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DETECTING AND DIAGNOSING DISTURBANCES IN NATURAL GAS PROCESSES WITH SIGNAL ANALYSIS

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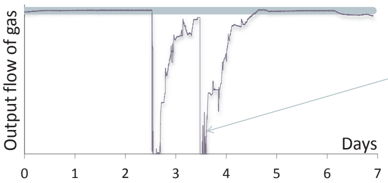
Why should we care?

- Natural gas is the single biggest source of energy in the UK.

Natural Gas Production in a week (expected vs. actual)

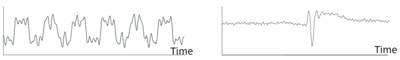


- But disturbances in the process of producing gas can unexpectedely stop production...
- ... and compromise safety and energy-efficiency.
- Disturbances in the process increasingly come from the electrical utility.
- If disturbances can be detected and diagnosed in good time, the production of gas will be enhanced.

What am I doing about it?

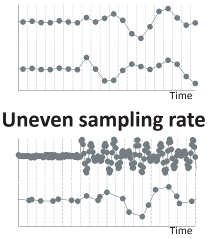
- Signal analysis is a powerful tool to detect and diagnose disturbances.
- And the new challenge is to analyse together signals from the chemical process and the electrical utility.
- Why a challenge? Because of new types of disturbances and more complex data conditions.

Persistent disturbances **Spiky disturbances**



Even sampling rate

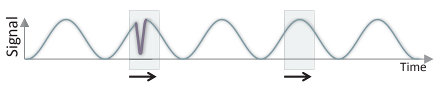
Uneven sampling rate



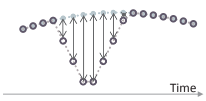
	Persistent disturbances	Spiky disturbances
Even sampling rate	State-of-the-art	Method A ✓ (using building blocks 1, 2 and 3)
Uneven sampling rate	Method B ✓ (using building blocks 1, 4 and 5)	Future work

The building blocks of the new methods

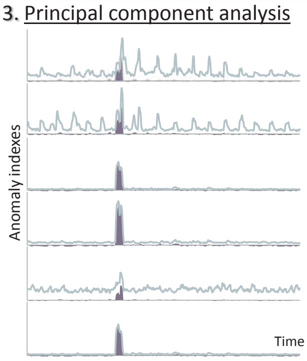
1. Nearest neighbours of embedded vectors



2. Euclidean distance



3. Principal component analysis

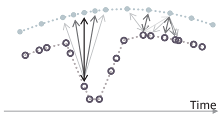


Method A. Detection of spiky disturbances

Step 1) Make anomaly index for each signal using **1** and **2**; anomaly index is higher the more distant each embedded vector is from its near neighbours.

Step 2) PCA on the anomaly indexes, using **3**, allows multivariate approach and highlights common features.

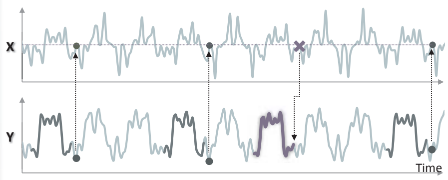
4. Kernelized distance



Method B. Determination of causality between unevenly sampled signals with persistent disturbances

Step 1) Find the indices of the near neighbours of each embedded vector in signal Y, using **1** and **4**.

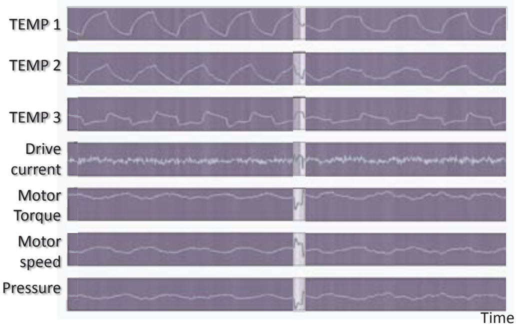
5. Nonlinear mutual prediction



Step 2) For each point in X (x), compare it with the values of X associated with the near neighbours indices in Y. This gives a measure of how well Y predicts X (**5**).

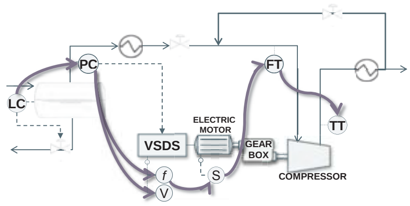
Showing it works

A. Detection of spiky disturbance throughout process and electrical signals

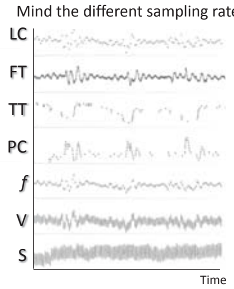


- The light colour indicates the presence of a spiky disturbance.
- All signals affected are identified, even if spike is hidden by other trends.

B. Determination of propagation path of oscillating disturbance throughout a process unit



Mind the different sampling rates.



- This example uses signals from the process, mechanical and electrical systems.
- The cause of the disturbance is the level control loop.

In a nutshell

- Industrial sites which process natural gas and supply millions of customers are susceptible to disturbances.
- In a data-rich world, signal analysis is a powerful tool to detect and diagnose disturbances in the operation of the process.
- The novelty of my work is to analyse process signals together with signals from the electrical utility. This requires new signal analysis methods.
- The key contributions of the methods presented in this poster are:

a) Robust detection of spiky disturbances, in a multivariate approach

b) Determination of causality when data has uneven sampling rate

- Ultimately, these provide actionable information to those responsible for taking decisions to produce gas safely and economically.

I was born in Portugal. In 2009 I graduated with an MSc from the Technical University of Lisbon, Instituto Superior Técnico. I am currently a PhD candidate at Imperial College London. I gratefully acknowledge the financial support from the Portuguese Foundation for Science and Technology (FCT) under Fellowship SFRH/BD/61384/2009, and from the Marie Curie FP7-IAPP project "Using real-time measurements for monitoring and management of power transmission dynamics for the Smart Grid - REAL-SMART", Contract No: PIAP-GA-2009-251304.

Imperial College London

MARIE CURIE ACTIONS

FCT Fundação para a Ciência e a Tecnologia