Team 32
Danfoss
Advisers
Team Members/Roles
Team Email
http://sdmay18-32.sd.ece.iastate.edu/

Revised: 9/23 (v1)

Project Title

Project plan

Contents

1 Introduction

1.1 Project statement

Explain what the project is about. What are you trying to do?

Danfoss would like to do some analytics over data they've been collecting about their assembly lines. In this project we will build a system that uses that data to predict machine maintenance and equipment malfunction, using machine learning tools. We want the system to predict and detect the failure pattern way before it actually takes place. Since Danfoss already has sensors that monitors and collects data timely (putting a timestamp on it), about their machine lines therefore, having that data available to us, our goal is to predict at time x (using data up to that time) whether the equipment will fail in the near future.

1.2 purpose

Explain what is driving this project. Why is this work of benefit to the society?

Today, a large number of modern manufacturing companies are starting to incorporate data analytics and machine learning in their production and manufacturing process. This kind of predictive systems allows these companies to plan machine maintenance adaptively rather than on a fixed schedule. The purpose of such a system is to improve quality control, product quality and reduce costs, by forecasting equipment breakdowns and scheduling maintenance before they actually occur. Besides providing all these benefits this would also improve the accuracy of detecting such failures and optimize periodic maintenance operations that are carried out. Automating the manufacturing process which machine learning technique can help companies, significantly reduce the unplanned downtime and waste due to machinery failure .

1.3 Goals

Explain what you hope to accomplish through this particular senior design project. What would you like to achieve? Enlist as many goals as you can envision.

1. Solution Goals
    a. Danfoss should have a UI that displays useful data analytics
    b. Danfoss should be able to predict when they should order machine parts, so that maintenance can be done quickly
    c. Danfoss should be able to manage their workers more efficiently, given data about what line worker is at a particular workstation at any given time.
2. Senior Design Team Goals
    a. Everyone should contribute an equal amount of work to the end product
    b. If scheduling conflicts arise, the team should be notified in advance

2 Deliverables

These tie in with the goals. What deliverables are necessary to meet the goals outlined in the introduction?

1. Danfoss should have a solution that properly consumes existing assembly line data, and displays it to managers in such a way that allows them to do work efficiently.
2. The senior design team should be able to provide proper project reports and design documentation that is comprehensible to the business client (Danfoss) and to the academic client (Iowa State University)

3 Design

Describe any possible methods and/or solutions for approaching the project at hand. You may want to include diagrams such as flowcharts to, block diagrams, or other types to visualize these concepts.

3.1 Previous work/literature

In past machine learning has been used in automotive plants to implement a predictive maintenance solution for a hydraulic press used in vehicle panel production. Detailed studies of the maintenance process showed that a lot of engineers' time was consumed by attending breakdowns instead of allocating resources for planned maintenance. The new solution developed using machine learning and data analytics enabled the company to predict equipment failure with an accuracy of 92% and plan maintenance more effectively. Overall equipment efficiency increased from 65% (industry average) to 85%. As a result, the optimization improved the scheduling and planning process as well as asset reliability and product quality (Romaniuk and Rutkowska, 2017).

NASA is one of the companies that has been using predictive maintenance for their turbofan engines. "Turbofan engine is a modern gas turbine engine used by the NASA space exploration agency. NASA has created the following data set to predict the failures of Turbofan engines over time. (Perera)"

Below is a diagram showing how machine learning and cloud technology is used by many manufacturing companies for predicting machine line maintenance and equipment failure.

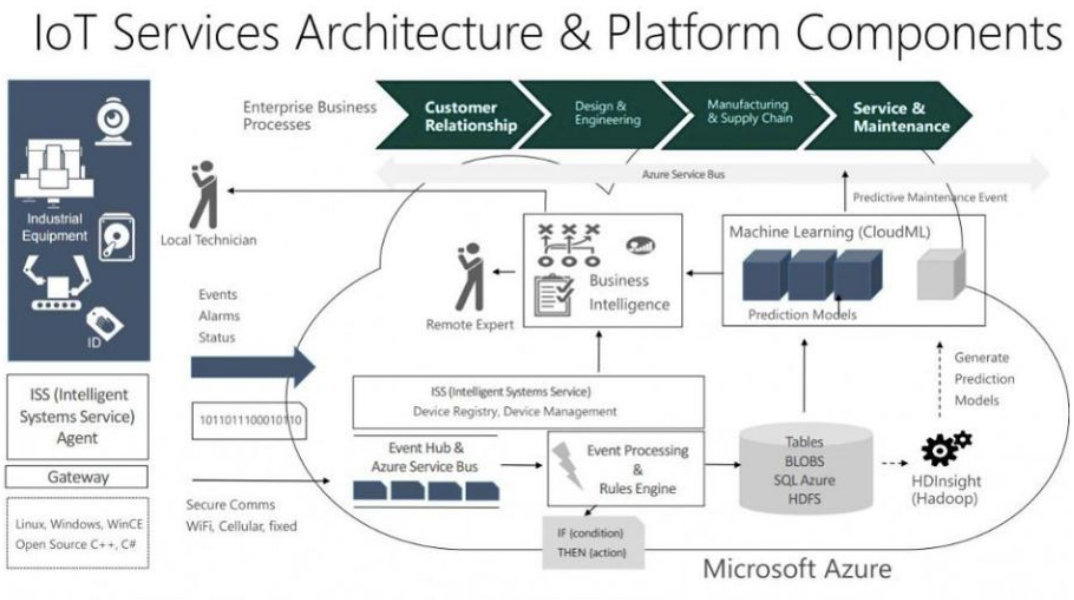
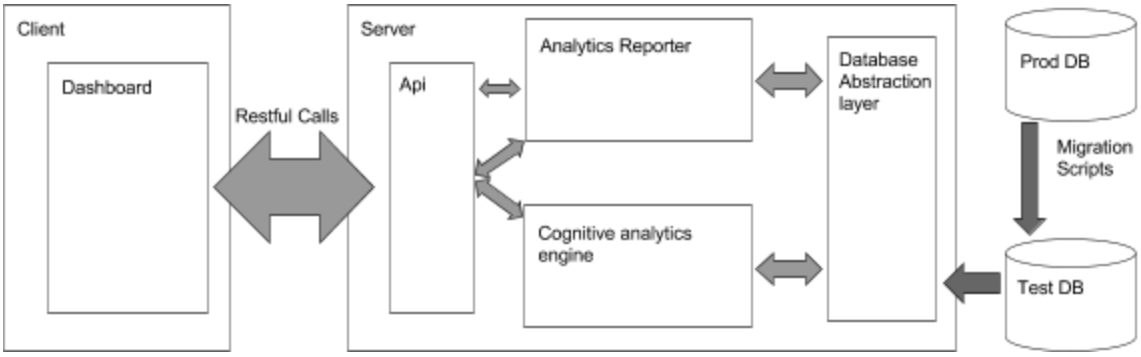


Figure 1 Ways Machine Learning Is Revolutionizing Manufacturing by Columbus, Louis. *Forbes*, Forbes Magazine, 26 June 2016

3.2 Proposed System Block diagram

For most groups you can include a flowchart of how the system will work. In case your project is not about putting together some sort of a system, you may describe the process that you will follow to achieve your deliverables.



Dashboard: The dashboard is the main front end that will deliver the information to the user. This will use Ignition for the main dashboard rendering.

API: This api is the middleman between server modules and the frontend. This api can also function as an interconnect between the cognitive analytics engine and the analytics reporter.

Analytics Reporter: The analytics reporter is responsible for gathering and organizing relevant information to send to the client. This means gathering data from the DB and the analytics engine to then send to the client to display.

Cognitive Analytics Engine: This module is responsible for analyzing and interpreting the data from the assembly lines both in real-time and retrospectively. This means that we will have a constant flow of data and be able to analyze the past and present concurrently looking for relevant patterns in the data. The data will then be accessed and interpreted by the reporter.

Database Abstraction Layer: This layer is responsible for handling and formatting our DB queries. Since the prod DB will be oracle and the test DB may not be this layer will allow us to query either DB with no extra work on the Analytics Reporter or the CAE.

Test DB: This will be a sandbox DB that we can query without the restrictions and risk of running against a prod DB.

Migration Scripts: These will be simple scripts that will pull more information from the Prod DB onto our sandbox/test DB.

Prod DB: This is the main DB containing all of the data. This DB is being constantly fed data from the production lines. We will only be using this DB to feed into a test DB until we reach a high level of maturity on our project as to avoid any possible accidents.

3.3 Assessment of Proposed methods

Provide a short discussion about the different approaches available and the approach you want to follow in your work.

3.4 Validation

How will you confirm that your solutions work?

The validation for the project will come primarily from looking at the old data as far as it comes to amount of down time due to broken parts and the number of recalls the Danfoss experiences. If once our system is in place and the number of incidents go down then I would call our system a success.

4 Project Requirements/Specifications

4.1 functional

List and explain the functional requirements of the project. This would include all the technical requirements you fulfil during your senior design project.

1. The solution must interface with the existing Danfoss technology stack.
2. The solution must also work with the semi-isolated student system.
3. The solution must be able to parse large amounts of data.

4.2 Non-functional

List and explain the non-functional requirements of the project. This is where you would enlist non-technical requirements. This may still be a fundamental deliverable that your client needs at the end of the semester.

1. The designed UI must be intuitive for assembly line management to use
2. The designed UI must be intuitive for assembly line management to interpret data from
3. The machine learning API chosen must perform quickly enough to be useful
4. The solution must be scalable over large amounts of data.

4.3 Standards

Discuss the standard protocols that you follow in your lab or for writing code. Are these approved by standard organizations like IEEE, ABET etc. Will any of your practices be considered unethical by such organizations? Discuss how standards are applicable to your project.

Standard protocol will need to be based on what Danfoss defines. They, as the business client, are bound by legal specifications, and as such, we must abide by them.

5 Challenges

Include any concerns or details that may slow or hinder your plan as it is now. These may include anything to do with costs, materials, equipment, knowledge of area, accuracy issues, etc.

1. Knowledge
    a. The team knows little about the Danfoss internal technology stack
    b. Danfoss specializes in industrial manufacturing, which leans more hardware. Most of the senior design team consists of software-oriented peoples.
2. Team Distribution
    a. The senior design team meetup schedule is limited - many of us have part-time internships, as well as other classes, to manage
    b. The Danfoss representative, being an actual full-time worker, must also manage us as well as any full-time responsibilities

6 Timeline

You may want to include a Gantt chart/something similar to help visualize your timeline to complete the project.

Approximately 30% of allocated time to setting up necessary environment (IBM Watson or similar) remaining time to devise solutions like:
- analyzing station based cycle times to predict maintenance, detect equipment malfunctions and identify potential
piece part problems;
- forecasting shift and daily production numbers and inventory, etc.

6.1 First Semester

Breakdown your timeline into detail of what needs to be done by the end of the first semester. You may want to include division of work amongst the team.

Week	***Project Tasks***	***Class Deliverables***
1 - 8/21 - 8/25		
2 - 8/28 - 9/1	Contact client/advisor	
3 - 9/4 - 9/8	Meet w/client Research solutions	Weekly Status Report #1
4 - 9/11 - 9/15		Weekly Status Report #2
5 - 9/18 - 9/22	Tour Danfoss	Project Plan (v1)

		Team Web Site (v1)
6 - 9/25 - 9/29	Meet w/advisor Initial environment setup	Weekly Status Report #3
7 - 10/2 - 10/6	Finish Environment Setup	Design Document (v1)
8 - 10/9 - 10/13	Begin Dashboard Prototyping	Weekly Status Report #4
9 - 10/16 - 10/20	Apply Exported Data to Dashboard	Weekly Status Report #5
10 - 10/23 - 10/27	Testing Reiteration	Project Plan (v2) Weekly Status Report #6
11 - 10/30 - 11/3	Research Recommended Machine Learning Frameworks	Weekly Status Report #7
12 - 11/6 - 11/10	Prototype Machine Learning Framework	Weekly Status Report #8
13 - 11/13 - 11/17	Testing Reiteration	Weekly Status Report #9
X - 11/20 - 11/24	Thanksgiving break	Thanksgiving Break
14 - 11/27 - 12/1	Testing Reiteration	Project plan (final) Weekly Status Report #10
15 - 12/4 - 12/8		Design document (v2) Team Web Site (v2)
16 -12/11 - 12/15	Prototype Wrap-Up	Peer team evaluation survey

6.2 Second Semester

Detail what needs to be done in the second semester. You may want to include division of work amongst the team.

Week	***Project Tasks***	***Class Deliverables***
1 - 8/21 - 8/25	Semester Preliminaries	Semester Preliminaries
2 - 8/28 - 9/1	TBD	TBD
3 - 9/4 - 9/8	TBD	TBD
4 - 9/11 - 9/15	TBD	TBD
5 - 9/18 - 9/22	TBD	TBD
6 - 9/25 - 9/29	TBD	TBD

7 - 10/2 - 10/6	TBD	TBD
8 - 10/9 - 10/13	TBD	TBD
9 - 10/16 - 10/20	TBD	TBD
10 - 10/23 - 10/27	TBD	TBD
11 - 10/30 - 11/3	TBD	TBD
12 - 11/6 - 11/10	TBD	TBD
13 - 11/13 - 11/17	TBD	TBD
X - 11/20 - 11/24	TBD	TBD
14 - 11/27 - 12/1	TBD	TBD
15 - 12/4 - 12/8	Final Report	Final Report
16 -12/11 - 12/15	Final Presentations	Final Presentations

7 Conclusions

Sum up your project plan. Briefly re-iterate your goals for the project and the plan your team has put in place to achieve these goals.

Ultimately this project is meant to improve the total efficiency of the Danfoss assembly lines. We hope to accomplish this by implementing a machine learning system that can recognize when the testing machines are starting to fail and to monitor the efficiency of the human stations by watching if those stations are moving too quickly or too slowly. Ideally the system will then be able to notify the correct person in order to get these fixed before the parts get pushed out to the consumer.

8 References

List all the sources you used in understanding your project statement, defining your goals and your system design. This report will help you collect all the useful sources together so you can go back and use them when you need them.

Columbus, Louis. "10 Ways Machine Learning Is Revolutionizing Manufacturing." *Forbes*, Forbes Magazine, 26 June 2016.

Romaniuk Michal, Rutkowska Barbara. “Machine Learning for Applications in Manufacturing.” ***Deepsense.ai Blog***, 7 Sept. 2017, blog.deepsense.ai/machine-learning-for-applications-in-manufacturing/. Accessed 23 Sept. 2017.

Perera, Srinath. “Machine Learning Techniques for Predictive Maintenance.” ***InfoQ***, www.infoq.com/articles/machine-learning-techniques-predictive-maintenance. Accessed 24 Sept. 2017.

9 Appendices

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. You may also include your Gantt chart over here.