

# Reading Project: Industrial Mathematics

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Today

## Abstract

Industrial Maths is.....

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## 1 Introduction

## 2 Review of the International State of Industrial and Applied Mathematics, Mechanisms, Philosophy and Effectiveness

This report will mainly be focused on the UK but we will look elsewhere in the world for examples and comparisons.

### 2.1 Definitions

Defining the language and descriptors of Industrial Maths is not a simple task indeed many writers choose a range of definitions.

Even defining what it means to do Mathematical Research is fraught with complications. One can't just count all those employed by universities and higher education institutes as there are a large number of very talented mathematicians working elsewhere. Deloitte in their report 'Measuring the Economic Benefits of Mathematical Science Research in the UK' [?] count 'Mathematical Science Occupations' as those 'which either entail mathematical science research, or used mathematical science

research-derived tools and techniques' a broad definition which includes individuals which need no understanding of the underlying tools or techniques and includes all hospital and healthcare managers, social science researchers and public service administrative professionals. All very valuable jobs but not ones that I would put in the category of 'Mathematical Science Occupations'. In a similar report Deloitte produced on the Dutch economy ?? they narrow this definition slightly by considering 'only people in jobs requiring a higher education' to be included. A better but still quite broad definition. One might suggest those people who currently use or research 'modern' mathematical science research tools, to avoid including all those people that use an Excel spreadsheet to add up large numbers. But then the definition of modern is fraught, MORE HERE For the purpose of this report, I will consider Mathematics to be that which is of interest to academic mathematicians. Mathematics focuses on the underlying structure and pattern, looks for generalisations and derives exact or approximate solutions backed up by logical proof. The important clarification is that the application of well known techniques does not count.

Defining Industry is perhaps simpler as I define it to be any non-mathematical institution including: governments, businesses, manufacturers, other academic departments, hospitals, schools, charities etc.

For industrial mathematics, we could perhaps use words such as: 'applicable', 'interdisciplinary', 'applied', 'knowledge transfer' or 'mathematics communication'. The Bond Report [?] describes '*Impactful Mathematics*' as any mathematical method that has practical application and generates societal and/or economic value'.

For this report I will use the definition John Stockie describes in his essay 'Mathematics for Industry A personal Perspective' [4] that Industrial Mathematics includes:

- mathematics that is done by non-academic mathematicians who work as employee of a company
- mathematics that is done by academic mathematicians within research institutions for a company, or in collaboration with a company
- mathematics that is inspired by industry and arises from an industrial setting.

John Stockie essay [4].

## 2.2 Significance

Deloitte Report

Dutch Deloitte Report

## 2.3 Mechanisms

European Study Groups in Industry

Some study group reports

Innovate UK /Knowledge Transfer Network

Smith Institute

Canadian examples - CQAM, Fields

## 2.4 Successes

BOND Review

## 2.5 Challenges

BOND Review

### 2.5.1 Identifying Suitable Problems and Creating links

Especially SMEs

### 2.5.2 Building working relationships

A long process!!!! Intellectual Property issues

### 2.5.3 Funding

Talk about Bond Review and about 100 phd student places etc, boosting of EPSRC funding etc

### 2.5.4 Academic Career Paths

Needs to be seen as a viable career option How to prevent people being snaffled to industry

### 2.5.5 Brexit

I am reluctant to mention the 'B' word but i think no report that looks at the future of Mathematical Research, Industry or Mathematics in Industry can avoid the topic. The whole scientific community is concerned over the future of funding and ability to collaborate (BREXIT LETTER NOBEL LAUREATES) and industry in the UK is facing an uncertain future (REFERENCE OR MORE HERE).

I don't want to spend much time on this, but I would like to say that whatever happens, examples of success stories in industrial mathematics have demonstrated the need for collaboration: with industry, with other fields, with other departments and it will be vital for the continuing success of Industrial Mathematics that the spirit of collaboration is maintained.

### 2.5.6 Case Study 1: Trip Wire Detection for Land Mines

The first case study that really stood out to me, wht one brought to the second Industrial Problem-Solving Workshop (a Canadian version of the ESGI) held in Calgary in 1998. I follow an account of the project by one of the attendees, John Stockie [4] and the Study Group report [3].

The industrial partner was ITRES Research LTD and they were experimenting mounting a detection camera on a boom ahead of a slowly moving truck which would look vertically downwards. It was hoped that an automatic algorithm would be used to find trip wires appearing in the image.

A report, the Landmine Monitor, produced in 1999 [1] suggests that at the time the of the Study Group there were more than 250million Antipersonnel Mines in Stockpiles of which they were particularly concerned about remotely-delivered, surface laid anti vehicle mines that utilize trip wires which could explode from innocent acts by individuals.

A clearly defined problem, that could have huge benefits worldwide so why was this a study group problem? Why hadn't a solution been implemented already? There were some inherent difficulties in detecting a tripwire including:

- wires are often partially covered by foliage
- wires are not uniform in illumination
- wires are often purposefully camouflaged and come in a variety of colours and transparencies
- other image features may mimic lines such as vegetation
- images are often noisy or blurry as trucks and cameras move or the camera fails to focus. Natural elements also cause additional artefacts in the field of view

The goal of the week long study group was to have a first attempt at developing an algorithm that was *robust* enough to cope with the problems above; *reliable* enough to detect trip wires in with near perfect sensitivity and a high specificity and to be *fast* enough to run before the truck detonates a landmine.

We will look at 3 elements of their work: pre-processing, line detection and improving speed:

## **Pre-processing**

- laplacian filter
- Edge detection

## **Line Detection**

- Radon Transform
- Threshold transformed images

## **Algorithm Speed**

- Using the FFT
- Exploiting the method of image acquisition

The algorithm produced during the week was in no way perfect, struggling with some of the more 'difficult' images and ones where the wires were oblique. Results were presented to the industry partner but future collaboration was not forthcoming, a shame but potentially due to the military applications of such work. There is evidence that ITRES continued working on this problem with conference proceedings released in 2000 [2]. TO READ THIS PLEASE!!!!!!!

### **2.5.7 Case Study 2**

## **3 Real Case Study: Title here**

## **4 Final Thoughts**

## **References**

- [1] EXECUTIVE SUMMARY Landmine Monitor. Technical report, international Campaign to Ban Landmines, 1999.
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- [4] John M. Stockie. Mathematics For Industry: A Personal Perspective. sep 2015.