WEBINAR STARTS AT 14:00

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MACHINE LEARNING

BRUCE WALTON & CRAIG SMITH

WEBINAR SUPPORT

- Please use the Q&A Section to ask questions – we will answer as many as we can
- This is being recorded and will be available to review shortly
- The PDF slides are also available

ARTIFICIAL INTELLIGENCE

- Covers a lot of different techniques and algorithms
- We can't cover all of them in a 30-minute webinar
- So we will focus on a flexible framework that serves as the basis of many AI algorithms and techniques: ***artificial neural networks***

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INTRODUCTION

- What are neural networks and why do they work?
- What sort of things can we use them for?
- Where do I start if I want to do this?

WHAT IS A NEURAL NETWORK?

Pictures of a fixed size

Does the picture contain a dog?

Addition

Yes/No
$\{0,1\}$

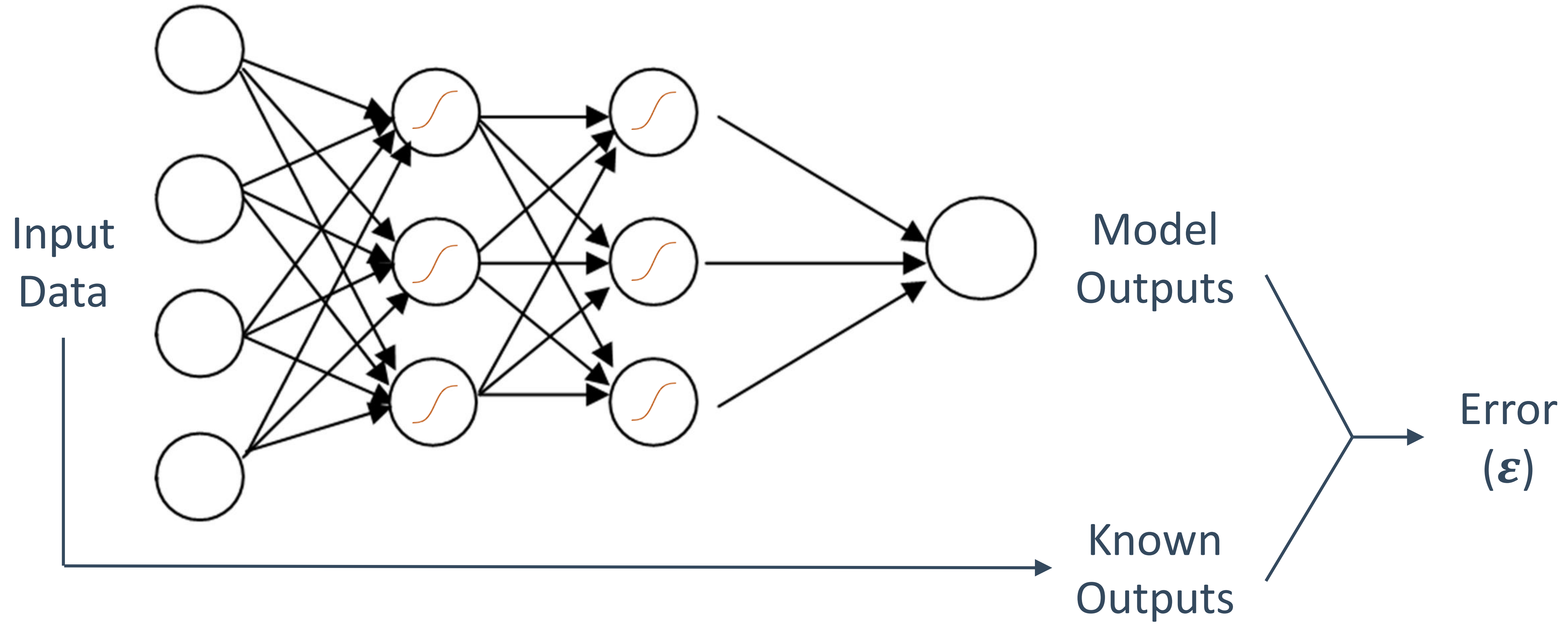
f

$\{x_1, x_2, x_3, \dots, x_n\}$

$\{y_1 = F(x_1),$
$y_2 = F(x_2),$
$y_3 = F(x_3), \dots,$
$y_n = F(x_n)\}$

Goal: Minimise error ($\boldsymbol{\varepsilon}$) between f and F on known data

WHAT IS A NEURAL NETWORK?



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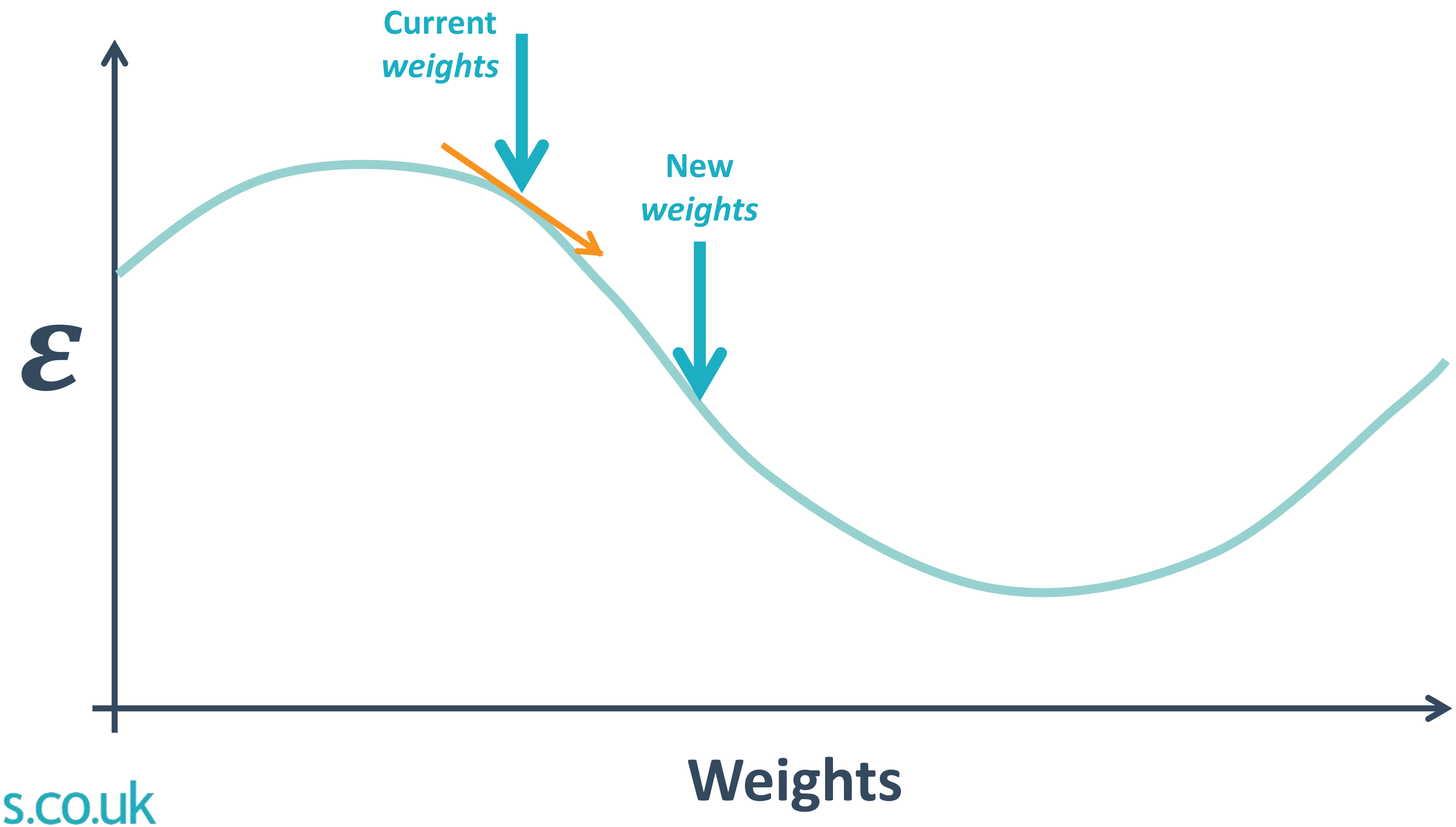

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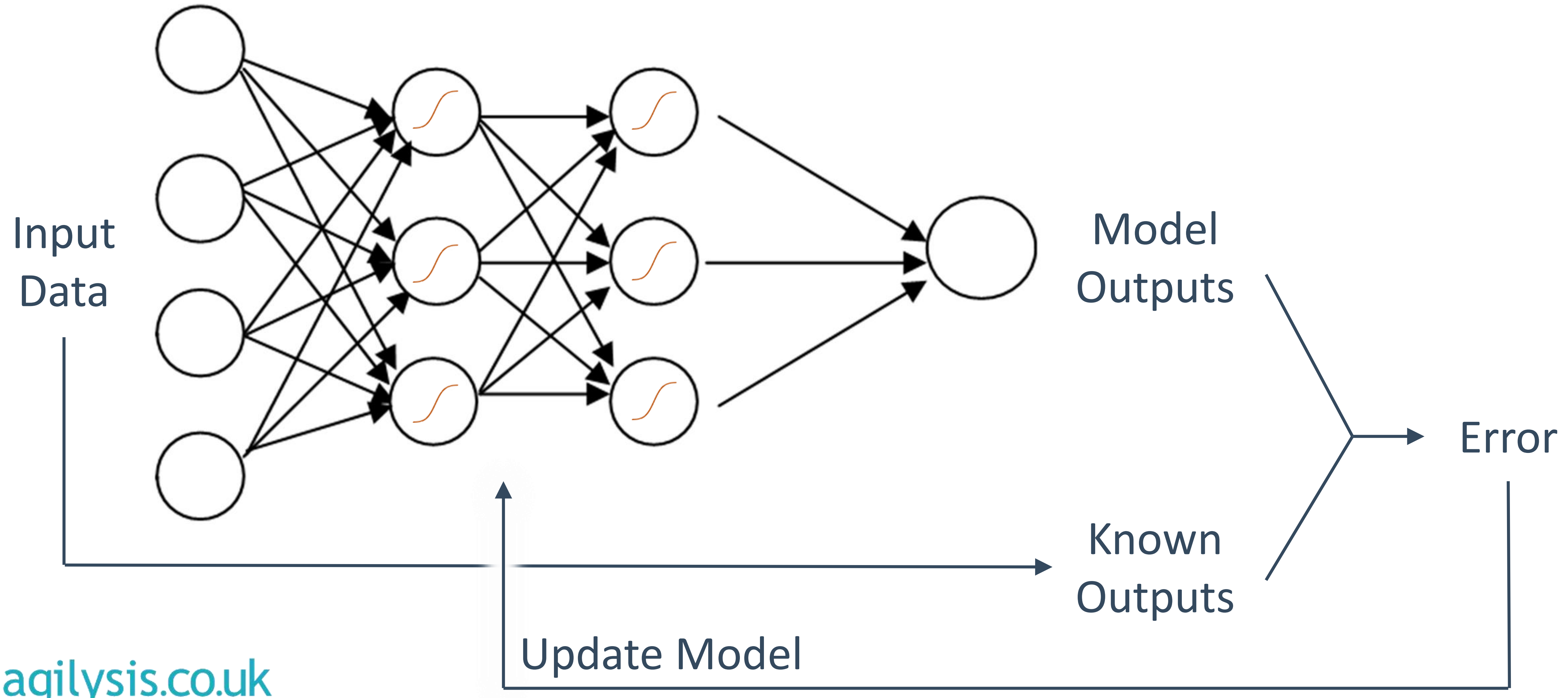

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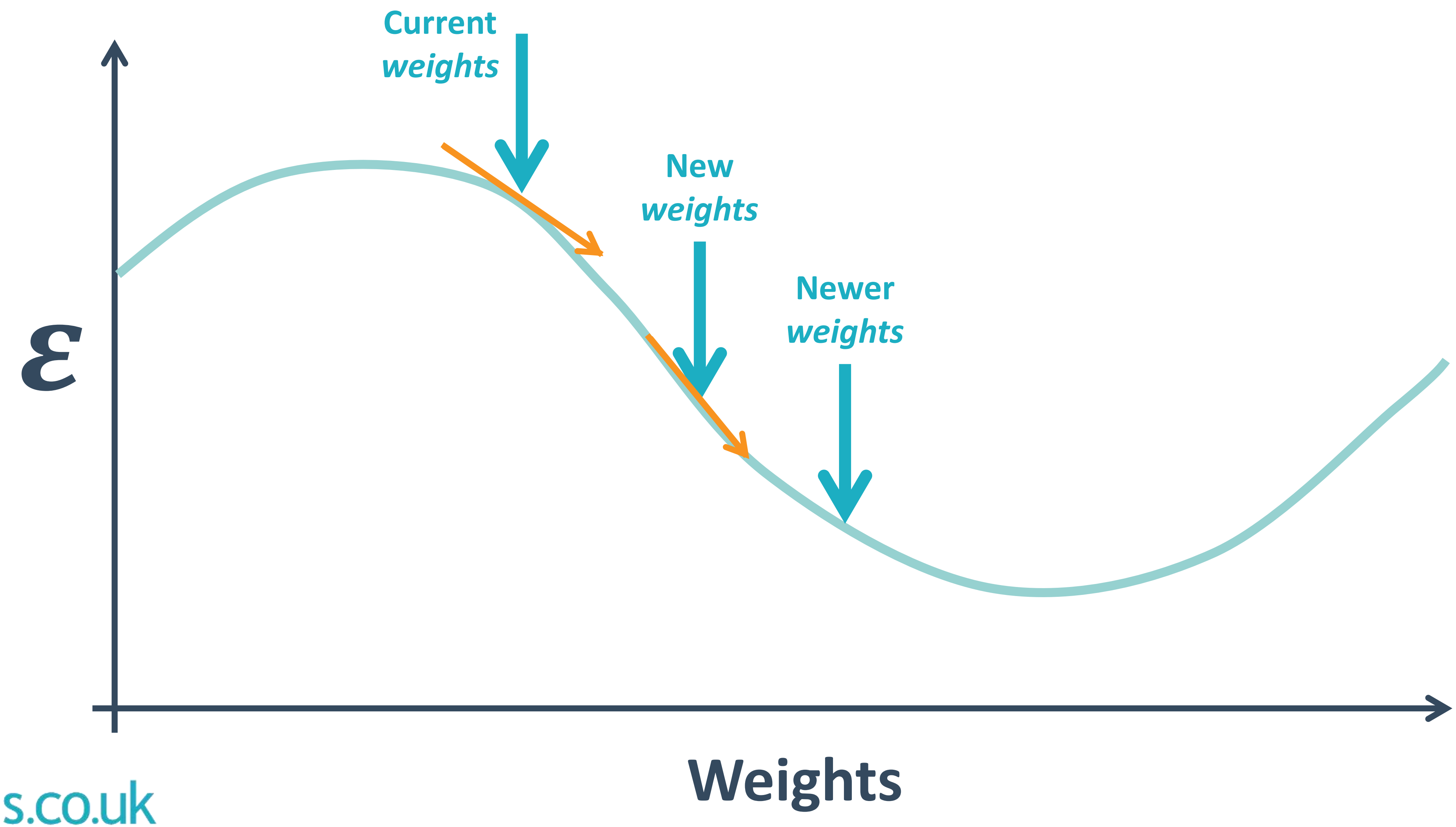

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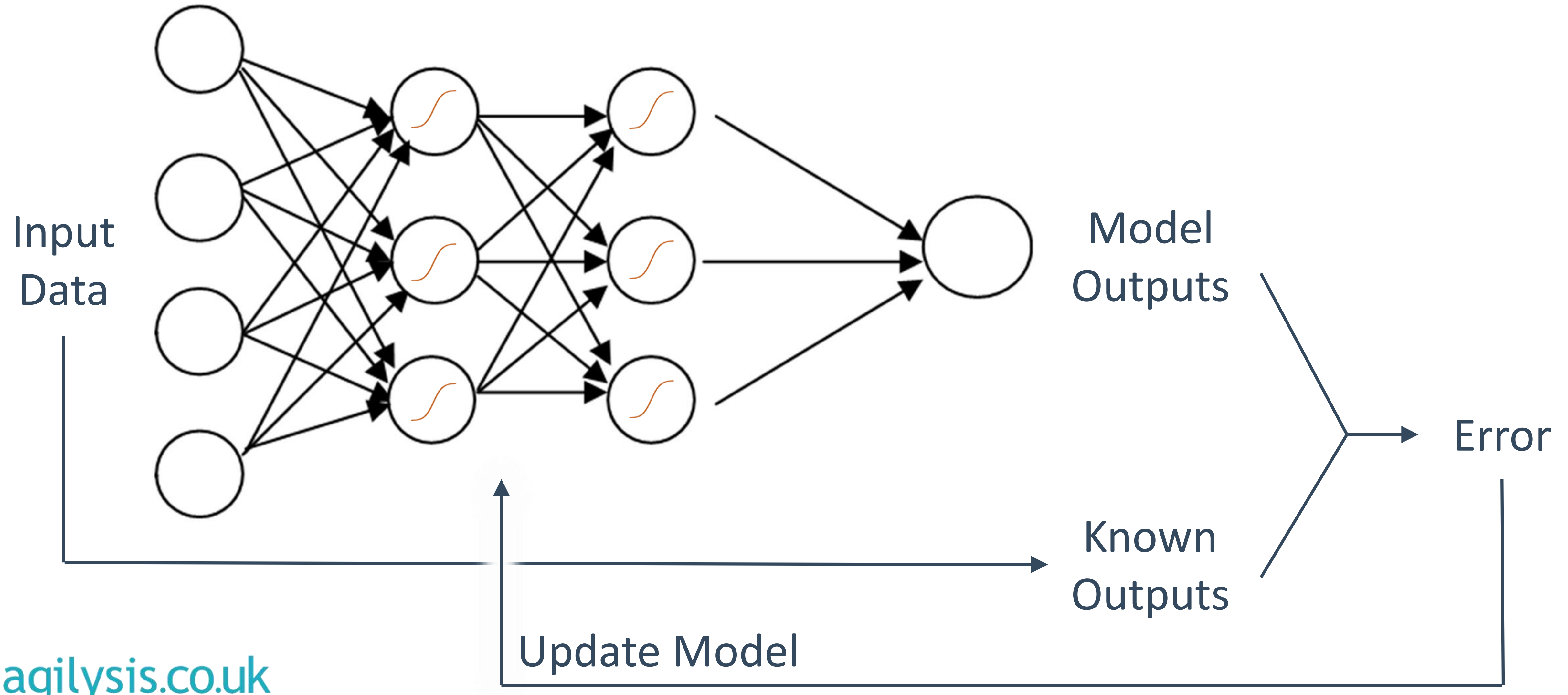

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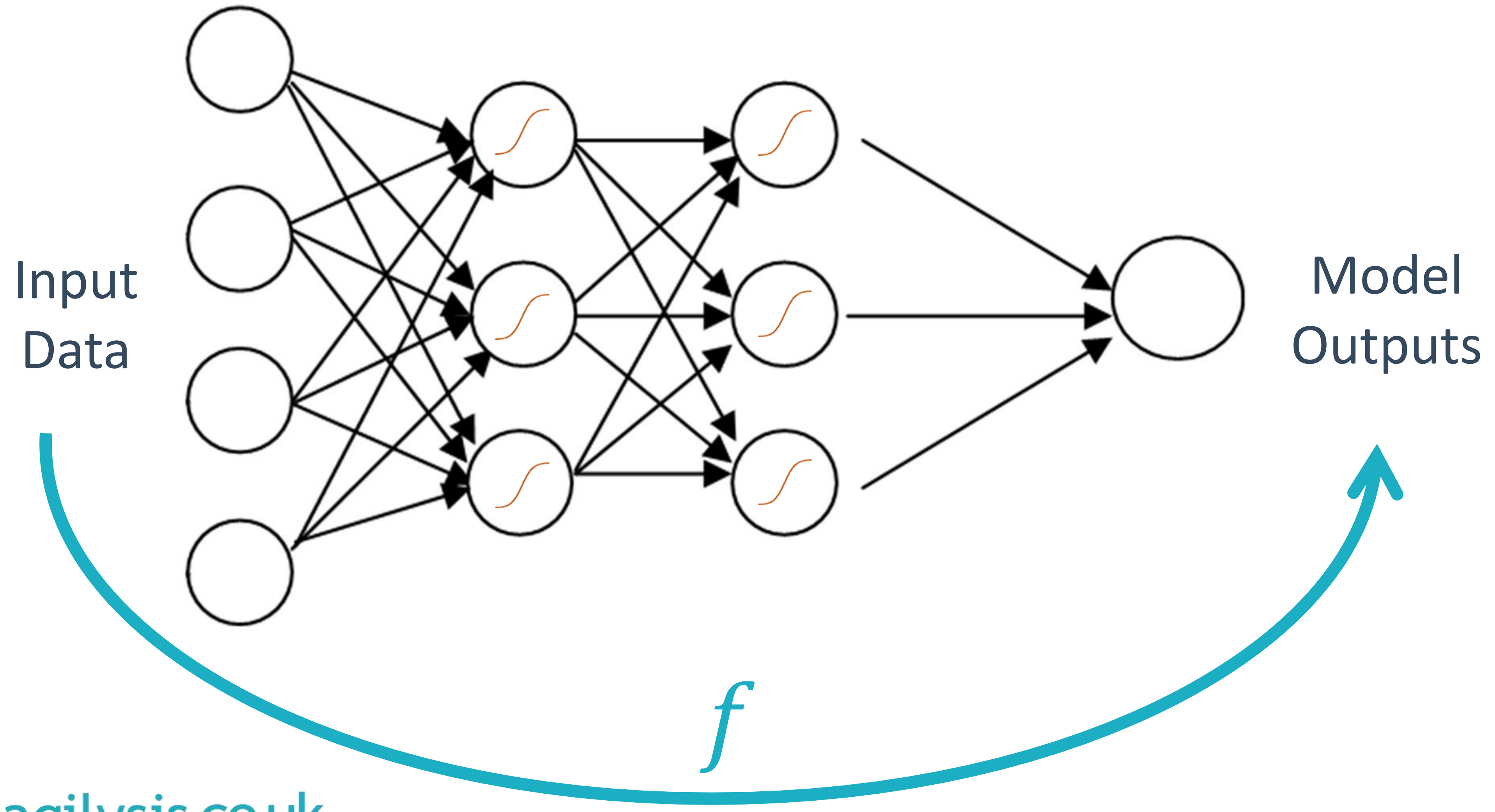

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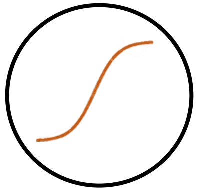
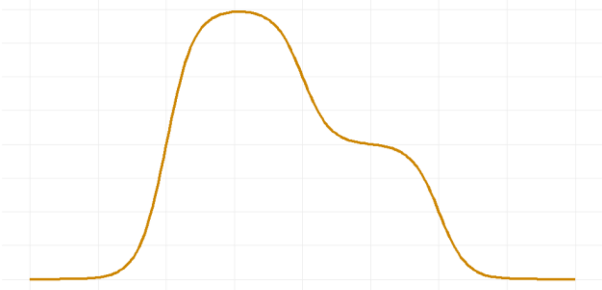
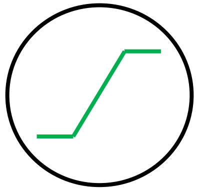
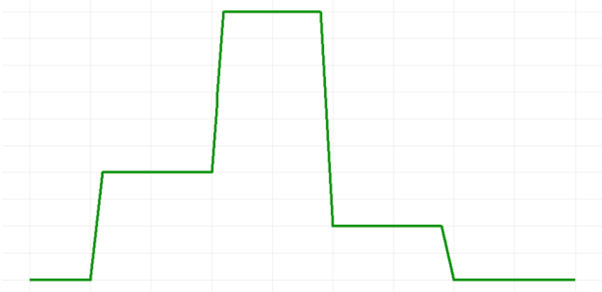


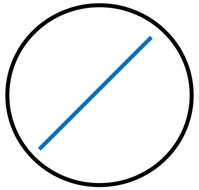
- *Sigmoid* activation builds the model out of curvy pieces



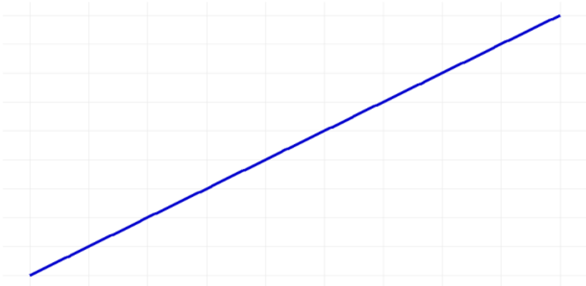


- *Relu* activation builds the model out of piecewise-linear pieces





- *Linear* activation builds the model out of linear pieces *(hence is linear)*



WHAT CAN WE USE THEM FOR?

- Regression models

(NON-LINEAR) REGRESSION

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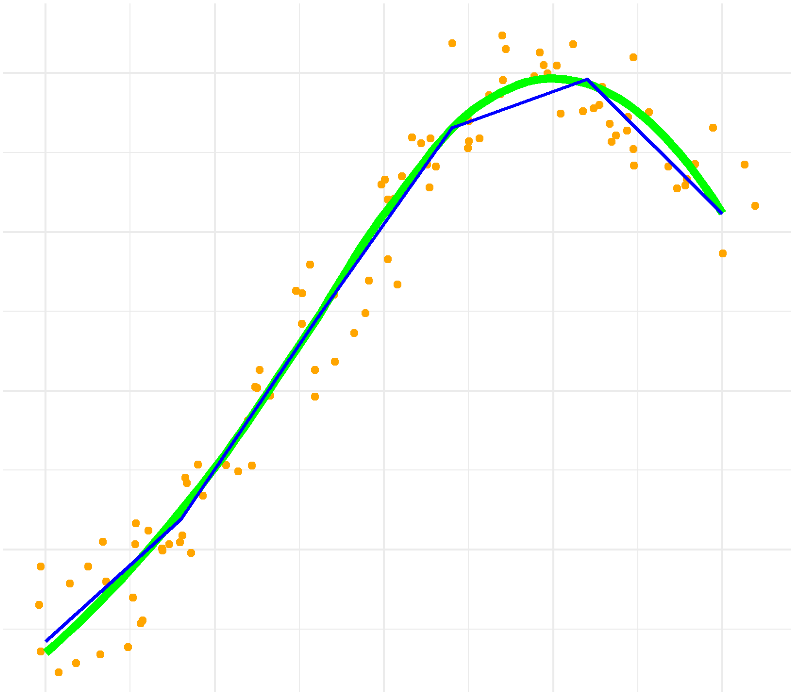
- Use a combination of discrete and continuous input variables
- Predicting continuous output values
- Interpolate data to cover blackspots
- Can have issues with extrapolation



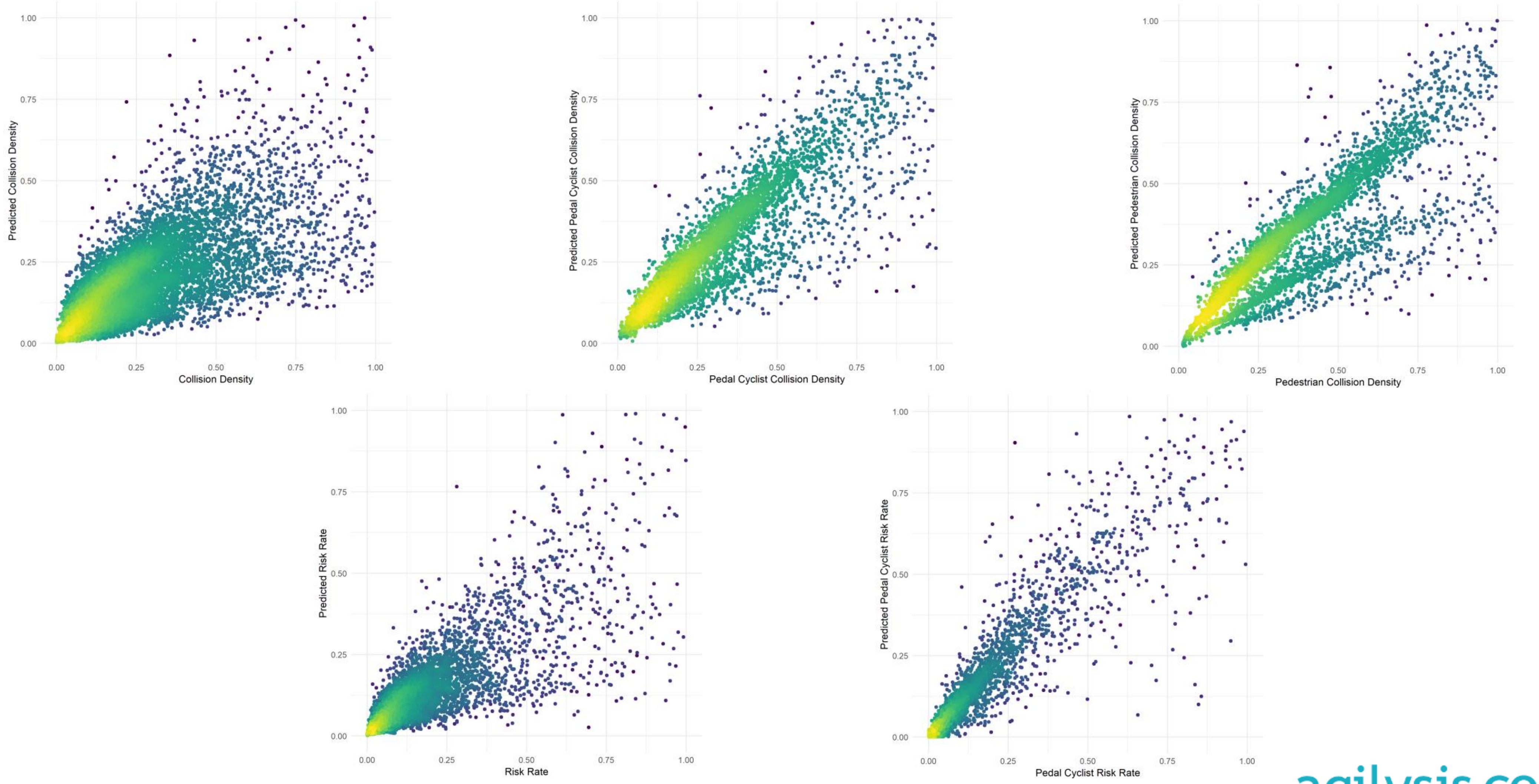
TFL ROAD DANGER REDUCTION

- Use historic STATS19 collision data, matched to a granular road network to calculate measures of risk:
  - *Collisions per km of road*
  - *Collisions per vehicle-km travelled*
  - *Pedal cyclist collisions per km*
  - *Pedal cyclist collisions per cyclist-km travelled*
  - *Pedestrian collisions per km*
- Match this to data on road infrastructure, local environment, and usage provided by Transport for London

TFL ROAD DANGER REDUCTION

- Train a Neural Network to predict observed measures of risk using this data on road infrastructure, local environment, and usage
- The result is a piecewise-linear function on the space of infrastructure, environment and usage data
- Values for each road segment correlate with observed risk
- The outputs of this function are measures of *Road Danger*

TFL ROAD DANGER REDUCTION



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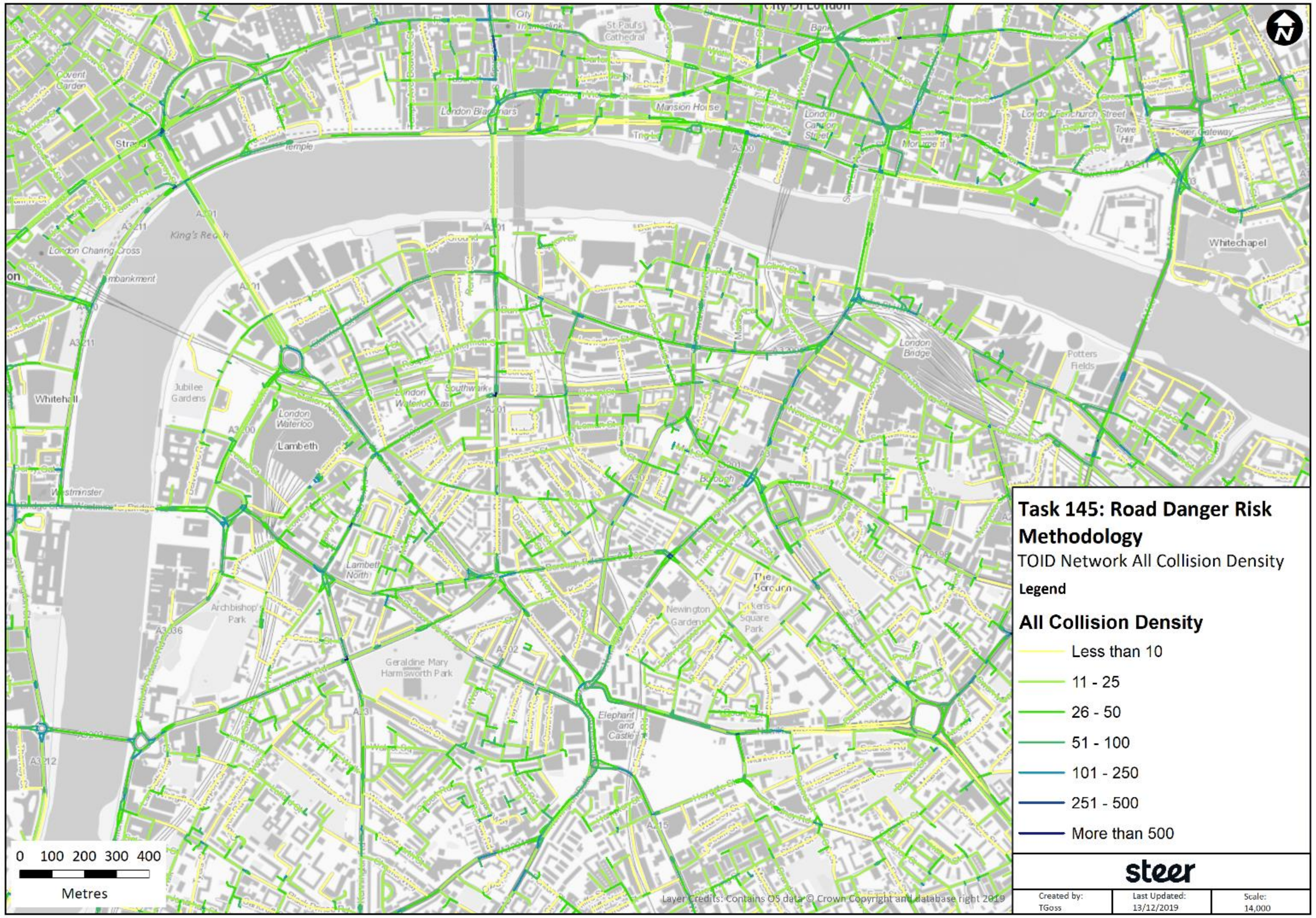
TFL ROAD DANGER REDUCTION



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WHAT CAN WE USE THEM FOR?

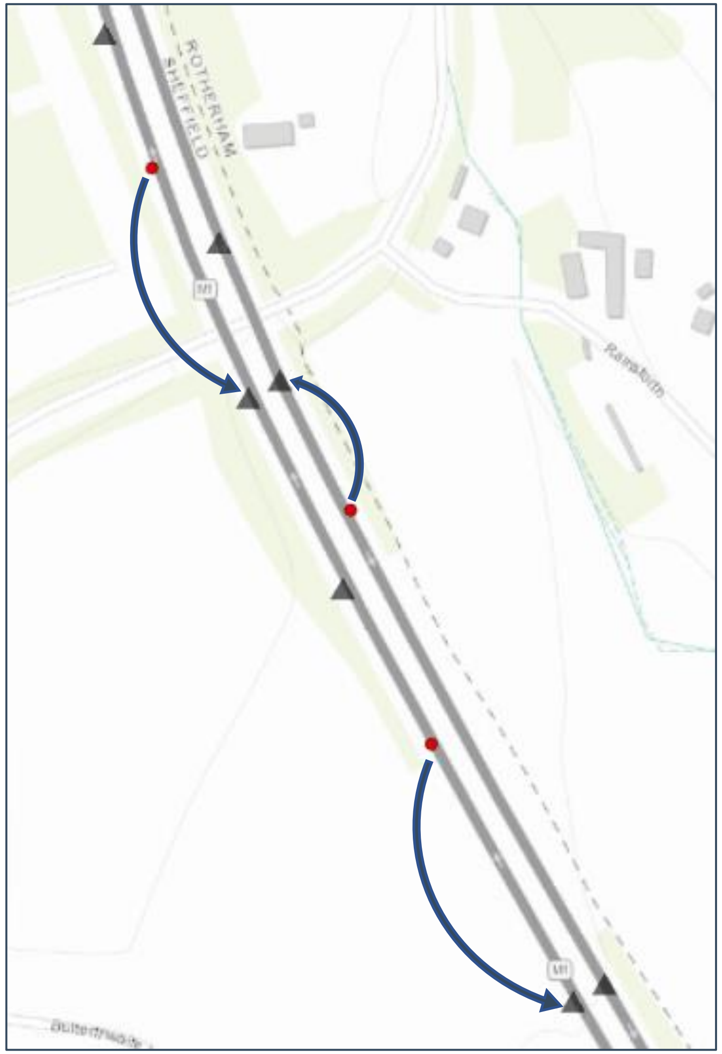
- Regression models
- Classification models

MIDAS COLLISION DETECTION

- The **MIDAS** network is a collection of sensors across strategic roads in England, collecting minute-by-minute data on speed, flow and headway for each lane
- This project matched these sensors to STATS19 collisions to investigate the extent to which collision effects are visible within MIDAS data

MIDAS COLLISION DETECTION

- The following parameters were used for selecting collisions
  - **Multi-vehicle** collisions only
  - Occurring **between 6 AM and 10 PM**
  - Unambiguously located on a specific carriageway, not on slip road
- The M1 was chosen as the study site and 2016 as the year
  - Choice was driven by data quality
  - Only 215 (54%) of in-scope 2016 M1 collisions had complete MIDAS data available
- All collisions in scope were matched to the nearest *preceding* MIDAS sensor, to capture changes in vehicle behaviour leading up to the scene of the collision both before and after it occurred



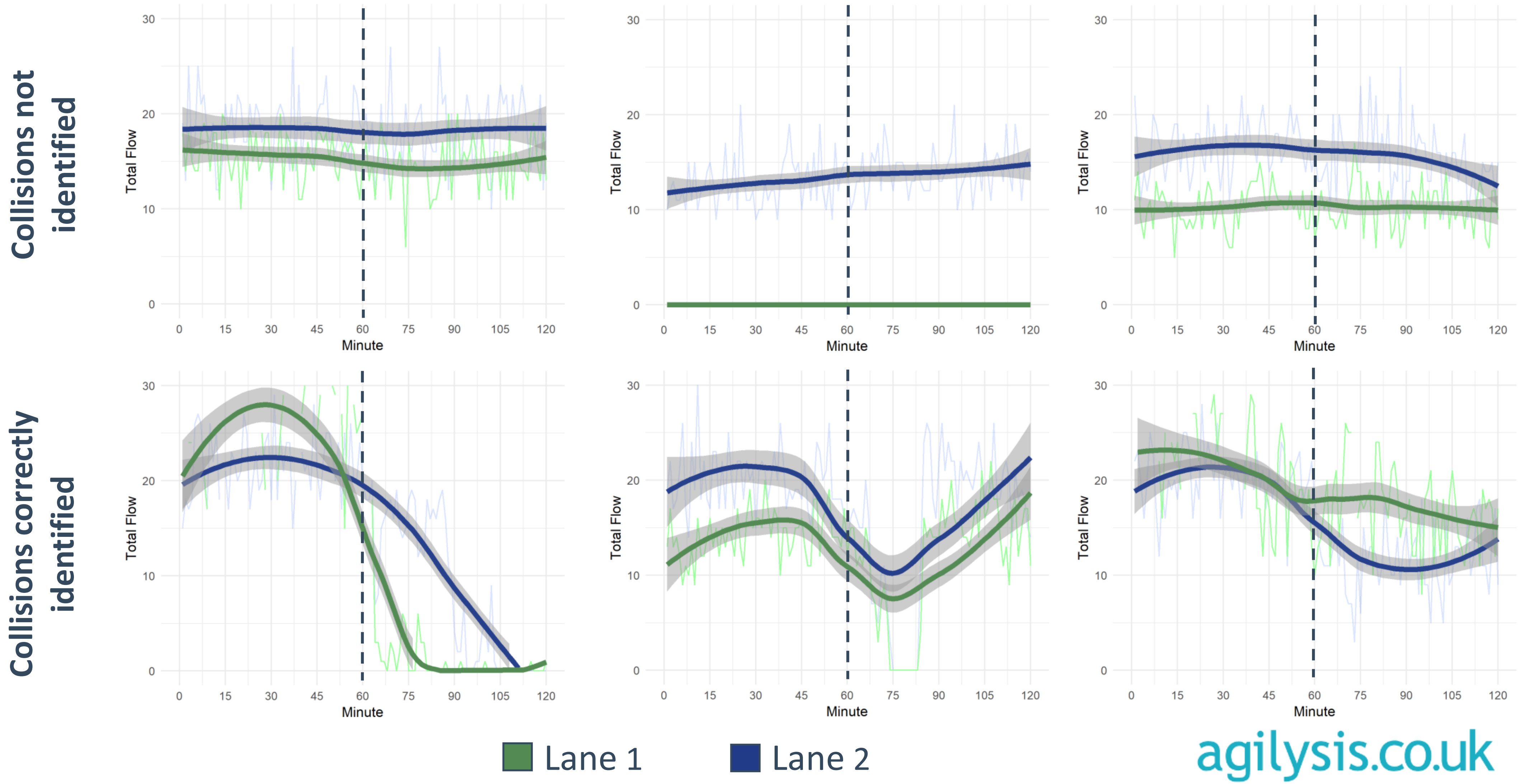
MIDAS COLLISION DETECTION

- Multiple two hour periods of MIDAS data were extracted using the RAC Foundation's R package *oneminutetrafficdata*
  - Some were the hour immediately preceding and immediately following a reported collision
  - Others were random comparator periods, between 6 AM and 10 PM on days when no collisions were reported at that location
- Data was only taken for lanes 1 and 2, to account for variation in the number of lanes at each sensor point
- Sensor points are about 300 meters apart on average
- Some datasets were incomplete

CONCLUSIONS

- The neural network could **accurately recognise** MIDAS data that was <u>not</u> associated with **a collision**, especially using flow data (100% success)
- The neural network was **more likely miss** a collision than it was to identify non-collisions as collisions falsely
- The best factor to use in training a neural network to recognise collisions is **flow** (with a 93% success rate), closely followed by **speed** (which was 89% successful)
- However, training using both seemed **reduce** the model's accuracy
- The neural network **struggled** to recognise patterns in **headway data** that indicated collisions

SAMPLE FLOW PROFILES



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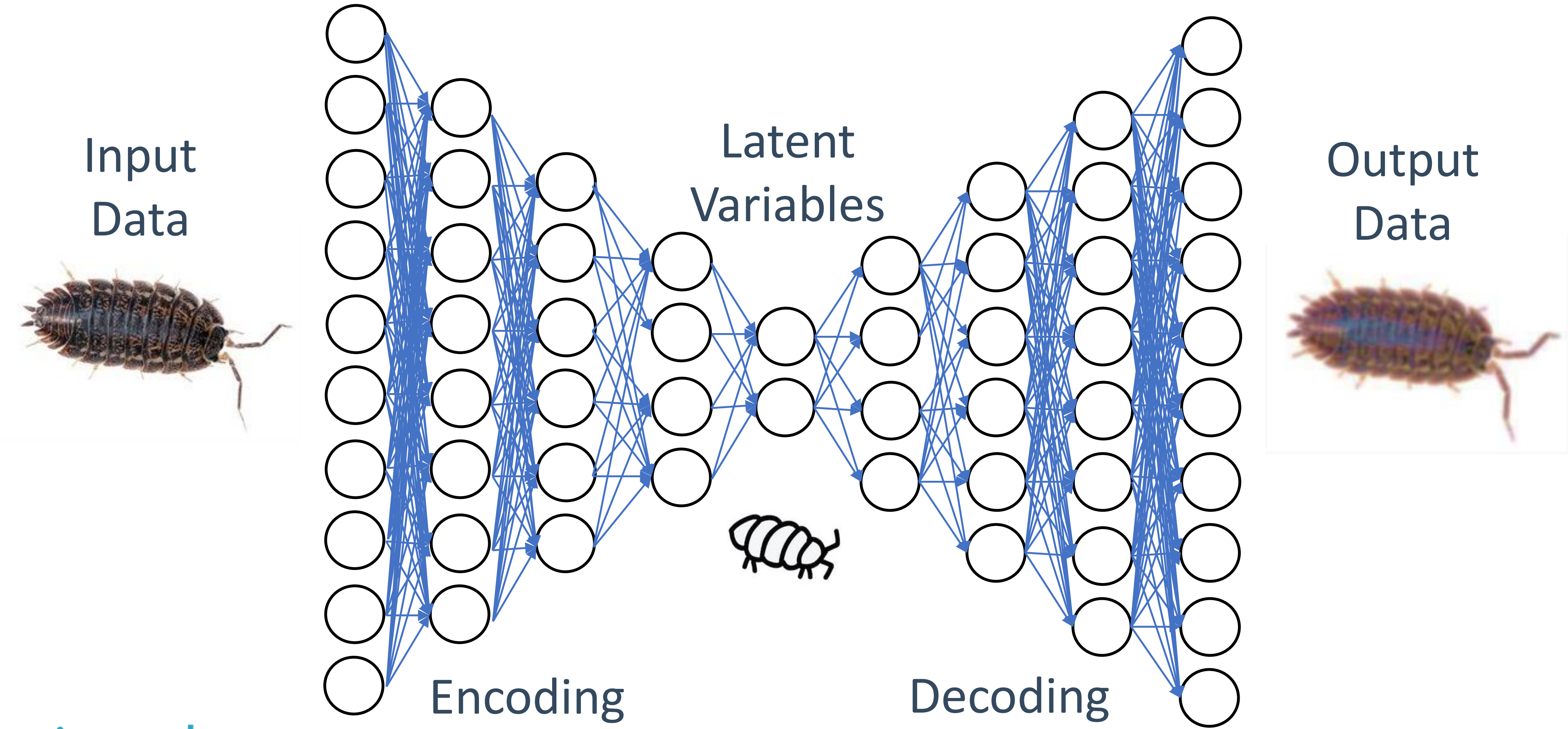
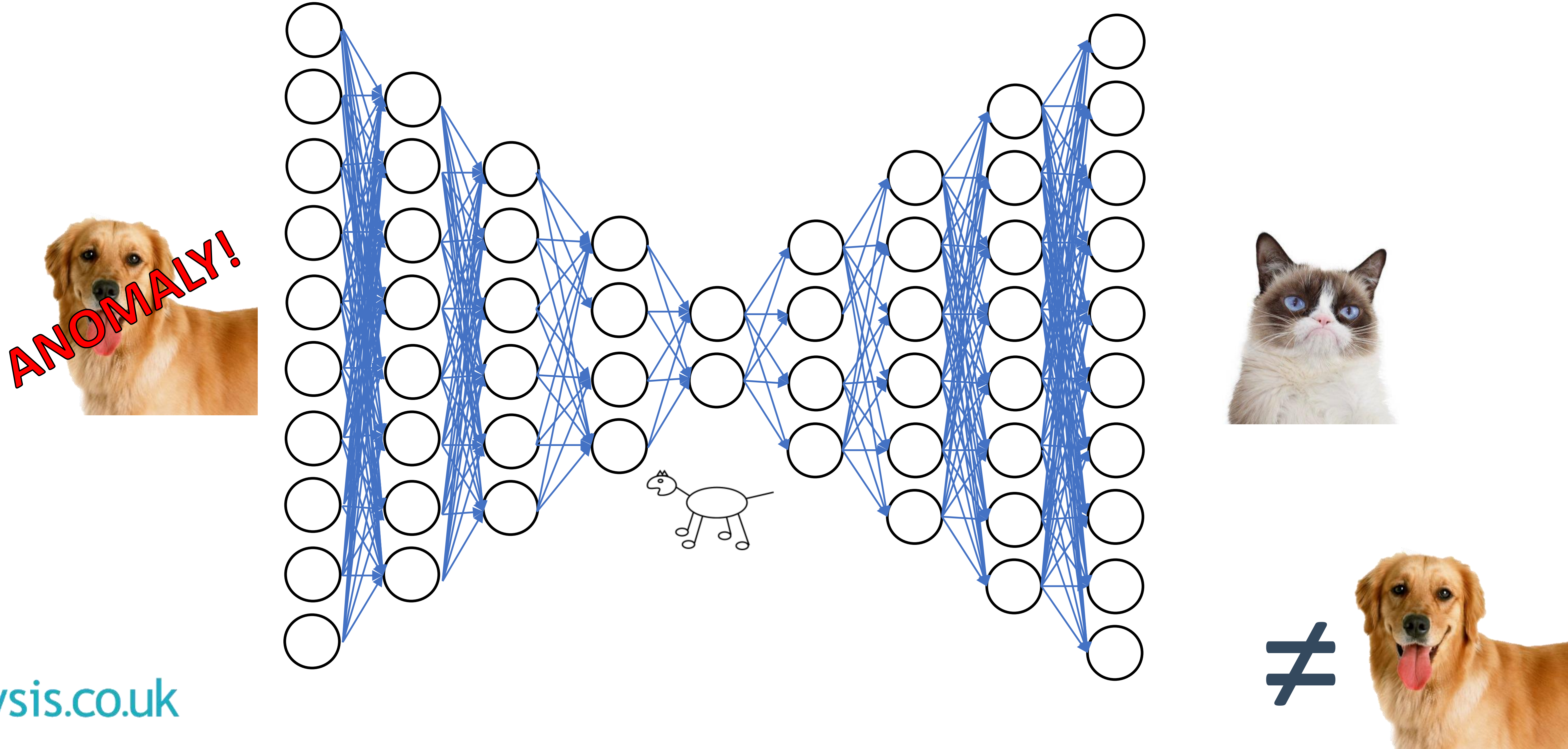
WHAT CAN WE USE THEM FOR?

- Regression models
- Classification models
- Anomaly/rare event detection

ANOMALY DETECTION



ANOMALY DETECTION



ANOMALY DETECTION

- Exploring the potential of using this to detect the conditions that are likely to precede a collisions in HE’s minute-by-minute MIDAS sensor data
- More generally can be used to remove outliers from datasets
- Or as the basis for “unsupervised learning”…

WHAT CAN WE USE THEM FOR?

- Regression models
- Classification models
- Anomaly/rare event detection
- Unsupervised learning/classification

UNSUPERVISED LEARNING

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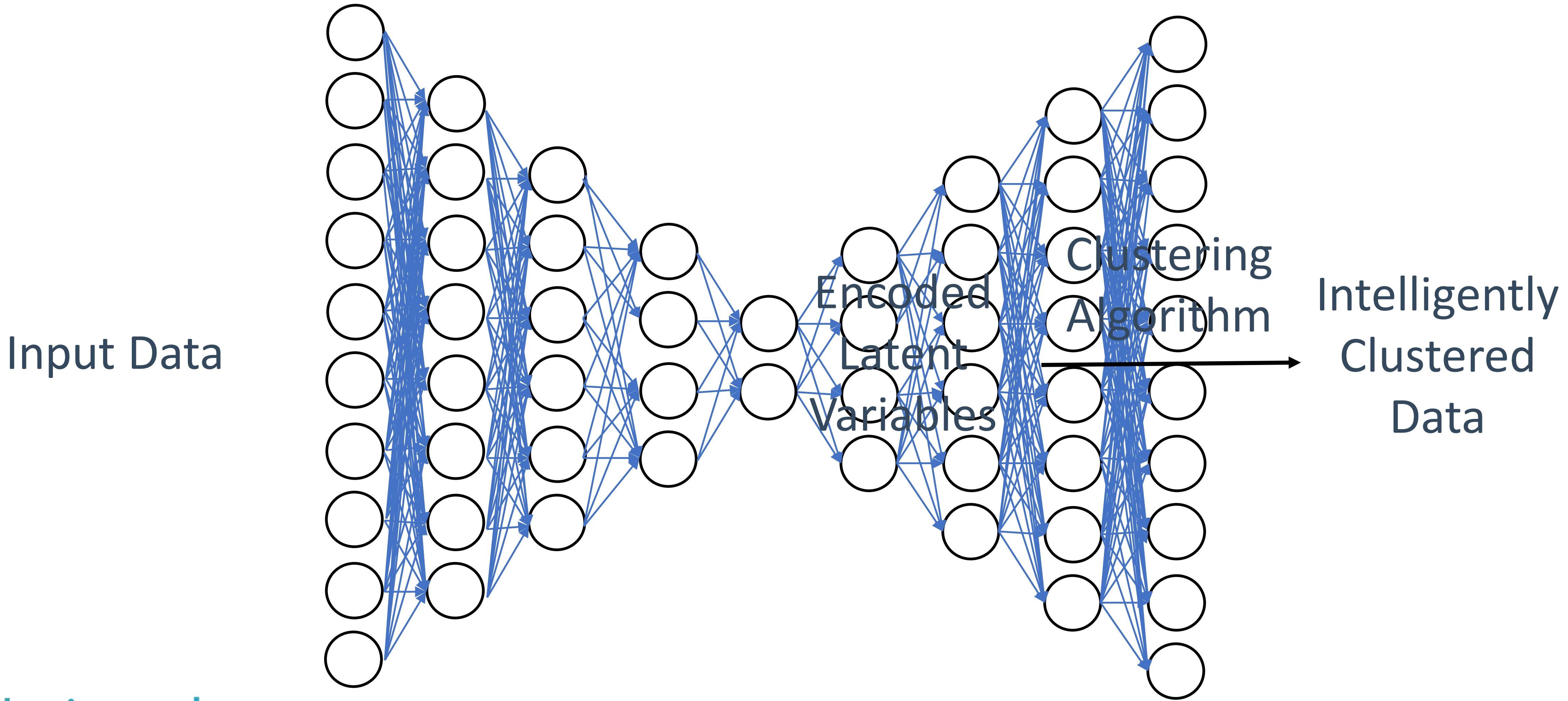

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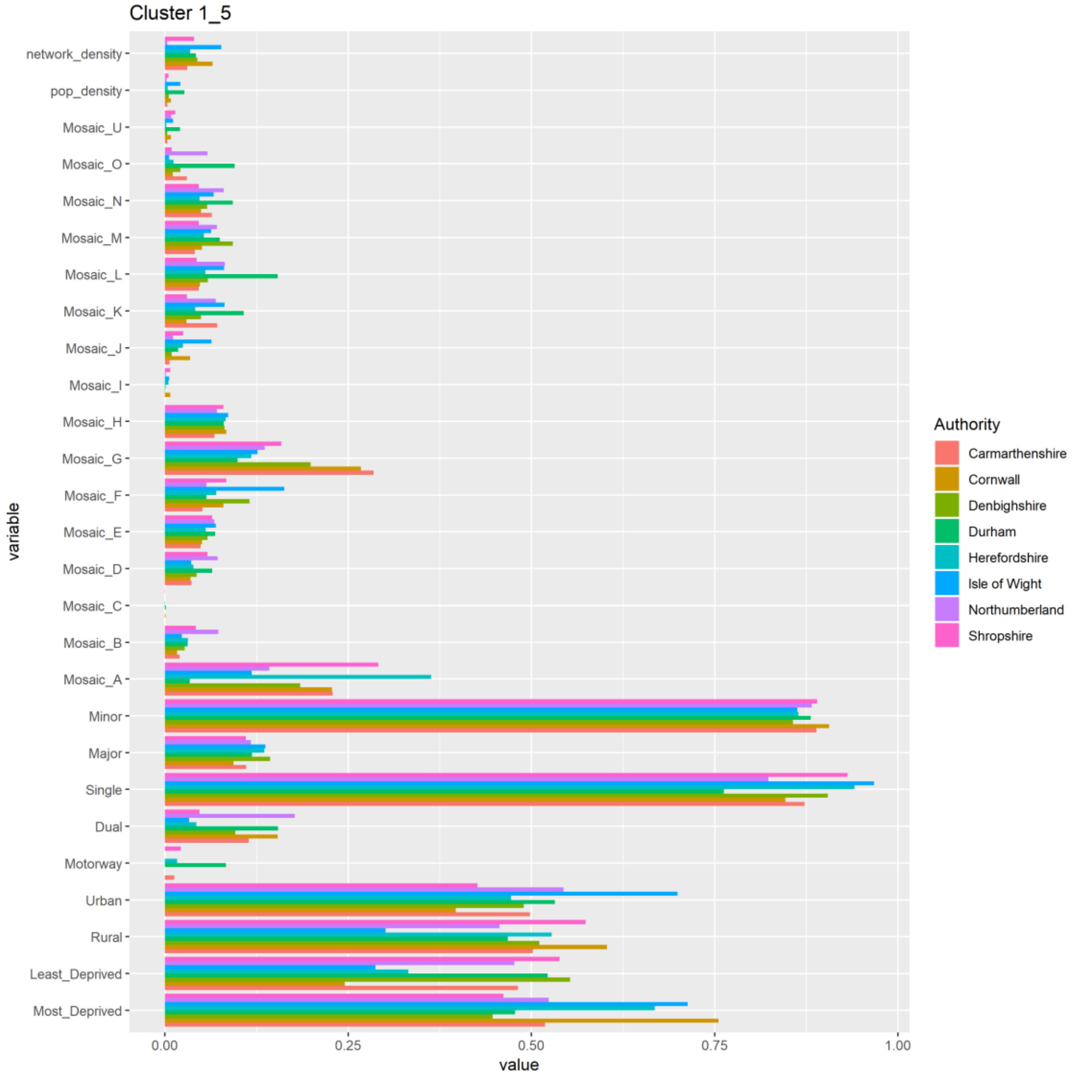
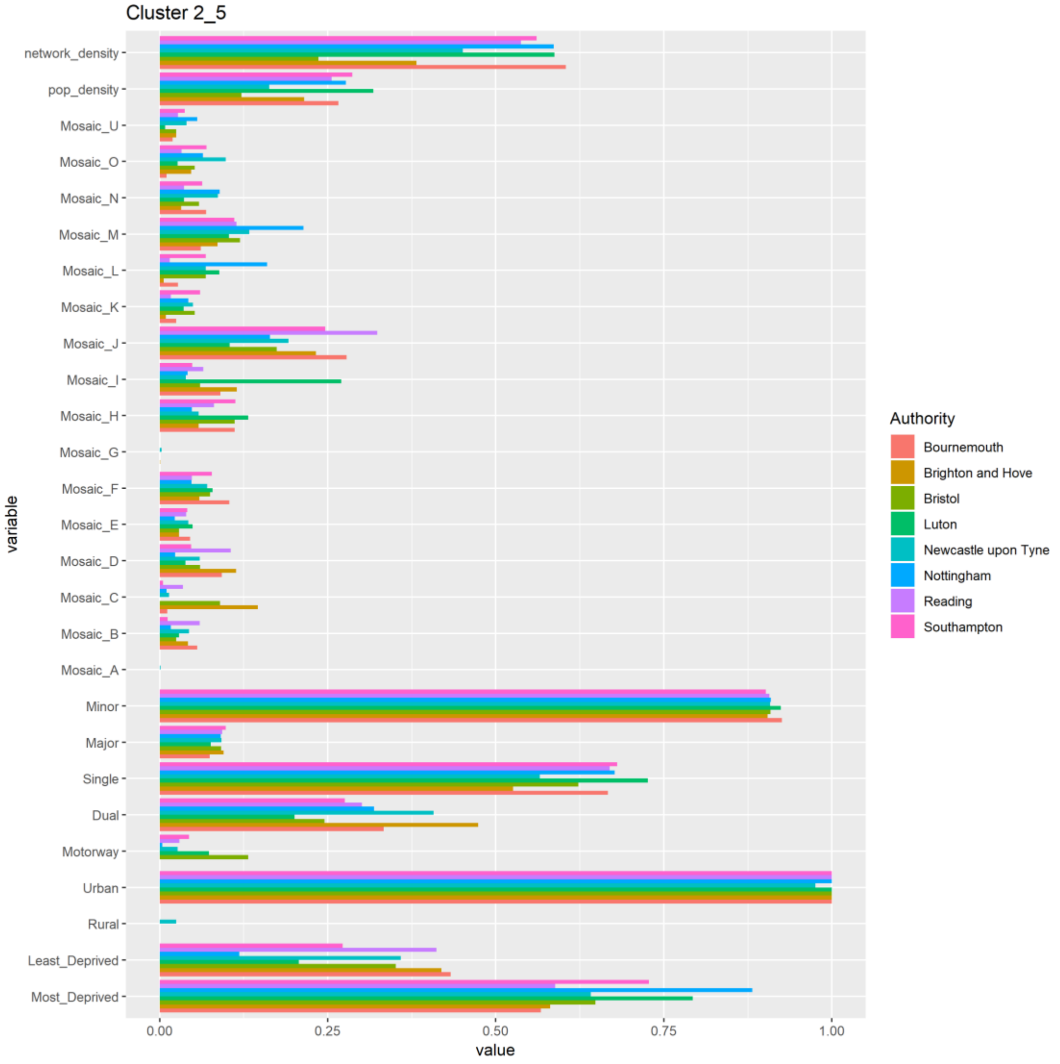
HANCS AND FINDING COMPARATORS

- We work alongside local authorities to analyse their collision data and determine what their biggest road safety issues are
- Only makes sense when compared against *similar* authorities
- Not enough to settle for *similar* meaning nearby
- Similarity should be data driven, and based on factors such as network density, rurality, population density, deprivation levels and socio-demographics
- The HANCS model uses unsupervised learning to cluster authorities into groups based on the level of similarity

HANCS AND FINDING COMPARATORS





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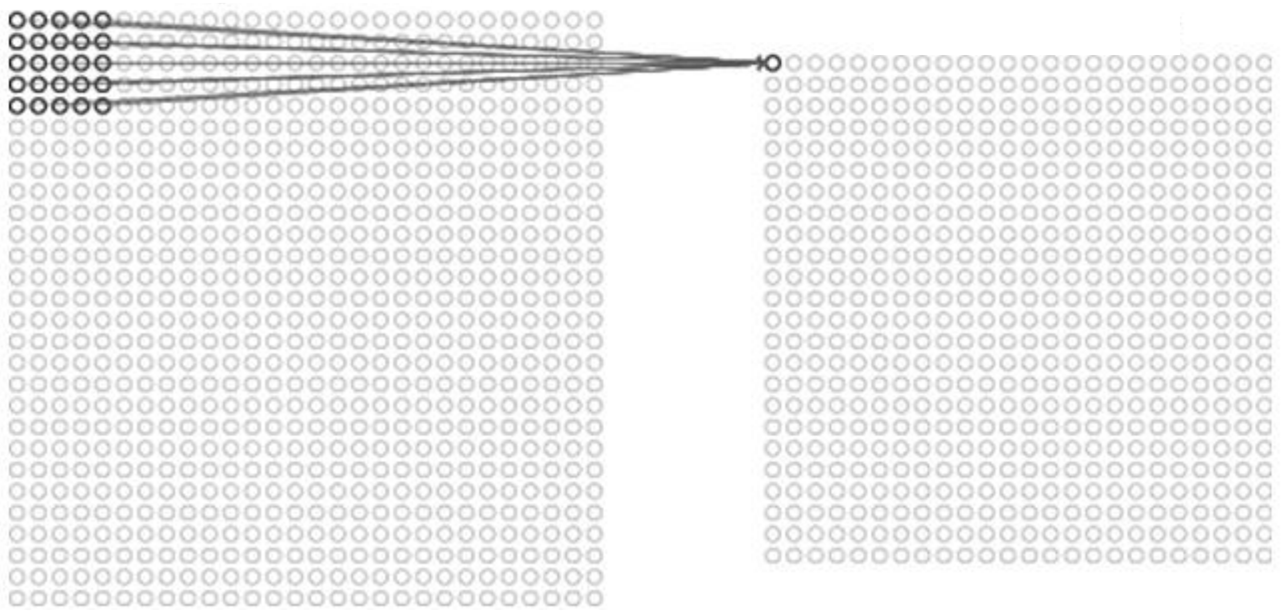
WHAT CAN WE USE THEM FOR?

- Regression models
- Classification models
- Anomaly/rare event detection
- Unsupervised learning/classification
- Image recognition and object detection

IMAGE RECOGNITION

Convolutional Layers



Pooling Layers

1	4	7	3	7	9
2	2	4	7	6	1
8	6	5	3	4	9
6	1	7	5	9	3
6	4	5	2	3	2
9	6	4	5	8	6

→

4	7	9
8	7	9
9	5	8

IMAGE RECOGNITION

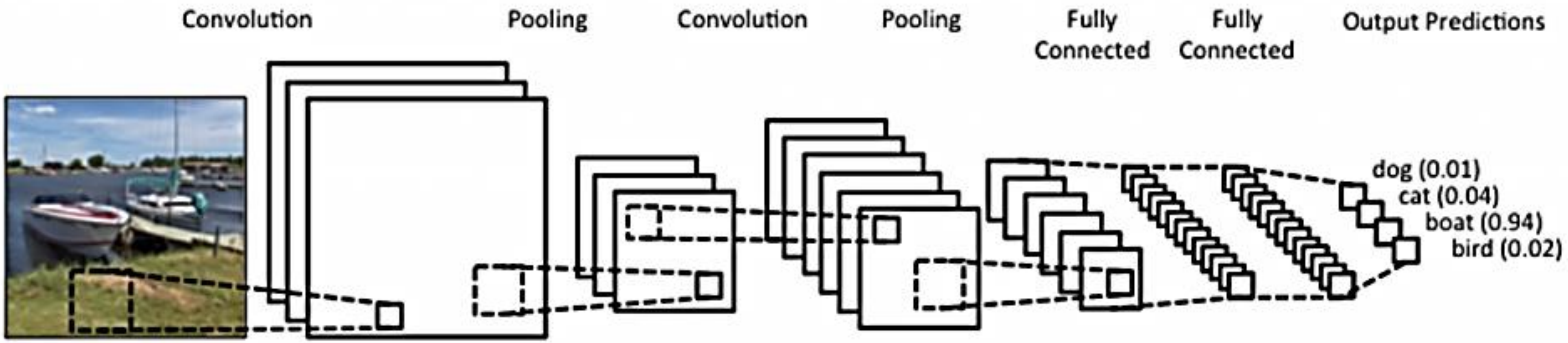
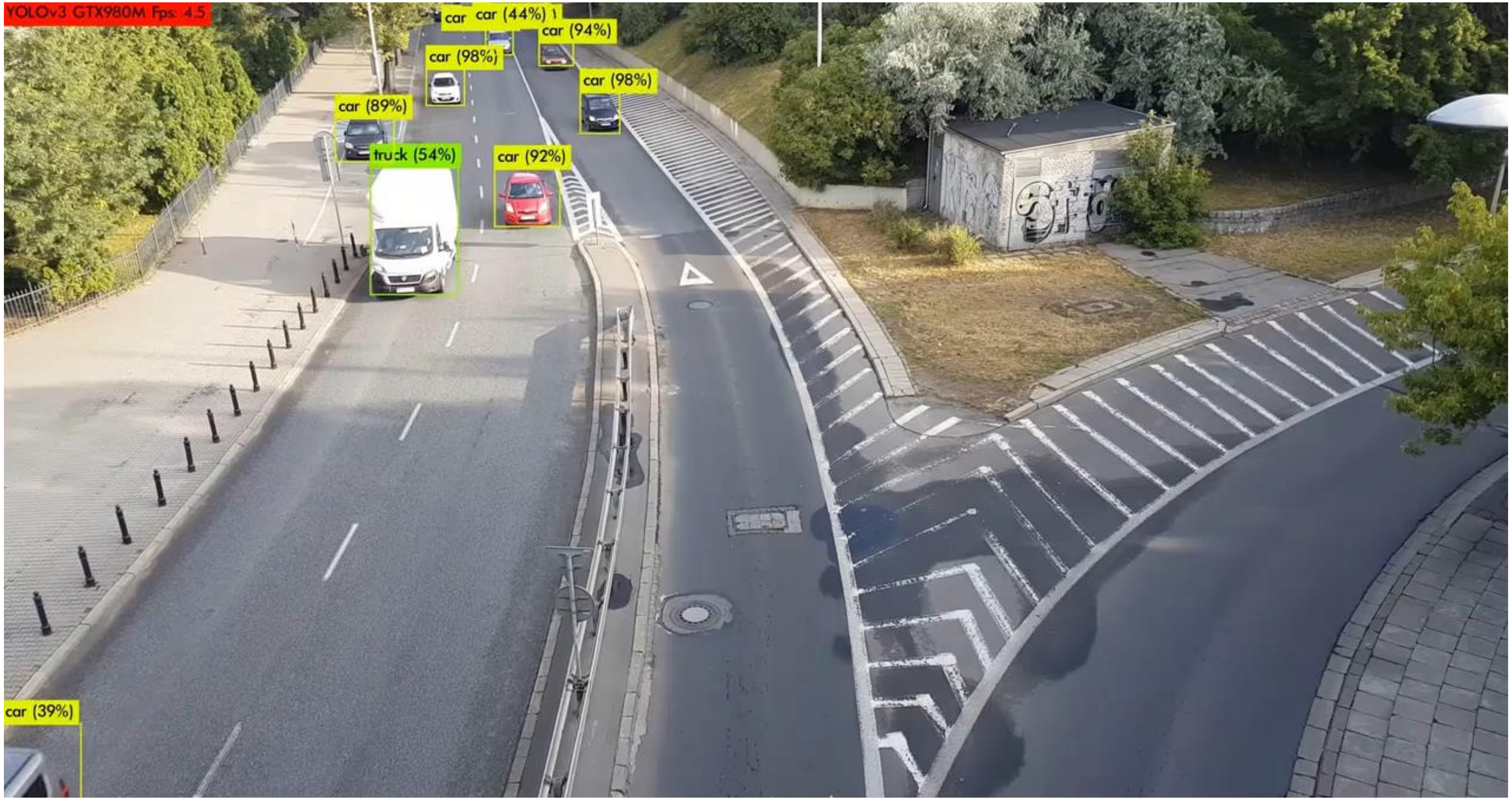


IMAGE RECOGNITION



RAPIER

- Road assessments can be hugely beneficial in determining how best to create a safe system
- A lot of these require manual coding of road features, which can be costly and time consuming
- This limits impact
- Long term goal to use machine learning techniques to programmatically code road infrastructure on the network using a combination of satellite imagery and video recorded by vehicles
- Used in combination with models that determine risk levels based on the coded infrastructure

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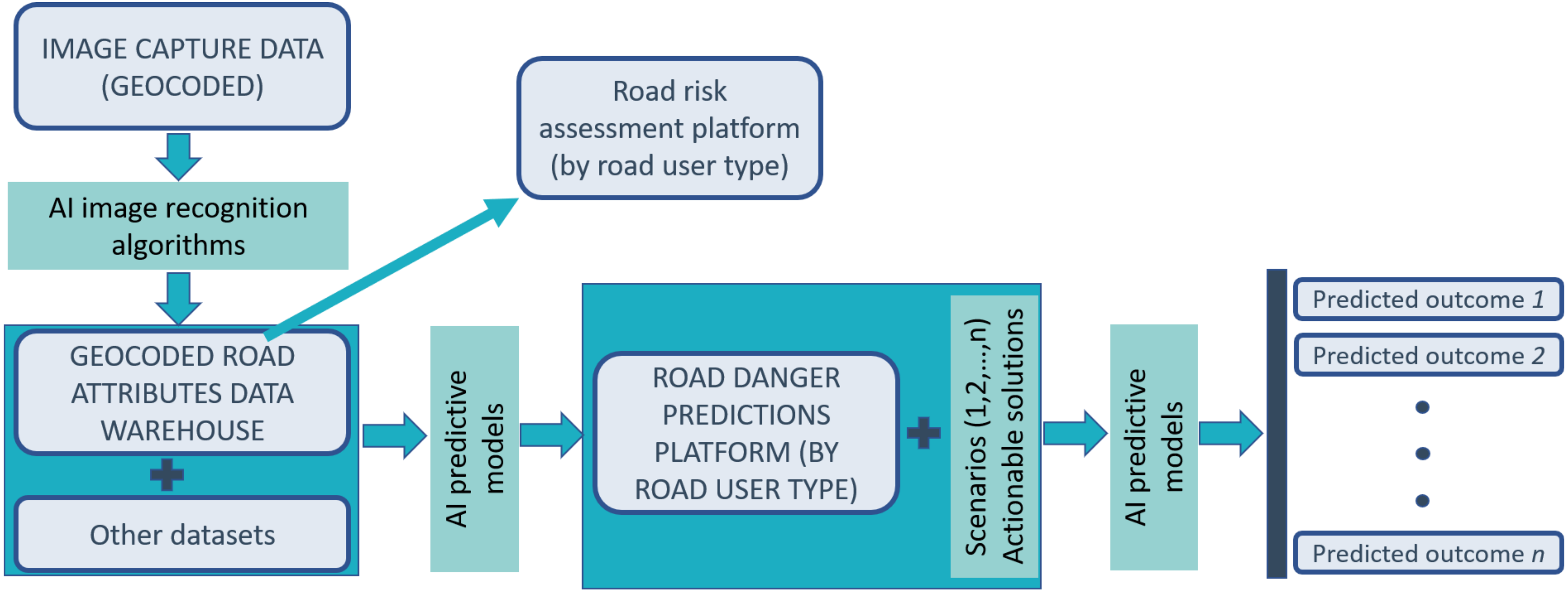
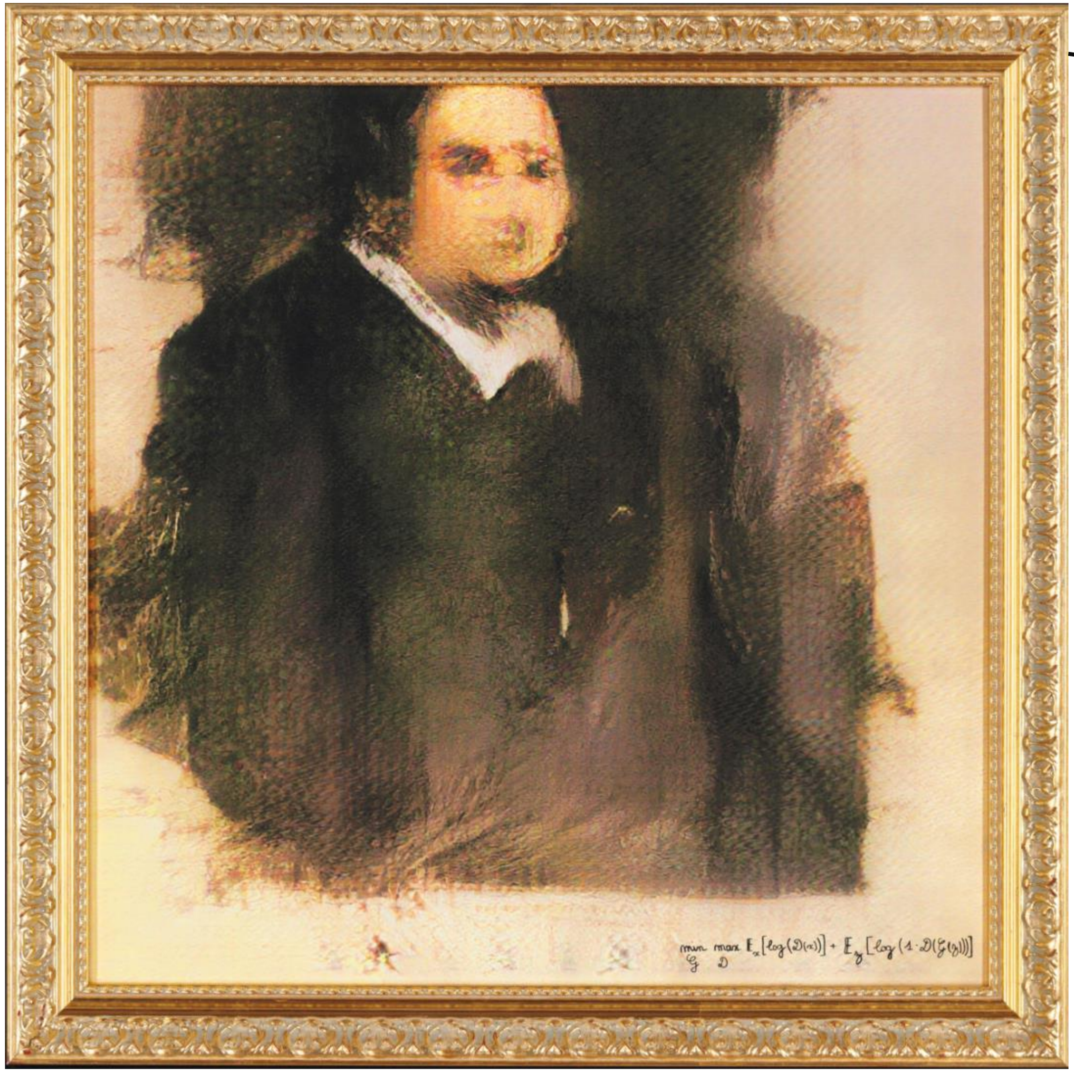
RAPIER



WHAT CAN WE USE THEM FOR?

- Regression models
- Classification models
- Anomaly/rare event detection
- Unsupervised learning/classification
- Image recognition and object detection
- Art

AI ART



$432,500
Christie's, 2018

DEEP DREAMING

More dog

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