SWTEST

PROBE TODAY, FOR TOMORROW

2022 CONFERENCE

The Use of AI and Big Data in the Production of Advanced Vertical Guide Plates

Alan Ferguson
Oxford Lasers

June 5 - 8, 2022

Summary

Introduction

Motivation : Towards the Production of Better Guide Plates

(1) The Use of Big Data

- Case Study (Service Interval / Position Accuracy)

(2) The Use of Artificial Intelligence (AI)

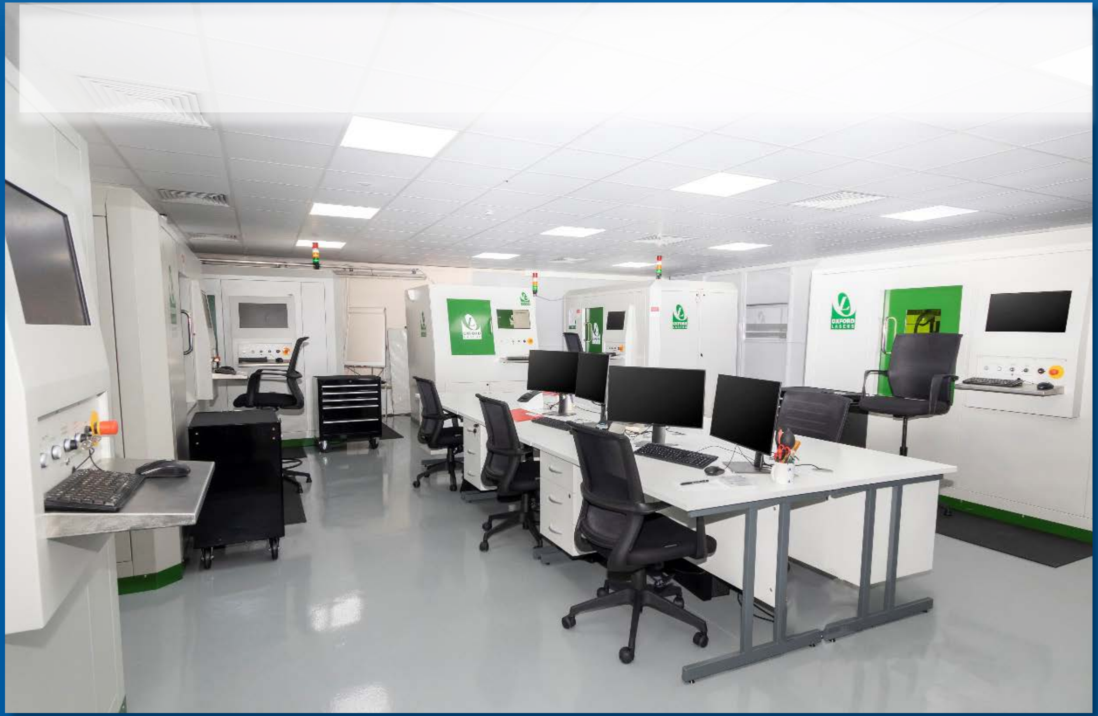
- Case Study (Hole Shape)

Conclusion

Introduction

Oxford Lasers specialize in the manufacture of guide plates :

- Over 20 years experience in guide plate production
- World Class subcontract micromachining facility
- Manufacturer of production laser tools



Laser Micromachining :
Ceramics, Polymers, Metals and Glasses

MOTIVATION

Motivation

Trends in Vertical Probe Cards :

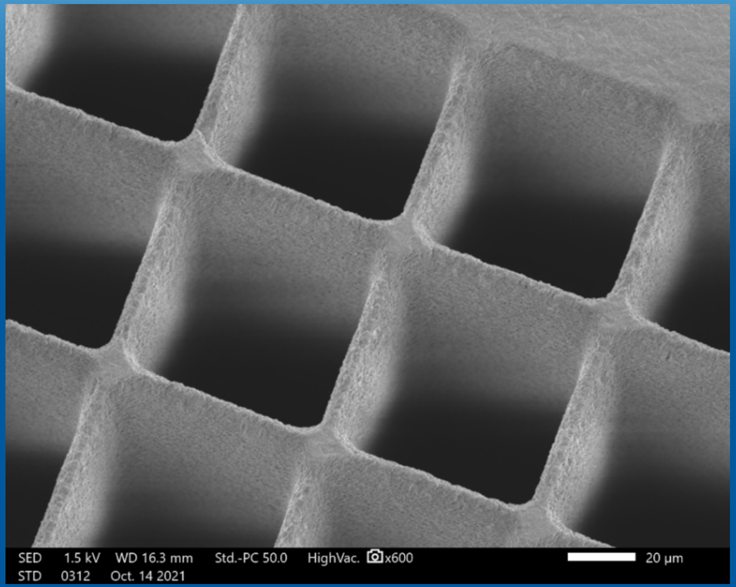
1) Smaller Holes

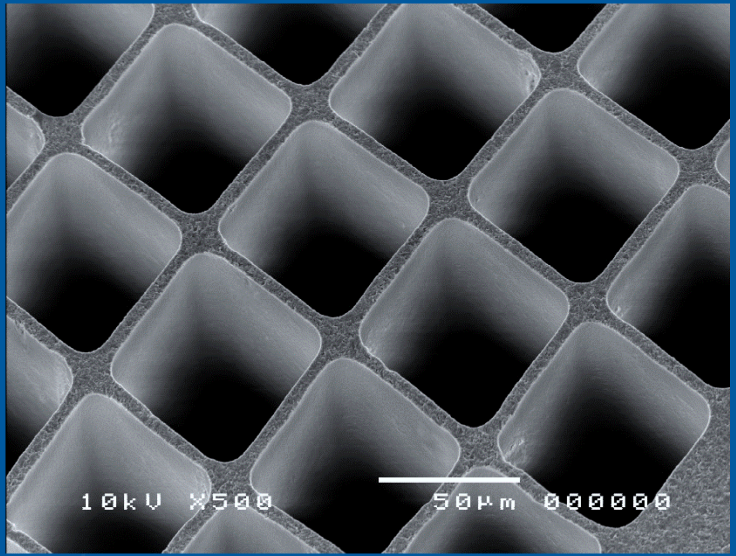
2) Tighter Pitch

The focus of this presentation is the improvement of guide plates for advanced Probe Cards :

- Look at Big Data to improve e.g. position accuracy

- Look at AI to optimise hole geometry and quality





6 microns land between holes

THE USE OF BIG DATA

What is Data Science ?

decision
mean
machine
number
training
processing
tasks
supervised
data
google
models
statistics
neural
learning
ai
machine
applications
algorithms
k-means
techniques
tensorflow
classification
functions
clusters
intelligence
deep
step
optimisation

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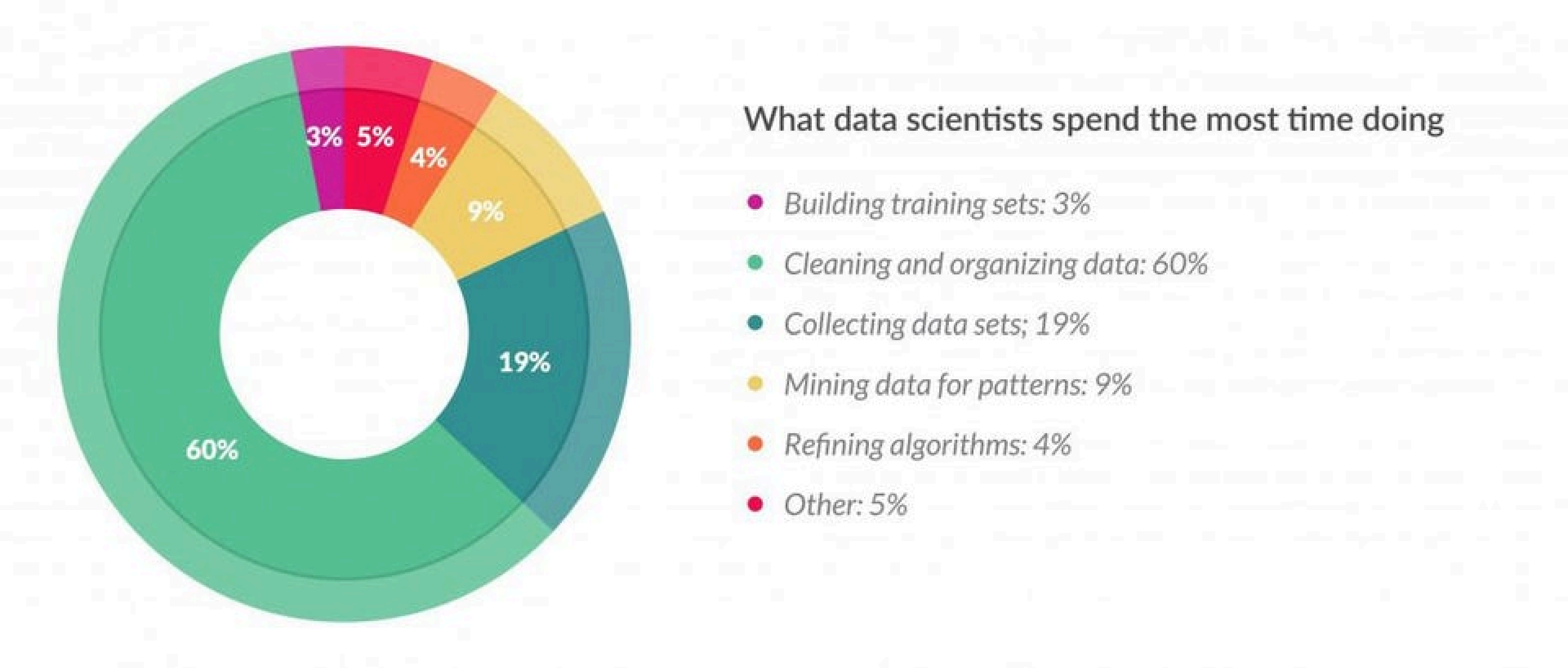
What is Data Science?



Cleaning Big Data : → Most Time Consuming, Least Enjoyable

Getting and Organising Data is 82% of the task

Source : Forbes 2016

Swamps, Lakes and Warehouses

Just because the data is stored - doesn't mean the job is complete

Swamps

Even though the data exists, the data swamp cannot retrieve the data without contextual metadata

Lakes

Any large data pool with undefined schema and data requirements

Warehouses

The data warehouse combines data into an aggregate, summary form, suitable for company-wide data analysis and reporting, tailored to business needs.

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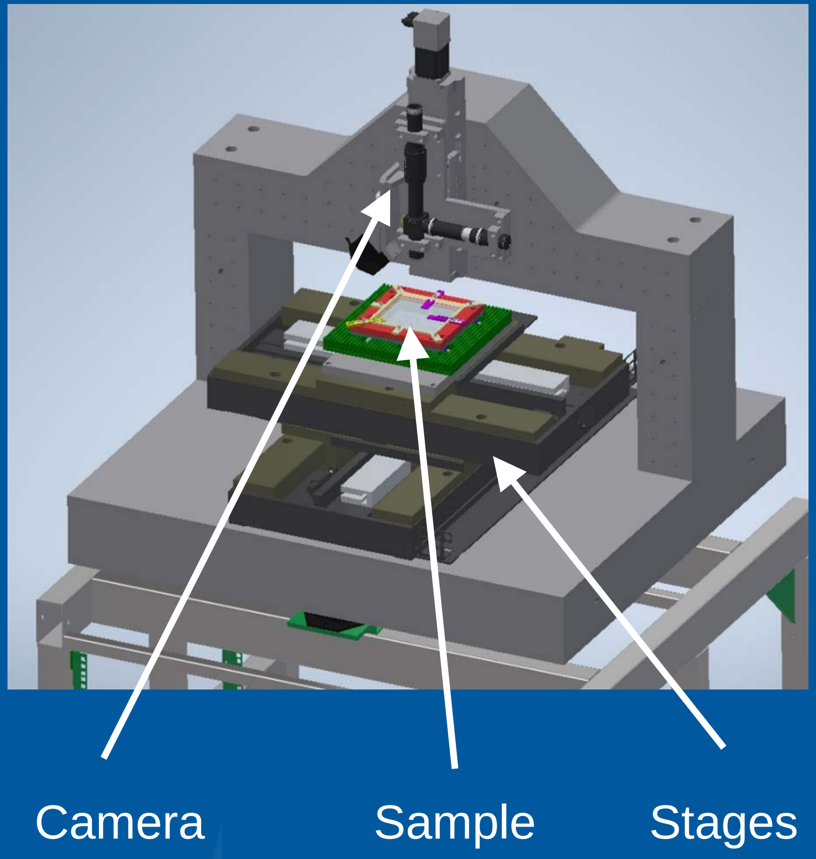
Getting the Data: Oxford Lasers CMM

- External vendors couldn't provide the level of control on the measurement that was required

- Therefore, a custom in house system was developed

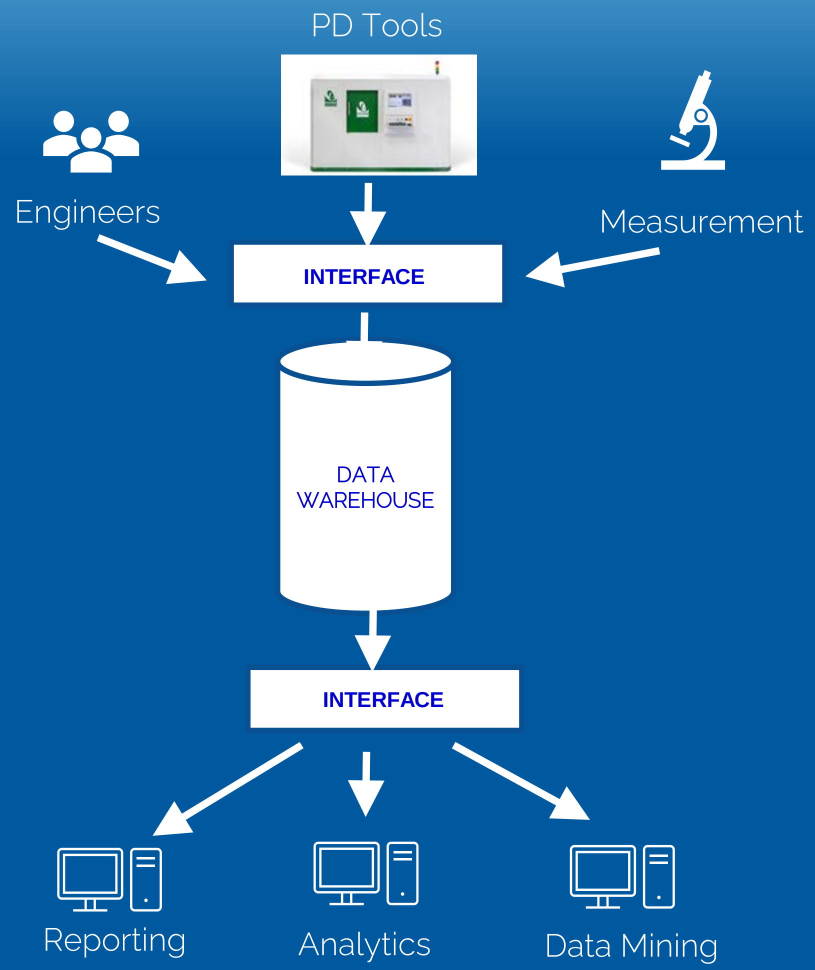
- Interacts with our Data Warehouse



Data Warehouse

Goal: Minimize the time spent gathering data and maximise the time analysing data

- CMM connected with the Data Warehouse.
- All measurements from the CMM are stored on an internal server.
- Web Portal built on top of the Data Warehouse



This data is used to inform the business's continuous improvement of processes and ensure that quality and precision are maintained.

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Current Uses of the CMM / Data Warehouse

Enables 100% hole inspection - hole size, position, hole shape... etc.

Can access any record easily

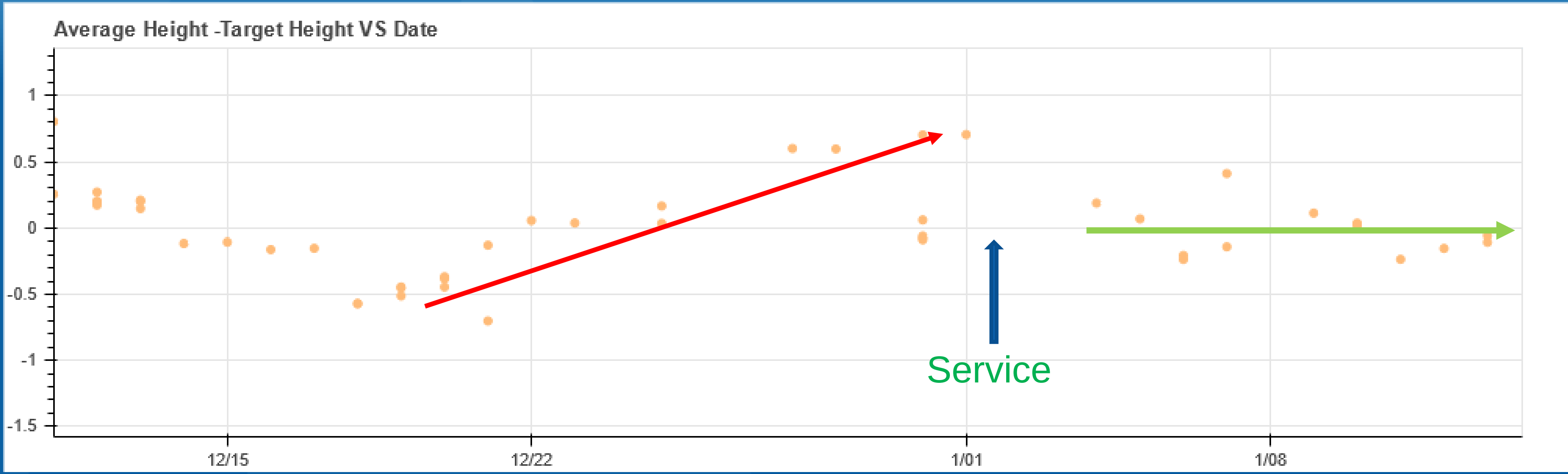
Inspect data for historical trends which can be used to inform service cycles

Used for recipe development - significantly speeding up the feedback loop between experimentation, results and analysis

Production algorithm improvement and verification

Optimisation of warm up cycles and machine utilisation

Case Study 1 : Laser Tool Servicing



Average Hole Height of holes Machined - Target Hole Height Vs Time for a single Drilling Tool.

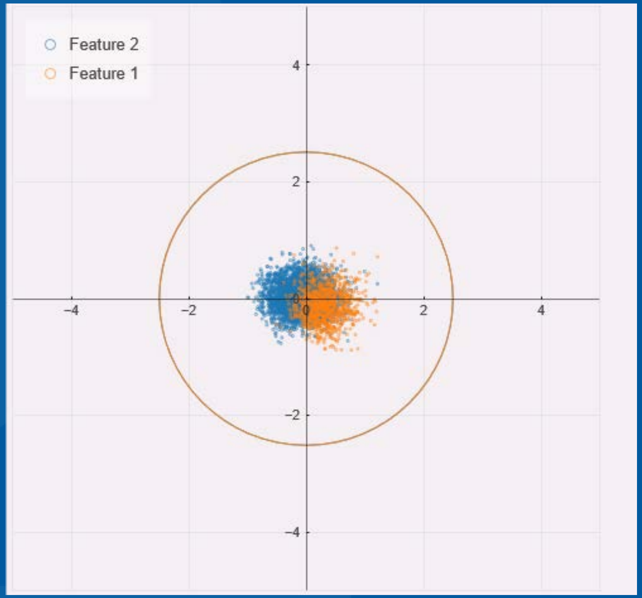
From around mid December a steady trend of rising difference between average and target hole height (red arrow) was observed - Indicating a system service was due.

Service carried out and this trend flattens out.

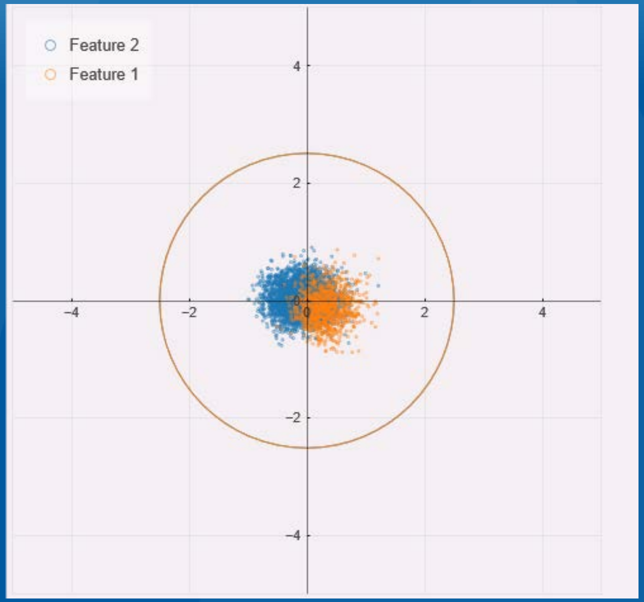
Data is based on multimillion data points taking ~20 seconds to generate

Case Study 2 : Optimisation

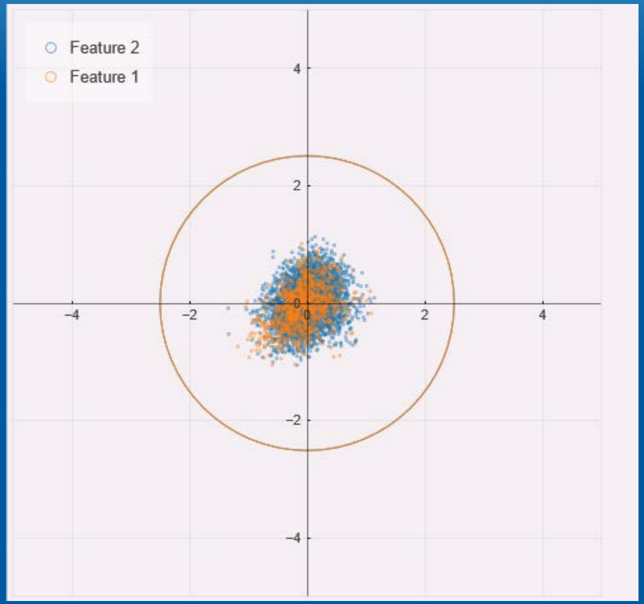
- Analysis of parts showed that the mean position error of two features were off by around 400 nanometres.
- Organisation of historical data allowed an investigation to be carried out quickly.
- Analysis suggested a single parameter tweak of a few precent.



Improving Positional Accuracy



Initial Recipe



Overlapping Spread

However : Position Error Standard Deviation increases from 244nm to 357nm

Pushing one performance metric down can
push another metric up !

We acknowledge part funding from Innovate UK, programme LAND, no. 52009

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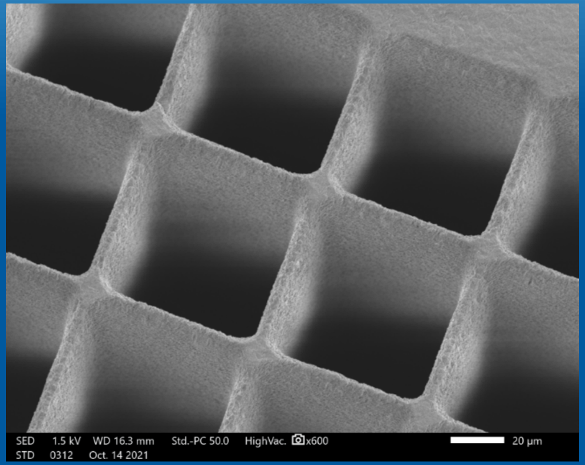
THE USE OF ARTIFICIAL INTELLIGENCE

The Use of Artificial Intelligence

How to Laser Drill the Perfect Hole ?



This can lead to optimising

a) Multiple parameters (e.g. laser power etc)
b) Multiple values of these parameters

With 15 parameters and 50 values leads to around 6 x 10^{58} different combinations or

60,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000

different combinations

Drilling 1 billion holes a second would take 1 X 10^{42} years

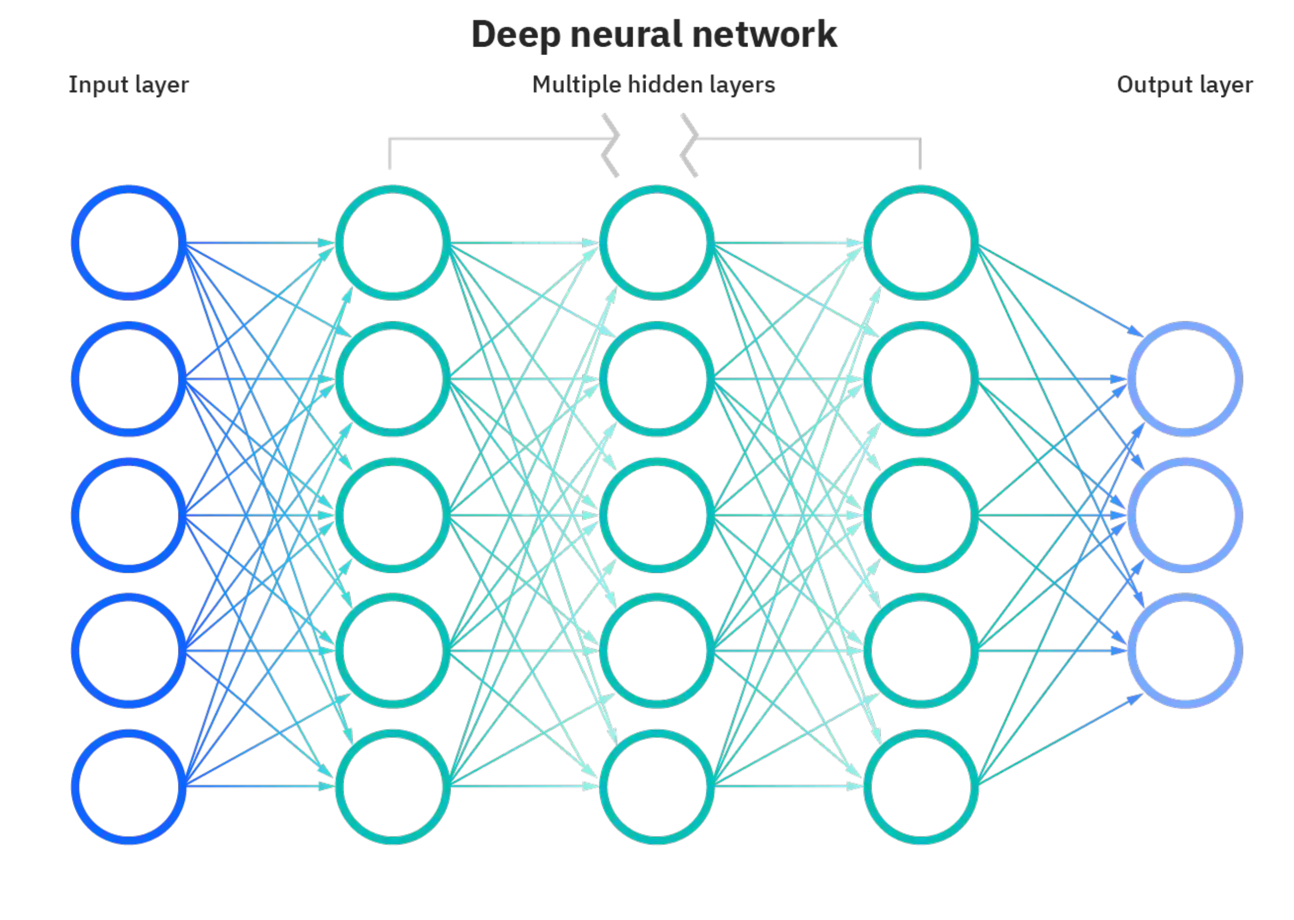
Can Machine learning help?

GOAL

Given an input of laser machining parameters, can a neural network predict what a drilled hole would look like?

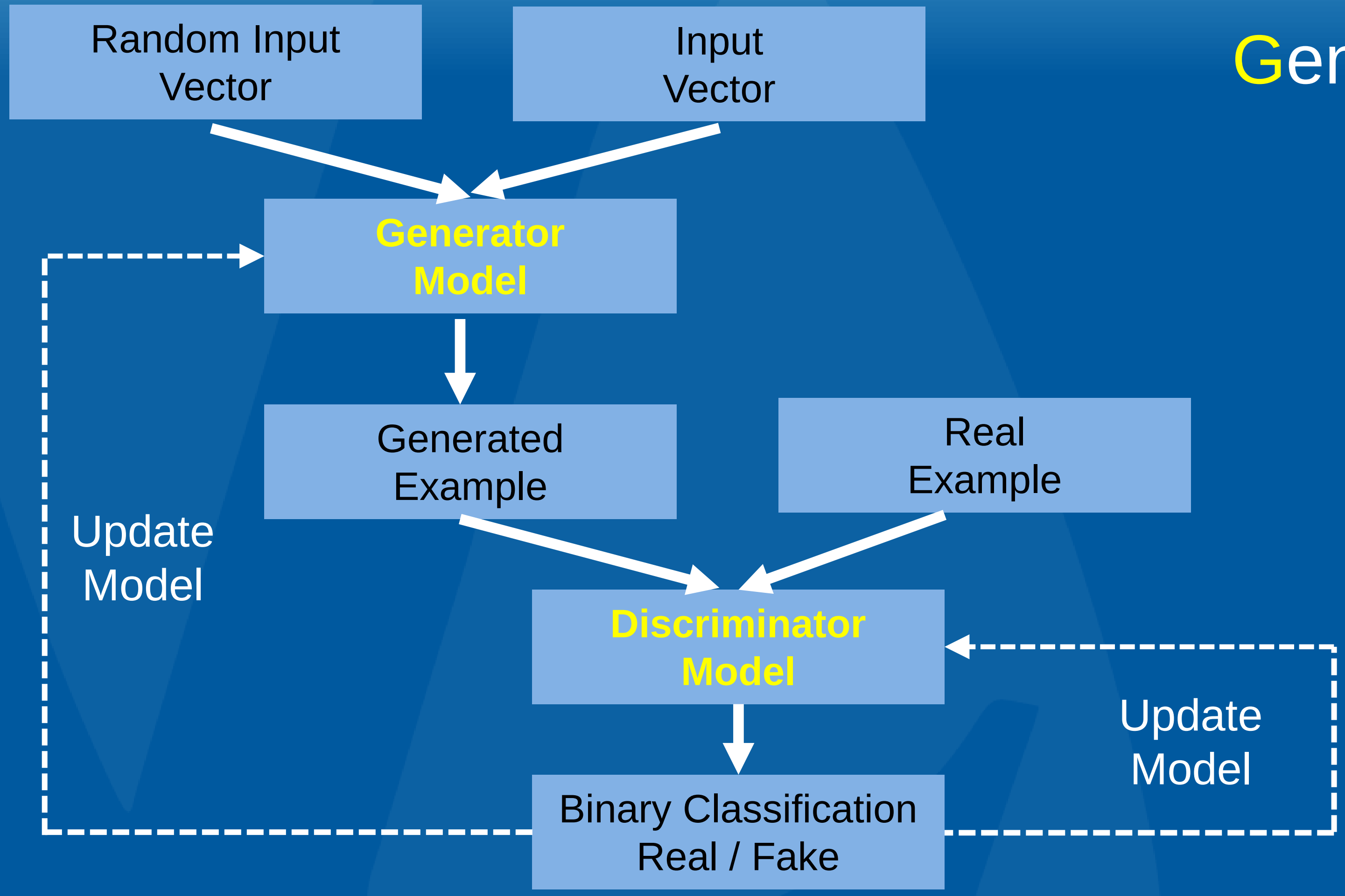
What is a Neural Network

- Modelled on how a neuron in the brain works.
- Neurons have a number of inputs and outputs.
- Each of these inputs and outputs have different weights applied and an activation function.
- The number of nodes and layers are determined by the data scientist.
- Training involves taking a set of training data with known inputs and outputs and finding the right combination of weights, layers and activation functions that will minimise the difference between what the neural network would predict and what the output really is.



Source: https://www.ibm.com/cloud/learn/neural-networks

More on Deep Neural Networks



Generative Adversarial Network

Two Neural Networks

Generator :
Noise + Input Parameters

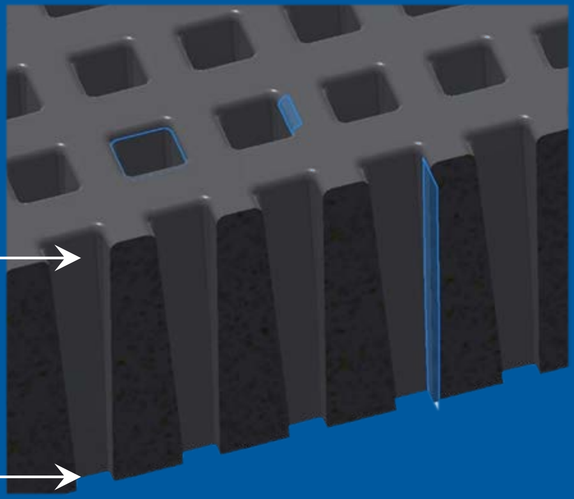
Discriminator :
Decides whether the example looks real of fake

A Neural Network can interpolate it can't extrapolate

Case Study

- Drill 2500 different combinations where 9 Laser parameters are randomly varied.

- Image these holes - Laser Exit and Neck of each hole.



- Split these into 2 sets :
  - Training Set with 1900 combinations and
  - Test Set with 600 combinations.

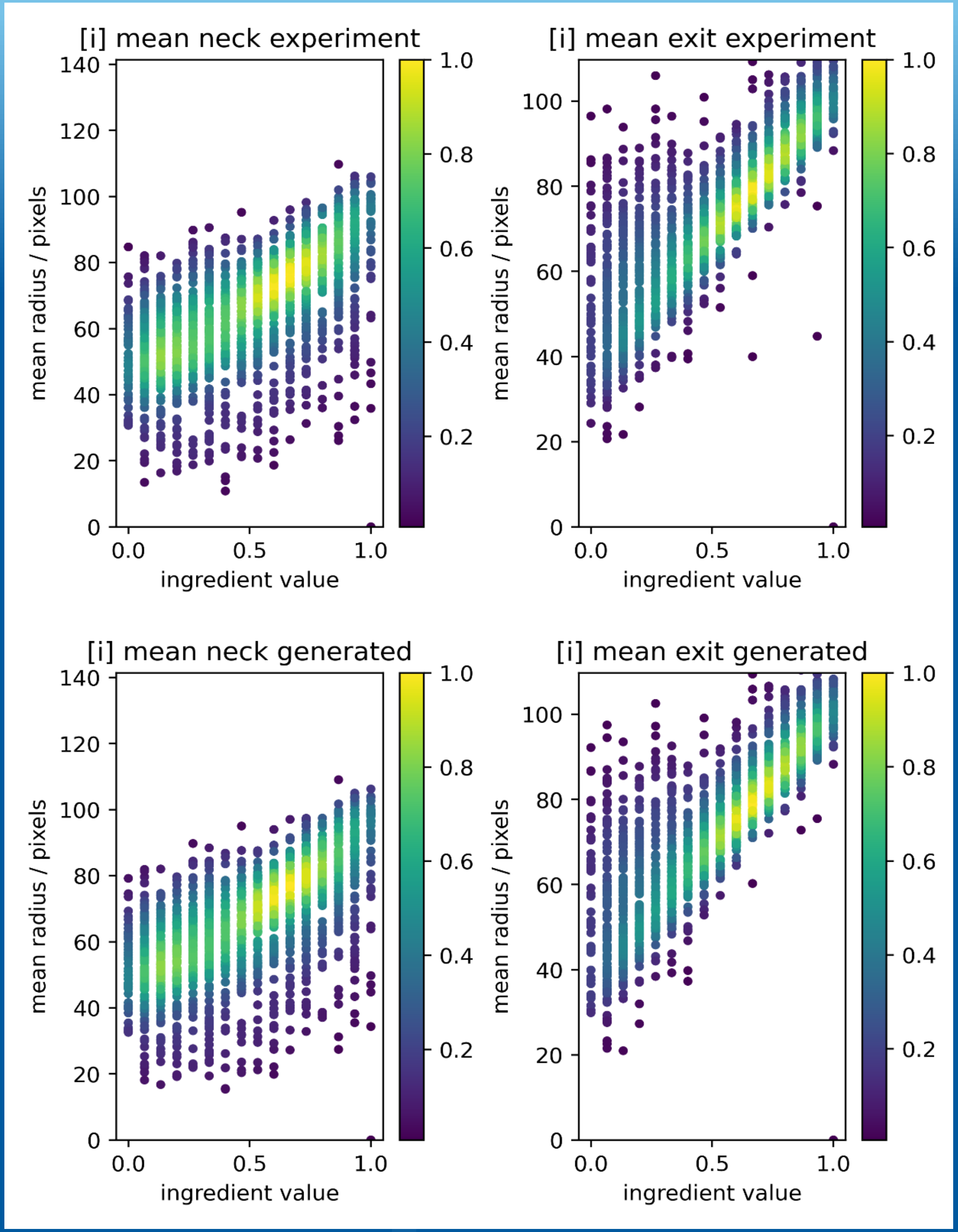
- Use the Training Set to train the Neural Network (NN) to learn - for a given set of laser parameters - what would the output images look like.

- Then see if this NN correctly predicts what the outputs in the test set look like.

Overall Distributions Comparison – Mean Radius of Hole

Taking a single ingredient (laser parameter) and seeing how the mean radius of the hole is predicted by the Neural Network.

Predicts the broad trend but also some of the outlying holes.



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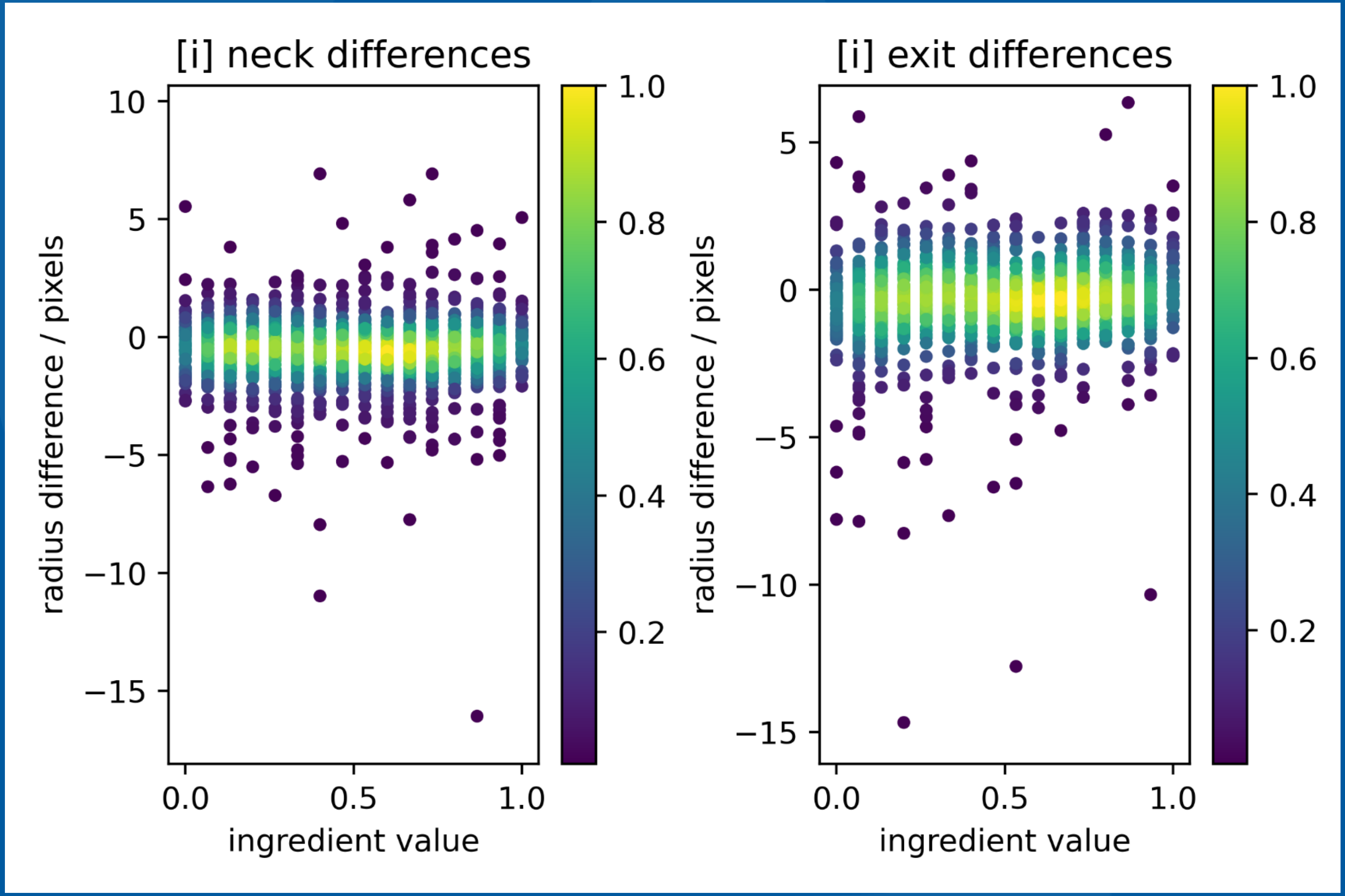
Overall Distributions

Comparison of Mean Radius Differences



Mean Absolute Error

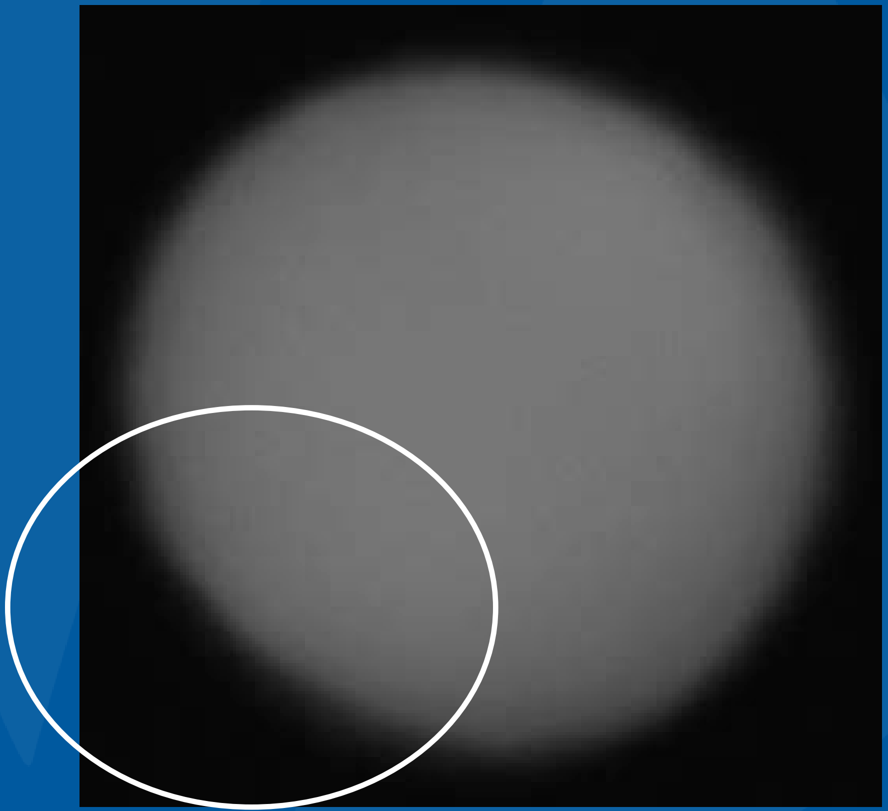
- Neck : 1.1 pixels
- Exit : 1.1 pixels

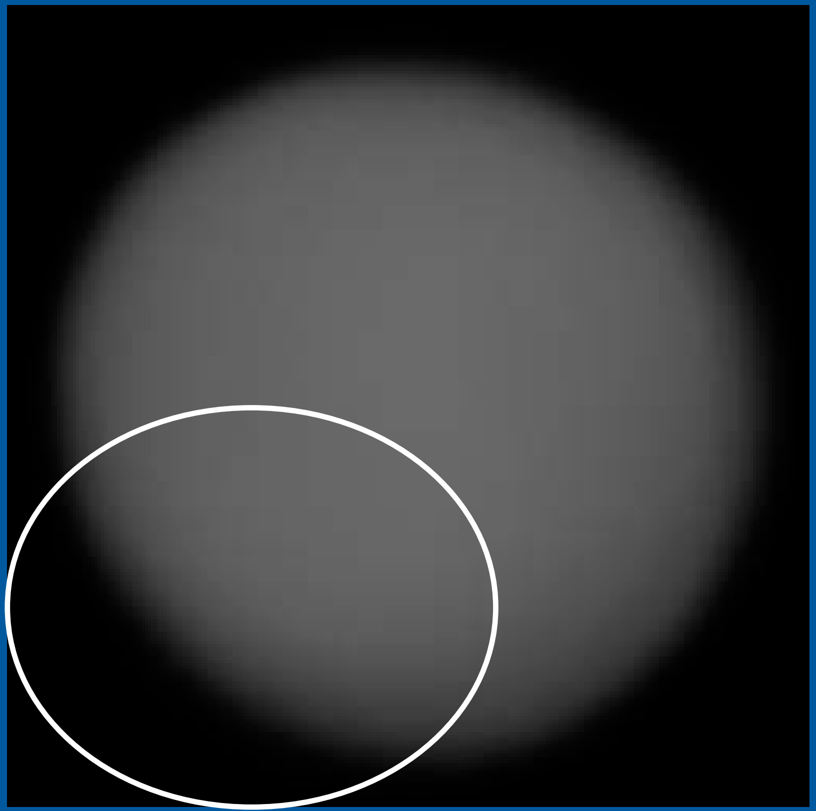
Average Radius

- Neck : 73.6 pixels
- Exit : 65.2 pixels

Hole Analysis

Neural Net vs Experiment - Neck

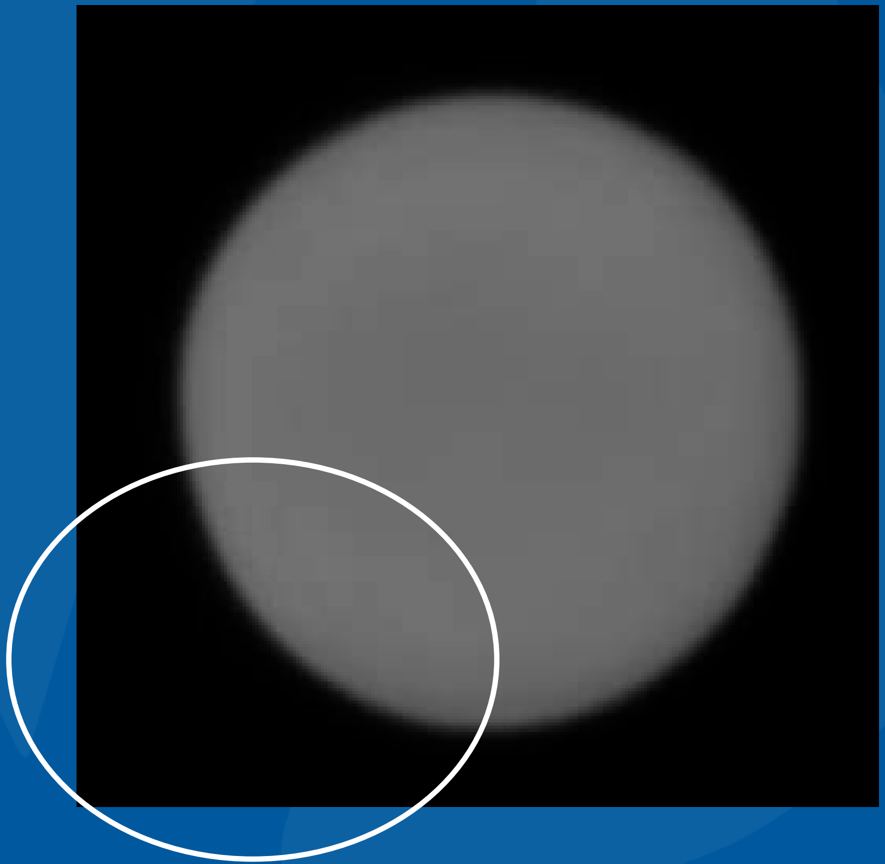


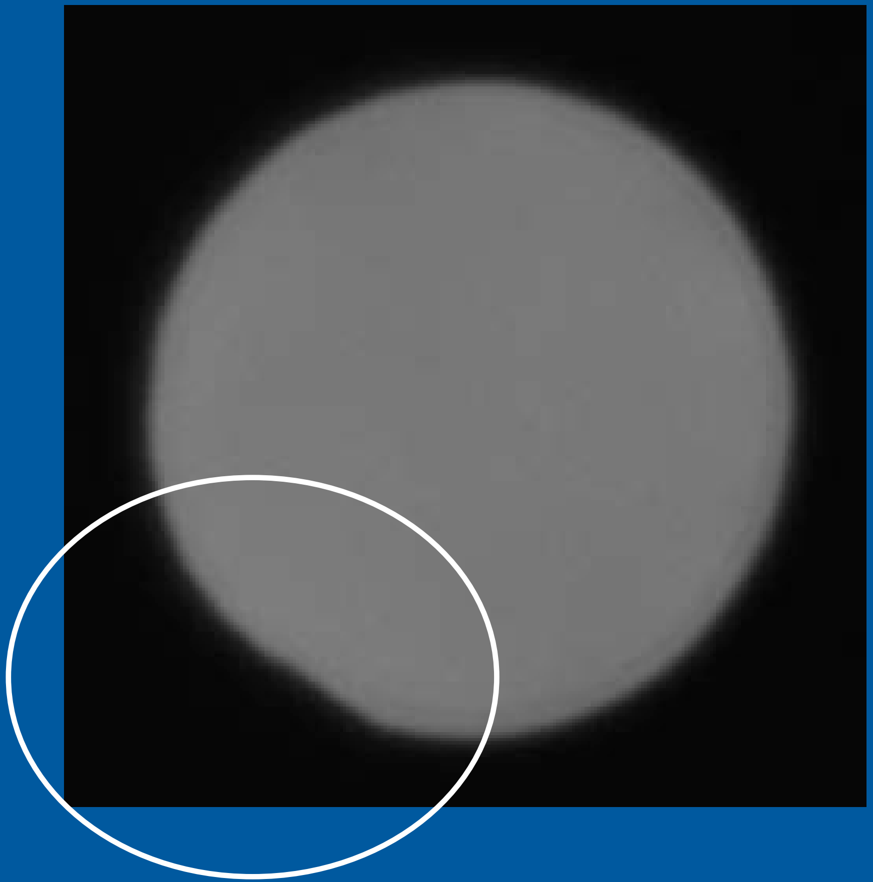


Note: Neural Network predicting the slight deviation from round on the bottom left

Hole Analysis

Neural Net vs Experiment – Exit





Note: Neural Network predicting the slight deviation from round on the bottom left.

CONCLUSION

Conclusion

- To bring data science to guide plate drilling requires - first the implementation of Data Engineering.

- In-house developed metrology and database systems in daily use and invaluable for data analytics.

- Neural Networks show promising results in becoming an additional tool in the quest for increasing quality.

Thanks

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From Oxford Lasers :

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Michael McDonnel

Thank you for your Attention