Bachelor thesis – Predictive Maintenance
Meeting Minutes

January 13, 2017
Present: Bertil Helseth, Ibrahim Hameed, Ottar Osen, Magnus Gribbestad, Eivind Fugledal, Robin Vågeskar and Kelvin Sundli
Next meeting: TBA

I. Announcements

Clarifying meeting regarding project work and Azure. Technical workshop with Azure in practice will be organized between the students and Intelecy 19th or 20th of January.

II. Discussion

a. Microsoft Azure accounts

Azure accounts for the students are under preparation. The accounts will be finished within coming weekend. 14th and 15th Januar
Action: Intelecy need to work out permissions. **Responsibility:** Bertil

b. Version control and administration tool. Jira?

Intelecy wants to use MS tools as far as possible. SharePoint for resource sharing and collaboration.
Action: Intelecy will setup the tools. **Responsibility:** Bertil

c. Course in Azure and Wonderware.

Course in Wonderware, probably within February. Hopefully tailored for the project and students. Hopefully Microsoft will set up a tailored course in Azure for the students.
Action: Dialog with Microsoft and Schneider. **Responsibiliy:** Bertil

i. **Ottar will look into possibilities for funding of travel and stay during courses.**

d. How accurate must the predictions be?

Tough question to answer. This will depend on each customers' application and system. This is a part of the task! Around 80% would be good. Any more would be a bonus. The results must of course be ready in a reasonable amount of time. Benchmarking the algorithms would be interesting. Intelecy also wants the students create our own solutions in Python and apply them, and try to improve the performance.
Action: Students will try to benchmark. Students will try their own algorithms. **Responsibility**: Students

e. Feedback on pre-project report.

Intelecy mentions that there are a few points that could be edited. They say that the report in general complies with their idea.
Intelecy receives updated pre-project report in Word format together with this MoM. They will comment and give further feedback on that.
Action: Students will send latest report to Intelecy. **Responsibility**: Students.

Action: Intelecy will look through the most recent report and give feedback. **Responsibility**: Bertil

f. Gantt diagram. Testing after each part? How to setup?

Gantt-diagram looks all right, but will be edited and updated continuously.
Action: Continuously update Gantt. **Responsibility**: Magnus.

g. Ideas for sub-targets.

No new ideas at this point. Students will improve sub-target definitions with experience.

III. Roundtable

Hacking in Azure will proceed from Monday the 16th. Intelecy will join this hacking from the 19th. Intelecy will help us getting started with database related issues.
Other discussions: Sampling (cyclic/ delta). Quality tag. External pre-processing of data.

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January 27, 2017
Present: Bertil Helseth, Ibrahim Hameed, Ottar Osen, Eivind Fugledal, Robin Vågeskar and Kelvin Sundli
Next meeting: TBA

I. Announcements

NA

II. Discussion

a. SQL - Azure

Issue regarding subscriptions in Azure and Machine Learning Studio. Microsoft must accept changes. Leif has made a SQL cheat sheet blog post.
Action: Intelecy will fix the issue in cooperation with Microsoft. **Responsibility:** Bertil

b. What to detect? (Flag, alarm/ equipment)

Intelecy have made user stories, and based on that created an appearance suggestion. This was presented for the group, and will be shared in SharePoint. Appearance can give some impression of what we need to do.
Action: Intelecy will upload appearance suggestion slides. **Responsibility:** Bertil

c. Pre-processing transparency (PCA)

A part of the task is to figure out what the system needs to know. Bertil is interested in opportunities for using algorithms like PCA for dimension reduction.
Action: Experiment with different solutions. **Responsibiliy:** Students

d. Discuss progress

Bertil thinks that our progress is good and our plan is reasonable.

e. Report expectations

Ottar says that the report needs to contain all relevant in the most consistent format. “As much information as possible in as few pages as possible.” A few lines in the introductions may be on a low technical lever, for anyone to understand the main idea of the report.
Bertil mentions that the introduction/ background can contain a story of a fatality (i.e. Deep water horizon, mining) to express the importance of the research.

f. Visual studio and Lean

Leif gave the students and introduction to the basics of agile software development and Visual Studio.
Action: Magnus was not present, and needs walkthrough. **Responsibility**: Students.

g. Intro to SharePoint

Espen gave the students a short introduction to SharePoint for sharing files, OneNote documents and groups.

III. Roundtable

SQL to Azure introduction is planned to be done within next week.

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February 9, 2017
Present: Bertil Helseth, Ibrahim Hameed, Ottar Osen, Eivind Fugledal, Robin Vågeskar, Magnus Gribbestad and Kelvin Sundli
Next meeting: TBA

I. Announcements

NA

II. Discussion

a. Discuss progress

Progress per plan. Wonderware – SQL – Azure was set up as discussed in last meeting.

b. Milestones

Some new milestones were introduced by Bertil. The milestones are introduced in their hopefully, soon-to-be signed pilot customer agreement.

c. Intervals for reporting

Meeting interval should proceed as is (approx. two weeks). If there is little or nothing to report, the progress report and meeting will be short. Bertil introduced the idea of having a demo of current situation at each meeting. Students and other supervisors agrees that this is a good idea.
Action: Goal is to demonstrate something at each meeting. **Responsibiliy:** Students

d. Formalities regarding Gantt.

Ottar confirms that the main purpose of having a Gantt diagram is dynamically updating it according to progress.

III. Roundtable

A demo of current situation is to be given at each meeting. This demo might be small, and not properly working, but it is a good way to confirm that the project is on the right track! We will avoid proceeding in the wrong direction.

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February 24, 2017
Present: Bertil Helseth, Eivind Fugledal, Magnus Gribbestad and Kelvin Sundli
Next meeting: TBA

I. Announcements

NA

II. Discussion

a. Discuss progress

Progress per plan. Started to detect time series anomalies – with luck.
Bertil wants us to focus more on complex patterns with several signals, than time series on single signals. Robin will continue to test regression techniques for one signals, but the rest of the group will focus on finding patterns.

b. Status, real data

Potential pilot customer has indicated that contract is OK. Not yet signed.
Action: Further follow-up on potential customer. **Responsibility:** Intelecy, Bertil

c. Ibrahim, Ottar: input on approach? Suggestions?

Ottar and Ibrahim are not present. See point III.

III. Roundtable

It seems that the students and Intelecy has some differences in the impression of what is the target and what is possible.
We, the students, should have a discussion with Ibrahim and Ottar to clarify some of our ideas for approach and concerns. We need some guidance.

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March 24, 2017

Present:	Bertil Helseth, Ibrahim Hameed, Ottar Osen, Eivind Fugledal, Robin Vågeskar, Magnus Gribbestad and Kelvin Sundli
Next meeting:	TBA

I. Announcements

NA

II. Discussion

a. Discuss progress

Progress per plan. The students have started, and will continue, working with the NASA dataset and data from the simulator. The students have gotten results with this work, and will continue to improve and compare models.

b. Milestones

"RUL estimation on NASA dataset" and "Fault detection on simulator data" have been reached.

c. Demo

The students presented some of the results from their work in the last period.
Presentation on:

- Autocorrelation on temperature data
- OneClassSVM on simulator data
- Newral network on NASA dataset

d. Progress ahead / Focus

The supervisors thinks the progress is good, and on the right track. The students should not focus on every aspect on machine learning. The focus should be to study techniques in a scientific way. The students wish to make an application for simulating real time fault detection / prediction. Bertil suggested using Power BI for streaming and visualization of data.
Action: Make an application for simulating real time data. **Responsibility:** Students

e. One-class fault detection

For one-class fault detection systems, the student should try to use previous data as an input (memory element). PCA and SVD was suggested methods to try out.

f. Real time pull from simulator

Bertil have all the software necessary for this to be done, but have not yet installed it on the VM. The students should make an application for simulating real time data form a dataset before real time pull form simulator is a topic.
Action: Install necessary software on VM. **Responsibility:** Bertil

g. Real data

Contract with pilot customer is not yet signed, but there is an agreement. The students could at best have real data from pilot costumer in two weeks.

III. Roundtable

In the report, the students should discuss the quality, time, and other factors of different models to the same problem.

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Meeting Minutes

April 7, 2017

Present:	Espen Davidsen, Ibrahim Hameed, Eivind Fugledal, Robin Vågeskar, Magnus Gribbestad and Kelvin Sundli
Next meeting:	TBA

I. Announcements

NA

II. Discussion

a. Discuss progress

Progress per plan.
The supervisors thinks the progress is good, and on the right track. The value to Intelecy is to know what models gives good result, and therefore the students shall not focusing on optimizing the models for a specific task, but focus on finding the models that gives overall good results when applied to a dataset.
The students are going to try the models on different datasets to validate the performance and adaptability on multiple datasets.

b. Demo

The students presented some of the results from their work in the last period.
Presentation on:

- Anomaly detection by using One-Class SVM on simulator data
- Automatic hard limit detection approach for anomaly detection
- Remaining useful lifetime on NASA dataset

Action: Test explored models on different datasets. **Responsibility:** Students

c. Difficulties on anomaly detection using simulator data

The data from the simulator is very static and therefore the prediction on anomalies is hard, and an approach where detecting and remembering the normal states gives much better results. One-Class SVM have proven to give acceptable results with intensive parameter tuning. The exploration on k-NN and Gaussian Mixture Models have given useless results.
Intelecy cannot confirm when real process data can be available and the quality of this data.

d. Other

Nothing to add

III. Roundtable

The students have merged from using Azure to running Python scripts locally on their computers because of the extensive time consumption in Azure vs. locally. All the models can still easily be implemented in any system.

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Meeting Minutes

April 28, 2017

Present:	Bertil Helseth, Ibrahim Hameed, Ottar Osen, Robin Vågeskar, Magnus Gribbestad and Kelvin Sundli
Next meeting:	TBA

I. Announcements

NA

II. Discussion

a. Discuss progress

Progress per plan.
The students are validating models by applying them on different data sets. The focus forward will be to finish the experiments, document the results and start to finalize the report.
The student have found a new data set for anomaly detection, SECOM.
The validation on RUL prediction will be done on NASA engine data set and battery data set, and the validation on anomaly detection will be done on simulator data set and SECOM dataset.

b. Demo

The students presented some of the results from their work in the last period.
Presentation on:

- Predicting remaining charging cycles of battery
- Predicting discharge on battery
- Classification on remaining charging cycles of battery
- Results from anomaly detection when using One-Class SVM

c. Feedback on report

The students wishes to receive feedback on the structure and content.
Ibrahim have been given access to the report for drafting a paper on what the students have produced until now, and might give feedback to the students.
Ottar says that if he shall read through the report and give feedback, the parts where he have given comments and the students have not improved these parts, the result will be 3 times worse than if he had read it for the first time in the final report.
Bertil cannot say yes or no to publish a paper with the students results until he have seen the paper.

d. Other

Supervisor wonders if the students thinks they will reach their goal with a good results, and the students think so based on internal planning and discussion.

III. Roundtable

The students will be trying their developed experiments in Azure and compare the process time between running the experiment in Azure and locally in PyCharm.

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May 12, 2017

Present:	Bertil Helseth, Ibrahim Hameed, Ottar Osen, Robin Vågeskar, Magnus Gribbestad, Eivind Fugledal and Kelvin Sundli
Next meeting:	TBA

I. Announcements

NA

II. Discussion

a. Discuss progress

Progress per plan.
The students have finished the work on exploring and validating the different algorithms.
Experiments for anomaly detection on single signal have been performed, and compared between "Azure time series anomaly detection" and "Twitter anomaly detection".
A benchmark on process time between Python and Azure ML have been performed and the times documented.
Experiment on classification of errors on Simulator and SECOM dataset have been performed, and compared by using kNN, Gradient Boosting and MLP Classification.

b. Demo

The students presented some of the results from their work in the last period.
Presentation on:

- Anomaly detection on single signal by using Azure Time Series Anomaly Detection and Twitter anomaly detection
- Benchmark results on process time between Python and Azure ML
- Visualization on how One-Class SVM does fit training data and predict outliers
- Results from classifying anomalies on Simulator and SECOM dataset

c. Last meeting

The supervisors agree with the students that this meeting was the last official meeting.
The supervisors will still be available for help.

d. Report structure

The students will present a draft of the report structure to Ottar (Ibrahim, Bertil) next week, and he will give feedback on that.

e. Misc

Nothing to add.

III. Roundtable