification (linear and nonlinear), Programming (Matlab, Simulink), Experiments at testbench.

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References

[1] Johansson, H. Estimation of motor angle using extended Kalman filtering. Master's thesis, Dept of Machine and Vehicle Systems, Chalmers University of Technology, Göteborg, Sweden, Dec. 2004.

[2] Reinelt, W., C. Lundquist, H. Johansson. On-line sensor monitoring in an Active Front Steering System using Extended Kalman Filter-

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ing. In Proc. of the SAE World Congress. Detroit, MI, USA, Apr. 2005. Paper 2005-01-1271.

[3] Puusemp, R. Servotronic modelling and model based estimation of AFS motor angle. Master's thesis, Dept of Machine and Vehicle Systems, Chalmers University of Technology, Göteborg, Sweden, Jan. 2004.

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

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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.

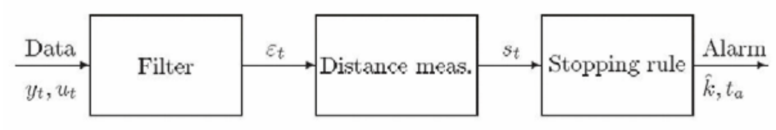

Fig.1: generic change detection scheme using filtering, distance measure and stopping rule, copy of [1, Fig.1.11].

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, simple stopping rules like direct thresholding (GMA with zero forgetting factor) and distance measures (*s(t)=ε(t)*) have been applied. More advanced strategies shall be examined and compared to each other in the thesis. A task list for the work could look as follows:

Apply and compare different distance measures such as mean, variance, correlation etc.

- Apply and compare different stopping rules like GMA, CUSUM etc
- Compare the above methods to the existing ones with respect to mean time between false alarms, mean time to detection, average run length, computational load etc. A particular question would be how to react th residuums that say "model not valid".
- In some cases, the filter is designed as a (extended) Kalman filter, that could be inte-grated 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.
- In case of monitoring a sensor signal, a second source of information has to be taken into account, namely low level sensor diagnostics (monitoring of analogue signals etc). This could be viewed as a

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multimodel approach to change detection and the interplay between these two information shall be investigated.

Although the approach will follow [2-5] quite closely, it should be noted that the results there have been derived in a different context, which is 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.

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References

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

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[3] 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.

[4] Razavi, C. AFS fault detection and fusion. Master's thesis, Dept of Automatic, Lund University, Lund, Sweden, Dec. 2005.

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