The Ronnie Shephard Memorial Address
Before Uber:

Professor Nira Chamberlain CMath CSci FIMA FORS OBE
Atkins Technical Fellow for Mathematical Modelling

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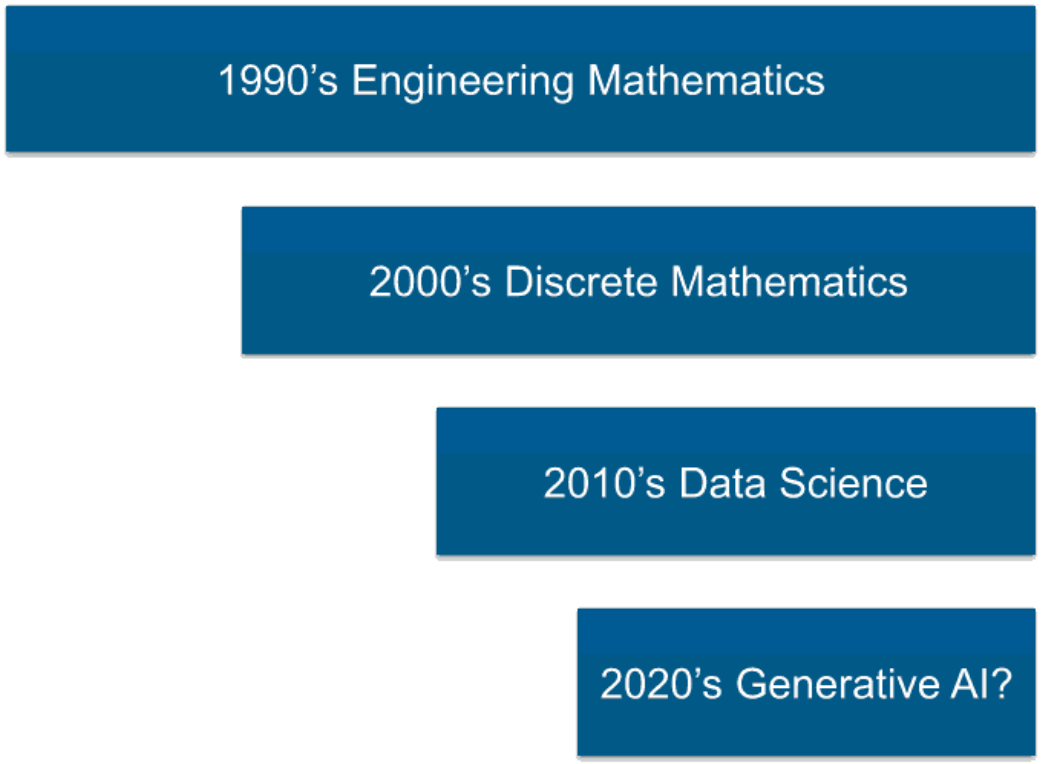
The Ronnie Shephard Memorial Address

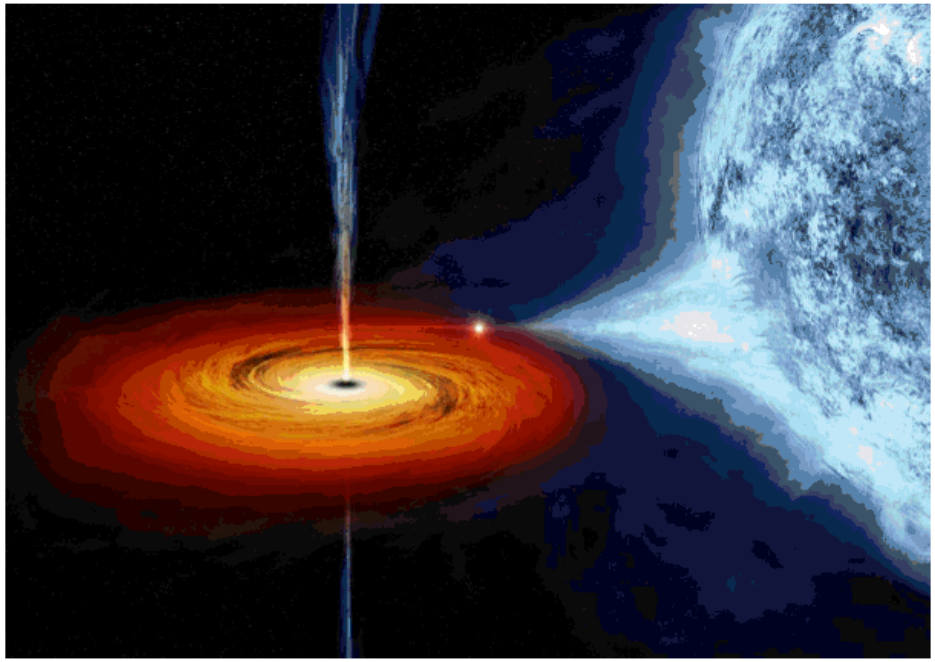
Ronnie Shephard was a professor in the United Kingdom who had joined the Army Operational Research Group (AORG) in 1942. Over the next few decades Shephard amassed a large collection of documents relating to military operational research, primarily of post-1945 conflicts. At one time, Shephard held the Chair of Operational Research at **the UK's Royal Military College of Science at Shrivenham**. In 1984, he founded The International Symposium On Military Operational Research (ISMOR)

Modelling Evolves every 10 years



Threat of AI – is the Deskilling of Present and Future Modellers

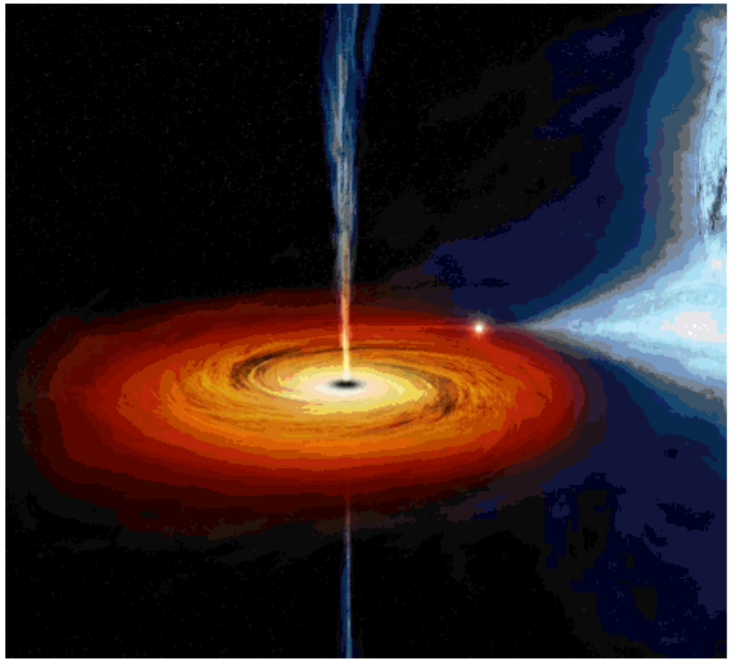
Pierre-Simon Laplace



Without a Computer, Laplace found the Hidden Logic

Threat of AI – is the Deskilling of Present and Future Modellers

Pierre-Simon Laplace



But by focusing purely on the Hidden Pattern (AI) do we risk throwing the baby out with the bath water!

Theme-
"Gauss is Wrong!":
The Challenges of Operational Research (OR) in an Increasingly Data-Driven World.

Professor Nira Chamberlain CMath CSci FIMA FORS OBE
Atkins Technical Fellow for Mathematical Modelling

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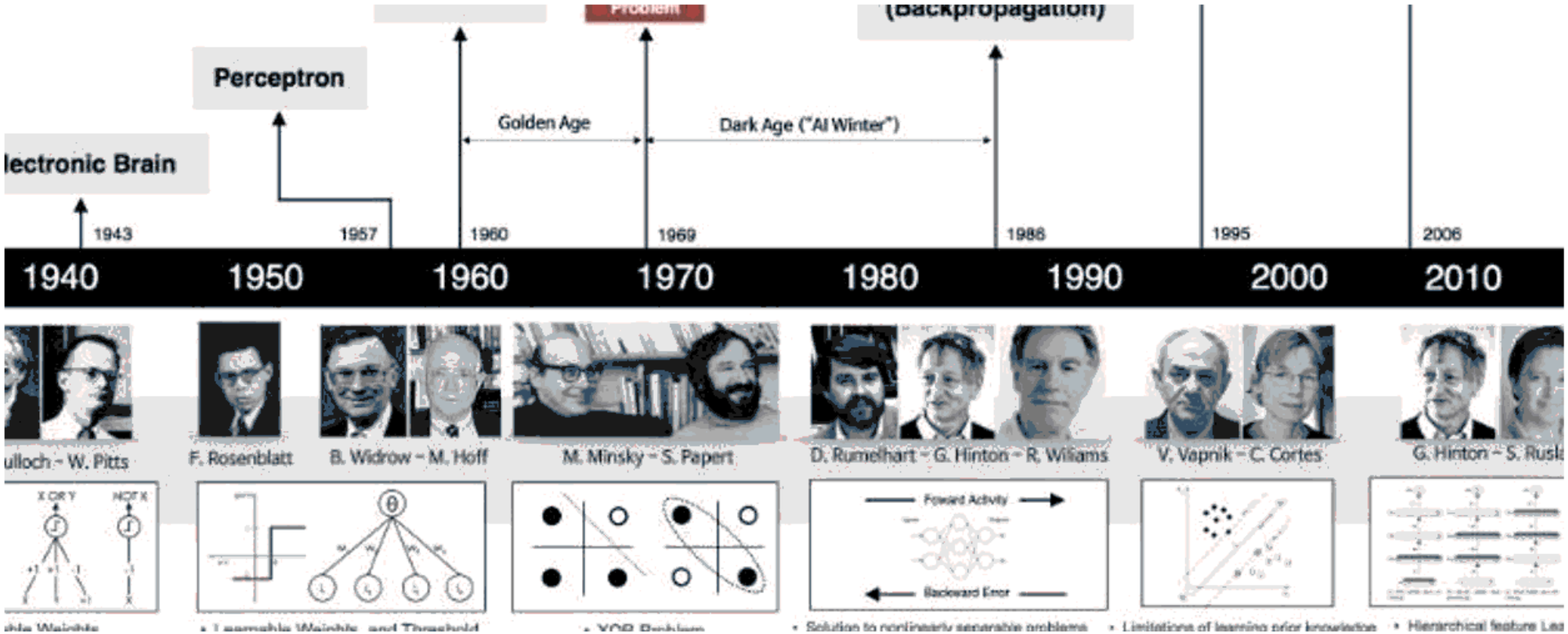
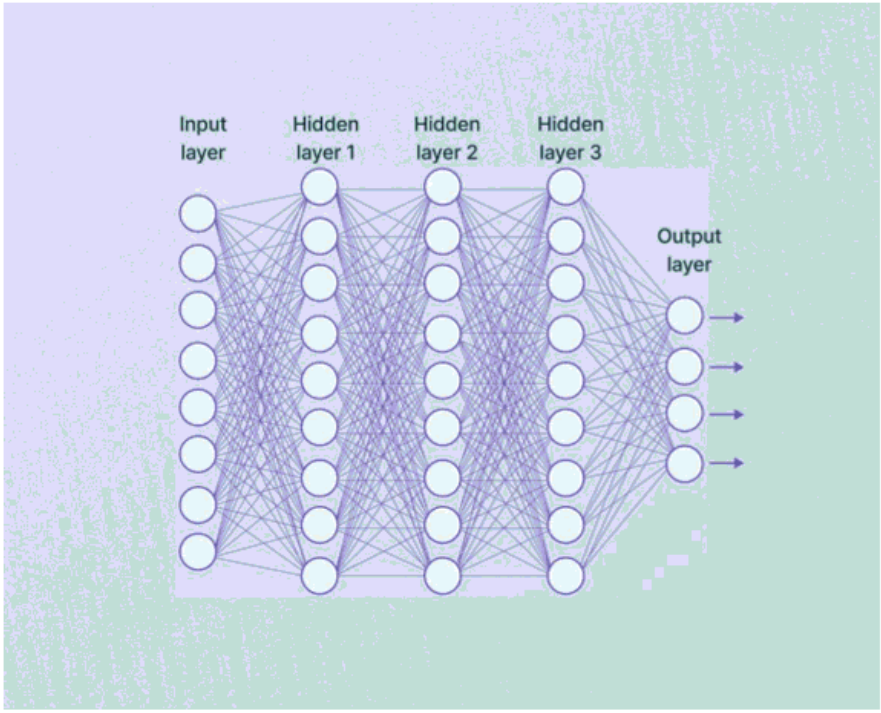
The Summer of 2001 – 22 years ago – met two academics

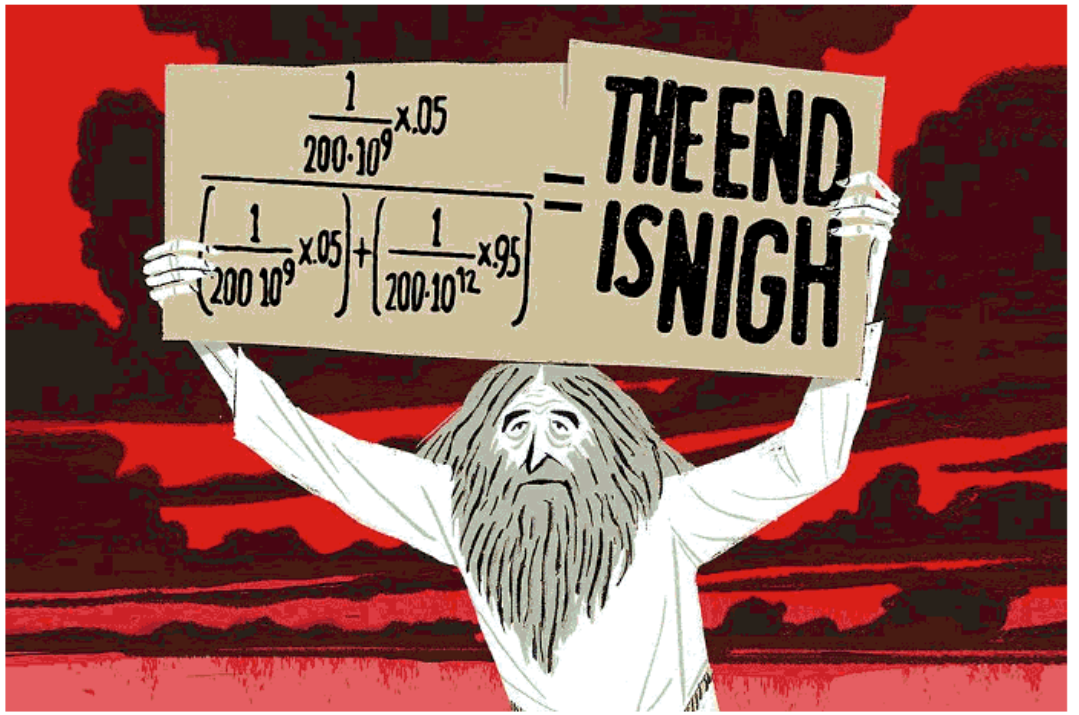
The History of Machine Learning



The rise and greatness of convolutional neural networks!



The end of OR and Mathematical Modelling!



2023 – 22 years later…. We are still here!

THE OPERATIONAL RESEARCH SOCIETY

Institute of mathematics & its applications

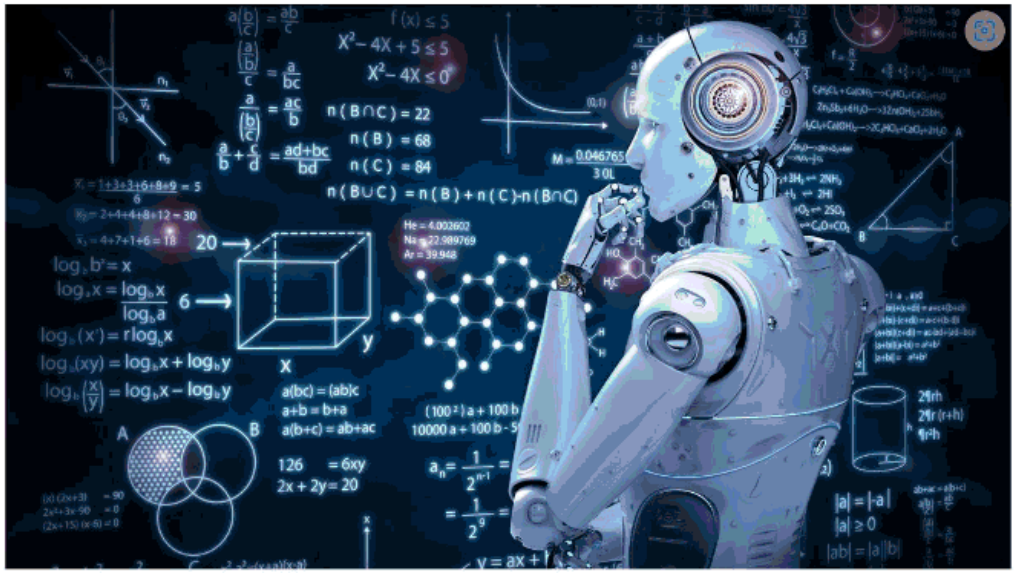
2045 – 22 years from now….What challenges will we face?…

THE OPERATIONAL RESEARCH SOCIETY

Institute of mathematics & its applications

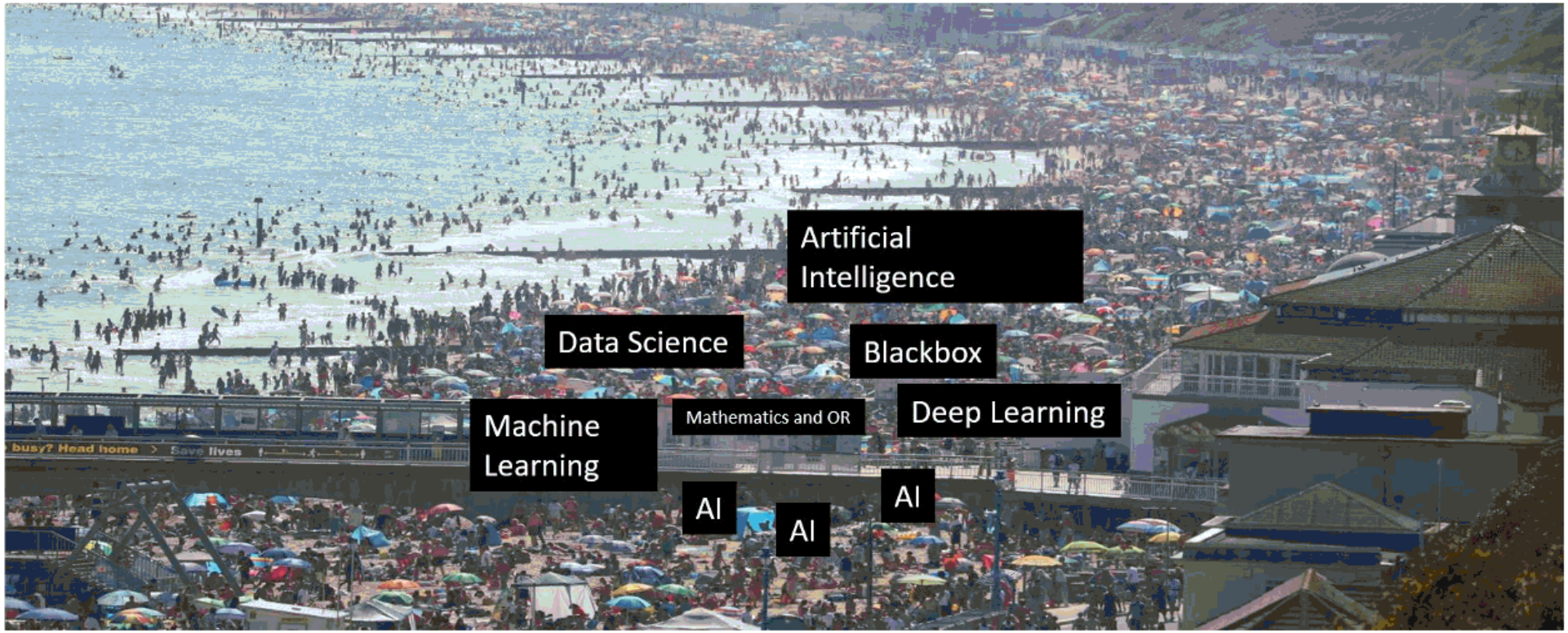
2045 – 22 years from now…. What challenges do we face…

Game Over for Maths A-level



The combination of ChatGPT with its Wolfram plug-in just scored 96% in a UK Maths A-level paper,

Is there a danger of being crowded out?



Or can with counter this by thinking more strategically?

My name is…This is my story

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I wear many hats

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Member of the SNC-Lavalin Group

Technical Fellow For Mathematical Modelling

Institute of mathematics & its applications

Past President

Academy for the Mathematical Sciences

Executive Committee

MATHEMATICAL ASSOCIATION
Supporting mathematics in education

Current President

The hat I'll wear today

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Member of the SNC-Lavalin Group

Technical Fellow For Mathematical Modelling

Institute of mathematics & its applications

Past President

Academy for the Mathematical Sciences

Executive Committee

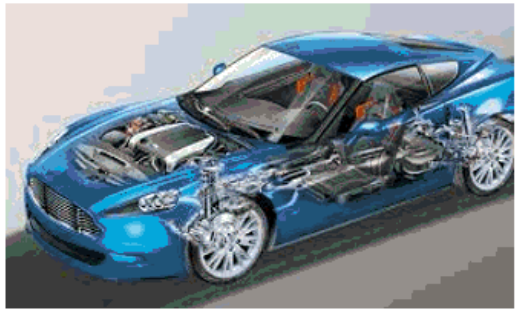
MATHEMATICAL ASSOCIATION
Supporting mathematics in education

Current President

Reflections – mixture of technical and personal opinions based on my experience so far

Defence

Energy and Utilities



Automotive

Retail

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Abstract

The challenges to OR and Mathematical Modelling in the increasing data driven world are real

But …

We can look at our discipline's USPs and learn lessons from the scientific past to see that our future is bright…

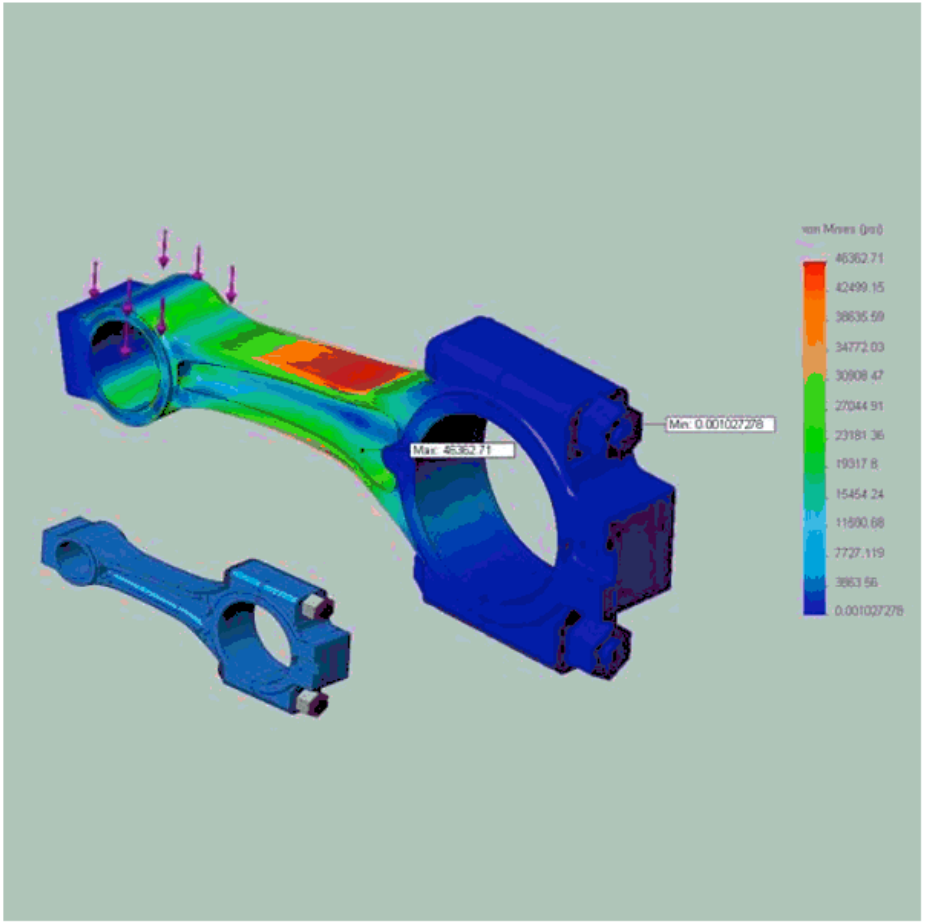
If we think strategically.

Question

Did the rise of theoretical physics signal the end of experimental physics?

Did the rise of finite element signal the end of continuous mathematical modelling?

Did the rise of computational fluid dynamics signal the end of fluid dynamics



Question

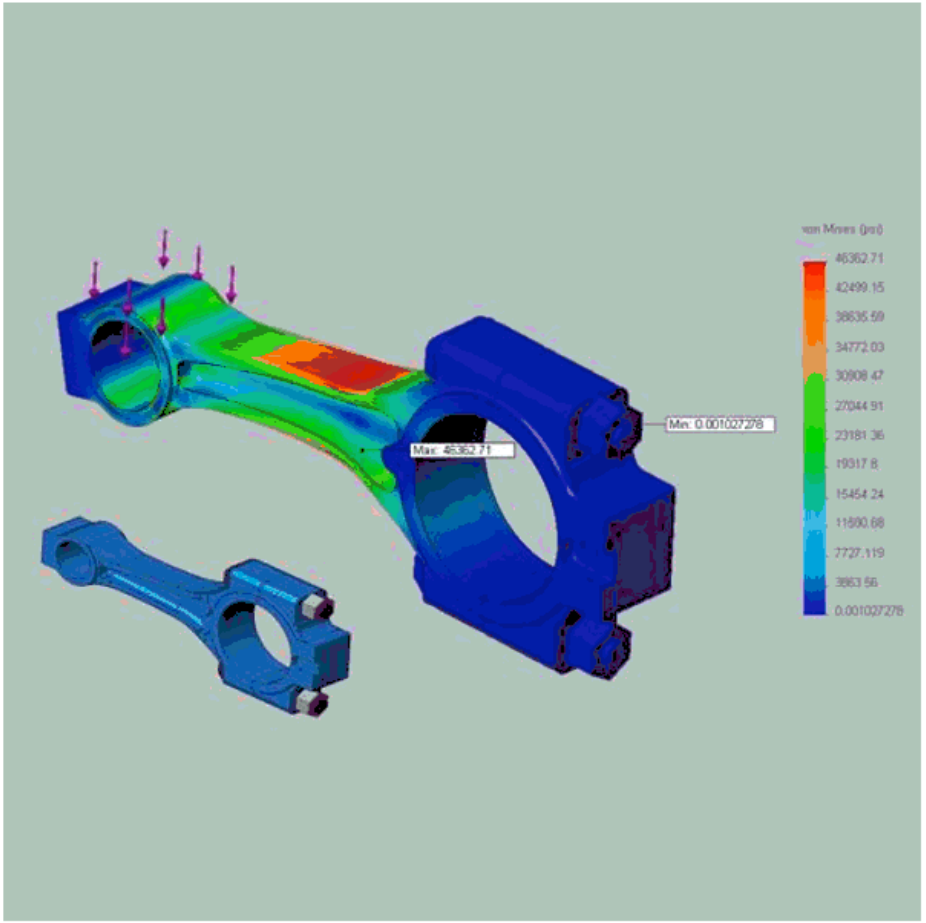
Did the rise of theoretical physics signal the end of experimental physics?

Did the rise of finite element signal the end of continuous mathematical modelling?

Did the rise of computational fluid dynamics signal the end of fluid dynamics

NO – Both disciplines evolved and enhanced each other

Cooperation not competition.



Numerical Simulation versus Analytical Approximation

For my PhD

Numerical Simulation was not used to replace an Analytical Approximation

but both techniques were used in tandem to enhance understanding of the problem.

EXTENSION OF THE GAMBLER'S RUIN PROBLEM PLAYED OVER NETWORKS

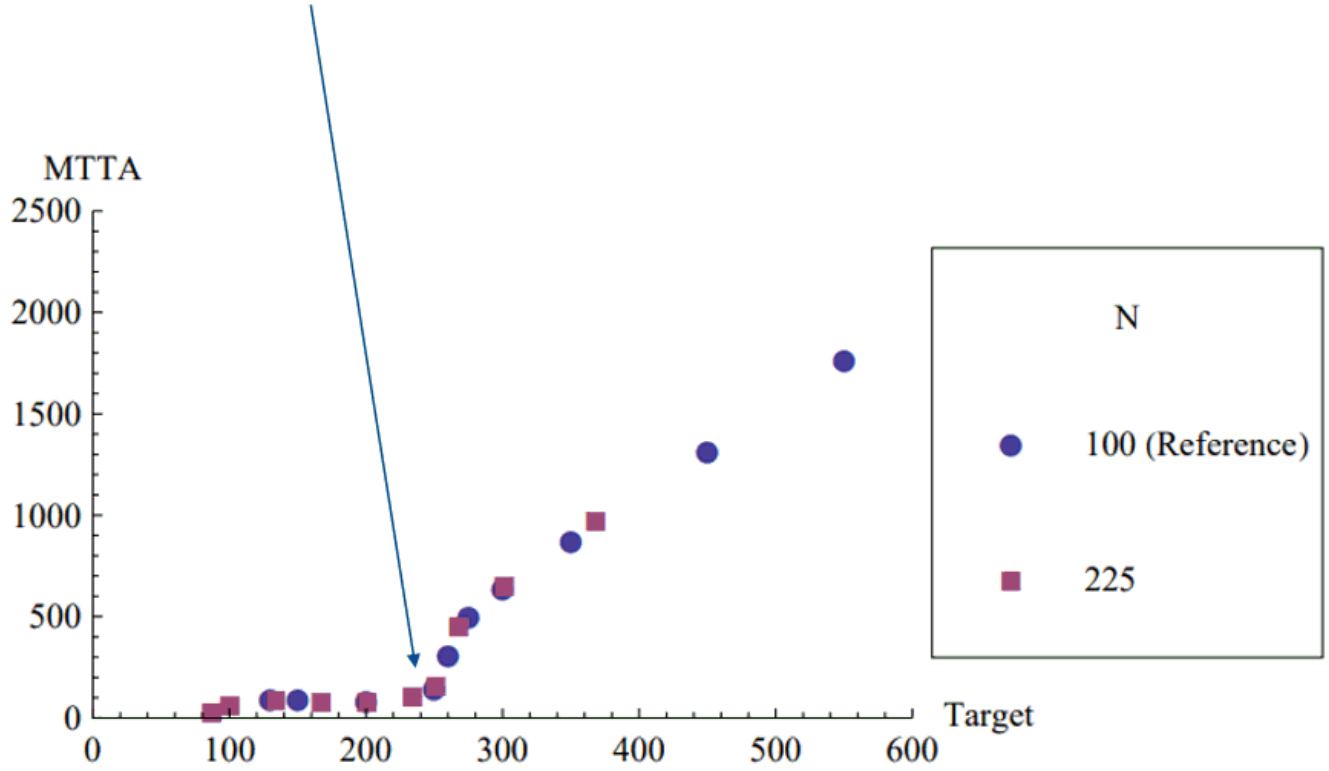
THE THESIS IS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE DOCTOR OF PHILOSOPHY OF THE UNIVERSITY OF PORTSMOUTH.

December 30, 2013

By
Nira Chamberlain

Department of Mathematics

What influences the position of the Critical target



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Analytical approximation and Numerical Simulation

$$N\frac{I}{T} \times (C-1) \times k = T - I. \tag{5.3.2}$$

The variables are:

N - the initial size of the network.

I - the initial resources of each player.

T - the target for each player.

C - the number of offspring of an achiever.

k - the degree of the offspring player.

$T - I$ - the estimated size of the kudos population. There is the assumption that

Rearranging the above expression, the critical target can be approximated by:

$$T^* \approx \frac{1}{2} \times \left(I + \sqrt{I^2 + 4 \times N \times I \times (C-1) \times k} \right). \tag{5.3.3}$$

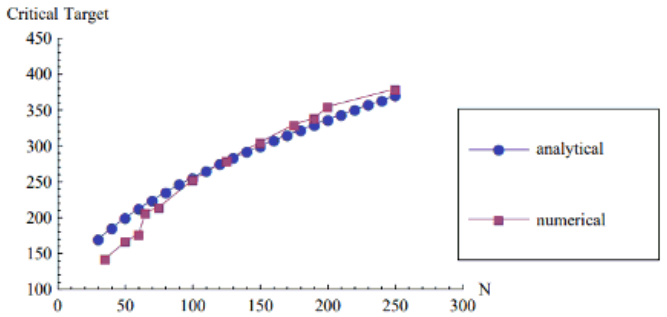
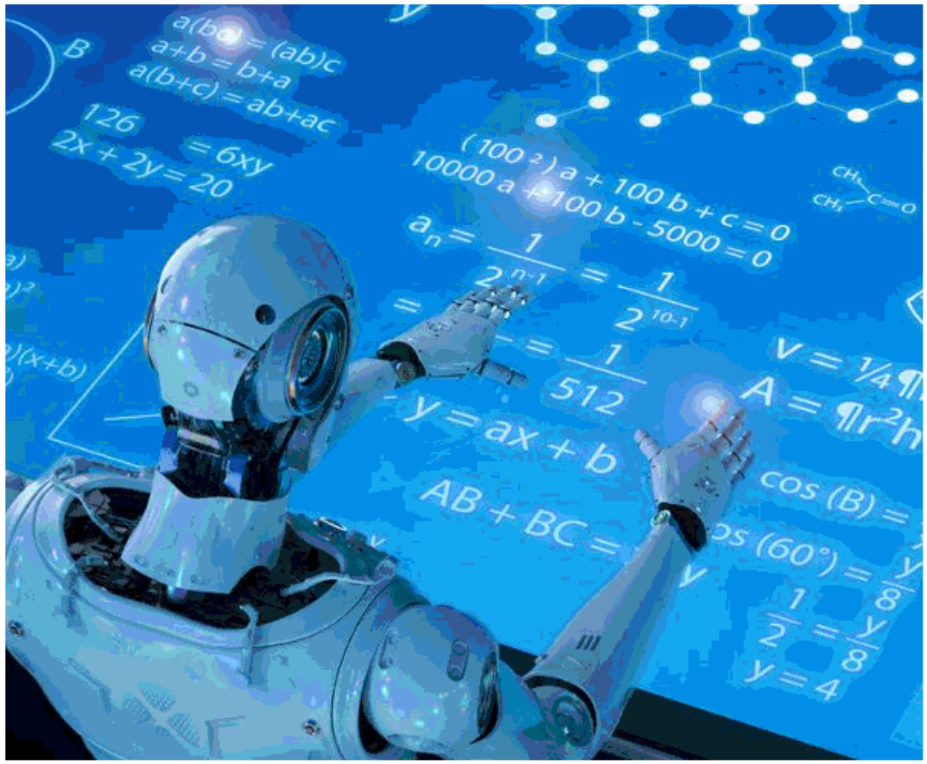


Figure 75: Critical target estimate comparison between the numerical simulation model and the analytical approximation. The initial resource is fixed at 100 units; offspring entrance degree =2; 10,000 rounds. Result averaged over 50 histories for the numerical simulation.

However, my academic “friends” were adamant

The rise of data-driven modelling techniques will mean the downfall of OR and Mathematical Modelling eventually



Katherine Johnson on the rise and fall of subjects

"We will always have STEM with us. **Some things will drop out of the public eye and will go away**, but there will always be science, engineering, and technology. And there will always, always be mathematics**…[and operational research]**."

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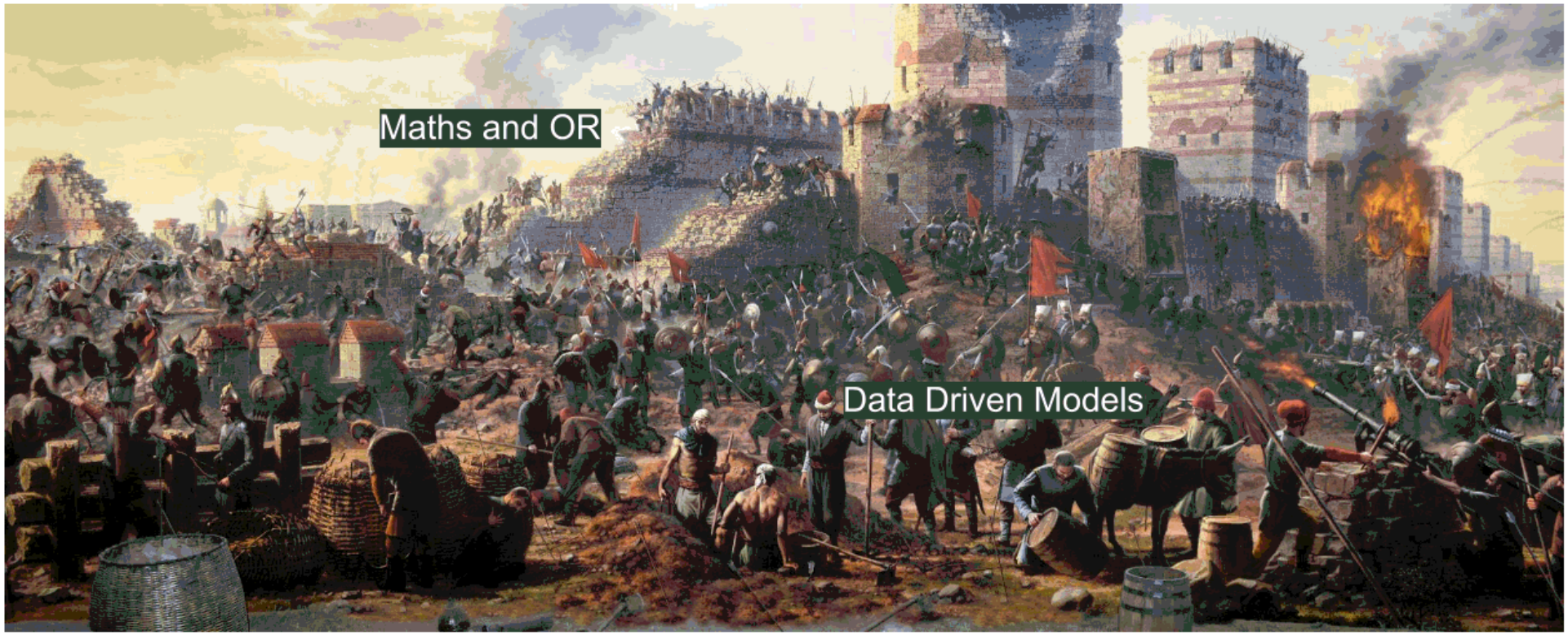
Artificial Intelligence, ML etc…

In an increasing Data Driven world this very much in the public eye and will continue to be so….

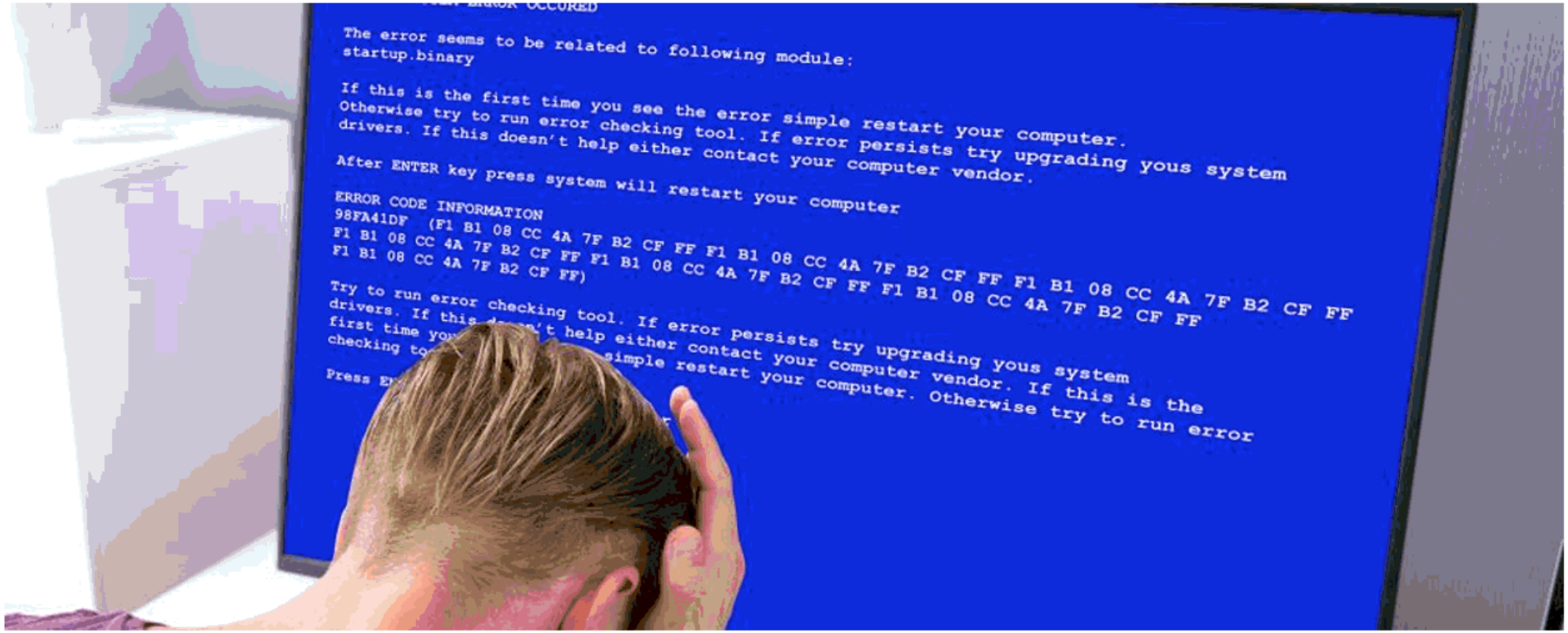
Artificial Intelligence, ML etc…

It is powerful and its potential
is immense!

If our subjects fall – what could happen?



Possibility of Future Real World Applications not being Sustainable



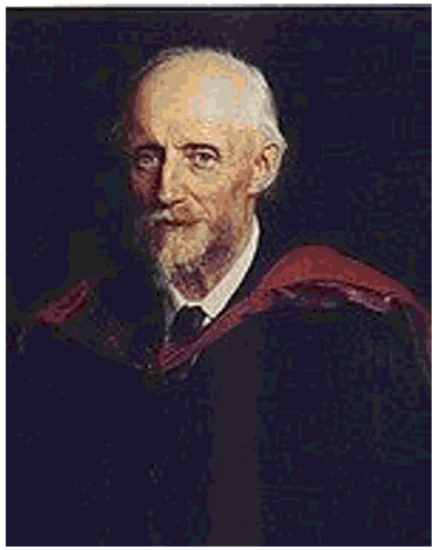
Warning: When the maths can no longer sustain an application Lesson Learnt from the World of Engineering

Many Engineering applications use Mathematics and OR in the right way.

However, when we remove scientific and mathematical foundations in some cases, it could lead to **compromising and/or corruption of the solution.**

The story of the Reynold's Equation

$$\frac{\partial}{\partial x}\left(\frac{\rho h^3}{12\mu}\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial y}\left(\frac{\rho h^3}{12\mu}\frac{\partial p}{\partial y}\right)=\frac{\partial}{\partial x}\left(\frac{\rho h\,(u_a+u_b)}{2}\right)+\frac{\partial}{\partial y}\left(\frac{\rho h\,(v_a+v_b)}{2}\right)+\rho\,(w_a-w_b)-\rho u_a\frac{\partial h}{\partial x}-\rho v_a\frac{\partial h}{\partial y}+h\frac{\partial \rho}{\partial t}$$



Osbourne Reynolds

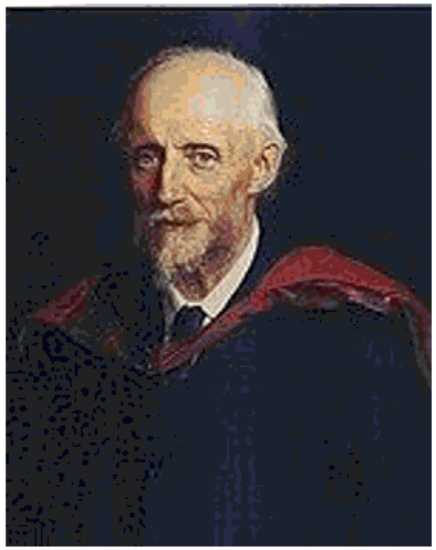
Piston Dynamics & Lubrication

Personally saw cases where the mathematical and scientific principles were abandoned and the solution were bent and twisted to fit the customer's desired outcome.

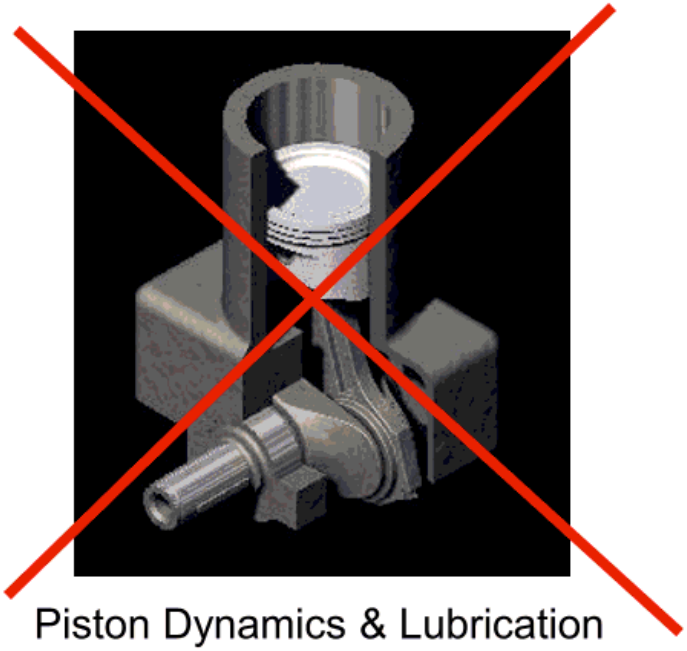
$$Load = \iint p(x,y)dxdy$$

The story of the Reynold's Equation

$$\frac{\partial}{\partial x}\left(\frac{\rho h^3}{12\mu}\frac{\partial p}{\partial x}\right)+\frac{\partial}{\partial y}\left(\frac{\rho h^3}{12\mu}\frac{\partial p}{\partial y}\right)=\frac{\partial}{\partial x}\left(\frac{\rho h\,(u_a+u_b)}{2}\right)+\frac{\partial}{\partial y}\left(\frac{\rho h\,(v_a+v_b)}{2}\right)+\rho\,(w_a-w_b)-\rho u_a\frac{\partial h}{\partial x}-\rho v_a\frac{\partial h}{\partial y}+h\frac{\partial \rho}{\partial t}$$



Osbourne Reynolds

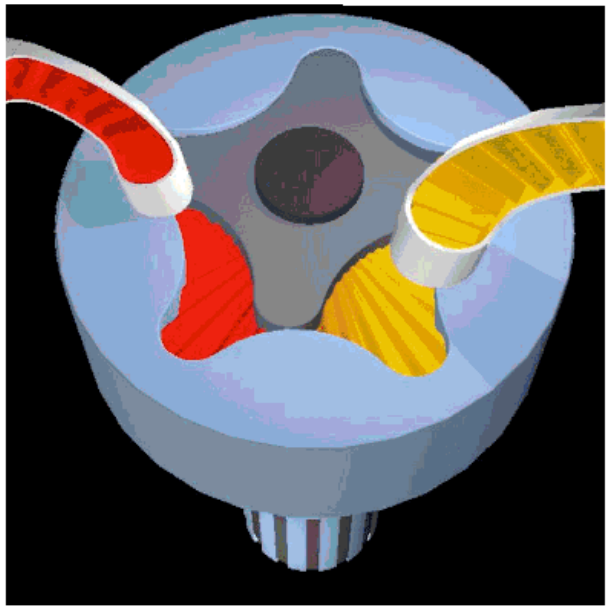


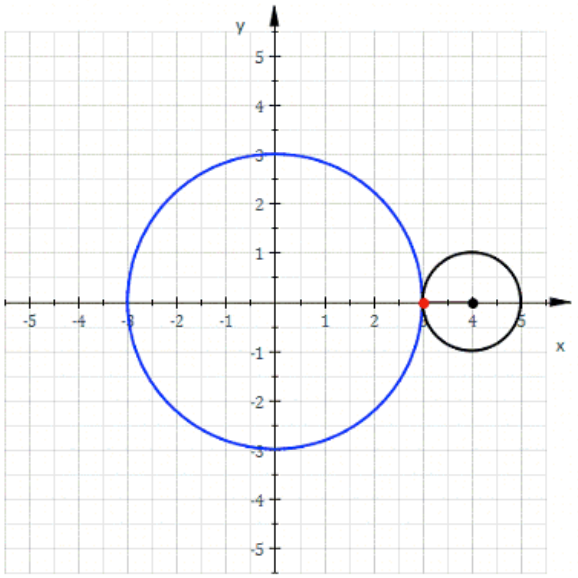
Piston Dynamics & Lubrication

Personally saw cases where the mathematical and scientific principles were abandoned and the solution were bent and twisted to fit the customer's desired outcome.

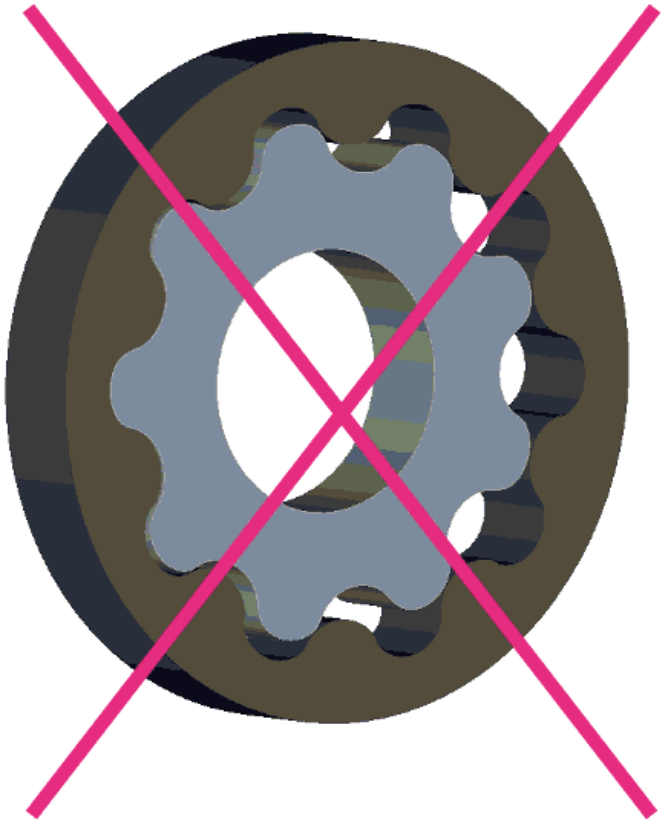
$$Load = 100 \times \iint p(x,y)dxdy$$

Designing a Gerotor and the misuse of Vector analysis





$$x(\theta) = r(k+1)\cos\theta - r\cos((k+1)\theta)$$
$$y(\theta) = r(k+1)\sin\theta - r\sin((k+1)\theta).$$



The science of better decision making in a complex world

The Science of Better

Using Professor G. Keith Still's principles there are three Modelling Outcomes:

The Science of Better

Using Professor G. Keith Still's principles there are three Modelling Outcomes:

To understand

The Science of Better

Using Professor G. Keith Still's principles there are three Modelling Outcomes:

To understand

To predict

The Science of Better

Using Professor G. Keith Still's principles there are three Modelling Outcomes:

To understand

To predict

To influence

But for certain Data-driven methodologies

Using Professor G. Keith Still's principles there are three Modelling Outcomes:

~~To understand~~

To predict

To influence

Using a Data Driven AI Tool that predicts, influences but we do not understand the problem

Involves a lot of calculations.

These calculations can go into many layers of depth with

different numbers and combinations of numbers carrying various meanings.

- Answer questions concerning job and career choices
- Offer in-depth personal analysis of personality and behaviour patterns
- Discuss the trend of events to come
- Assist with personal growth and self-evaluation
- Propose a selection of dates for special events
- Help to choose a professional name, business name, or stage name

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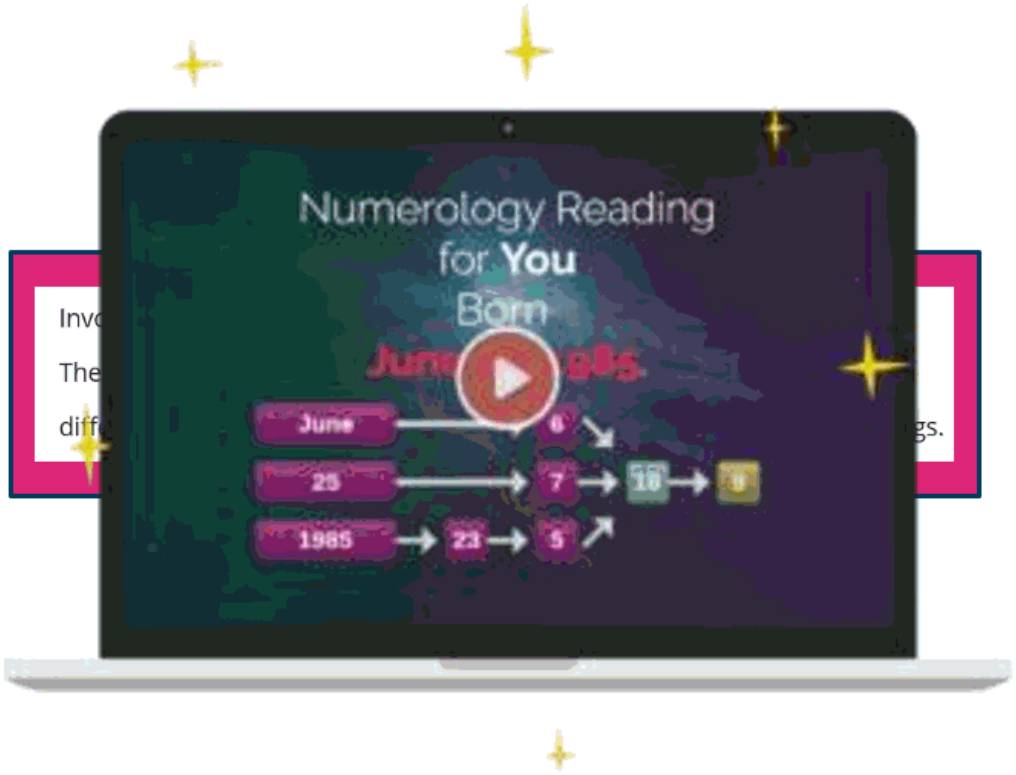
No it is a Numerology Tool!



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Prediction without Understanding

Data Driven Modelling

1. Collect data
2. Make Predictions
3. To Influence Outcome

Numerology

1. Collect Data
2. Make Predictions
3. To influence Outcomes

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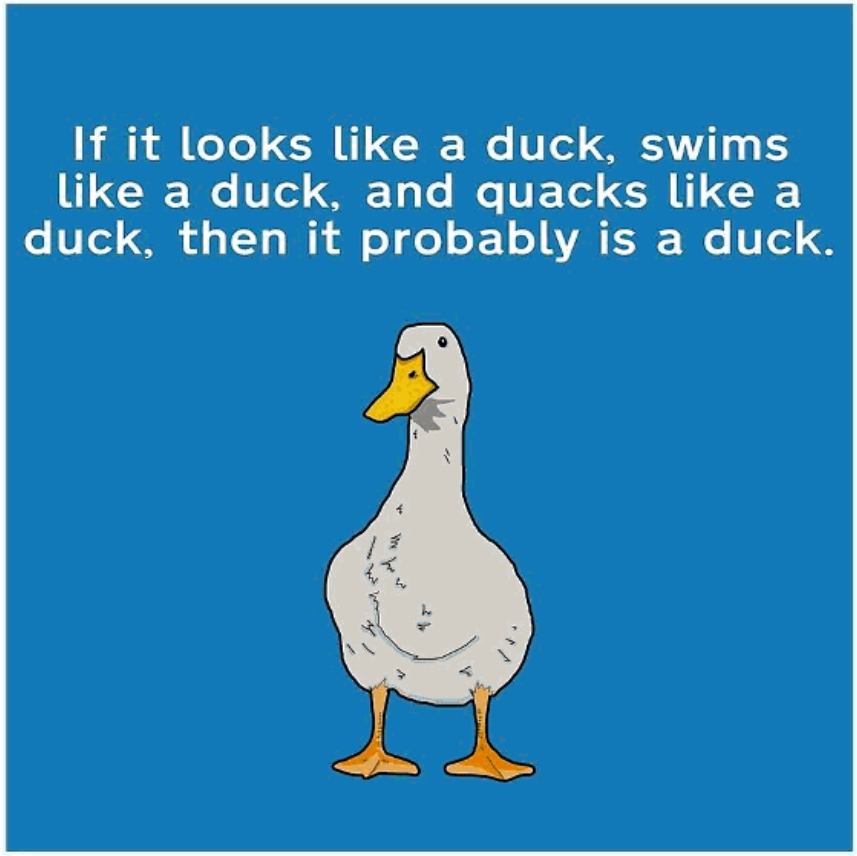
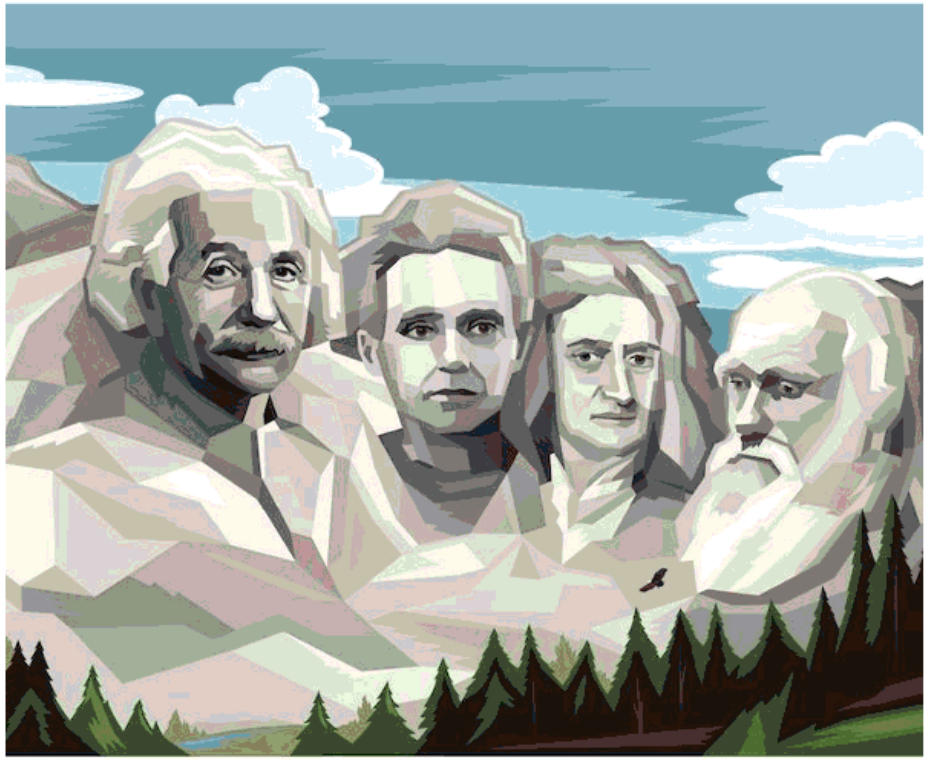
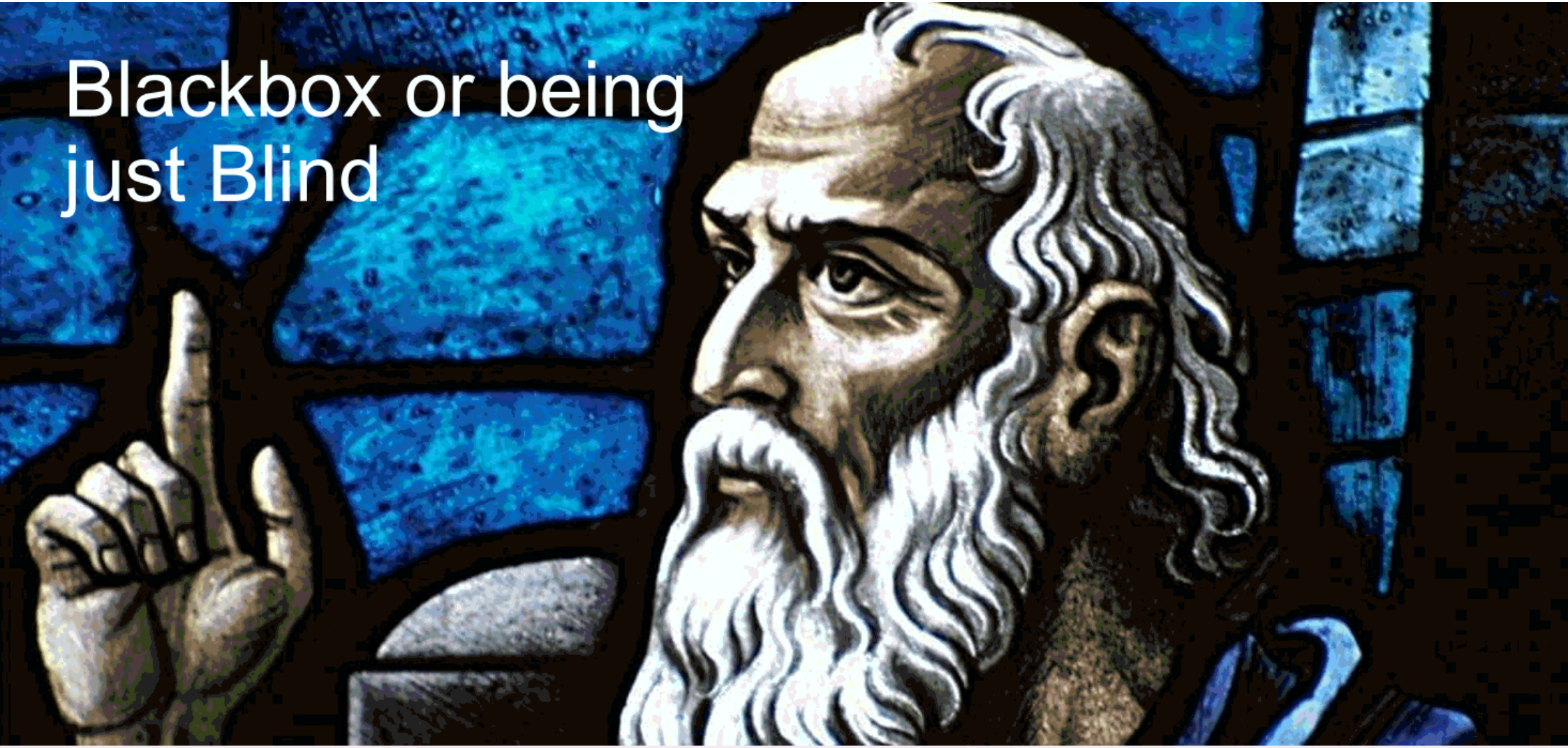

If it looks like a duck, swims like a duck, and quacks like a duck, then it probably is a duck.

In an increasing Data Driven World which direction do we wish to move more towards



Blackbox or being just Blind



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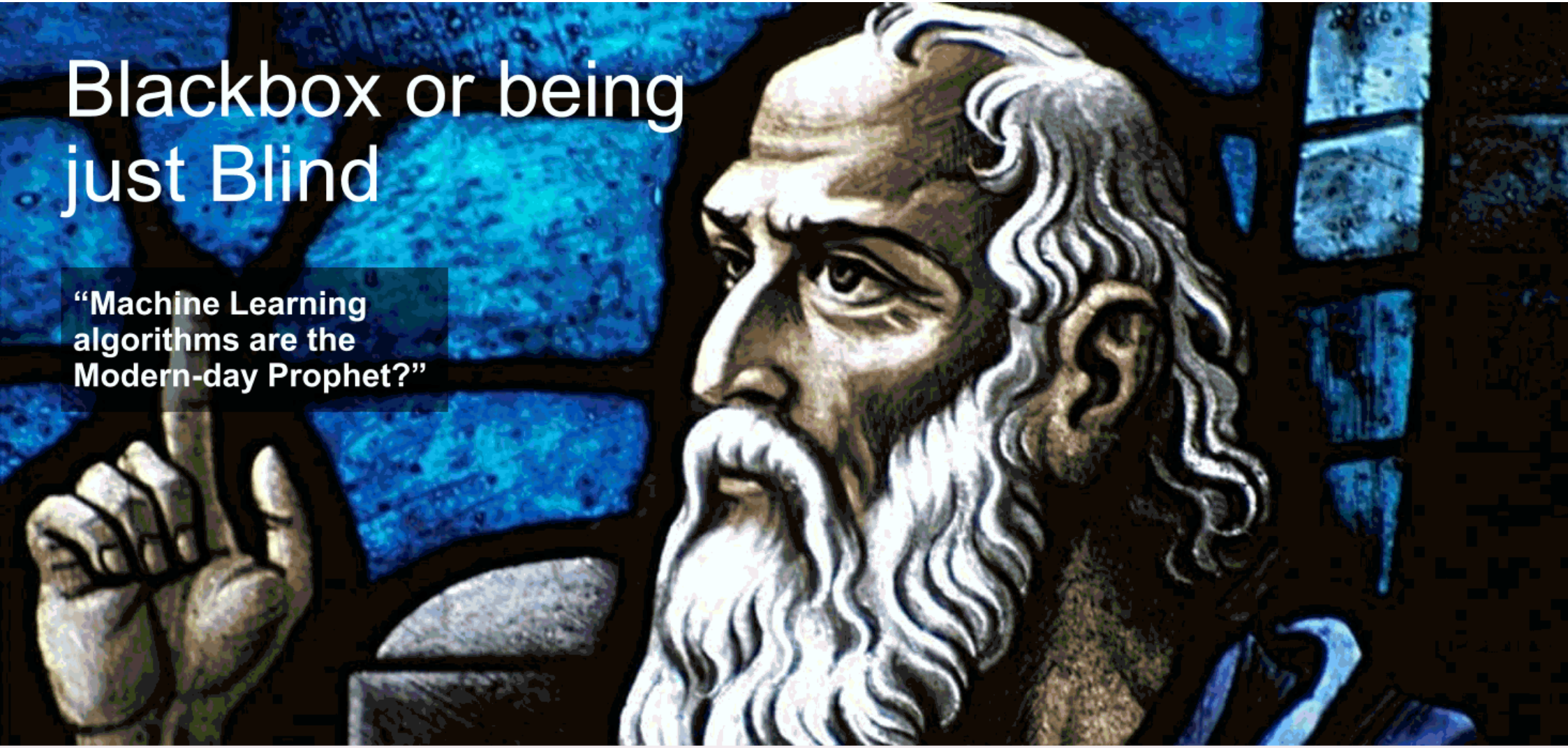
Blackbox or being just Blind



“Machine Learning algorithms are the Modern-day Prophet?”

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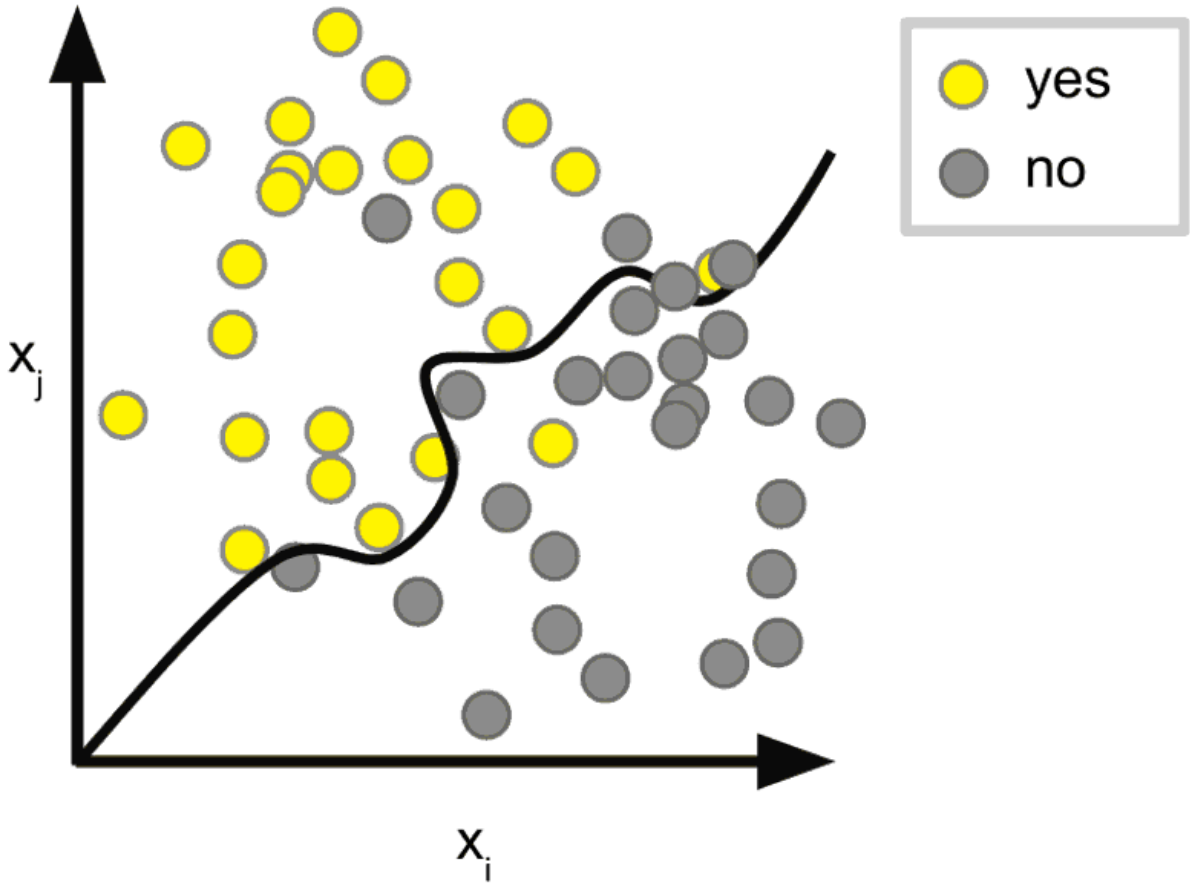
Classifications

Retail Business Blackbox advocate wanted to use a new AI algorithm to do classifications

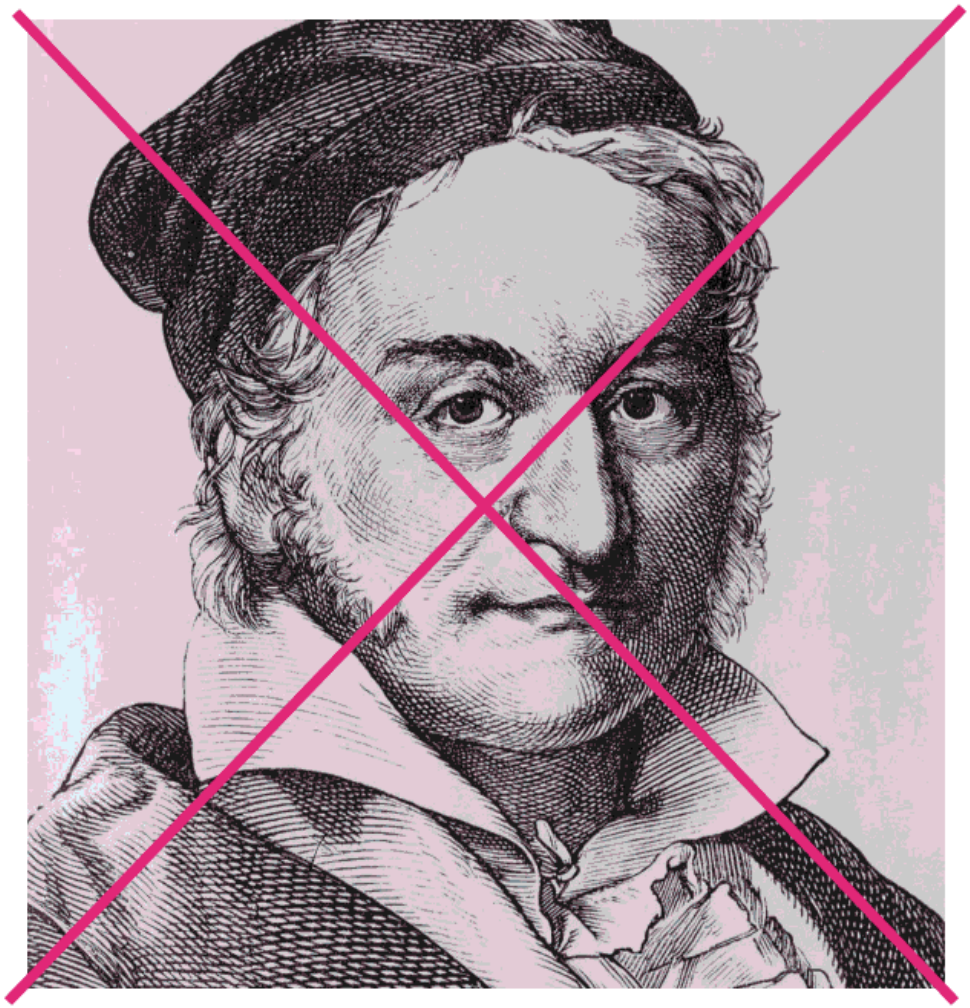
Challenge – I understood the underlying mathematics I wasn't sure that the objectives were achievable

Decided to run with the AI algorithm but undertake a statistical test of the results



Carl Friedrich Gauss

Carl Friedrich Gauss



"Well Gauss is wrong!"

- Machine Learning Expert

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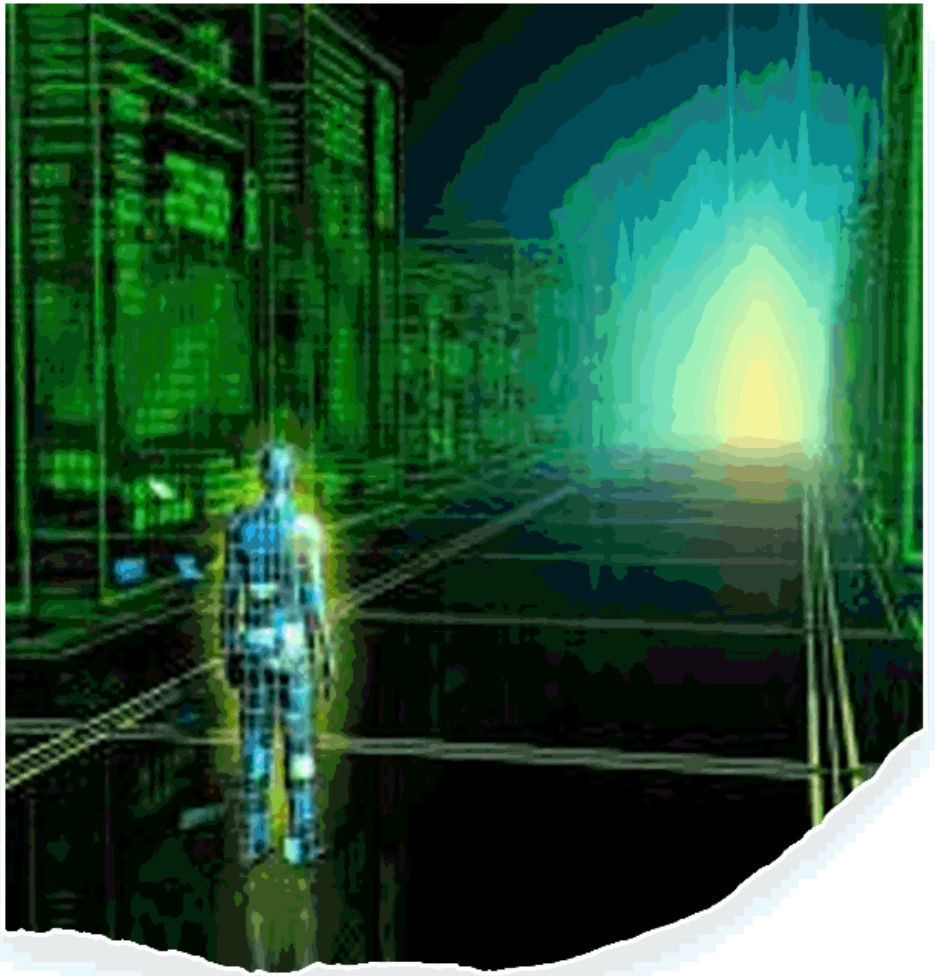
In an Increasing Data-Driven World

The role of OR and Mathematical modelling is not to decline

NO

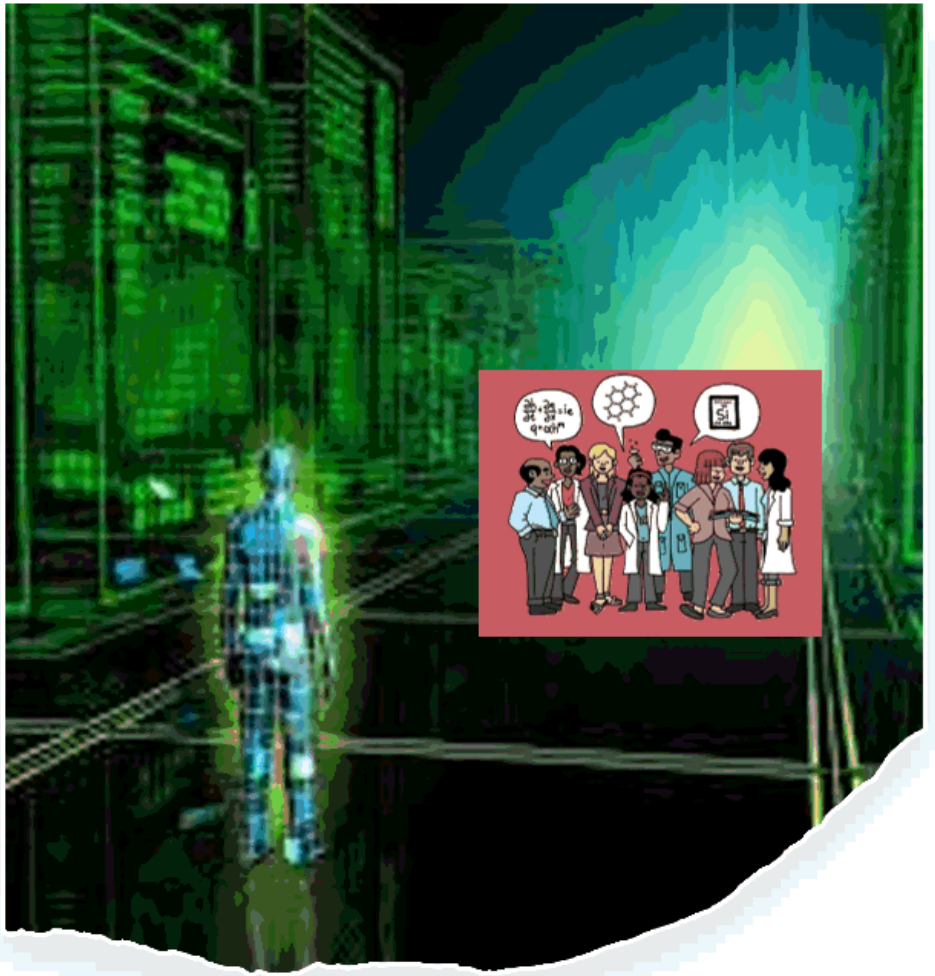


In an Increasing Data-Driven World

The role of OR and Mathematical modelling is not to decline

NO

But to become the Strategic Modellers and the Scientists in the room!



May 2017 - When AlphaGo beat the Go World Champion

Everybody talked about the Deep Learning – Artificial Neural Network algorithm

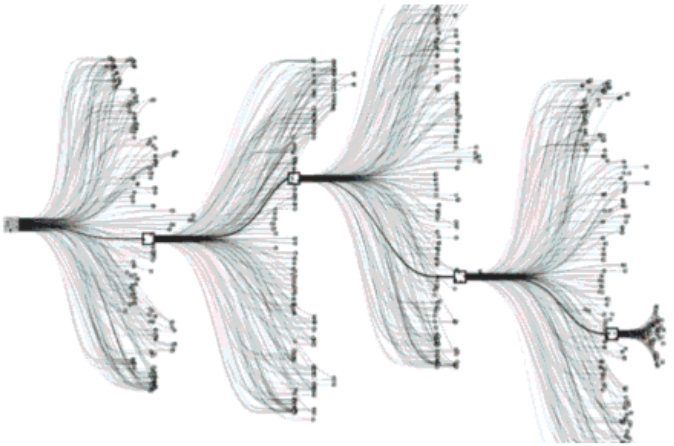
May 2017 - When AlphaGo beat the Go World Champion

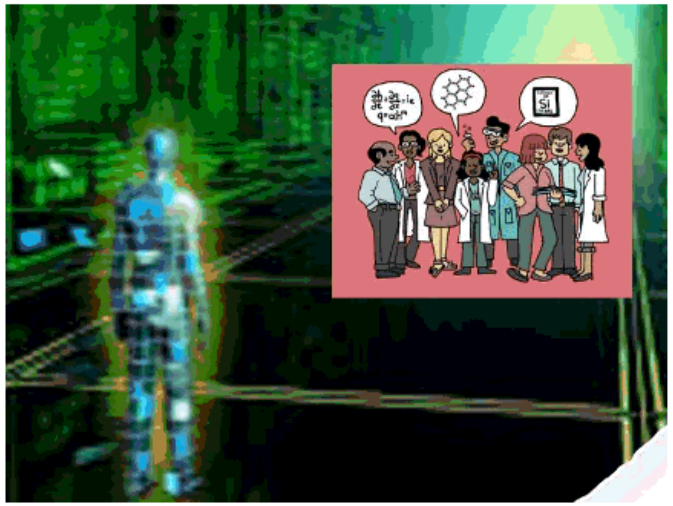
Everybody talked about the Deep Learning – Artificial Neural Network algorithm

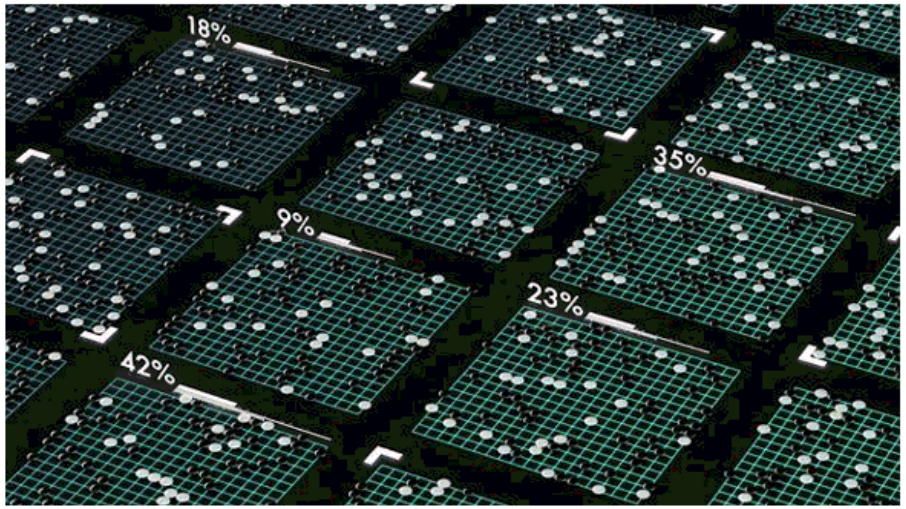
But what about the OR modelling that was also part of the algorithm?

Monte-Carlo Tree Search

It would have been near impossible for AlphaGo to beat the World Champion purely on Machine Learning and **without OR mathematical algorithm**







Before Uber: Case Study – The Dynamical Travelling Repairperson

Professor Nira Chamberlain CMath CSci FIMA FORS OBE
Atkins Technical Fellow for Mathematical Modelling

ATKINS
Member of the SNC-Lavalin Group

Before Uber – The Contract

The contract stipulates that 80% of problem that occurs any where in the world must be resolved within 48 hours

Before Uber - Question

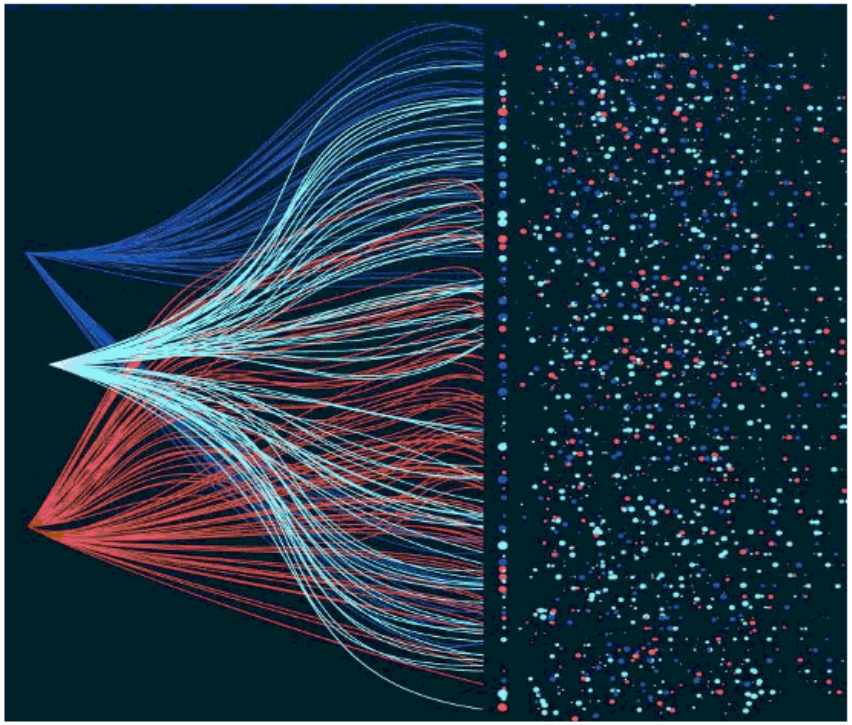
How many Engineers do we need in order to reach a problem any where in the globe within 48 hours and where should they be located?

Before Uber - Question

How many Engineers do we need in order to reach a problem any where in the globe within 48 hours and where should they be located?

The answer is not infinity and everywhere!

After Uber – Hidden Pattern



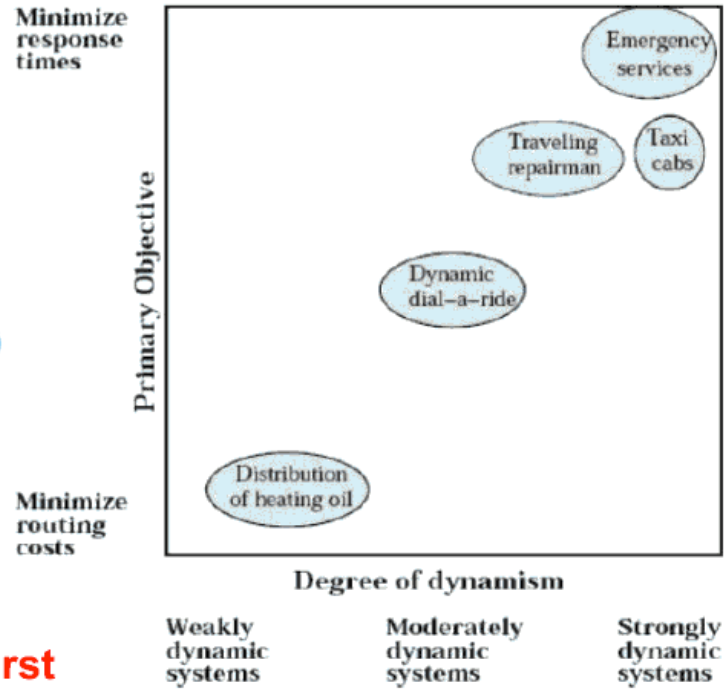
Before Uber – The Hidden Logic

The Dynamic Travelling Repairperson

The Dynamic Repairperson Problem

Variation on the Travelling Salesperson Problem

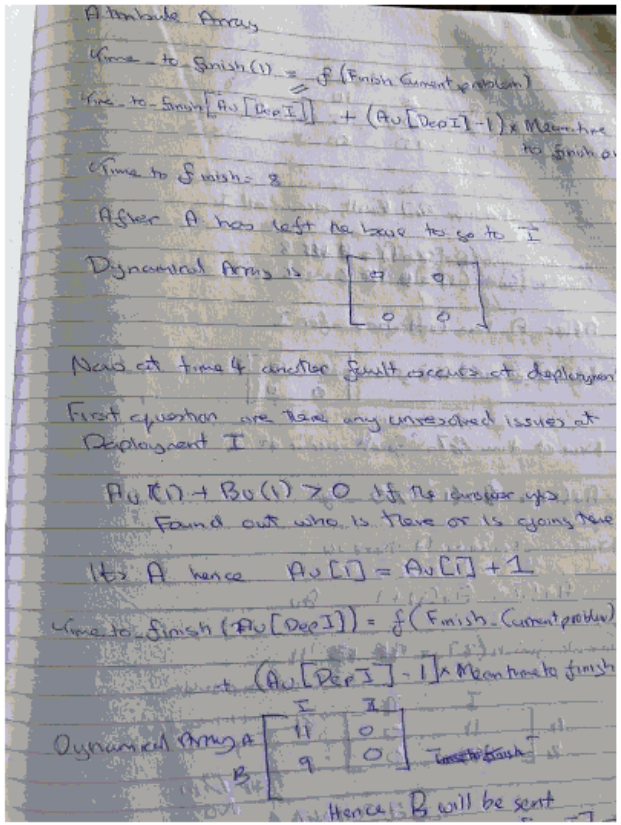
Looking to minimize time as oppose to distance.

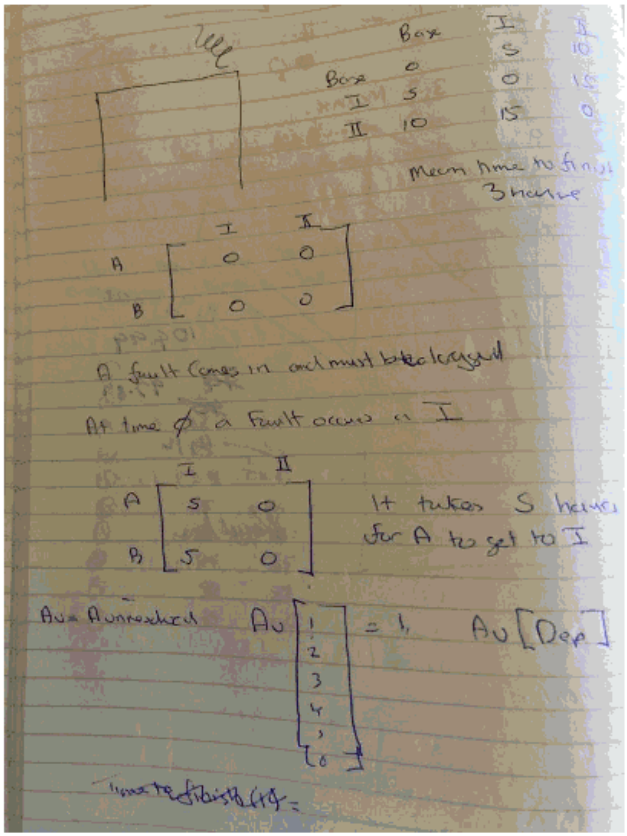


The Rule

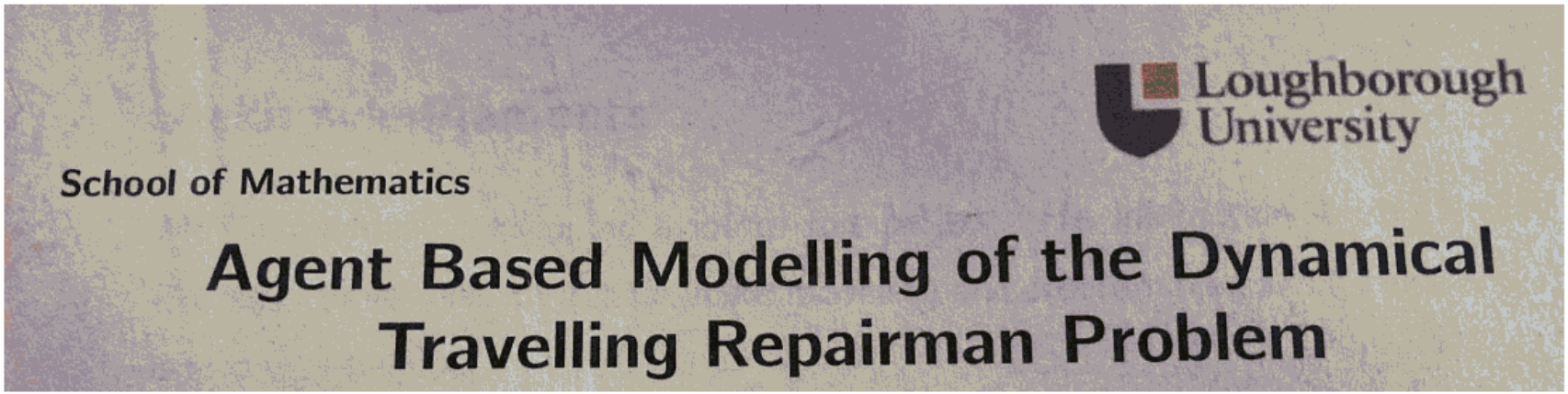
The Engineer out of all the Engineers who can start the job first gets the job!

Before Uber – Hidden Logic





Inspired MSc Projects



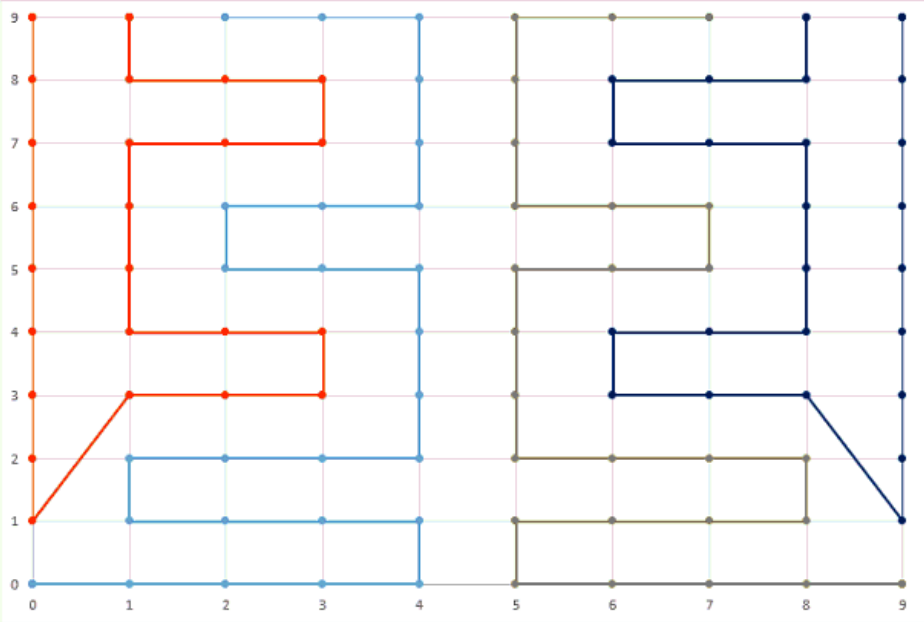
Outreach

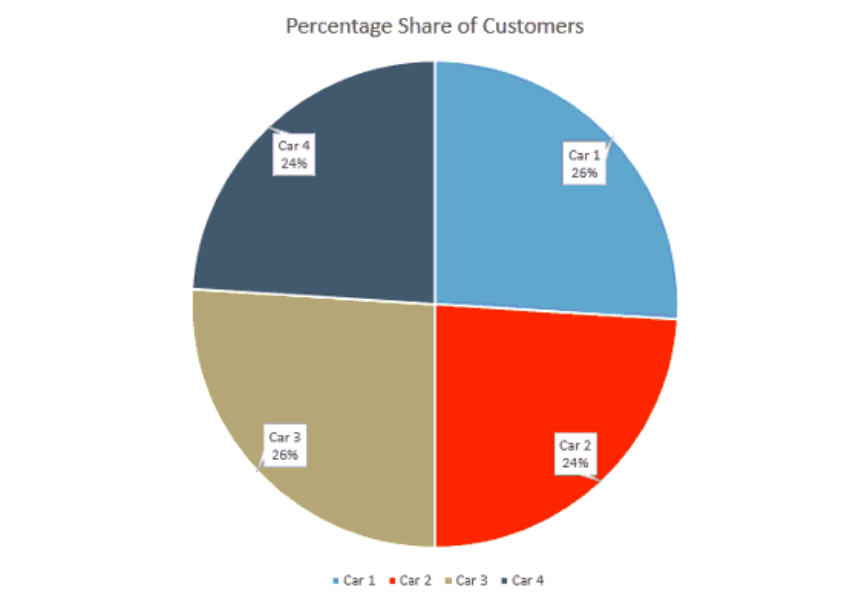
Status	Car 1	Car 2	Car 3	Car 4
Shift start	12	12	12	12
Base X location	0	0	9	9
Base Y location	0	9	0	9

Timestart		
0		

Simulation

Reset





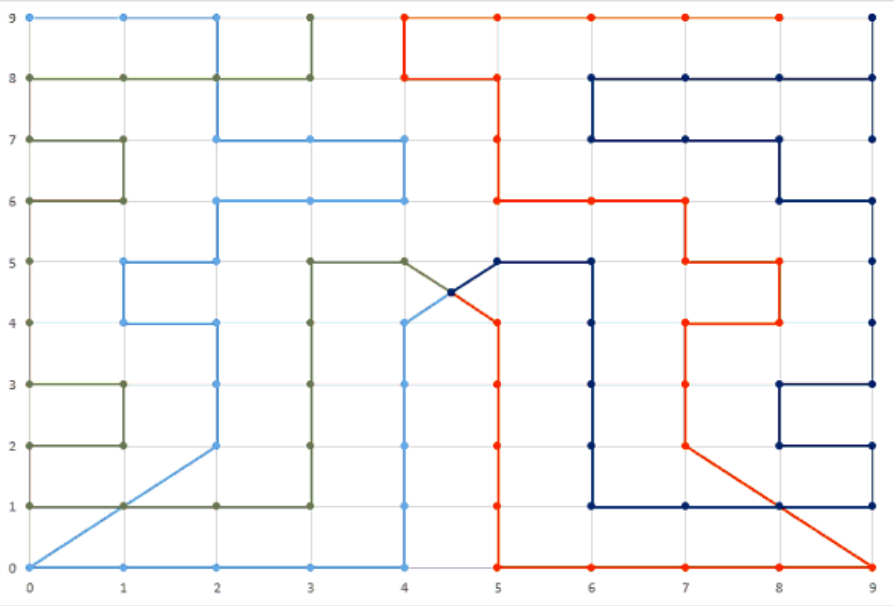
Outreach

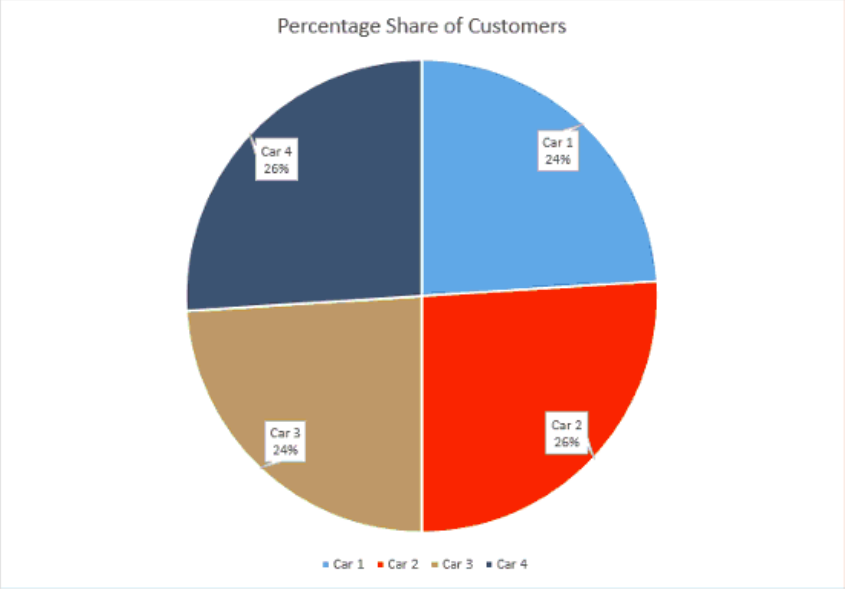
Status	Car 1	Car 2	Car 3	Car 4
Shift start	12	12	12	12
Base X location	4.5	4.5	4.5	4.5
Base Y location	4.5	4.5	4.5	4.5

Timestart		
0		

Simulation

Reset





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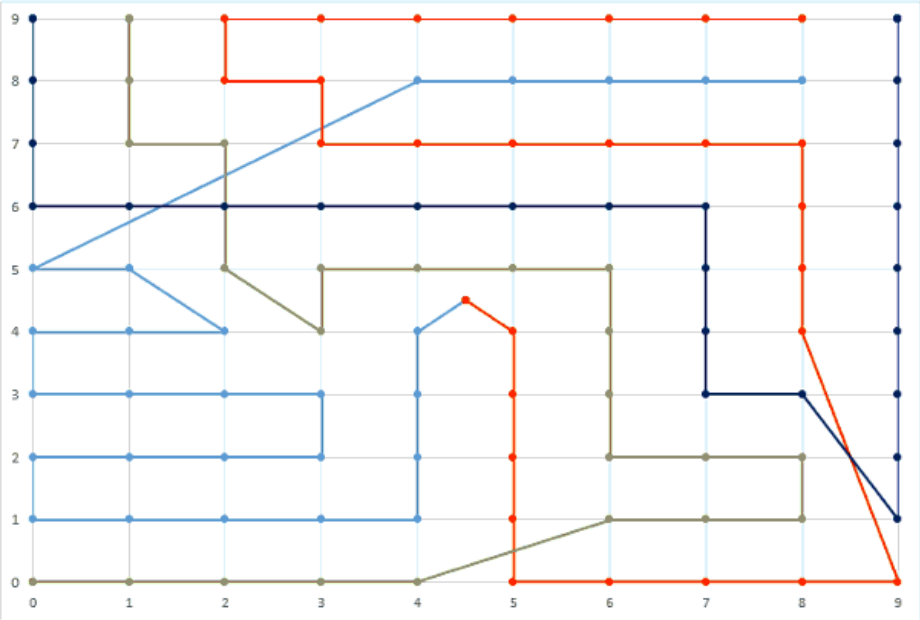
Outreach

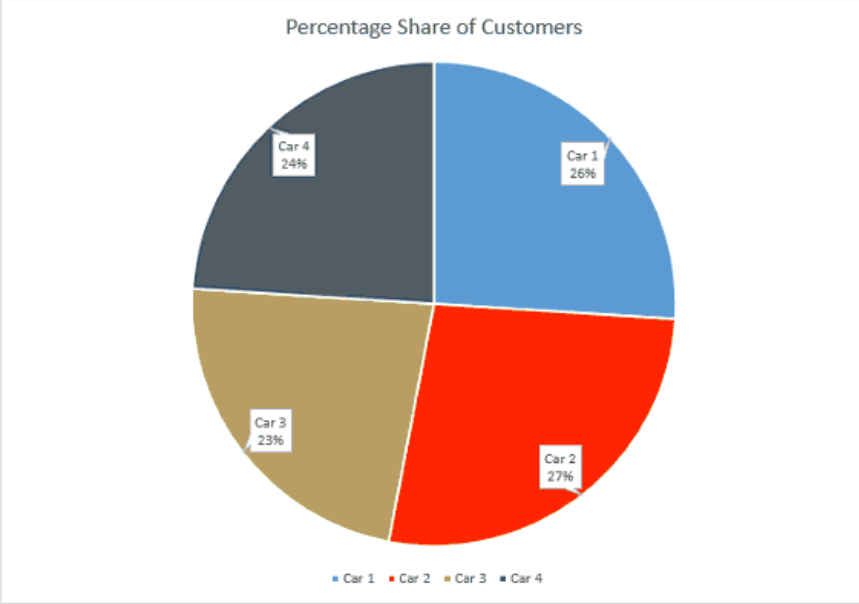
Status	Car 1	Car 2	Car 3	Car 4
Shift start	12	12	12	12
Base X location	4.5	4.5	0	9
Base Y location	4.5	4.5	0	9

Timestart		
0		

Simulation

Reset





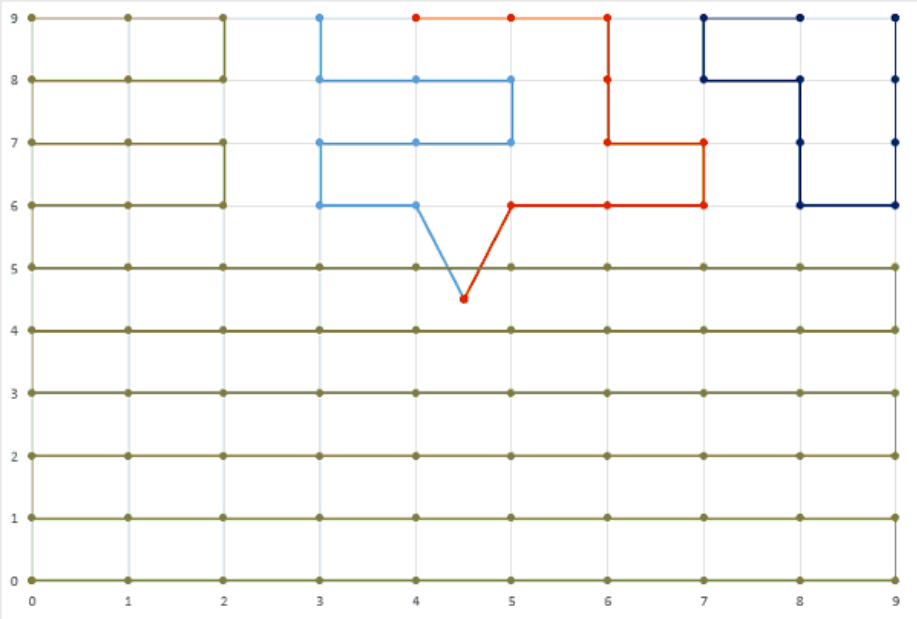
Outreach

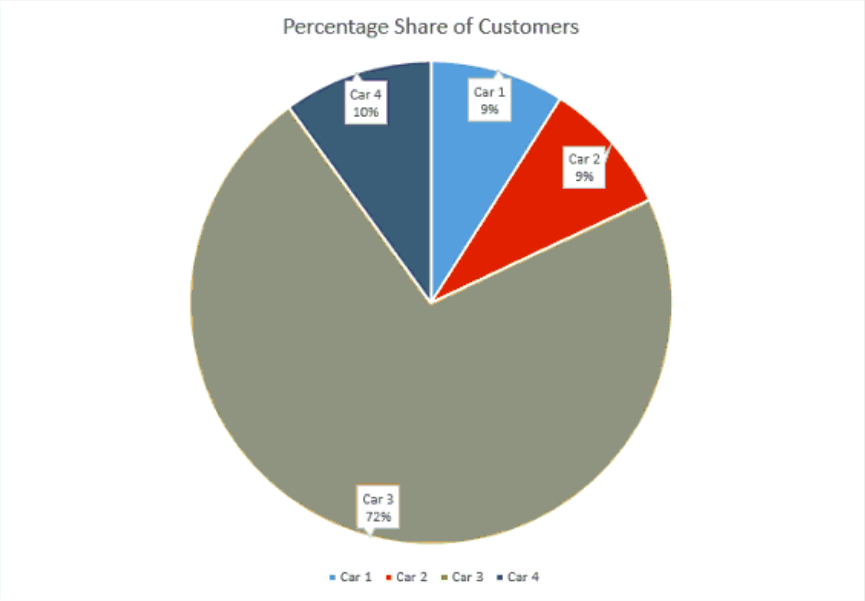
Status	Car 1	Car 2	Car 3	Car 4
Shift start	12	12	10	12
Base X location	4.5	4.5	0	9
Base Y location	4.5	4.5	0	9

Timestart		
0		

Simulation

Reset





Agent Based Simulation and Visualisation of Emergency Relief Effort Strategies

By Dr Nira Chamberlain

IMA Conference on Mathematics in Defence 2015

Before Uber - Question

How many Engineers do we need in order to reach a problem any where in the globe within 48 hours and where should they be located?

Before Uber - Conclusion

Depend on the factors but the Dynamic Travelling Repairman is a viable approach that looks for the Hidden Logic not just the Hidden Patterns

Before Uber - Conclusion

Depend on the factors but the Dynamic Travelling Repairman is a viable approach that looks for the Hidden Logic not just the Hidden Patterns

In the original project a 50% saving was realised and we could understand why!

Before Uber: Case Study – The Dynamical Travelling Repairperson

Professor Nira Chamberlain CMath CSci FIMA FORS OBE
Atkins Technical Fellow for Mathematical Modelling

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Alliance for Data Science Professionals

We are defining the standards needed to ensure an ethical and well-governed approach so the public, organisations and governments can have confidence in how their data is used.

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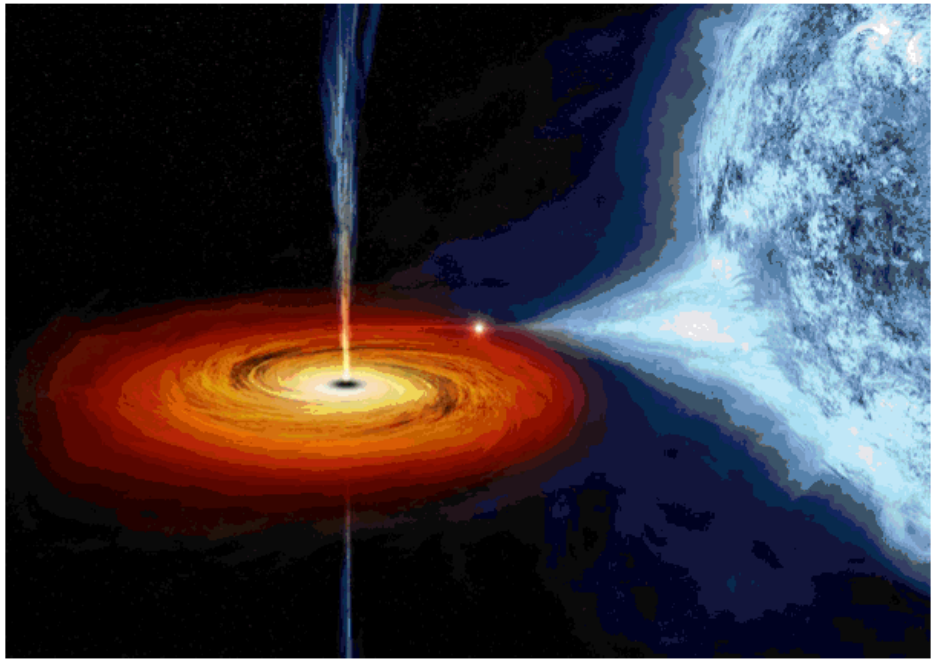
Get yourself certified

We are committed to...

- Defining the standards of professional competence and behaviour expected of people who work with data which impacts lives and livelihoods. These currently include data scientists, data engineers, data analysts and data stewards.
- Delivering these standards as data science certifications offered by the Alliance members to their professional members, with processes to hold certified members accountable for their professional status in this area.

Threat of AI – is the Deskilling of Present and Future Modellers

Pierre-Simon Laplace



Without a Computer, Laplace found the Hidden Logic

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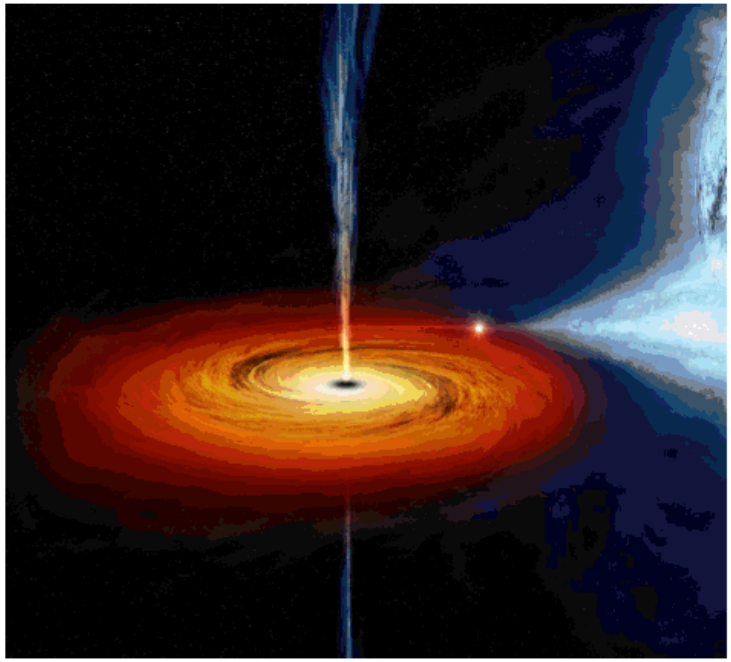
Threat of AI – is the Deskilling of Present and Future Modellers

Pierre-Simon Laplace



But by focusing purely on the Hidden Pattern (AI) do we risk throwing the baby out with the bath water!

Conclusion

The challenges to OR and Mathematical Modelling in the increasing data driven world are real

But ..

We can look at our disciplines USPs and learn lessons from the scientific past to see that our future is bright

If we think strategically.

The Ronnie Shephard Memorial Address
Before Uber:

Professor Nira Chamberlain CMath CSci FIMA FORS OBE
Atkins Technical Fellow for Mathematical Modelling

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