List of Final Year Thesis proposals for 2013-2014

Some topics are still in preparation, please look at
http://saas.ulb.ac.be/tfe.html
for the updated list

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Wind turbine monitoring with a view to predictive maintenance

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Context of the work

Within the POWER project (Walloon region), the team of SAAS is developing a monitoring system aimed at detecting degradation of wind turbine performance from the measurement usually available on such devices. The aim is to provide an early warning of the degradation in order to take an appropriate remedial action before the fault develops into a failure. The location of the fault should also be deduced from the available data when possible. This monitoring system is modular and appropriate approaches are used to handle the various parts of the wind turbine.

The aim of the proposed work is to take part in the developments of certain monitoring modules. In particular monitoring of the hydraulic actuator used for pitch control will be investigated both by resorting to loop monitoring methods as well as indicators characterizing the global wind turbine performance. Both model-based approaches as well as methods based on classification tools such as support vector machines will be investigated.

Description of the work

The work will consist of the following steps:
- Bibliographical study;
- Acquaintance with the wind turbine AERODYN/FAST wind turbine simulator and its MATLAB SIMULINK interface;
- Study of the faulty modes of the actuators and their effect on wind turbine performance;
- Design of a condition monitoring system for the actuators using both model-based methods and/or data classification;
- Validation of the different approaches on the wind turbine simulator: comparison of the different methods with regard to their performance and the ease of design parameter tuning.

Requested skills

Control engineering, modelling of mechanical systems, programming in the MATLAB/SIMULINK environment.
Fault tolerant control of wind turbine

Contact persons

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Context of the work

Mitigating fatigue load and extreme mechanical loads in wind turbines is of paramount importance in order to reduce maintenance costs. Previous work has shown that Individual pitch control allows one to reduce fatigue load. Yet extreme mechanical loads are observed upon occurrence of faults in the network that induce abrupt turbine disconnection. These appear to be very damaging to the different components. The aim of this project is to study how to handle such disconnections at best and to investigate whether individual pitch control may help “softening” the high transient mechanical load.

Work to be done

- Bibliographical study (mechanical load control, wind turbine simulation with a view to investigation of network faults, ...);
- Adaptation of the available wind turbine simulator to account for possible faults in the power grid;
- Quantification of the mechanical load under various fault scenarios;
- Development and validation, through simulation, of control schemes for load reduction.

Requested skills

Control engineering, modelling of power systems, programming in the MATLAB/SIMULINK environment.
Control of a force-feedback teleoperated palpation device for minimally invasive thoracic surgery

Contact persons

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Matteo Cappello, Hôpital Erasme

Context of the work

Minimally invasive surgery (MIS) consists in operating through small incisions in which a camera and the surgical tools are inserted. This approach allows performing many interventions with reduced trauma for the patient. One of these is the ablation of peripheral pulmonary nodules. Nevertheless, the means for detecting nodules during MIS are limited. In fact, because of the lack of direct contact, the surgeon cannot palpate the lung to find invisible lesions, as he would do in classical open surgery. As a result, only clearly visible nodules can be treated by MIS presently.

One of the projects of the department consists in developing a teleoperated force-feedback palpation device in order to extend the possibilities of MIS in the thoracic field. This instrument, depicted on figure 1, is made of a master device, manipulated by the surgeon, and a miniaturized slave device which is in contact with the lung and reproduces the task imposed by the master. Adequate control laws between these two parts should allow restoring the operator’s haptic sensation. In other words, the device permits the surgeon to feel the lung, as if he was actually touching it.

Description of the work

The student is asked to design teleoperation control laws suitable for the palpation task. These control laws will be validated through a simulation and then implemented on the existing device. The palpation will be performed on a mock-up reproducing a human lung.

Performance criteria have to be defined and experiments have to be designed in order to compare several controllers. The performance of surgeons when using the device will then be evaluated. Finally, based on the surgeon’s feedback, the student will have to choose the most efficient controller.
**Requested skills:** control engineering, medical background, programming in MATLAB/SIMULINK and LABVIEW environment, experimental skills.
Design of a teleoperated palpation device for minimally invasive thoracic surgery

Contact persons

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Matteo Cappello, Hôpital Erasme

Context of the work

Minimally invasive surgery (MIS) consists in operating through small incisions in which a camera and the surgical tools are inserted. This approach allows performing many interventions with reduced trauma for the patient. One of these is the ablation of peripheral pulmonary nodules. Nevertheless, the means for detecting nodules during MIS are limited. In fact, because of the lack of direct contact, the surgeon cannot palpate the lung to find invisible lesions, as he would do in classical open surgery. As a result, only clearly visible nodules can be treated by MIS presently.

One of the projects of the department consists in developing a teleoperated force-feedback palpation device in order to extend the possibilities of MIS in the thoracic field. An initial design for this instrument is depicted on figure 1. It is made of a master device, manipulated by the surgeon, and a miniaturized slave device which is in contact with the lung and reproduces the task imposed by the master. Adequate control laws between these two parts should allow restoring the operator’s haptic sensation. In other words, the device permits the surgeon to feel the lung, as if he was actually touching it.

Description of the work

The aim of the work is to improve the design of the teleoperated tool in the following ways. First a wrist should be added to the slave device in order to make the access to the palpation workspace easier. Second, the master device should be made as compact as possible so that the entire tool could be manipulated with a single hand. Precise specifications will be based on previous work on the topic, as well as interaction with the thoracic surgeons.

Figure: CAD model of the palpation device
Requested skills: mechanical design, medical background
Bubble robotics – Towards Controlled-Loop Actuation of a Microrobotic Platform Driven by Droplets and Bubbles

Contact persons

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Description

We are developing (in collaboration with the AS2M microrobotic group in FEMTO-ST, France) a surface tension actuated micro-robotic platform supported by three bubbles (in liquid environment) or droplets (in gaseous environment). The actuation principle relies on the force developed by surface tension below a millimeter, which benefits from scaling laws, and is used to actuate this new type of compliant robot. This work has been reported in [Lenders2012].

![Figure 1: (a) Working principle: three inlet pipes allow to control separately the pressure in 3 bubbles or droplets, which provides 3 degrees-of-freedom motion to the millimetric platform (about 2.5 mm); (b) actual size of the first metallic platform; (c) current extension of the work: the device has been manufactured by rapid prototyping thanks to a collaboration with the Lycée Technique de Morteau (France)](image)

By separately controlling the pressure inside each bubble, three degrees of freedom can be actuated. We recently investigated three sensing solutions to measure the platform attitude in real-time (z-position of each droplet, leading to the knowledge of the z position and Θx and Θy tilts of the platform). The comparison between optical, resistive, and capacitive measurement principles was done, from which it turns out that the resistive technique (i.e. measuring the electrical resistance of a path flowing through two droplets and the platform) leads to three pairs of resistances, from which the resistance in each drop can be deduced, thus determining the platform position. This method has been proven reliable and is simple to implement.
Figure 2: Simulation results of the resistance of a drop as a function of its volume and height (called gap in the figure). The experimental validation of these simulations will be presented in [Casier2013].

This work opens perspectives toward an interesting sensing solution for micro-robotic platforms.

**Description of the work**

The student will have a full prototype and an experimental set up to study the shape, the resistance and the capillary force developed by a liquid meniscus. These experimental tools will be useful to identify models of a single droplet actuator on one side and of the full platform on the other side. Note well that besides, theoretical models have already been developed and experimentally validated [Lenders2012].

The objectives of this master thesis are the identification of the model of a new experimental set up which has not yet been tested, and the design and implementation of an adequate strategy to control the platform position (z) and attitude (theta_x, theta_y). Appropriate software sensors will be designed to estimate the controlled variables z, theta_x and theta_y from the available measurements. Disturbances like evaporation will have to be handled properly by the control law. These evaporation issues will addressed by making the distinction between a slow droplet variation due to evaporation and a fast change due to the sudden application of a force. The compensation mechanism will amount to refilling the droplets with liquid.

Successful results could be submitted for publication in an international journal.

**References**


**Requested skills:** mechanical design, control, microfluidics, experimental skills, matlab
Identification of simplified dynamic models for power plants

Contact persons
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Context

One of the main missions of each Transmission System Operator (TSO) is to ensure security of supply of the power system. In order to reach this goal the power system is modeled. Dynamic models are used to virtually place the power system in critical situations and then to estimate the stability of this power system in case of short-circuits, forecast error of renewable generation or load and in case of sudden failure of lines or generation.

As each continental European country is interconnected to the others through AC links, dynamic behavior of both internal (within the country of the TSO) and external (other European countries) generators must be modeled. Greater attention is given to internal generators as their influence in case of internal short-circuit is more important. Furthermore, in order to reduce the computing time of dynamic simulations and to ease the exchange of data, simplified standardized models are used to represent external generators.

Each TSO must therefore have detailed but complex models to represent internal generators and simplified standard models of the same generators to be given to neighboring TSO.

The goal of this work is to propose a methodology to select a standard model from a library and tune the parameters of the model in order to achieve the best fit with the initial complex model used by the TSO.

To this end, a modular approach will be sought in which subparts of the complex model will be matched to the corresponding modules of the approximated model. Appropriate simulation scenarios will be designed for the complex model in order to generate data that allow precise estimation of the parameters characterizing the simplified model. The parameter estimation problem will then be solved by resorting to adequate numerical optimization tools. Finally the comparison between simulations of the power network with the complex model and with the different simplified models will be performed to determine the most suitable reduced order standard model for a given experiment.

Description of the work:

The following phases can be considered
1. Bibliographical study of dynamic network models. A MFE realized in 2012-2013 on a related subject will provide some input.
2. Implementation in the MATLAB/SIMULINK environment of a simulator for a small part of the power network based on both complex and simplified standard models for the power plants
3. Determination of the simulation scenarios to be run on the complex model with a view to identification of the simplified model
4. Parameter estimation and simplified model validation
5. Comparative study in order to determine the quality of the fit between complex and standard models for a given experiment.
6. Proposal of a methodology including design of virtual experiments to first identify the most suitable standard model then tune the parameters of this model
**Requested skills:** power system modeling, parameter estimation and numerical optimization, programming in the MATLAB/SIMULINK environment.
Power System Dynamic Model Update by Moving Horizon Estimators

Contact persons

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Context

One of the main missions of each Transmission System Operator is to ensure security of supply of the power system. In order to reach this goal the power system is modeled. Dynamic models are used to virtually place the power system in critical situations and then to estimate the stability of this power system in case of short-circuits, forecast error of renewable generation or load and in case of sudden failure of lines or generation. Of course, all these simulation tests are useful only if the correctly represents the reality. However, the models used for the dynamic stability assessment contain uncertain parameters, as they are not necessarily correctly updated upon power plant revamping (and notably controller retuning). Therefore, in order to improve the reliability of the simulations used to assess stability, it would be useful to update the model parameters on the basis of the available measurements. Such models are typically made of a combination of linear systems and saturation nonlinearities associated to the physical limitations of the actuators, and they contain many parameters. The parameter update should thus focus on the most uncertain parameters and on the parameters which are the most sensitive to the available measurements.

Moving Horizon Estimators (MHE) offer an attractive way to deal with state and parameter estimation for the considered class of systems, while exploiting at best the information available in the data. Indeed, they allow one to take into account the saturation nonlinearities, while using a numerically efficient approach to determine the optimal model parameters. Different options exist among MHE, notably regarding the selection of the cost function optimized to determine the state and parameter estimates. Hence the aim of the work is to examine what form of MHE is the most suitable for the considered application and to validate the proposed solution through a case study.

A first MFE has already proved that this approach is efficient to solve such a problem. This part of the work will be dedicated to the identification of the most adequate group of measurements/observable parameters/network even as well. This part of the work will also update the existing model in order to match existing power plant model.

Description of the work:

The following phases can be considered
1. Update of the bibliographical study of dynamic network models and moving horizon estimators (MHE). A previous MFE can be used as a basis for this step.
2. Extension of the previously obtained results on observer based parameter estimation for power plant, including MHE. This involves using more complex models like standard power plant models and studying the sensitivity of those models w.r.t. experimental data.
3. Determination of systematic guidelines to adjust the design parameters of the MHE for the considered application
4. Generalization of the approach to different standard power plant models
**Requested skills:** power system modeling, parameter estimation and numerical optimization, programming in the MATLAB/SIMULINK environment.
Digital control of a self-erecting double inverted pendulum

Contact persons

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Description

The double inverted pendulum of our laboratory is composed of a screw driven cart on which the pendulum is connected. The cart position is controlled by a direct current motor. A simplified scheme of the process is the following:

![Diagram of double inverted pendulum with cart and pendulum](image)

Different sensors are available to measure: the position of the cart and the angles of the two pendulum poles.

The control objective is to take the pendulum from its stable position to the upright position by moving the cart.

Phases of the project

- Study of the process, familiarization with the existing simulator, validation of its parameters.
- Bibliographical study on inverted pendulum control
- Pendulum sizing (length of the poles)
- Design of different control laws
- Validation and comparison of the control laws in simulation
- Validation on the real process.
Modeling and control of a didactic rolling mill

Contact persons
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Description
The rolling mill of our laboratory is a cold reversible one. The rolled metal consists of aluminum strips. The mill is controlled with 4 direct current motors: two winders, one roller and one for the tightening. Each motor is controlled in current. Different sensors are available to measure: the velocity of the different motors, the upstream and downstream tractions, the rolling force and the thickness before and after the roller.

The objective of the work is to control the rolling mill. In order to do that, different control loops have to be designed: velocity of the winders and the roller, upstream and downstream tractions and strip thickness.

Phases of the project
- Bibliographical study
- Study of the process, understanding of the existing simulator, validation of its parameters.
- Design of the different control loops
- Validation of the control loops in simulation
- Validation on the real process.
Modelling and control of a seasonal thermo-chemical solar heat-storage

Contact persons
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Context
Through on-going projects, and notably the SoTherCo project (EU FP7 project), an innovative process for thermo-chemical solar heat-storage is presently in development. A dynamic simulator of this process has been developed by teams from UMONS and ULg in cooperation with BE-SOL and ESEsa, and prototypes are in construction. The next steps in the development of this new process include the design of a suitable control scheme that would allow keeping process operating at maximum efficiency while meeting the technological constraints. To achieve this goal, a process model that reproduces the experimental data at best is needed. Hence the work will first focus on updating the available model on the basis of process measurements, and then proceed to the design and validation of the control laws.

Description of the work
The planned work is made of the following steps
- bibliographical study, acquaintance with the process operation and with its simulator,
- design of experiments to allow adjusting the simulator parameters on the basis of the available control actions and sensors,
- determination of the optimal operating conditions,
- study of the process model in the vicinity of the optimal set point and controller design,
- implementation and validation of the control scheme on the simulator,
- if time allows, implementation of the control scheme on a prototype process.

Requested skills
The main required disciplines will be thermal system modelling, control engineering and programming in the MATLAB/SIMULINK environment.
Piecewise Quadratic and Polynomial Functions in Control

Contact persons:
Emanuele Garone, (egarone@ulb.ac.be, tel. +32-(0)2-650.26.86)
Roberto Ambrosino, University Parthenope, Naples, Italy

Context:
This Master Thesis will be developed at the Service d’Automatique et d’Analyse the Systemes (S.A.A.S). This is a research thesis on a real research problem for highly motivated candidates desiring to have a genuine experience in research on control theory. The methodological domain is the applications of Piecewise Quadratic and Polynomial Functions to Control and System Theory.

Project:
The goal of this thesis is to investigate the idea of using Piecewise Quadratic Function and more in general Piecewise Polynomial Function for analysis and control purposes. Very recent and encouraging results on the use of Piecewise Quadratic Function to determine the stability of uncertain systems seems to suggest such a class of functions very interesting for many control applications.

Possible directions for the master thesis includes the problem of approximating convex surfaces with piecewise quadratic (or polynomial) functions and application to the problem of stability for certain classes of uncertain and nonlinear systems.

Phases of the Project:
1. Bibliographical research on the use of piecewise functions in control
2. Analysis on the properties of the class of functions at hands
3. Selection of a set of possible applications
4. Development of algorithms taking advantage of Piecewise Quadratic Functions

Needed Knowledge:
Basic System Theory (Lyapunov Theory, Controllability and Reachability). Notions of optimization can help.

Organization and Other Information:
The student is usually asked to have a meeting every 2 weeks with the academic promoter. This thesis will be developed in collaboration with the university Parthenope of Naples (Prof. R. Ambrosino will be co-promoter)
Automatic patrolling: The drug smuggler problem

Contacts:

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Roberto Naldi, University of Bologna

Context:
This MFE will be developed at the Service d’Automatique et d’Analyse the Systemes (S.A.A.S). It is a research thesis. The methodological domain is that of optimal path planning for a dynamical network of vehicles.

Project:
This thesis proposal is aimed at exploring the capability of a heterogeneous network of vehicles to patrol a certain area in order to detect possible attempts of drug smugglers to reach the mainland without being detected. In particular, we consider the case in which a vehicle carrier, typically slow but with virtually infinite operative range, and a carried vehicle, which on the contrary is typically fast but with a shorter operative range, cooperate to accomplish such a task.

Early works on this class of vehicle networks have investigated the capability of this class of combined vehicles to be used in rescue missions. In particular the problem of determining the optimal trajectory amongst a list of points and suboptimal solutions for the Travelling Salesman Problem have been explored for the single carrier/single vehicle configuration.

This thesis will study how to employ this class of vehicle for the patrolling of a certain coastal area. In particular we will try to determine which is the optimal patrolling strategy allowing the network of vehicle to always detect a drug smuggler that tries to reach the mainland with a vehicle of given maximum velocity.

Phases of the Project:
1. Introduction to the problem;
2. Bibliographical search and development of a survey on related topics;
3. Mathematical definition of a possible problems to deal with.
4. Definition of a solution to the problem
5. Analysis of the obtained results

**Needed Knowledge:**
In order to accomplish the goal of this project it is preferable to have some basic knowledge of optimization.

**Organization:**
The student is usually asked to have a meeting every 2 weeks with the academic promoter.
Control of Tethered Unmanned Aerial Vehicles

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Roberto Naldi, University of Bologna

Context:
This MFE will be developed at the Service d’Automatique et d’Analyse the Systemes (S.A.A.S). It is a research thesis.

Project:
This thesis proposal aims at elaborate control strategies for a small quadrotor connected to a winch on the ground. Many interesting control problems can be defined for this configuration. Specific objectives will be discussed with the interested students and may include: control of the UAV with loose cable, control of the UAV with tight cable, coordination schemes to reject disturbances through the cable and possibility to make the winch mobile using a small terrestrial rover. Possible further subject may regard the navigation in presence of obstacles.

Phases of the Project:
1. Introduction to the problem;
2. Bibliographical search and development of a survey on related topics;
3. Mathematical definition of the problem of interest
4. Definition of a solution to the problem
5. Validation of the obtained results (simulation and possibly experimental validation)

Needed Knowledge:
In order to accomplish the goal of this project it is preferable to have had the course “Control System Design”.

Organization:
The student is usually asked to have a meeting every 2 weeks with the academic promoter.
Construction, Modeling Validation and Control of a test-bench for the study of bi-stable beams.

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Laurent Catoire (laurent.catoire@ulb.ac.be,

Context:
This MFE will be developed at the Service d’Automatique et d’Analyse the Systemes (S.A.A.S). It may be tuned either as a research oriented thesis or as a more applicative one, depending on the student attitude. It concern with the construction, the modeling, the validation and some preliminary schemes of control for a bi-stable beam will be developed at SAAS.

Project:
This project concerns the realization, the analysis and the control of a pioneer testbed finalized to study the closed-loop control of lightweight multi-stable shape morphing structures. In particular, in this project, we will focus our attention on the control of a very well-known multi-stable structure, the bi-stable buckled beam i.e. a beam subject to end-shortening conditions.

The experimental setup we wish to realize will be exploited to investigate both theoretical and technological open issues related to the control of this simple but significant morphing shape structure. Depending on the student interests and attitude, this thesis will touch partly of all the following subjects:

1) Design and construction of the experimental apparatus
2) validation and tuning of the developed theoretical models;
3) development of an estimator and technological considerations on the beam instrumentation in terms of sensors;
4) analysis of the actuators requirements and limitations to perform transitions between the two stable configurations;
5) implementation, tuning and comparisons of ad hoc control schemes able to drive in a controlled way the transitions between different stable configurations of the morphing structure while taking into account integrity constraints, actuator limitations and performance criteria.

The activities presented in this project represent a part of a wider research activity regarding the control of multi-stable morphing structures. The expected results have potential applications in several fields such as energy harvesting, aerospace structure deployment and responsive architecture.

Phases of the Project:
A tentative schedule (that may vary depending on an agreement between the student and the promoter) is the following
1. Bibliographical search and development of a survey on related topics
2. Design and Realization of the test bench
3. Analysis and Identification of the model
4. Test of some Control law

**Needed Knowledge:**
In order to accomplish the goal of this project it is preferable to have some basic knowledge of control and of mechanics.

**Organization:**
The student is usually asked to have at least a meeting every two weeks with the academic promoter.
Distributed Command Governor and applications to the motion of mobile robots

Contacts:
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Context:
This MFE will be developed at the Service d’Automatique et d’Analyse the Systemes (S.A.A.S). It is an applicative thesis with some aspects of research. It is concerned with activities to test the effectiveness of distributed command governor as a mean to coordinate-by-constraints small team of mobile robots.

Project:
The problem of interest here is the implementation on an experimental setup composed of a small team of mobile robots of Distributed supervision strategies based on Command Governor (CG) ideas. The CG is a nonlinear device based on simple Quadratic Programming optimization which is added to a pre-compensated control system. Whenever necessary, the CG modifies the reference to the closed-loop system so as to avoid constraint violations. Recently, preliminary Distributed CG schemes have been proposed for multi-agent systems where the use of a centralized coordination unit is impracticable because requiring unrealistic or unavailable communication infrastructures.

Goal of this project is to study these techniques and to use them to coordinate mobile robots so that they can follow in a coordinated way a certain pre-assigned trajectory.

Phases of the Project:
A tentative schedule is the following

1. Bibliographical search and development of a survey on related topics
2. Identification of the model and design of the low-level control law
3. Tuning of the Distributed Command Governor to the particular system at hand and design of the tests
4. Simulative/Experimental Verification
**Needed Knowledge:**
In order to accomplish the goal of this project it is important to have some “not too basic” knowledge of control (Control System Design course needed)

**Organization:**
The student is usually asked to have at least a meeting every two weeks with the academic promoter.
Measurement Network Design and Validation of Nonlinear Hybrid Models for electrical networks

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Fortunato Villella, Tractebel Engineering GDF SUEZ

Context:
This MFE will be developed in the framework of a collaboration between an industrial partner (Tractebel Engineering GDF SUEZ, Avenue Ariane 7, Brussels) and the Service d’Automatique et d’Analyse des Systemes (S.A.A.S). It will focus on a relevant industrial issues arising in engineering practice in the context of designing the networks of sensor for a power systems for the sake of validating the model of the system itself.

Project:
The goal of this thesis is to study methods for the validation and the parameter identification of certain classes of electrical networks.

The operative scenario is the following: it is assumed a certain nonlinear hybrid model of an electrical network, this model is given in a form of a Differential Algebraic Equations. Such a model may also represent very large networks with thousands of variables involved. The main problem to be solved is to the validation of the model and estimation its parameters. Moreover the problem of optimal positioning of the sensors will be studied. It is of fundamental importance to develop techniques for the positioning of the sensors that allows to obtain good estimation property while minimizing, at the same time the number of sensor to be used.

Phases of the Project:
This thesis proposal will consists of the following phases:
- Together with the company, understanding the problem and its requirement, and formalize it.
- Perform a bibliographical study on the validation and the parametric identification of large hybrid nonlinear models, with particular focus to power networks. The main goal of this activity is to understand which are the existing techniques that better matches with the problem at hand
- Development of techniques/algorithms to ensure good sensor placement to perform the validation and to tune the parameters.
- Test the developed techniques and algorithms on real/simulated measurements.
**Needed Knowledge:**

In order to accomplish the goal of this project it is preferable to have knowledge of:

- Control Theory
- Electrical networks

Basic notions of optimization may help.

**Organization:**

The thesis will be developed in the framework of a collaboration between the SAAS and the industrial partner. The student is asked to spend some periods at the industrial partner place and to have biweekly meetings with the academic promoter. The possibility to have an internship at Tractabel on subjects related to this thesis proposal may be discussed with the company.
Tuning and Analysis of PSS for large scale systems

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Fortunato Villella, Tractebel Engineering GDF SUEZ

Context:
This MFE (and the possibly related internship) is proposed in the framework of a collaboration between an industrial partner (Tractebel Engineering GDF SUEZ, Avenue Ariane 7, Brussels) and the Service d’Automatique et d’Analyse des Systemes (S.A.A.S). The MFE will focus on a relevant industrial issues arising in engineering practice in the context of designing advanced tuning methods for control systems applied to synchronous machines connected to large scale electrical power networks.

Project
Inter-area oscillations are a phenomenon common in power systems that can cause issues in the stability of the power system when poorly damped. The rotor oscillations of couples or groups of generators against each other can cause large fluctuations of power with the consequence of cascading phenomena.

Power System Stabilizers (PSS) are implemented in the voltage regulation of the synchronous machines to improve the damping of these mechanical oscillations. PSS are usually tuned to improve the local oscillations of a single synchronous machine w.r.t. the whole network. The tuning of several PSS installed on several generators in remote locations to damp inter-area oscillations of a large power systems is a challenging and complex task.

The goal of this thesis/stage is to develop a tool for automatic tuning of PSS and of methods to assess the property of the overall scheme.

Finally, the tool will be tested on a large scale model of the European network and the obtained results will be compared to other results previously obtained.

Phases of the Project:
This thesis proposal will consists of the following phases:
- Together with the company, understanding the problem and its requirement, and formalize it.
- To do a bibliographical study on the possible solutions
- Try to develop tuning method on simplified and low dimension systems
- Evaluate the proposed results on the actual system of interest and using the already developed software’s.

Needed Knowledge:
In order to accomplish the goal of this project it is preferable to have knowledge of:
- Control Theory
- Electrical networks
Basic notions of optimization may help.

Organization:
The thesis will be developed in the framework of a collaboration between the SAAS and the industrial partner. The student is usually asked to spend some periods at the industrial partner place and to have meetings every 2 weeks with the academic promoter. The possibility to have an internship at Tractabel on subjects related to this thesis proposal may be discussed with the company.
Substation topology optimizer for short circuit (MFE)

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Context:
This MFE will be developed in the framework of a collaboration between an industrial partner (Tractebel Engineering GDF SUEZ, Avenue Ariane 7, Brussels) and the Service d’Automatique et d’Analyse des Systemes (S.A.A.S). It will focus on some relevant industrial issues arising in engineering practice in the context of modeling, simulation and optimization of power grids.

Project:
The aim is to Optimize the operation of a given substation in order to minimize the short circuit power on each single equipment (or other functions). The operation of a substation (i.e. how many busbars and how they are connected with the feeders) has a significant impact on the Short Circuit power of the different elements of the substation, this may cause problem if the rated power of the circuit breakers is exceeded.
The aim of this thesis is to develop a mathematical formulation of the problem to be able to get the optimal configuration for short circuit purposes or for other purposes (e.g. minimization of the load on a transformer). The mathematical model proposed should be defined in terms of an optimization problem using a standard package (e.g. GAMS, AMPL) and tested on a simple test case system. The optimization problem may involve discrete variables.

Phases of the Project:
1. Introduction to the topic;
2. Problem formulation. Analysis of the relevant issues;
3. Bibliographical search and development of a survey on related topics;
4. Mathematical definition of the optimization problems
5. Implementation with standard packages
6. Complexity analysis and possible developments of low-complexity heuristics
7. Validation of the obtained results

Needed Knowledge:
In order to accomplish the goal of this project it is preferable to have knowledge of:
- Control Theory
- Electrical networks
Notions of optimization may help.

**Organization:**
The thesis will be developed in the framework of a collaboration between the SAAS and the industrial partner. The student is usually asked to spend at least one day per week at the industrial partner place and to have biweekly meetings with the academic promoter.
Automatic initialization of state variables starting from a load flow solution (Internship/MFE)

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Context:
This MFE (and the possibly related internship) will be developed in the framework of a collaboration between an industrial partner (Tractebel Engineering GDF SUEZ, Avenue Ariane 7, Brussels) and the Service d’Automatique et d’Analyse des Systemes (S.A.A.S). It will focus on some relevant industrial issues arising in engineering practice in the context of modeling and simulation of power systems.

Project:
The simulation of electrical power networks involves a Hybrid Differential Algebraic Modeling. The dynamical simulation is based on a steady-state solution of the network equations (Load flow calculation) and involves the initialization of dynamical variables based on the steady state values of some of the algebraic variables. Several variables can be automatically initialized but for what regards user-defined models, the user should define them explicitly. This definition of the initialization is repetitive and error-prone and may be automated using a different formulation of the problem.

The aim of this MFE is to investigate the possibility of automating the initialization of state variables and of proposing an algorithm based on a mathematical formulation to solve this problem.

\[
\begin{align*}
\dot{x} &= f_q(x, y, p) \\
0 &= g_q(x, y, p) \\
q &\in Q
\end{align*}
\]

\[
\min_{x \in X}
\begin{align*}
\dot{x} &= f_q(x, y, p) \\
0 &= g_q(x, y, p) \\
y &\in Y \\
q &\in Q
\end{align*}
\]

Phases of the Project:
1. Introduction to the topic
2. Problem formulation and analysis of its relevant issues
3. Bibliographical search and development of a survey on related topics
4. Theoretical discussion of the possible solutions
5. Proposal of a solution on a simple test case
6. Implementation and Validation

**Needed Knowledge:**
In order to accomplish the goal of this project it is preferable to have knowledge of:
- Control Theory
- Electrical networks
Notions of graph theory may help.

**Organization:**
The thesis will be developed in the framework of a collaboration between the SAAS and the industrial partner. The student is usually asked to spend at least one day per week at the industrial partner place and to have a biweekly meeting with the academic promoter.

It is also possible to do an internship at Tractabel on subjects related to this thesis proposal. The objective of such an internship is to make the student familiar with the specific tools and issues related to the modeling and simulation of power systems.