"Feel the pulse of the factory" – To be competitive UK industry must embrace digital technologies to improve productivity through data analytics

By David Brown, Ann Swift , Edward Smart and Hongjie Ma

Connected Everything: Industrial Systems in the Digital Age

Who are we?
An EPSRC-funded Network Plus project, Connected Everything aims to identify the key challenges we face as digital technologies transform our industrial systems and to highlight research excellence relating to these challenges. It is creating and supporting new collaborations
between academics from diverse discipline areas to address these challenges. It provides a forum for discussion and knowledge exchange, as well as funding for risky early-stage research projects in partnership with industry.

What are we doing?

- Feasibility studies
- Thematic areas
- Road mapping
- People movement and skills
- Annual conferences
- Dissemination and impact

connected everything.
industrial systems in the digital age

Thematic areas
Design for Future Manufacturing
Cyber-Physical Systems
Service Design and Customisation
Data Analytics and Decision Making
Industrial Internet of Things
The Future Industrial Worker

Disciplines currently involved

Manufacturing
Design
Computer Science
Cyber Security
Human Factors
Business

Digital Economy
Engineering
Operational Research
Robotics
AI/Virtual Reality
Psychology

EPSRC
Engineering and Physical Sciences
Research Council

University of Nottingham
UK | CHINA | MALAYSIA

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The UK Getting Smart – Digital Technology

The mistakes of the Big Financial Crash in 2007/2008 should not be repeated; opportunists seeking short-term gains by receiving excessively valued bonuses. The long-term effect has been economic stagnation right up to now, over a decade later.

Digital manufacturing can make use of a set of technologies for reducing product development times and cost as well as for addressing the need for customisation, increased product quality, and faster response to the market.

The 4th industrial revolution

Manufacturing is undergoing a transformation to the fourth industrial revolution. This transformation will see greater integration of physical production with digital technologies to boost levels of productivity.

Katie Daniel, Head of Manufacturing at EPSRC said: "The Connected Everything network plus have worked closely with EPSRC to identify the key research challenges which need addressing to ensure UK industry takes best advantage of digitisation. The challenges will inform future strategy and priorities for EPSRC."

How can you get involved?
Visit www.connectedeverything.ac.uk to find out more, join the Network Plus and receive news of upcoming events and activities.

What is Connectivity?

Connectivity using 4G/5G/satellite/the cloud allows for factory to factory data comparisons and allows the optimisation of production linked to strategic business models – something that has been explored in several IIR EU-funded projects linked to data analytics and the manufacturing sector.

Basic Cloud-based platforms support data storage, usually have issues with speed of storage & no ability to easily share large quantities of data in real time. - Requires human intervention to perform the analysis.

The High Performance Computing (HPC) cloud provides high-performance data analytics, can deal with the larger quantities of real time data and the ongoing analysis. With cloud based HPC, it allows for the storage of data during processing and the **hosting of the algorithms** to facilitate near real time analysis of data. If your algorithm enables multithreading it will maximise the benefits of HPC to the end uses. With the inclusion of a web-based system this would lead to national and international accessibility by end users etc.

Lets Go Digital - the Trend for Practical Applications?

- In general, physical models are too complex to use for accurate diagnosis of health or performance. Data driven models can be more realistic. And encompass non-linearities.

- Connected Factories and Connected Transport
    - Logistics
    - Quality control, are my machines performing as expected?

- Digital Needs Mass Data Storage needs Extra Security

- Raw data kept safe

- Decisions need to be secure

Connected Everything: Industrial Systems in the Digital Age

One of the Feasibility Studies – Pathway to Autonomy for a SME Factory

Dr Hongjie Ma (Early career researcher, PI)

Ann Swift (University of Surrey)

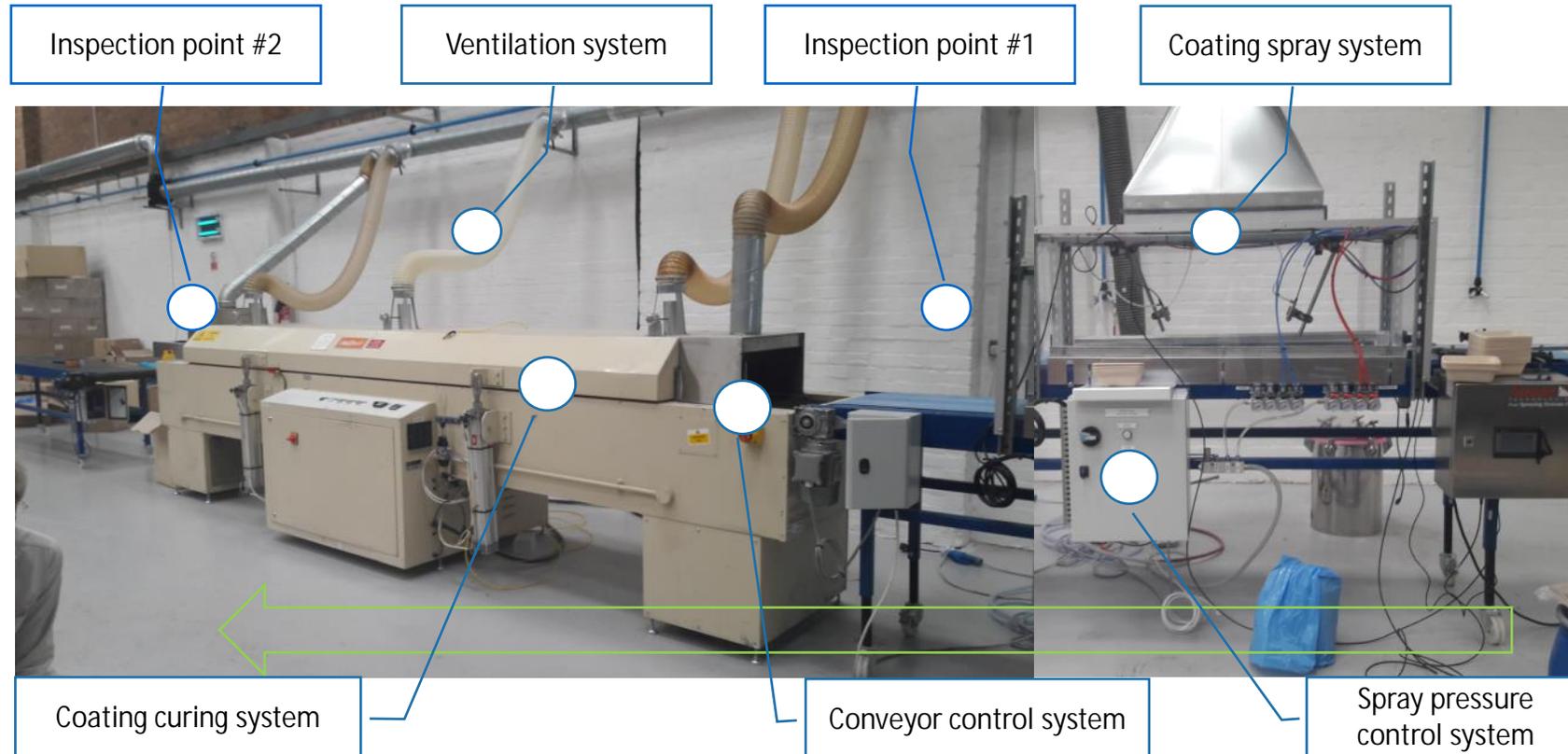Dr Ruby Hughes (AMRC with Boeing Sheffield Hallam University)
Prof David Brown (independent))
Dr Hui Yu (University of Portsmouth)

13-Nov-2017

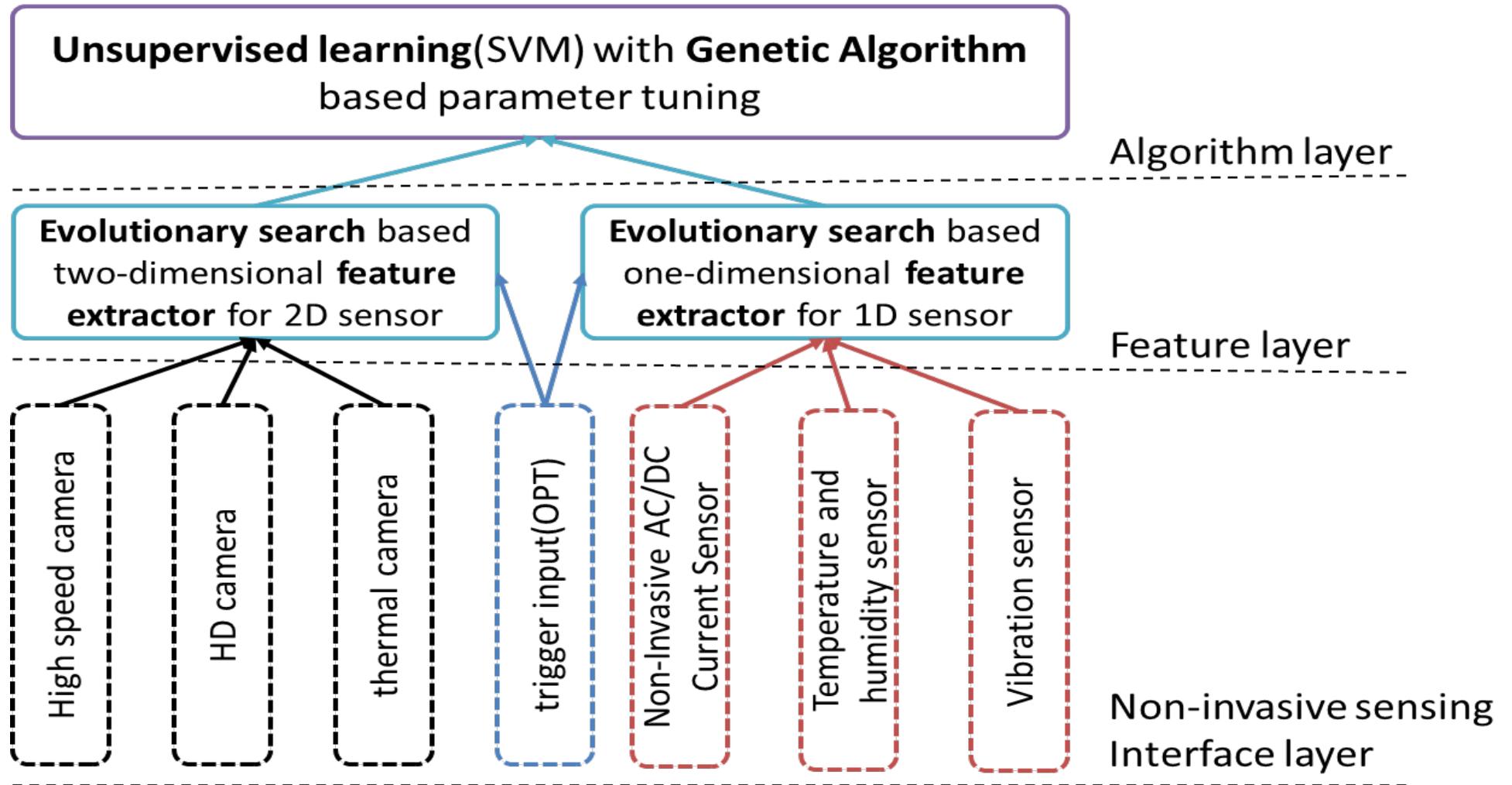# Introduction of AI for a SME Factory

Inspection point #2

Ventilation system

Inspection point #1

Coating spray system

Coating curing system

Conveyor control system

Spray pressure control system

Address to the challenges of maintenance costs and QC:

- Early stage fault detection algorithm for production line;
- Real time quality inspection algorithm for product;

Artificial Intelligence (AI) algorithm

Self Tuning algorithms - Lack of flexibility is the biggest problem with AI

Future: Easy to Set Up – AI Adapts to its Environment

Dairy Filling Machines

Typically a breakdown last 4-6 days and each machine experiences 3-5 breakdowns per year giving an annual breakdown costs of £3.6m – £9m per machine with 40 filling machines in the UK alone it is easy to see how cost escalate.

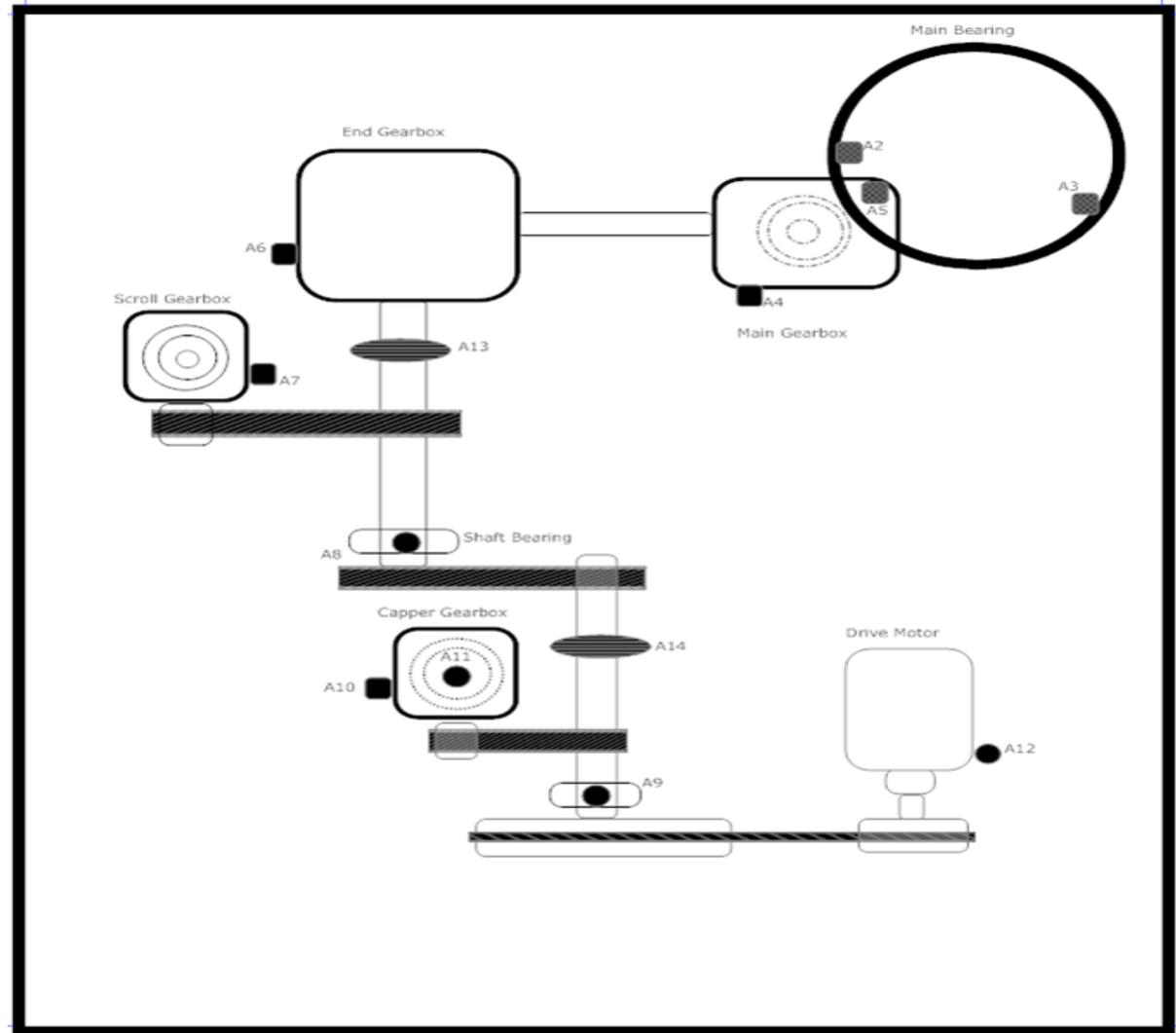Condition Based Monitoring can be cost effective

At £2m per machine and no Diagnostics

Dairy filling machine

Mechanical Transmission System
with strategically
placed sensors

Electrical Motors- Faults

Common motor faults such as bearing failure, eccentricity and broken rotor bars induce modulations in the stator current. This means that they can be detected by studying the time and frequency domains of the current signal.
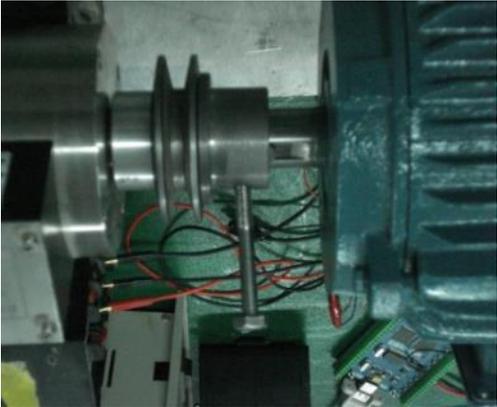

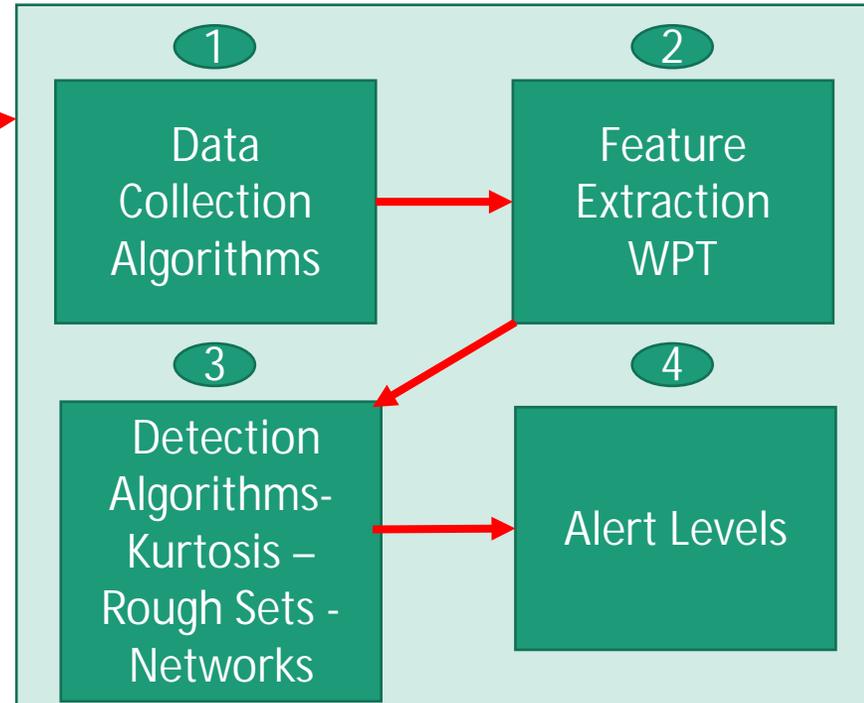Bearing Fault

Winding Fault

Broken Rotor Bar Fault

Eccentricity Fault

Data Fusion – Analysis with HPC

Factory Sensor Data

In Factory Data Processing Module

1. Data Collection Algorithms
2. Feature Extraction WPT
3. Detection Algorithms- Kurtosis – Rough Sets - Networks
4. Alert Levels

HPC Cloud Platform

Fusing in other data sources such as logistics, weather,
Product flow, incident reports ,
 unplanned maintenance,
 delivery of raw material or spare parts, insights into key causes of faults from other m/cs & other factories

Data to HPC Cloud
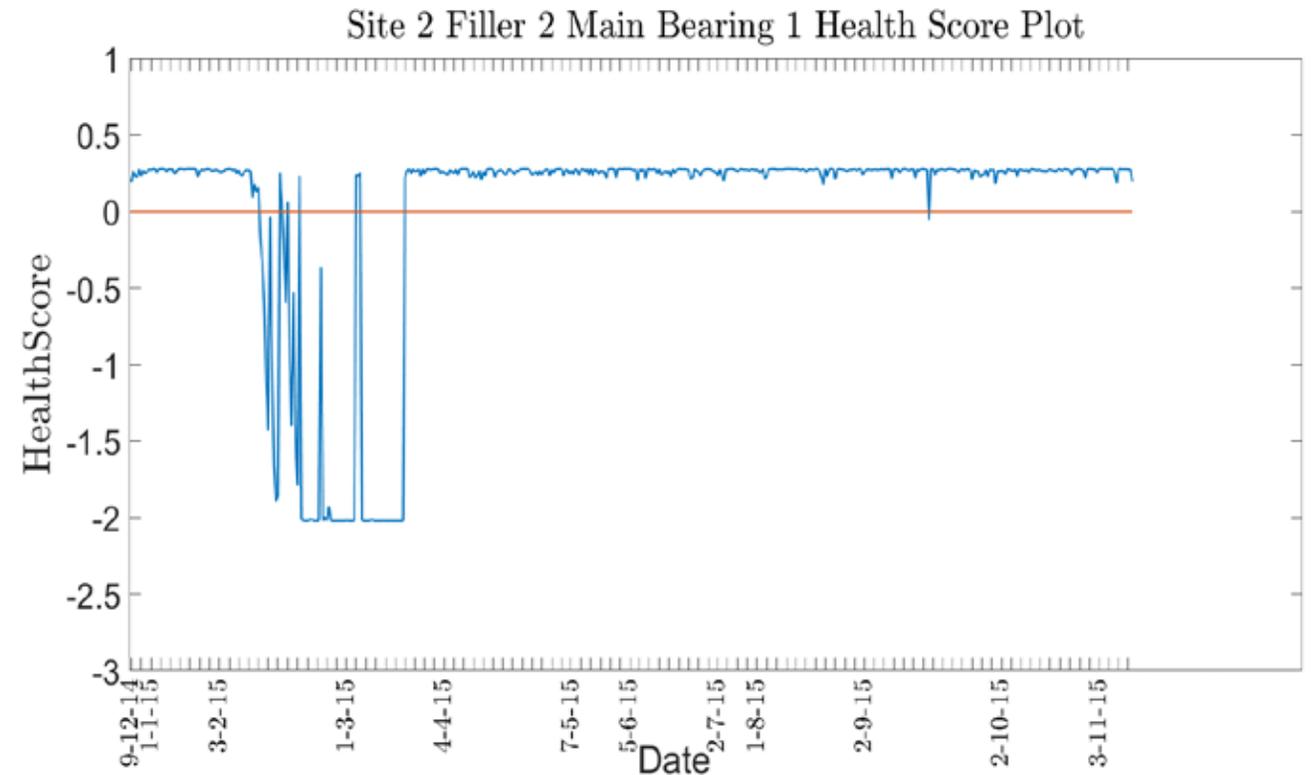
Serious Alerts to Maintenance Crew

Other Project:
Tea Bagging Machine

Vibration is part of the machine's operation, tea needs to be shaken into the bag – remove normal operation and then what is left?
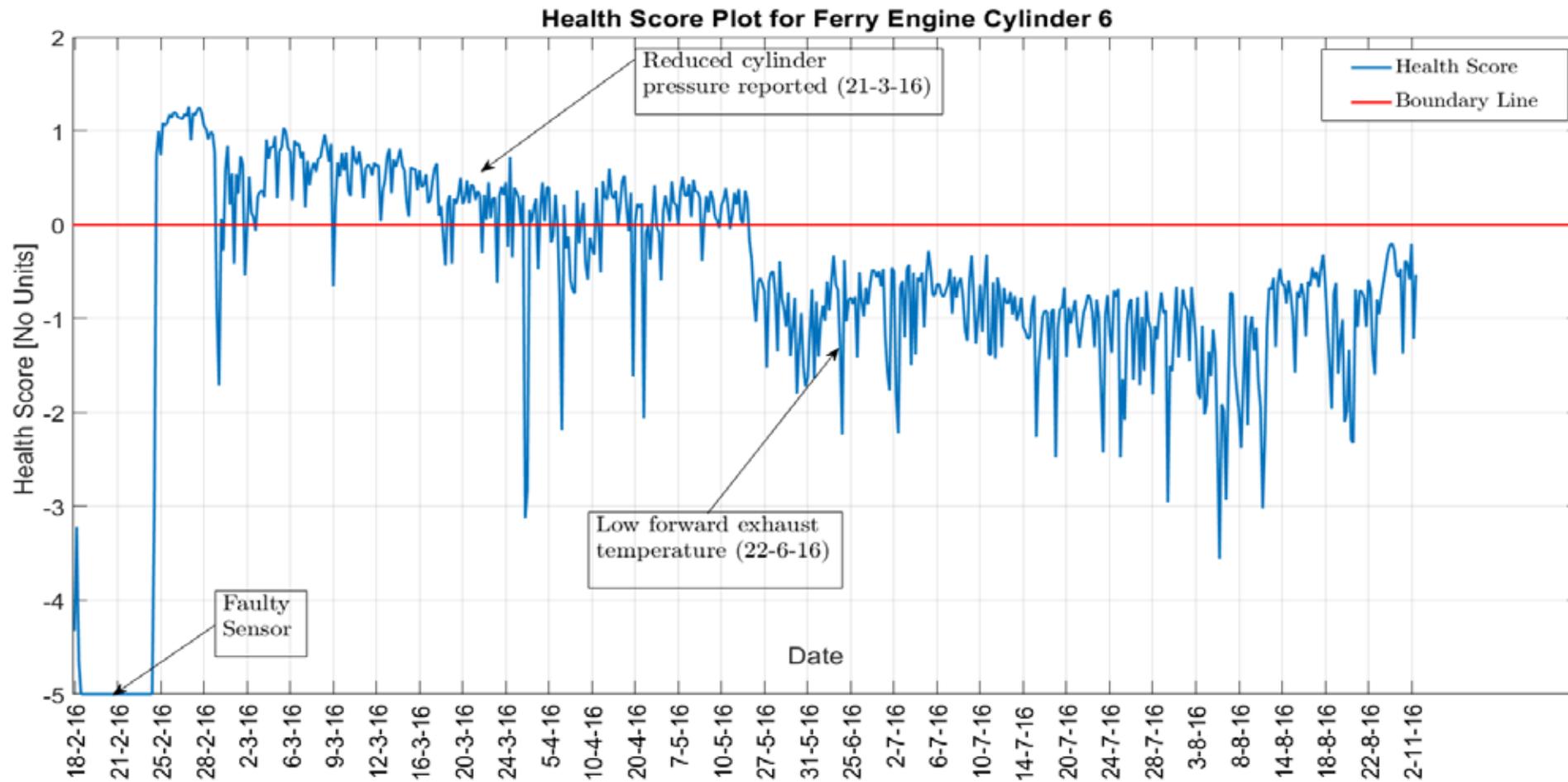
Case Study – Digital Analysis – Dairy Fillers

- Innovate UK funded project to detect faults on dairy filling machines
- Challenging due to incomplete machine information and resistant culture
- Developed method learnt from artificial data sets and required no knowledge of faults
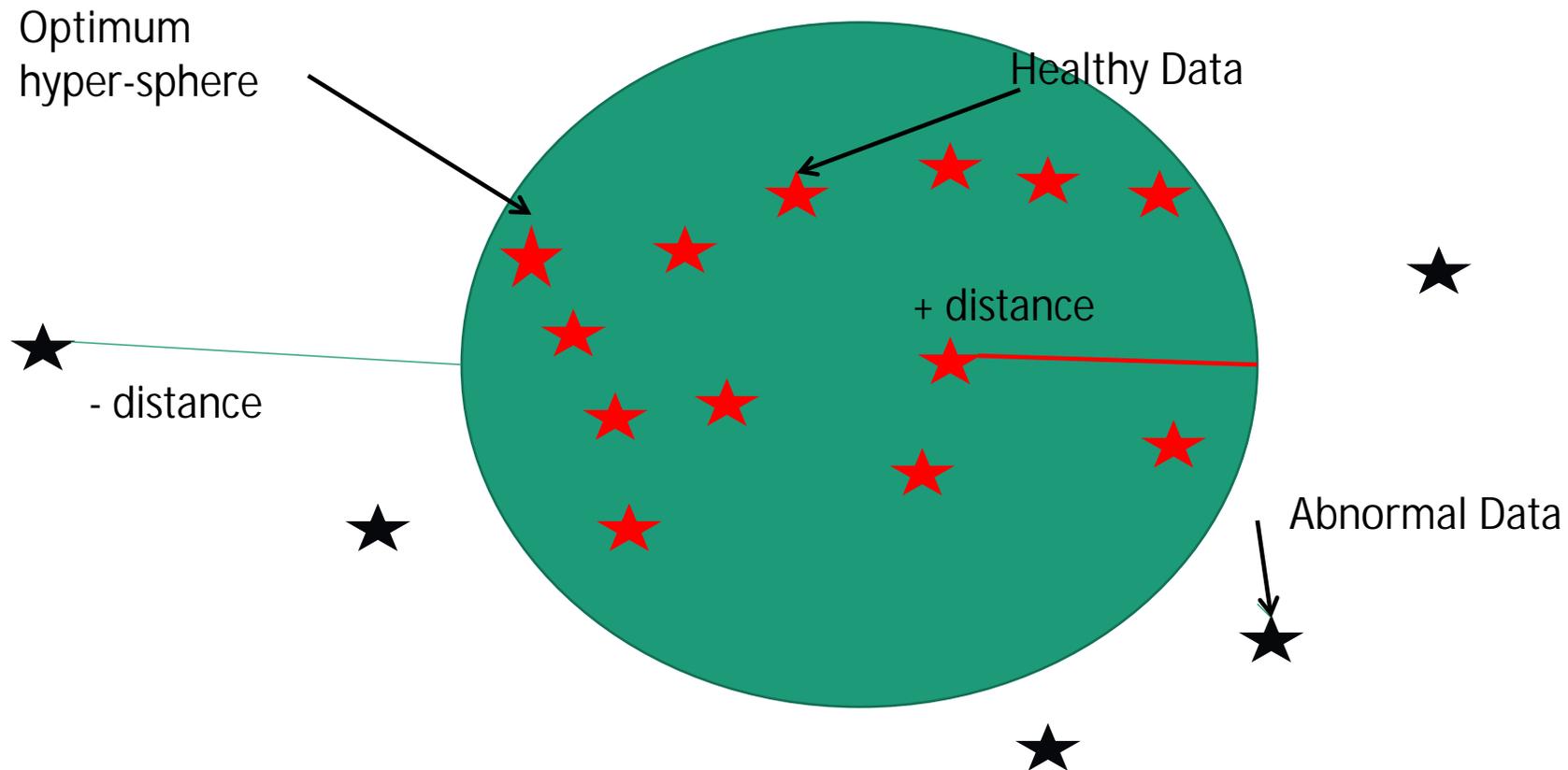- Detected 36 faults, saved the dairy over £30 million

Site 2 Filler 2 Main Bearing 1 Health Score Plot

Tells a Story - Look at Trend

Health Score Plot for Ferry Engine Cylinder 6

The Story is Lost

Distance Based Method – Try to Keep it Simple

The Abnormality Score for a given data point is the distance of the data point to the hyper-sphere boundary.

The larger the magnitude, the greater degree of abnormality/normality.

Optimum hyper-sphere

Healthy Data

+ distance

- distance

Abnormal Data

Digital Factory – The future is here

Data Analytics can make use of active visual displays running Augmented Reality and Virtual Reality technology high resolution displays

Displays that combine both AR and VR are being developed.

AR - augmented reality allows you to be more present.

Piggy Back on other Technologies. Media & Games …….

The End

References :

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- Data Analytics Report - http://uopnews.port.ac.uk/2018/12/05/feel-the-pulse-of-the-factory-uk-industry-must-embrace-digital-technologies-to-improve-productivity-through-data-analytics/

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