Anything Repeatable is Replaceable by AI

Opportunities and Challenges

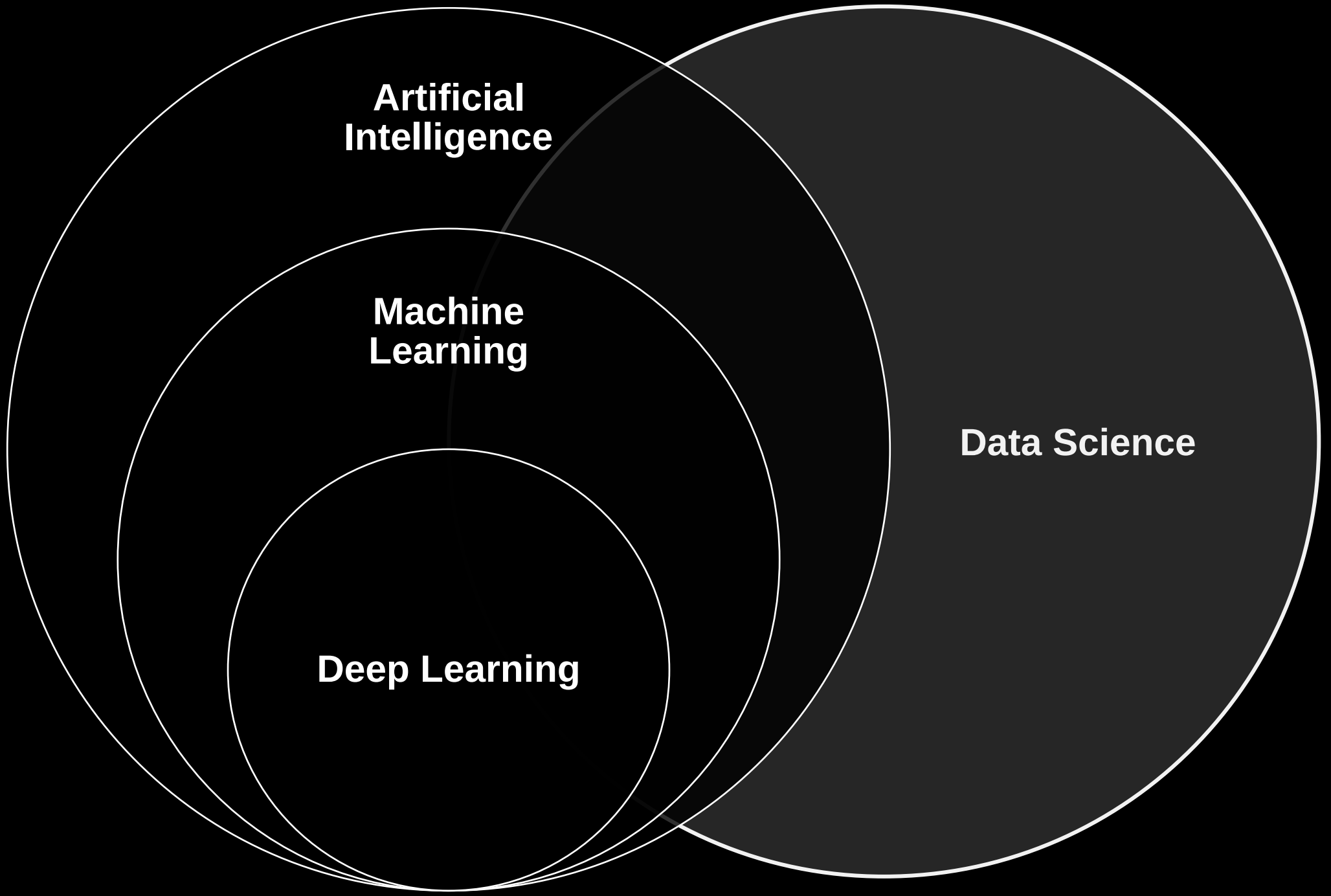
by
Dr Varun Ojha
Department of Computer Science, University of Reading
at
Themes Valley AI Hub, United Kingdom
16 March 2022

Agenda

1. What are the AI Tools?
2. What problems do they solve?
3. How do they solve problems?

What you want to know

1. Understanding the data
2. Predicting from the data
3. Optimizing the systems


Artificial Intelligence
Machine Learning
Deep Learning
Data Science

Artificial Intelligence

to create intelligent machines that think (react) and act (work) like human beings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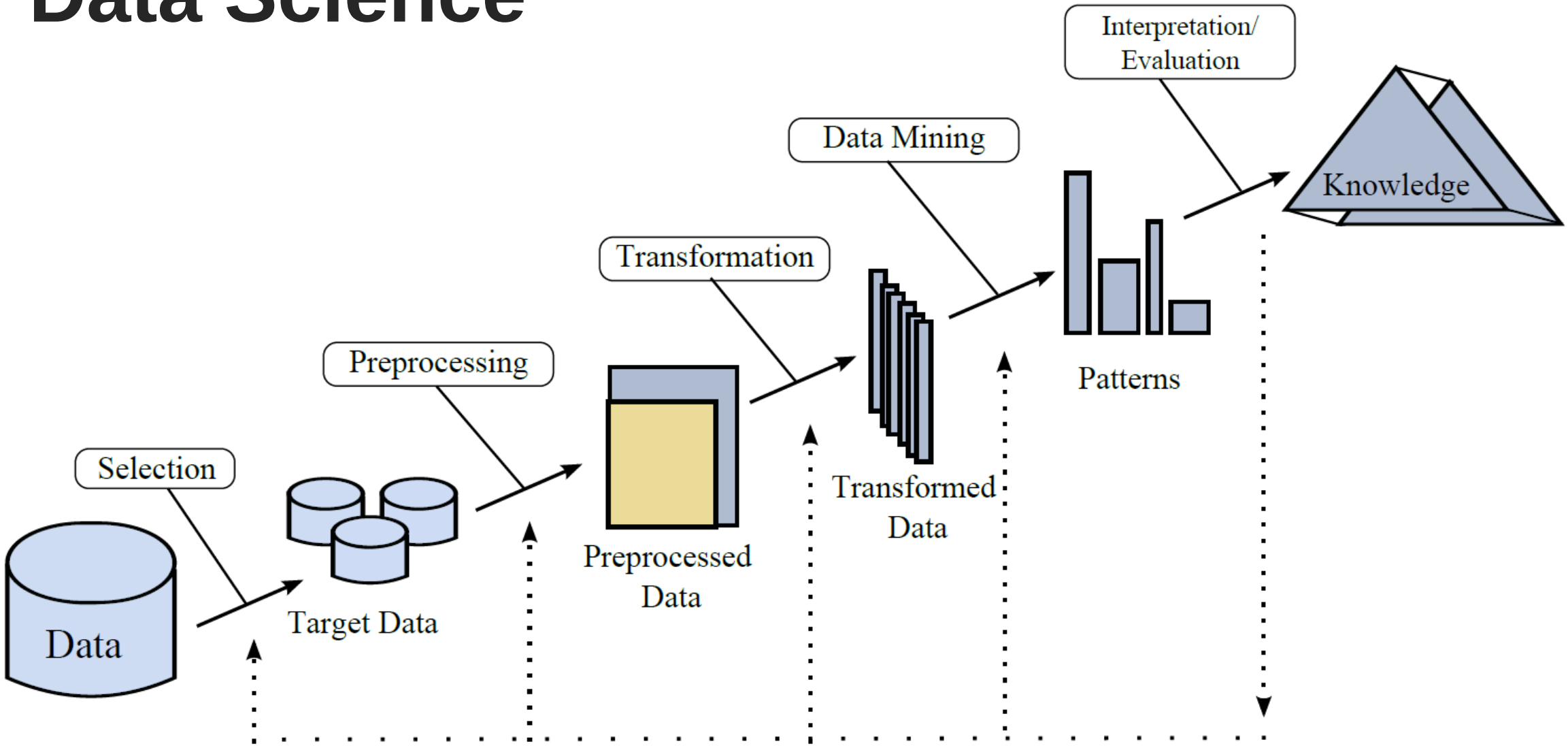
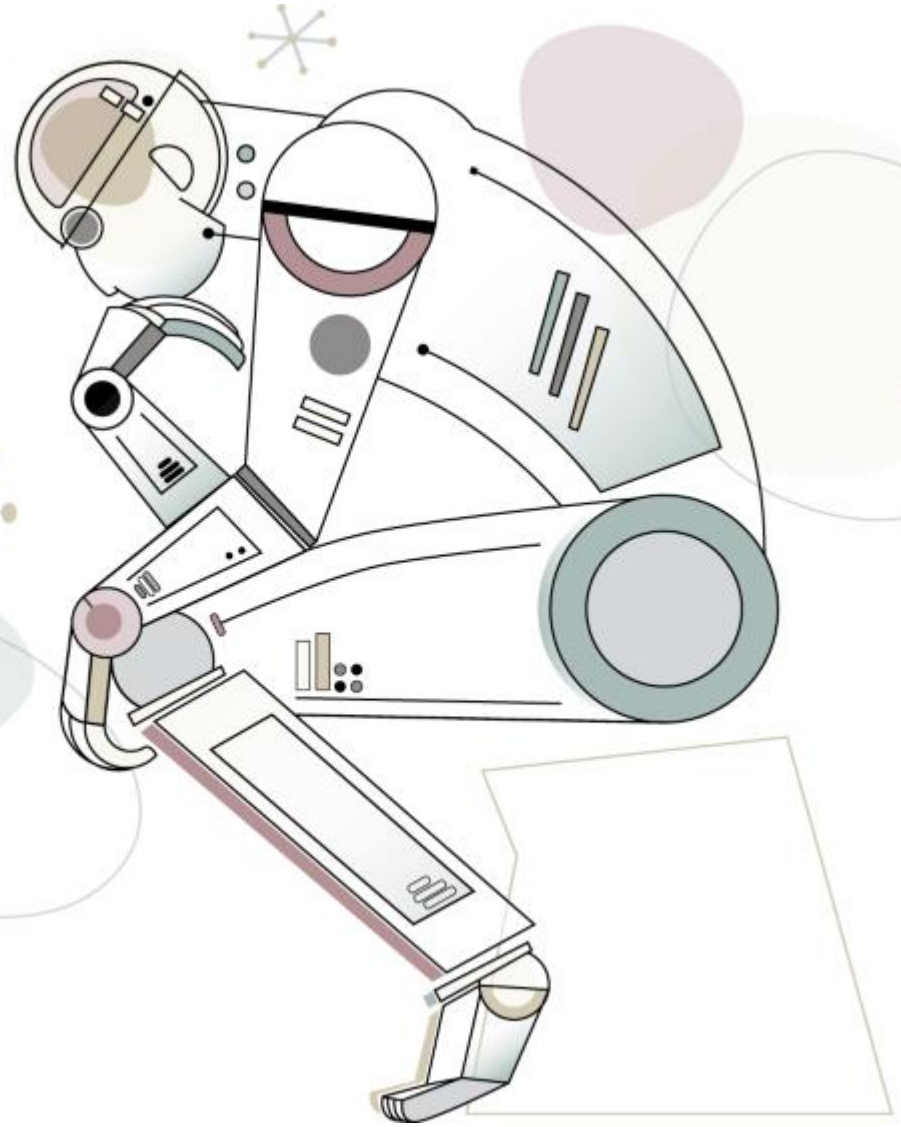
Data Science



Machine Learning

to create **machines** that **learn from examples** as living beings do

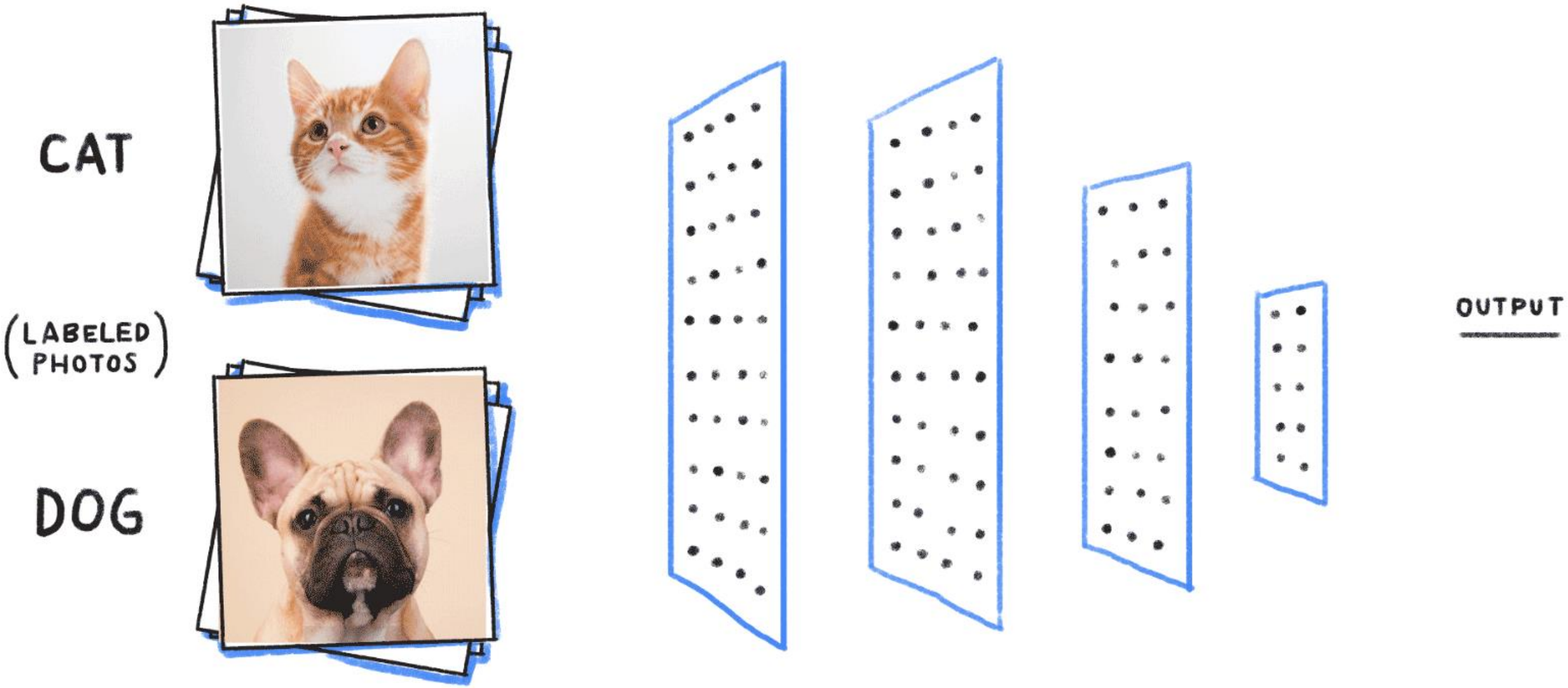


Learning

Video Source:
https://www.youtube.com/watch?v=Ak7bPuR2rDw
(Accessed on 21 February 2021)

Deep Learning

Source: https://becominghuman.ai/building-an-image-classifier-using-deep-learning-in-python-totally-from-a-beginners-perspective-be8dbaf22dd8



Optimization

Optimization

to solve a **problem** that has a number of influencing factors that **need to attain certain values** in order to offer a **solution**

Applications of AI

1. Engineering
2. Pharmacy & Drugs
3. Environment (Physiology & Architecture)
4. Civil Engineering
5. Physics
6. Biology
7. Hydrology
8. Climate Science
9. Final Year Student Projects

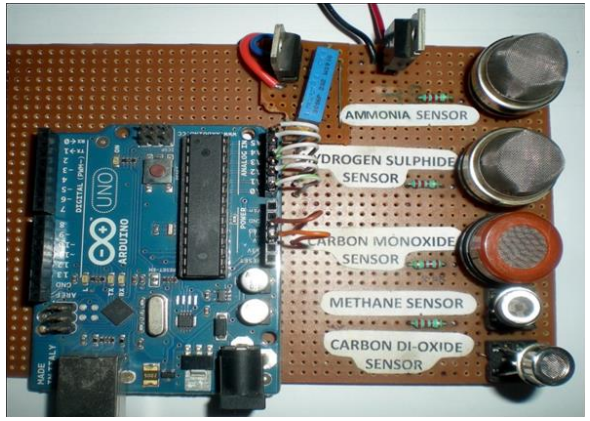
Electronics Engineering

Protection of health and life of sewer pipeline workers

Pattern Recognition

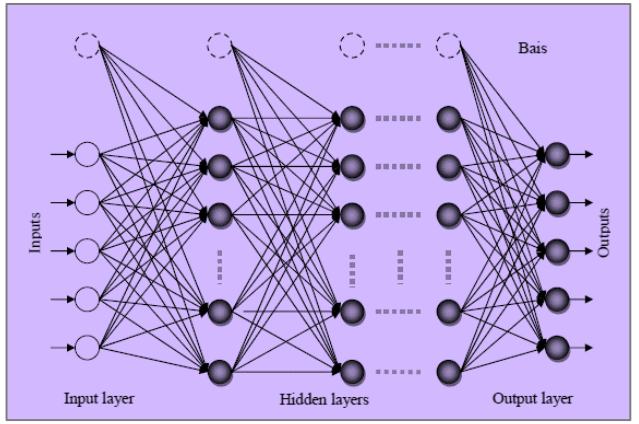
Intelligent recognizer for the component analysis of toxic mixture of (sewer) gases

Gas mixture collection



Sensor array formation

Data collection and simulation



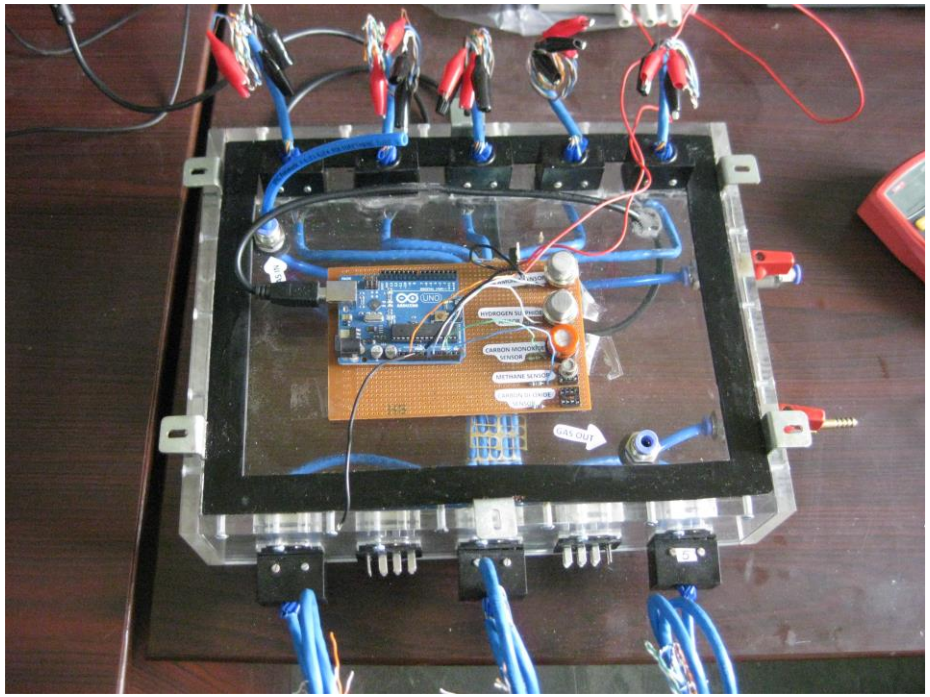
Pattern Recognition

Ojha et al. (2012) *ISPTS*

Ojha et al. (2017) *Neural Computing and Applications*

Prototype of Intelligence Sensor

This was the objective ☺



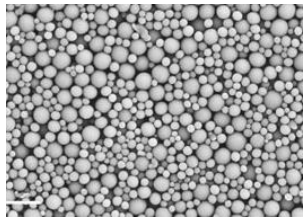
We managed to get this one nonetheless! (2011-2013)

Pharmaceutical

Drug manufacturing process variables and drug property analysis

Pharmaceutical (Drugs Production)

Pharmaceutical



Particle Properties

(Material type, density, size, shape and etc.)

Powder Properties

(Flowability, compactibility) + (Roller gap and roller speed)

Ribbon Properties

(Density, Hardness, Porosity) + (Milling speed etc.)

Granule Size Distribution + (die filling process)

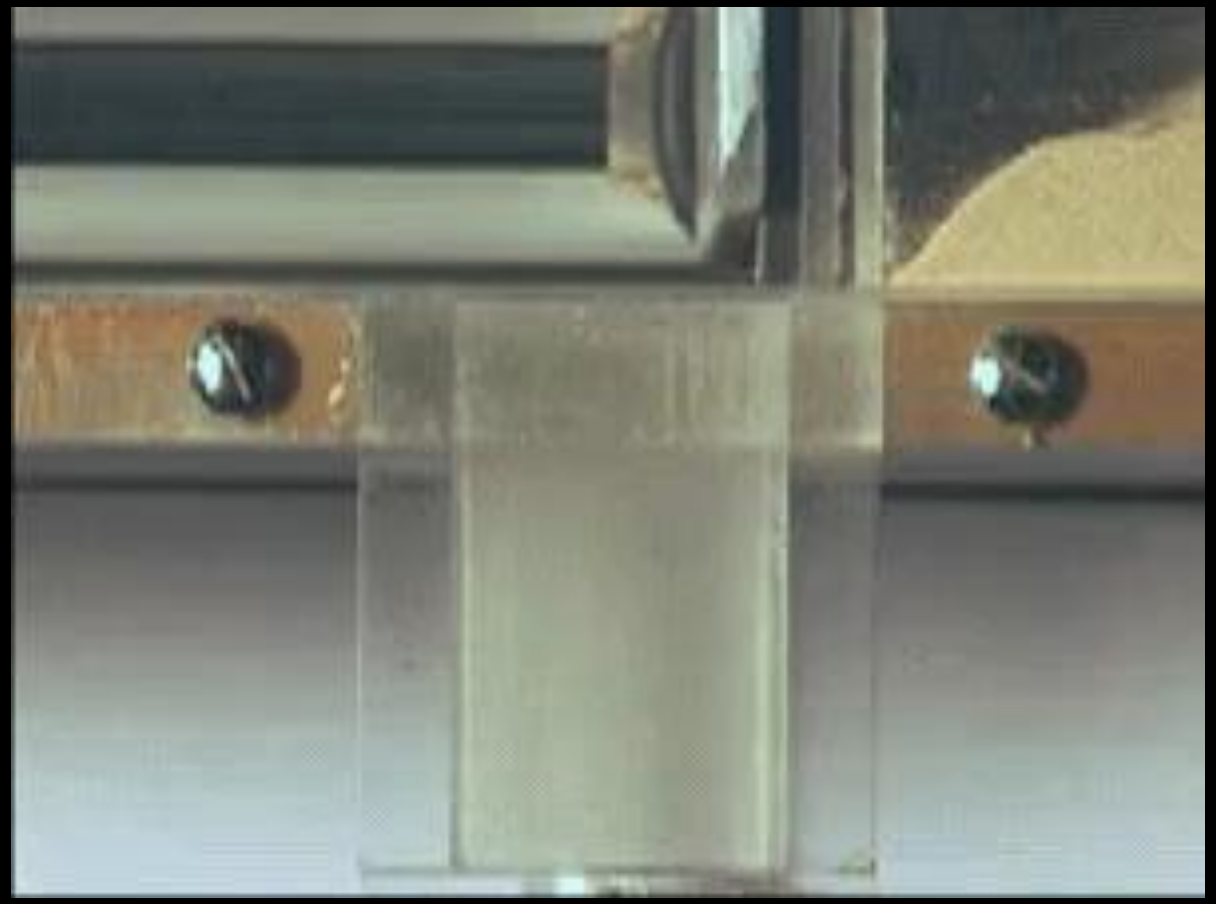
Tablet Properties

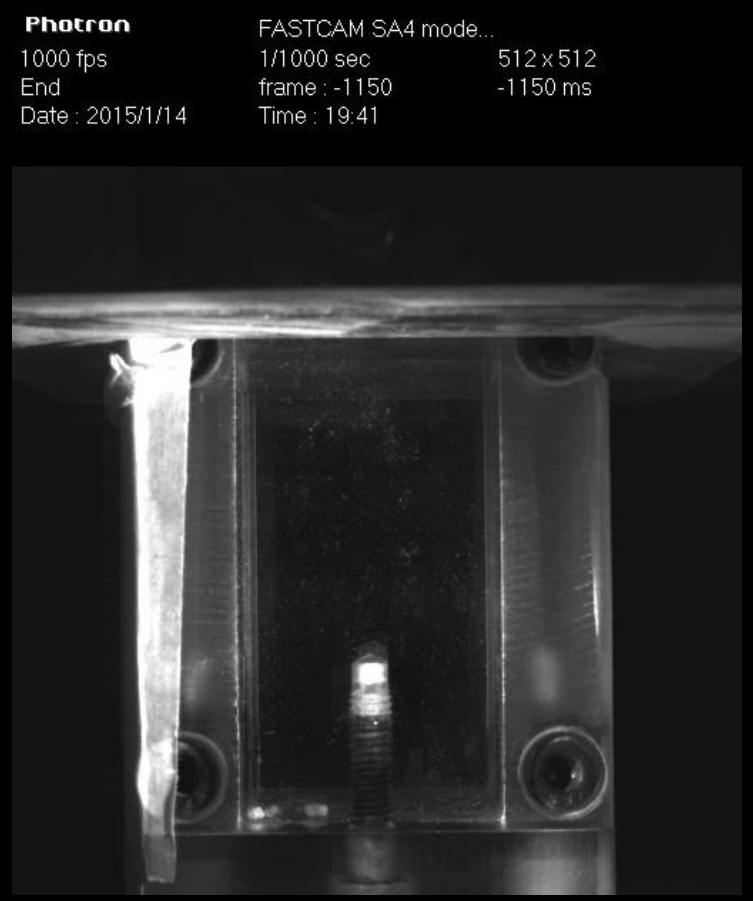
(Compressibility)

Ojha et al. (2017) *Neural Computing and Applications*

Pharmaceutical Industrial Processes Variable Identification

Prediction of the mass of deposited drug powder





Ojha et al. (2017) *Neural Computing and Applications*

Drug Dissolution

Ojha VK et al. (2015) International Journal of Nanomedicine

Three Hundred Descriptors of Drug Properties

PLGA: poly(lactic-co-glycolic acid)

Sl No	Group name	No of features	Importance
1	Protein descriptors	85	Describes the type of molecules and proteins used
2	Formulation characteristics	17	Describe the molecular properties such as molecular weight, particle size, etc
3	Plasticizer	98	Describe the properties such as fluidity of the material used
4	Emulsifier	99	Describe the properties of stabilizing/increase the pharmaceutical product life
5	Time in days	1	Time taken to dissolve
6	% of molecules dissolved	1	Output

Abbreviations: PLGA, poly(lactic-co-glycolic acid); Sl, serial; No, number.

Ojha et al. (2015) *International Journal of Nanomedicine*

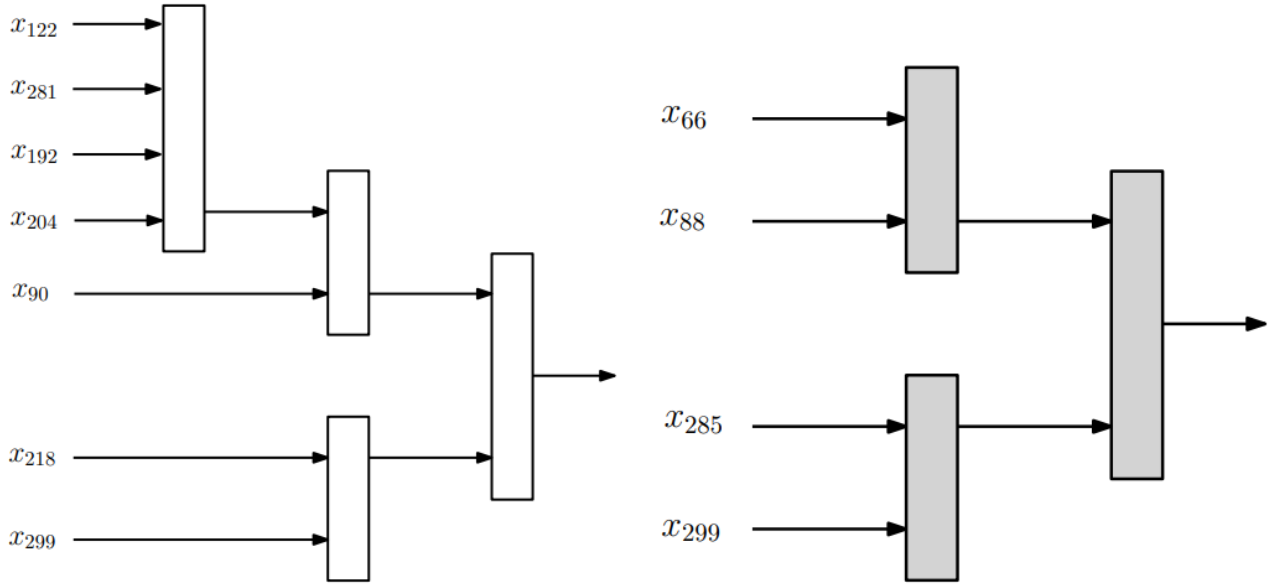
Balancing Prediction and Feature Selection

Algorithm	RMSE E_t	No. of features
MLP	14.3	17
Neural Tree	13.2	15
REP Tree	13.3	15
GPR	14.9	15
MLP	15.2	15
MLP	15.4	11
Type 1 Tree	18.6	7
Type 2 Tree	15.2	4

Ojha et al. (2018) *IEEE Transactions on Fuzzy Systems*

A Tree Model for Future Use

Can we also explain how the prediction was made?



Type 1 Tree Type 2 Tree

If *protein* is **A** and *plasticizer* is **B**, **Then** % *molecule dissolution* is **X**

Ojha et al. (2018) *IEEE Transactions on Fuzzy Systems*

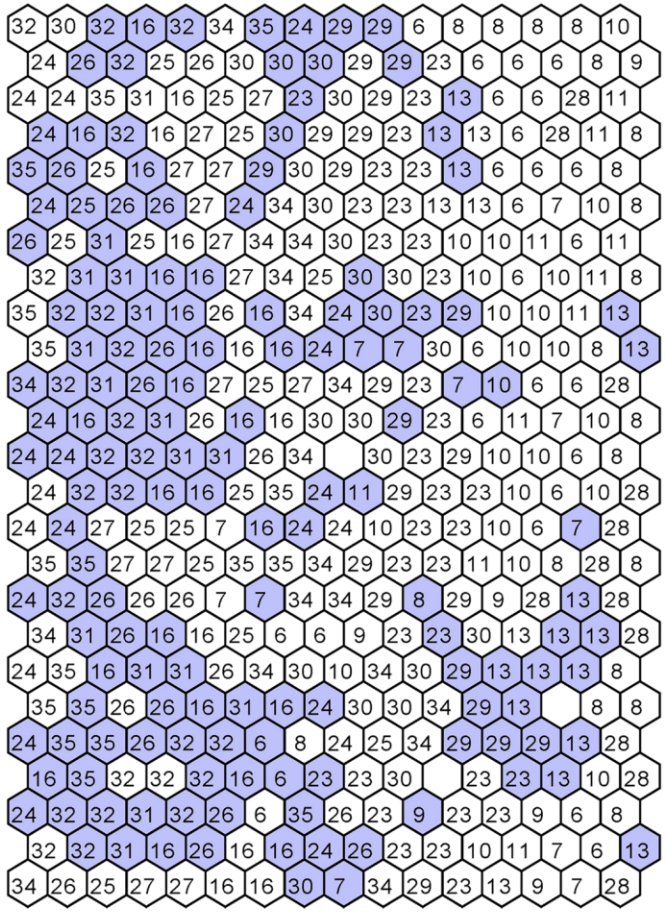
Environment and Build Architecture

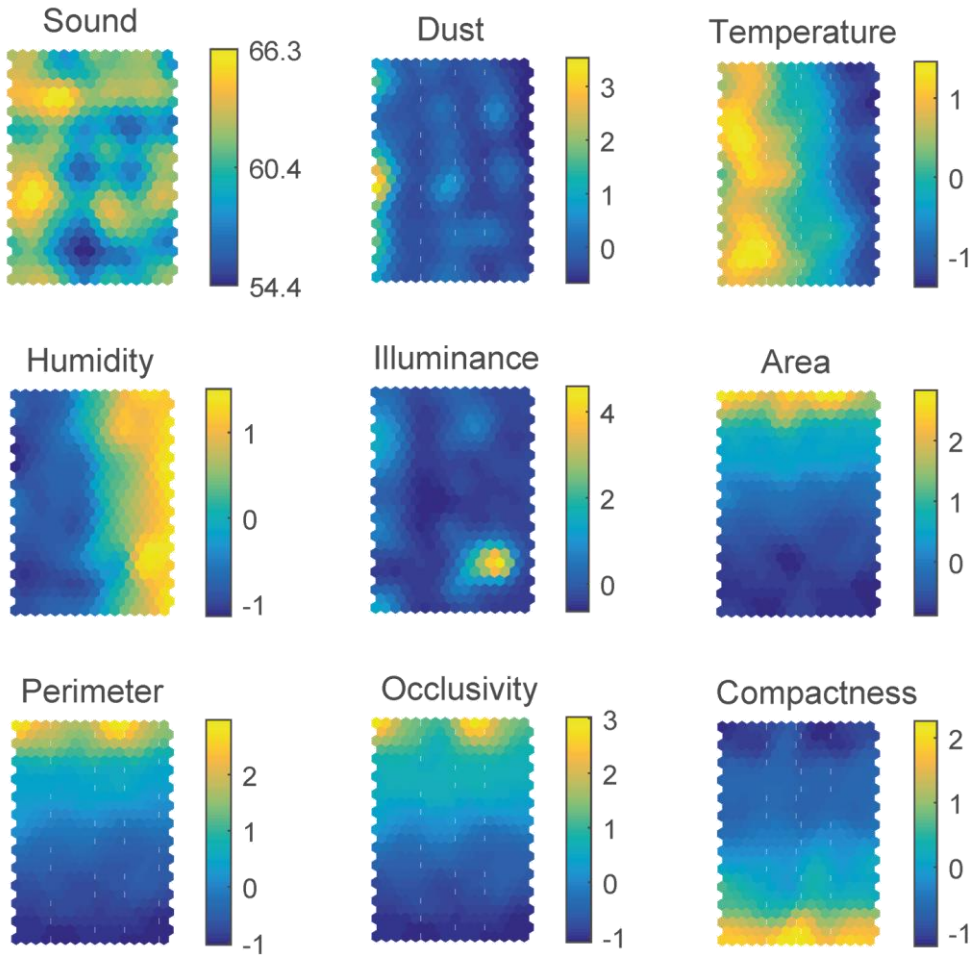
Understanding impact of environment and urban dynamics on humans

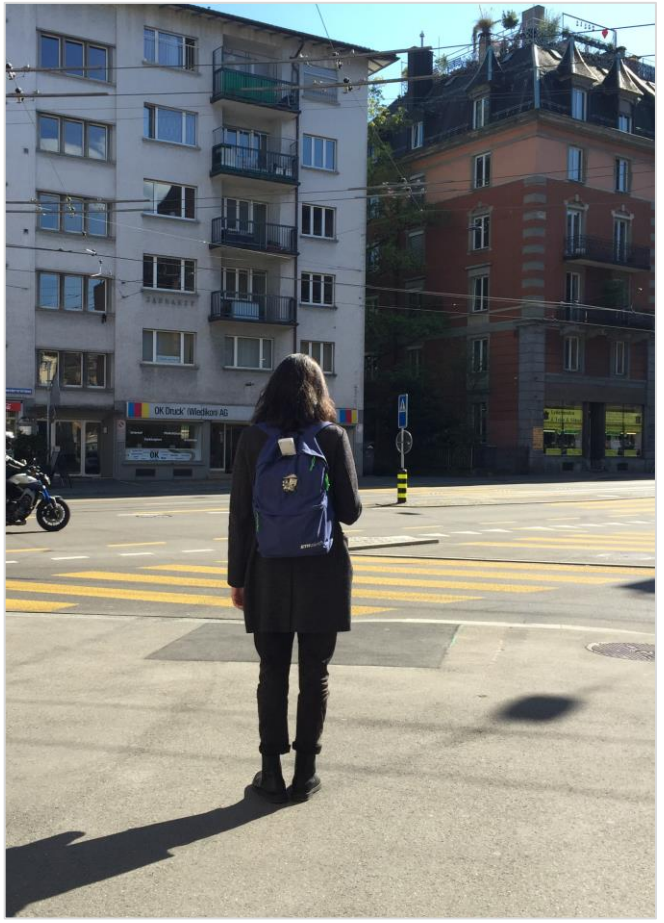
Perception of the Environment

Ojha et al. (2019) *Information Sciences* | Buš & Ojha (2017), *ETH Zurich*

Perceptual Experience







Ojha et al. (2019) *Information Sciences* | Buš & Ojha (2017), *ETH Zurich*

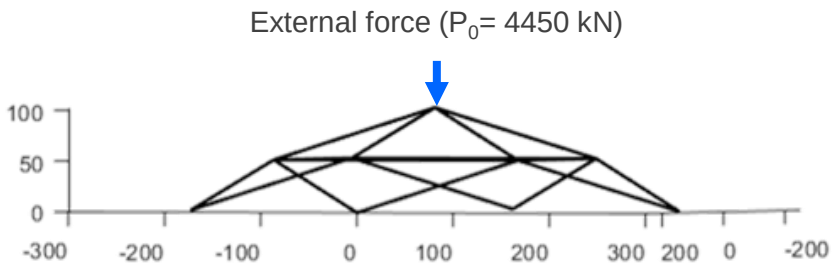
Civil Engineering

Structure buckling analysis

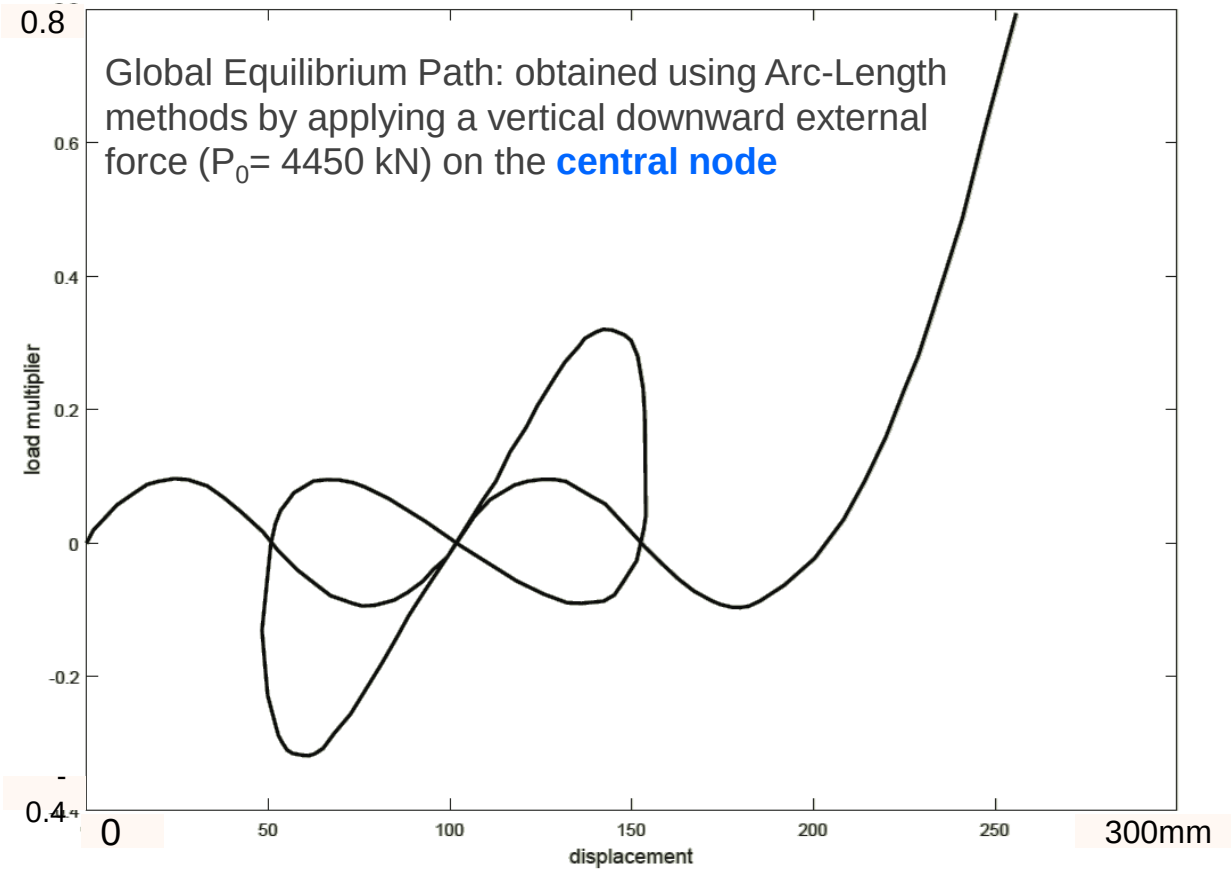
Civil Engineering Problem

Civil Engineering Problem

A tiny version of Millennium Dome can be the following structure



Dimensions in mm



Hrinda, G. (2010, April). Snap-through instability patterns in truss structures. In 51st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference 18th AIAA/ASME/AHS Adaptive Structures Conference 12th (p. 2611).

Civil Engineering Problem

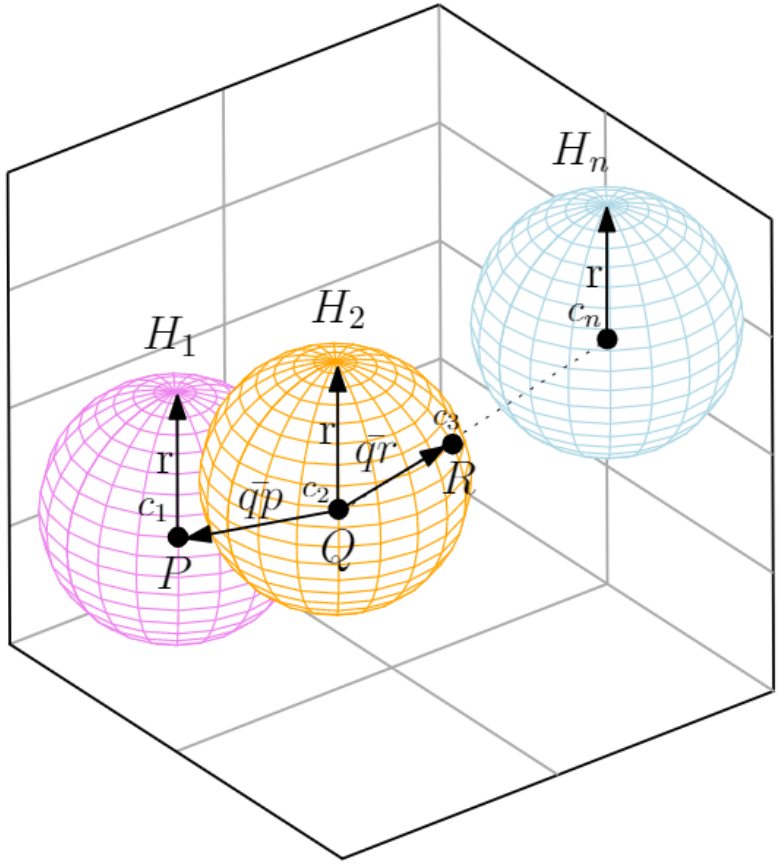


Fig A. Adaptive Hypersphere Search Algorithm for Structural Static Analysis

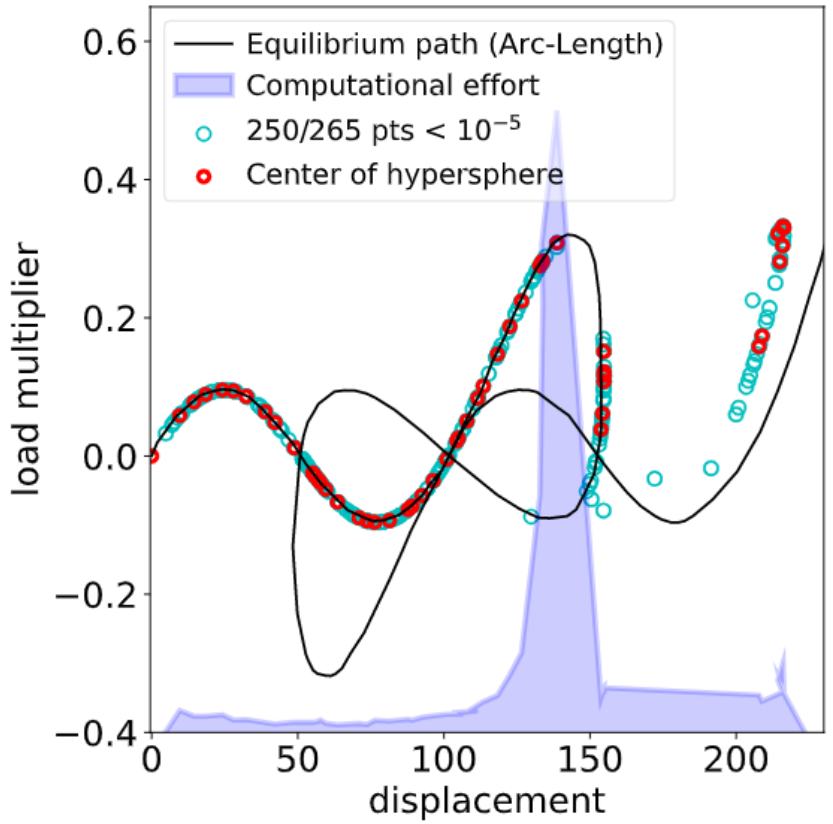
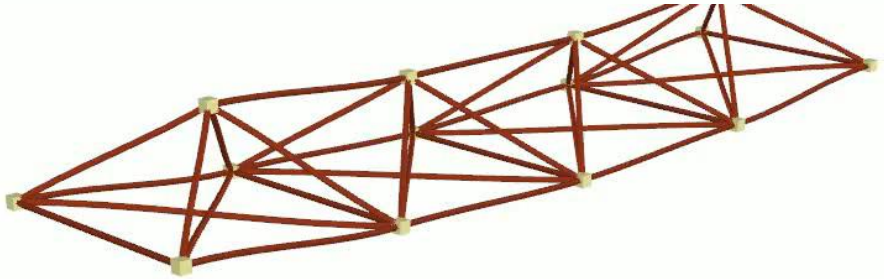


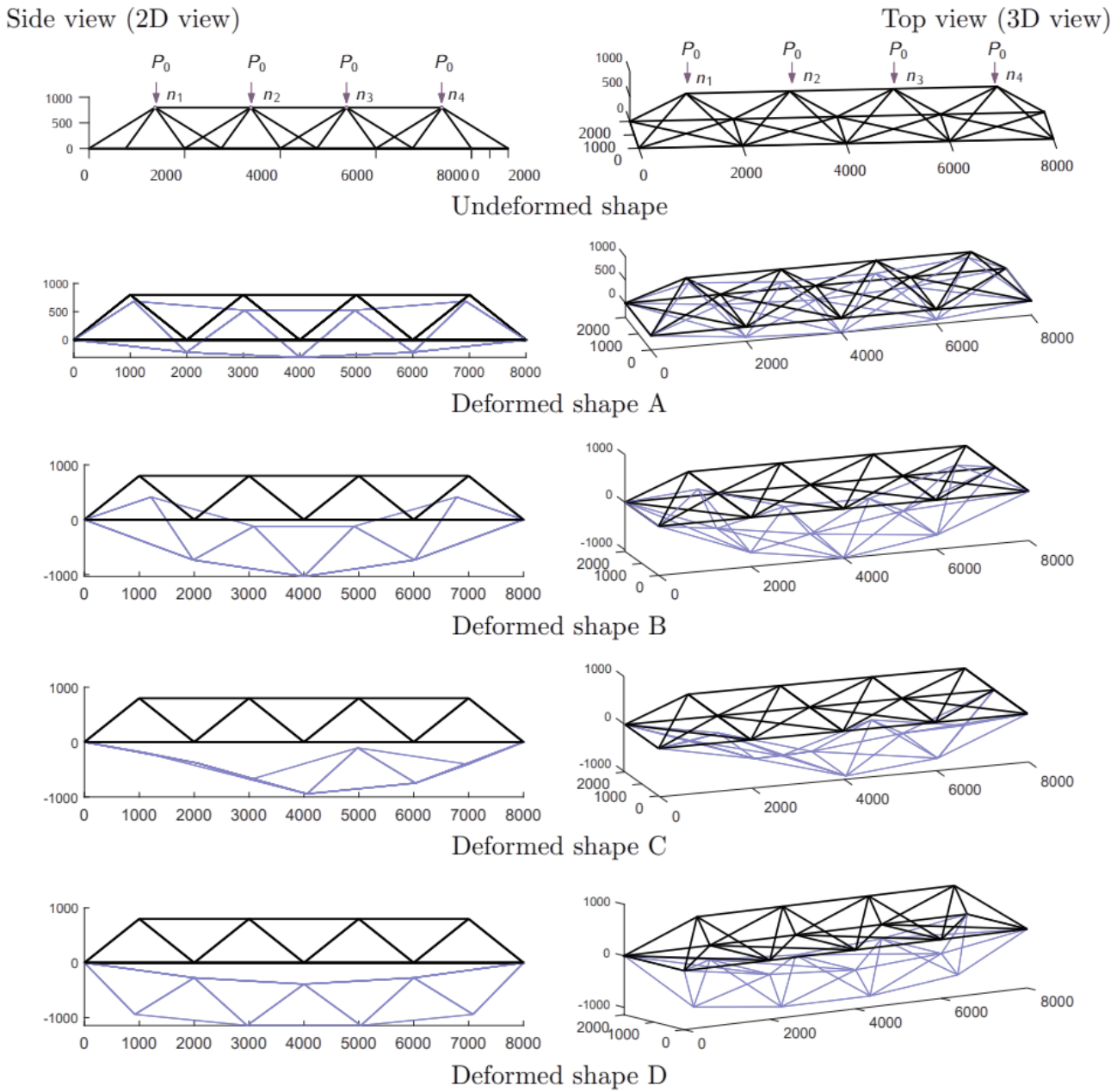
Fig B. Equilibrium Path traced using Adaptive Hypersphere Search Algorithm

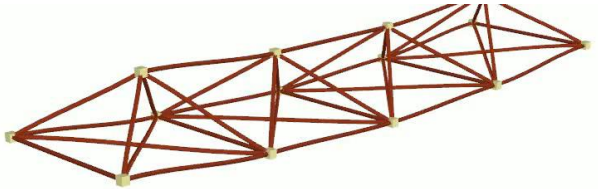
Ojha et al (in rev. 2022), *Engineering Application of Artificial Intelligence*

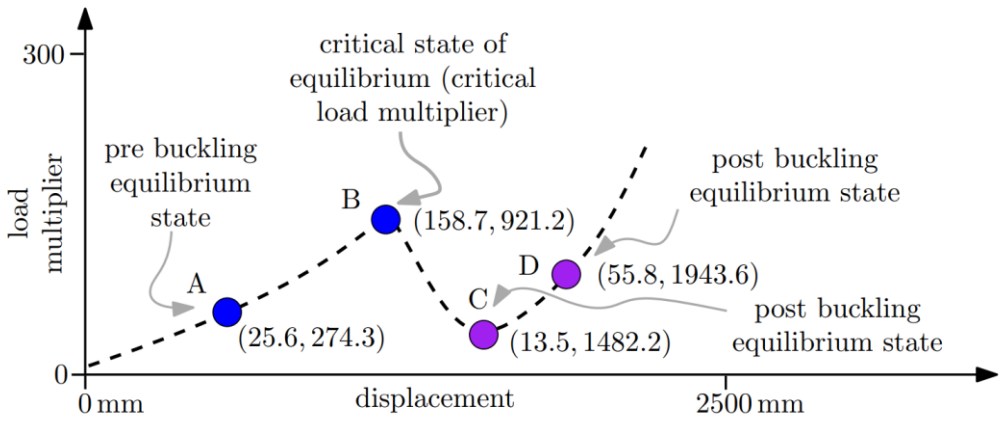
Prediction of the Collapse



Ojha et al (in rev. 2022), *Engineering Application of Artificial Intelligence*





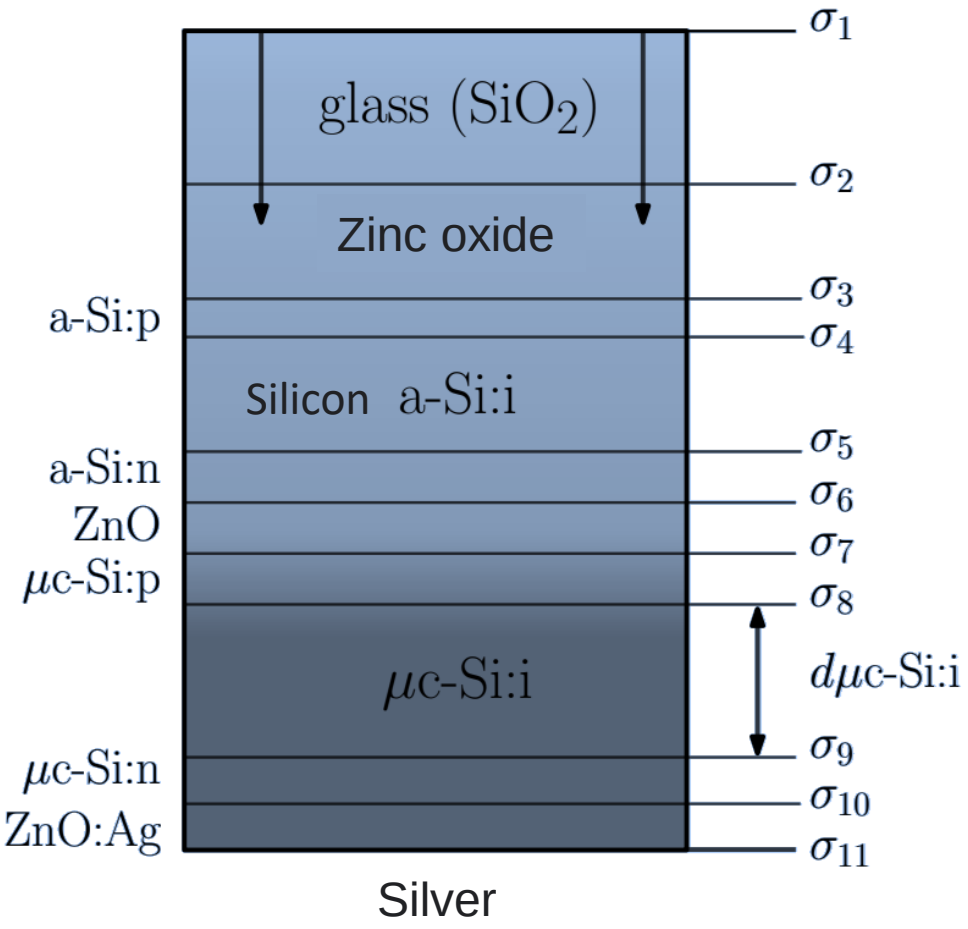


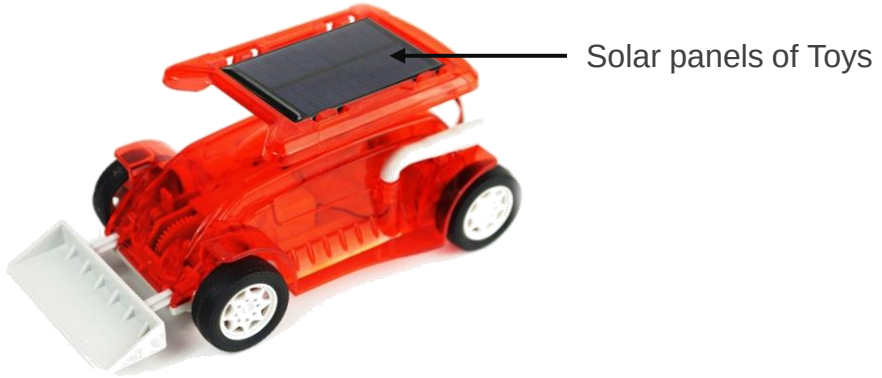
Ojha et al (in rev. 2022), *Engineering Application of Artificial Intelligence*

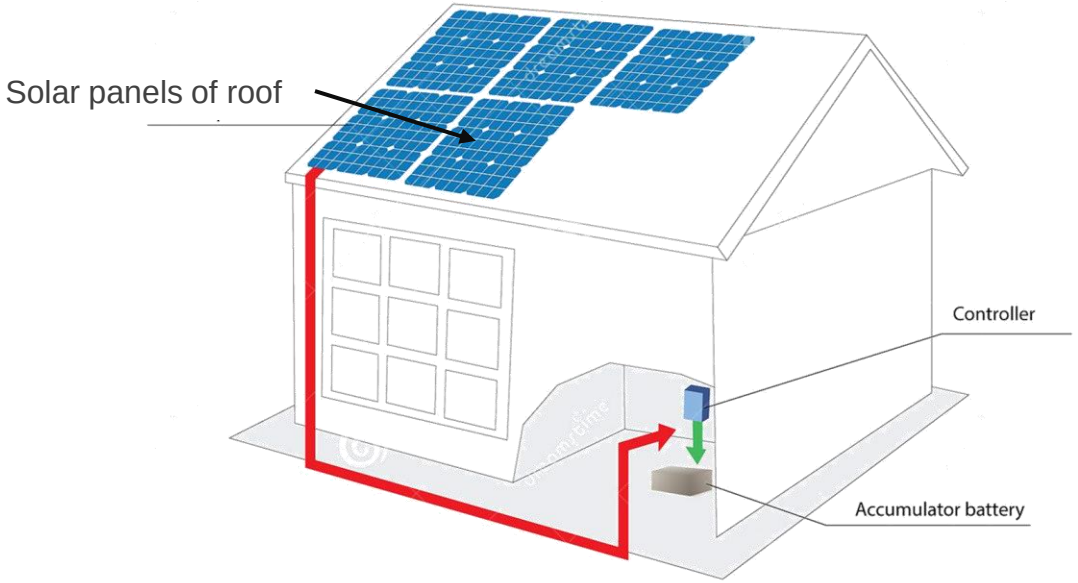
Physics

Solar cell design and characterization

Solar Cell – Energy Optimization



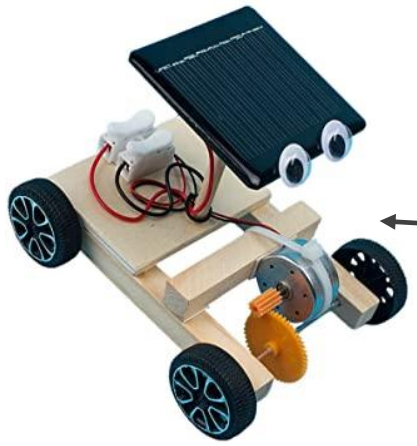


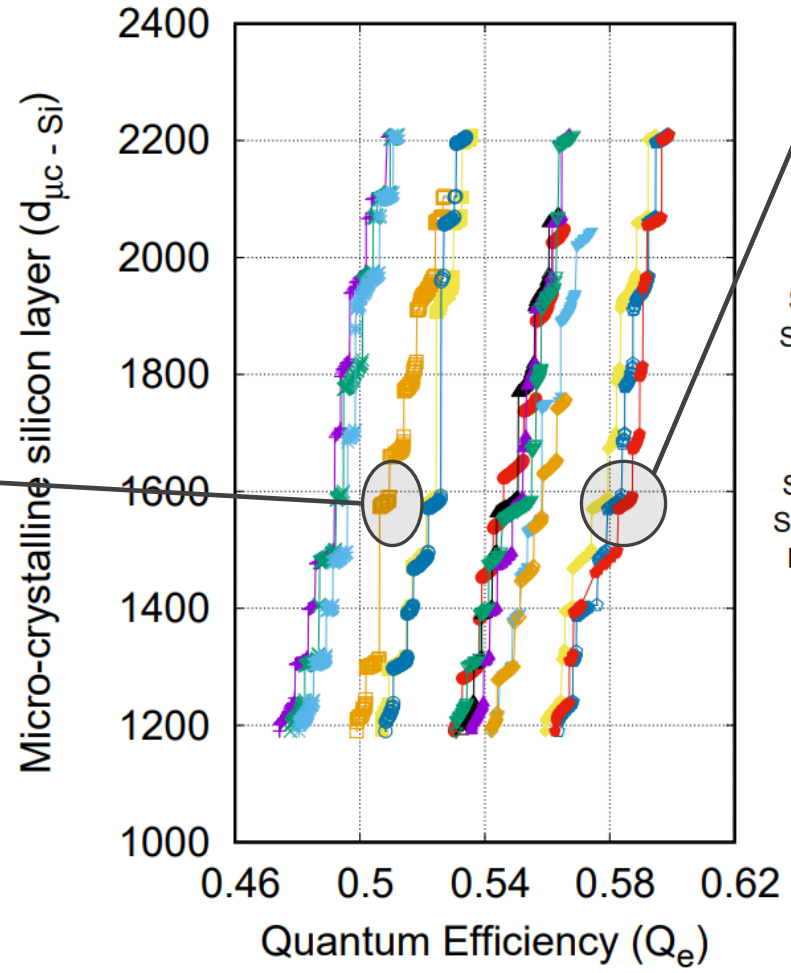


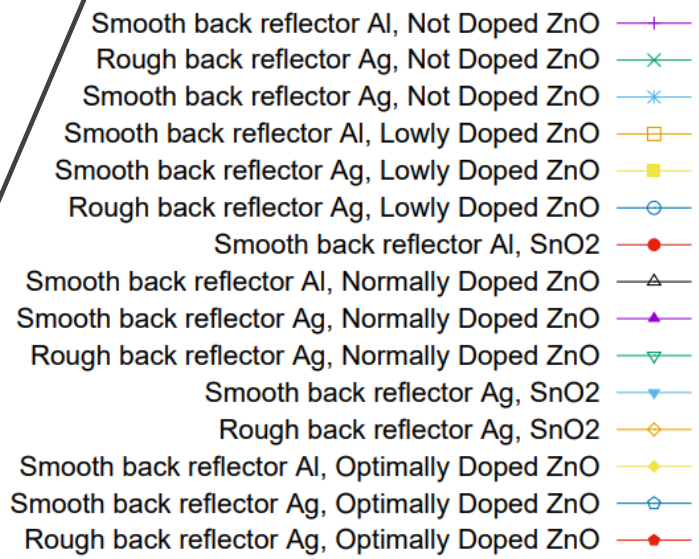
Ojha et al. (2021) *Energy Systems*

Solar Cell

Cost and Efficiency Trade-offs for its Usage







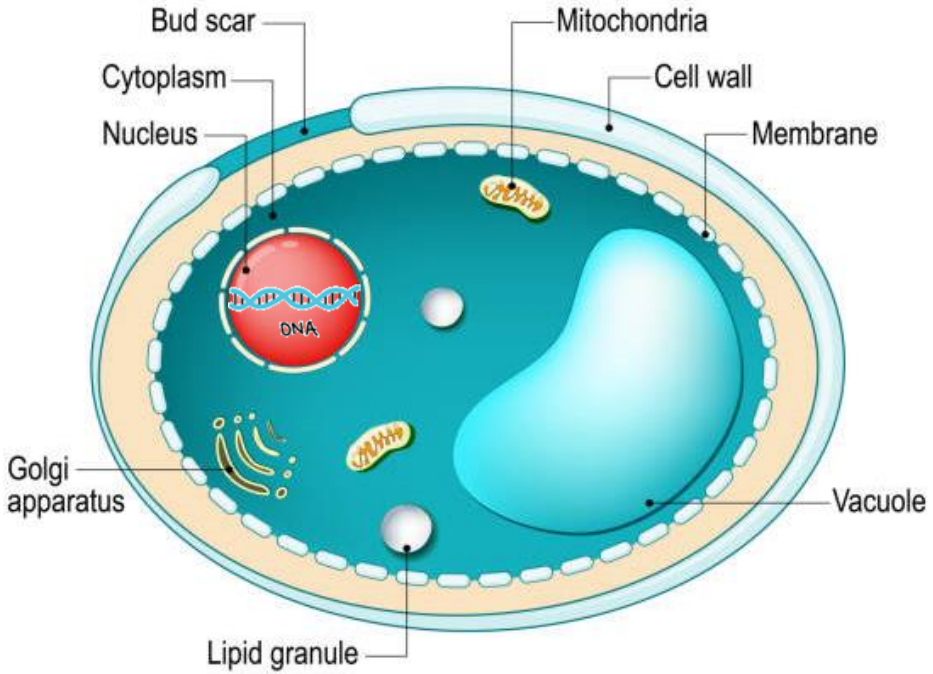
Ojha et al. (2021) *Energy Systems*

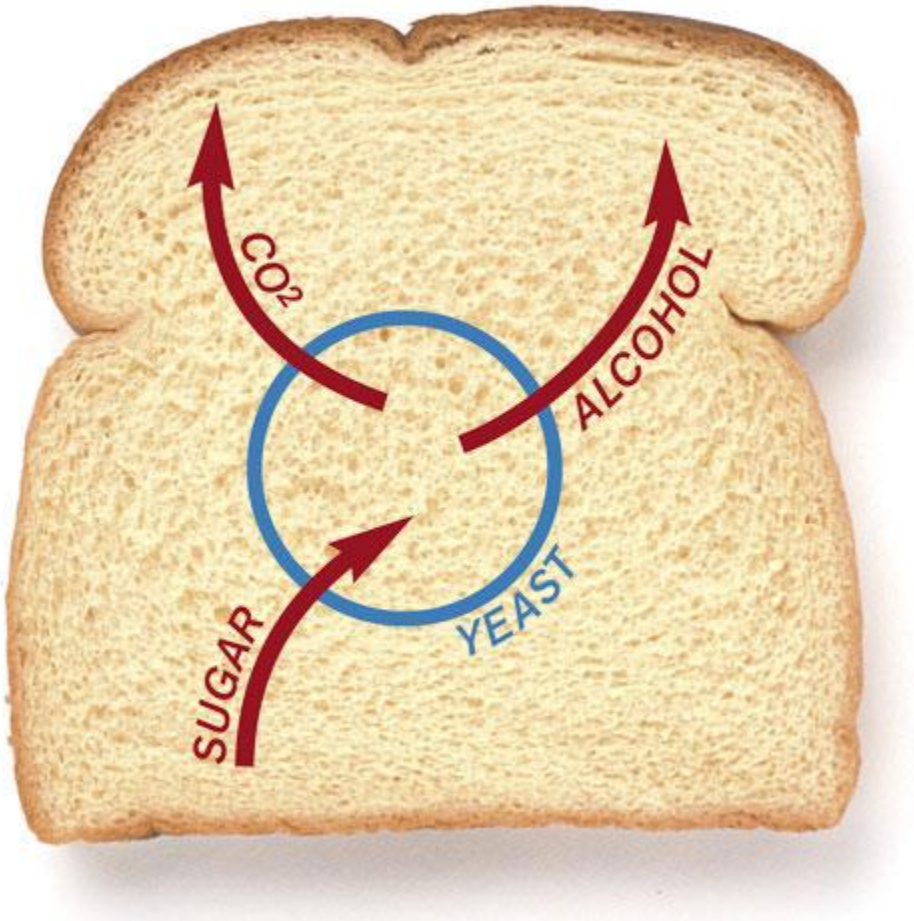
Biology

Metabolic engineering (searching for best strains)

Role of Yeasts in Food Production

Yeast Cell





Ojha et al. (in Rev. 2022) *Bioengineering & Biotechnology*

Metabolic Engineering

DNA

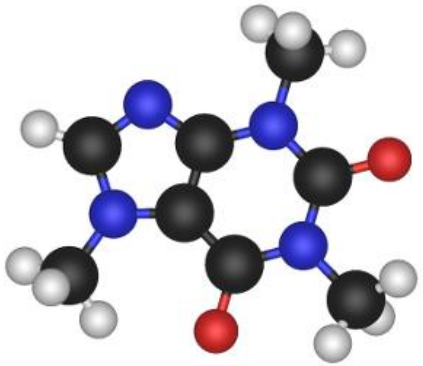
transcription

RNA

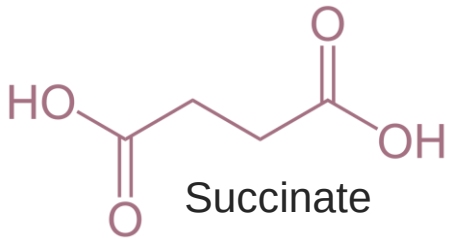
translation

Protein or enzyme

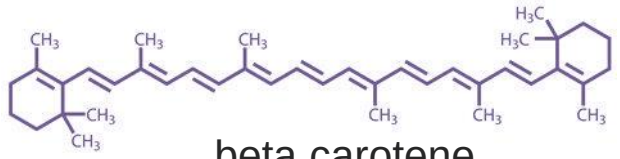
reactions



Molecular Structure of Ordinary Chemicals



Succinate

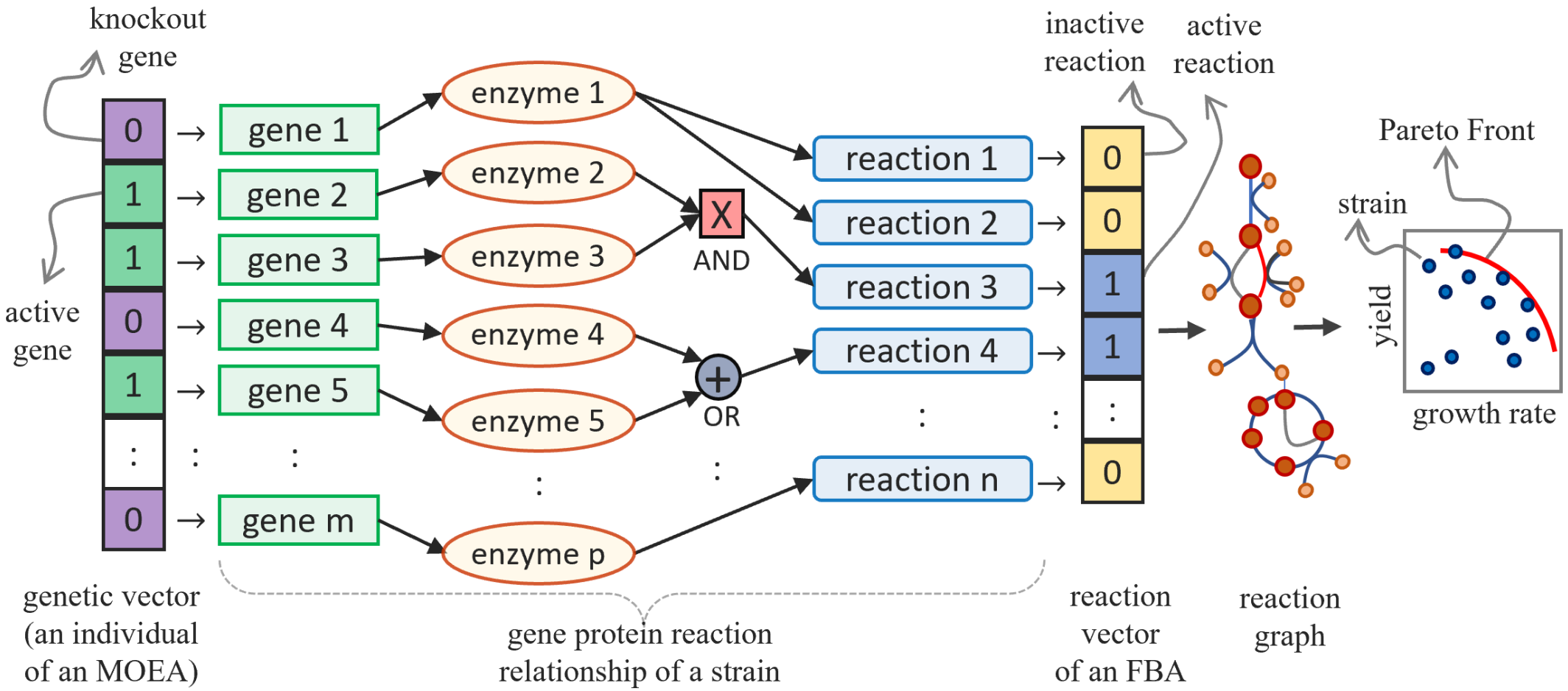


beta carotene

Molecular Structure of Target Chemicals

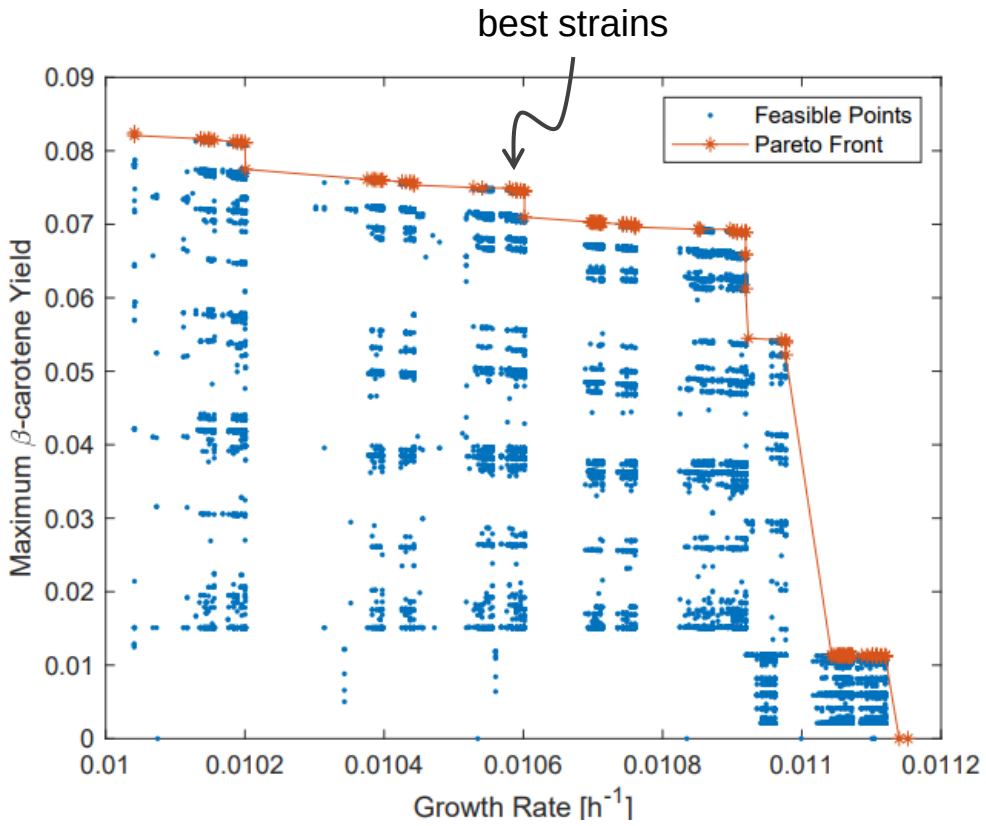
Ojha et al. (in Rev. 2022) *Bioengineering & Biotechnology*

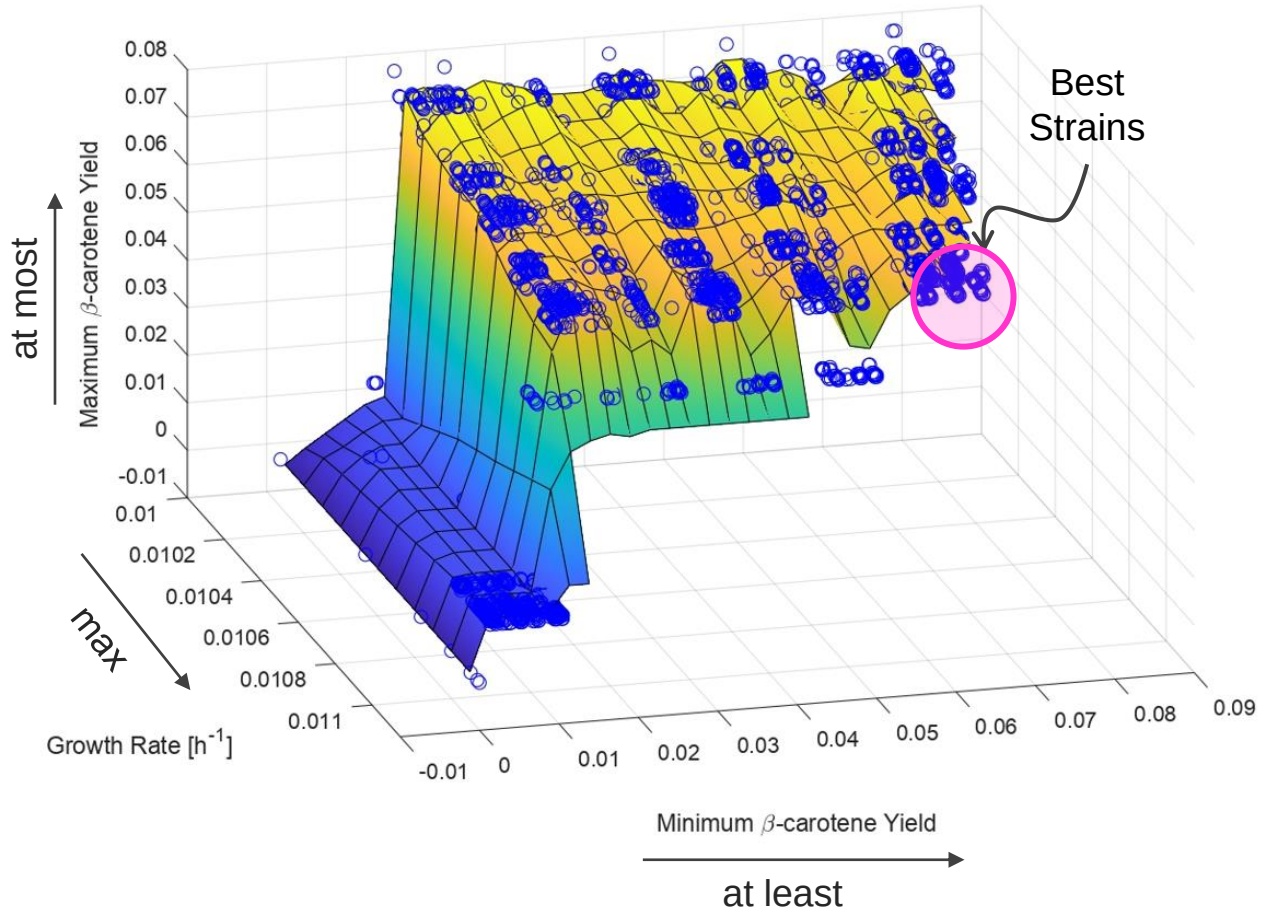
Metabolic Engineering for Chemical Production



Ojha et al. (in Rev. 2022) *Bioengineering & Biotechnology*

Optimal Strains of Yeast





Ojha et al. (in Rev. 2022) *Bioengineering & Biotechnology*

Hydrology

Prediction of flood events

Hydrology: Flood Event Prediction

A collaboration with Meteorology (Prof. Sarah Dance and Remy Vandaele)

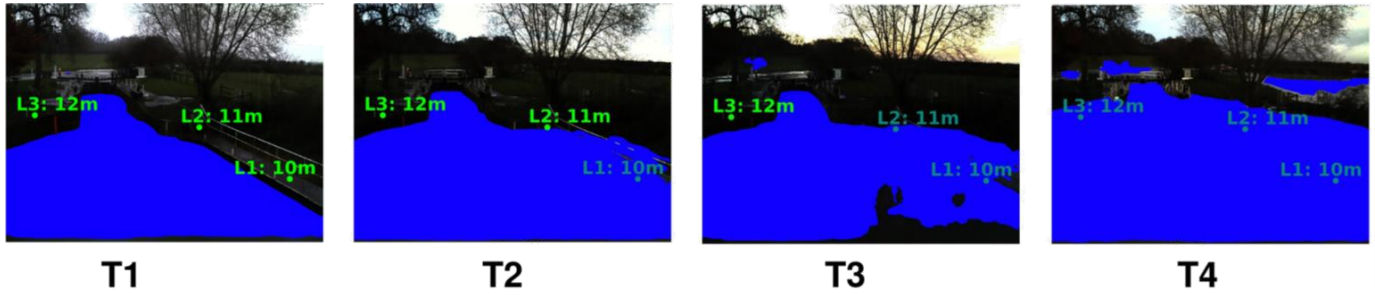


Fig. Time-series sequence of images of river. Blue pixels are water segmentation by using deep learning models

Credit: Farson Digital Watercams
https://www.farsondigitalwatercams.com/locations/keswick_greta

Vandaele, Dance, and Ojha, (2020), *GCPR*

Hydrology: Flood Event Prediction

A collaboration with Meteorology (Prof. Sarah Dance and Remy Vandaele)

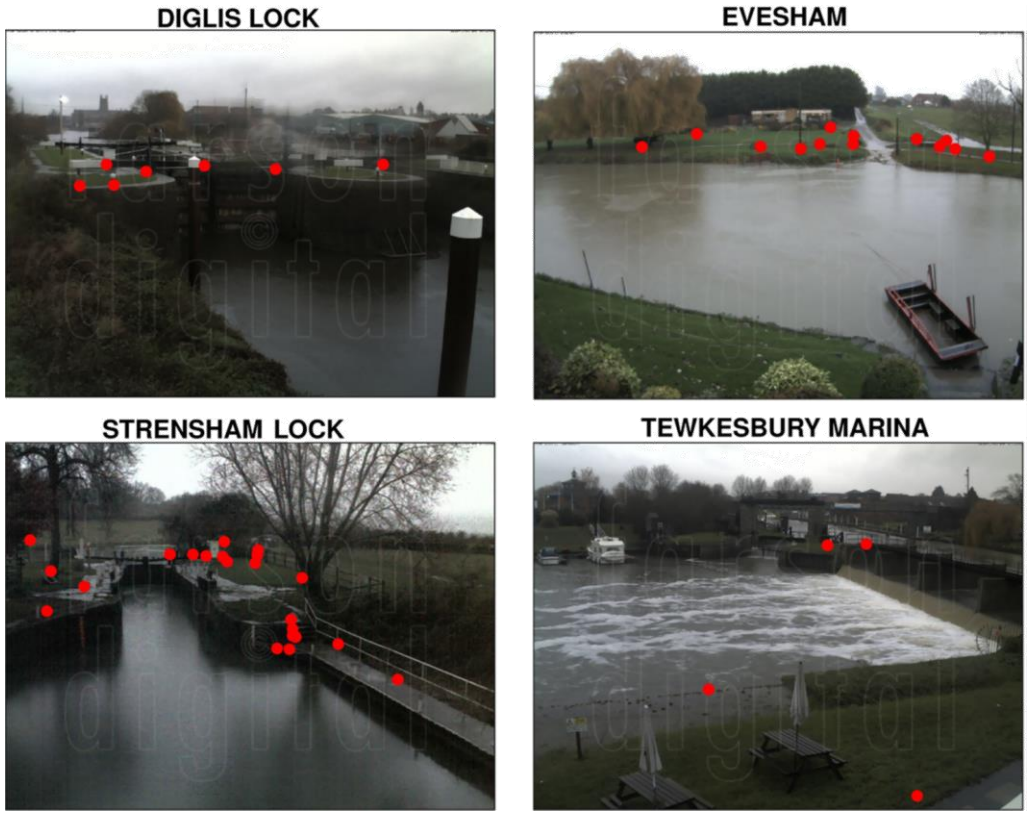


Fig A. Customized dataset:

Landmark annotation of waterline

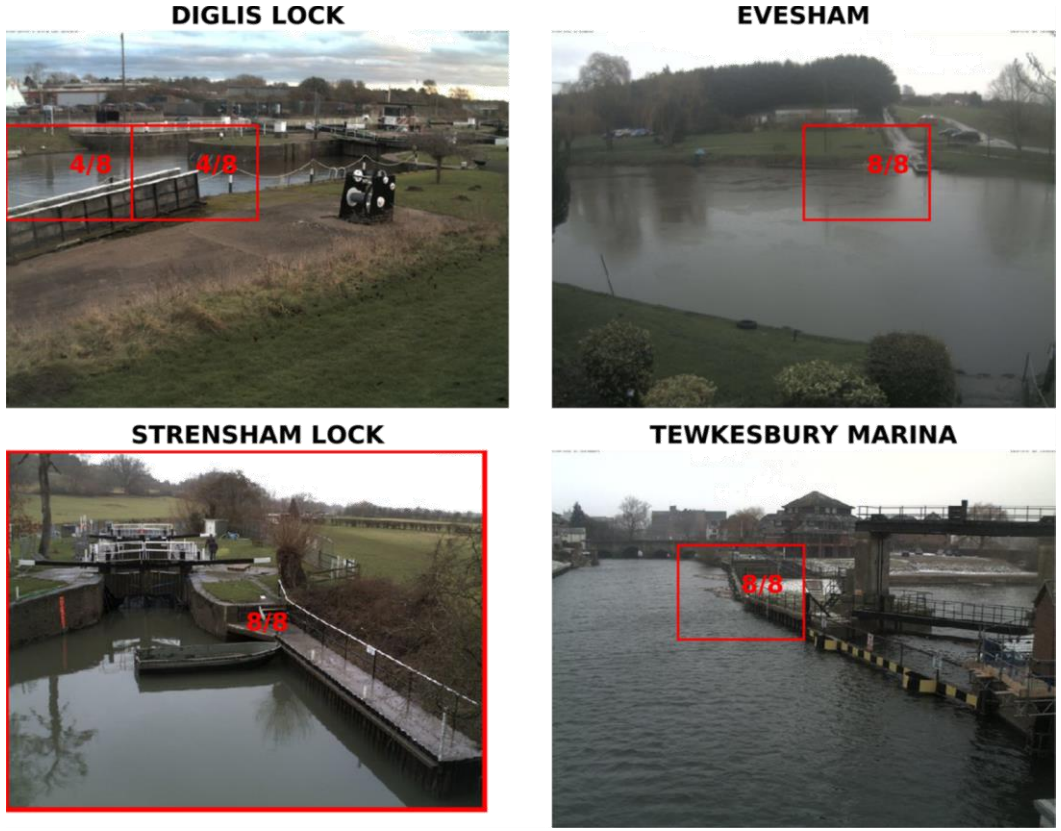


Fig B. Best window identification for prediction accuracy.

We achieve 94% accuracy in correctly predicting flood events.

Vandaele, Dance, and Ojha, (2021) *Hydrology and Earth System Sciences*

Climate Science

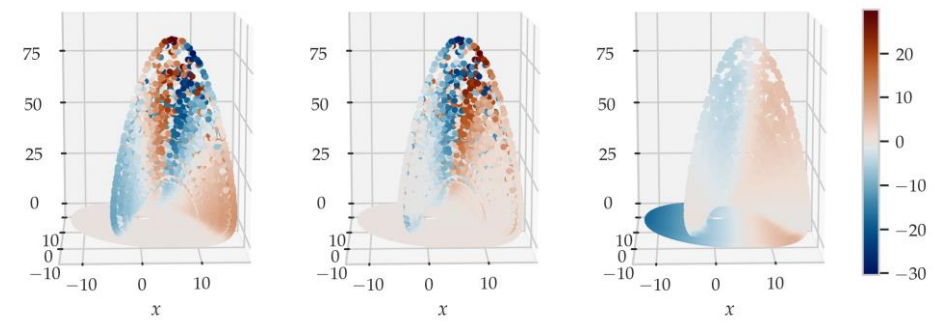
Non-intrusive modelling of dynamical systems

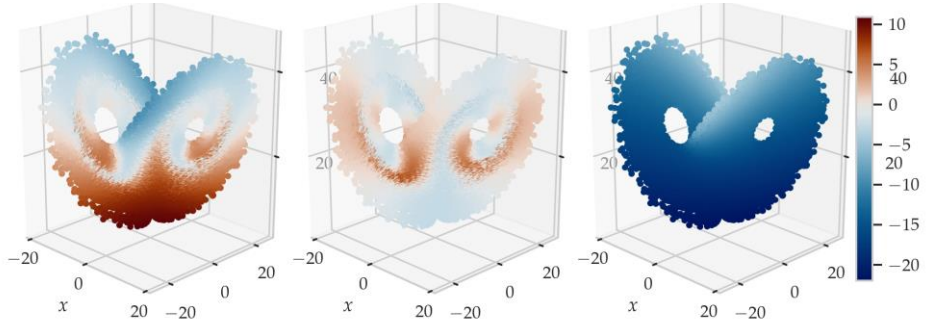
ML for estimating instabilities in chaotic systems

Rössler Model

Lorenz 63 Model

LLE distribution

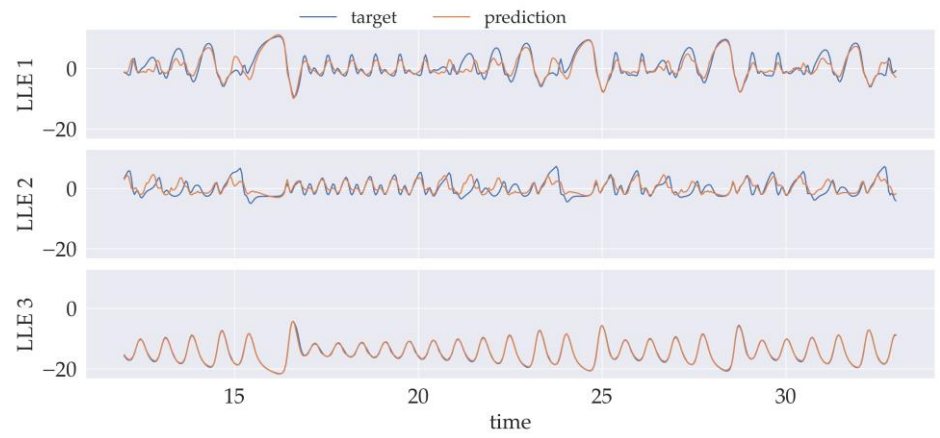


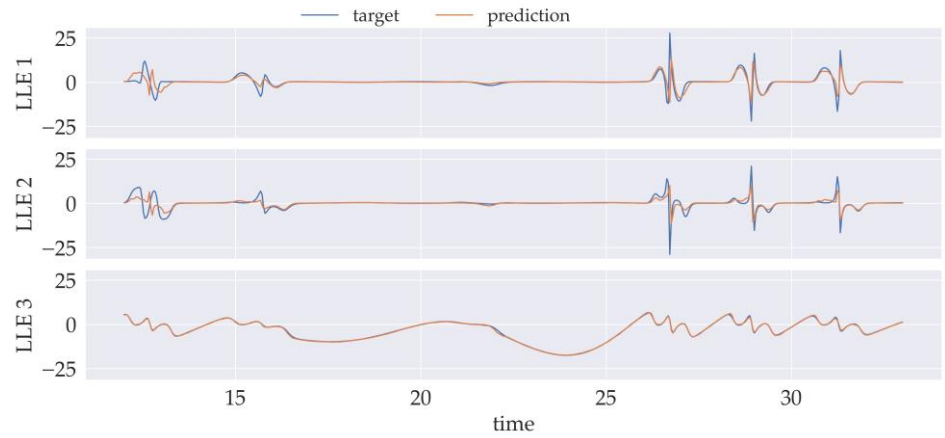


Simple Neural Network

Convolutional Neural Network

Prediction





Ayers, Lau, Amezcua, Carrassi, Ojha (in rev. 2022) *Quarterly Journal of the Royal Meteorological Society*

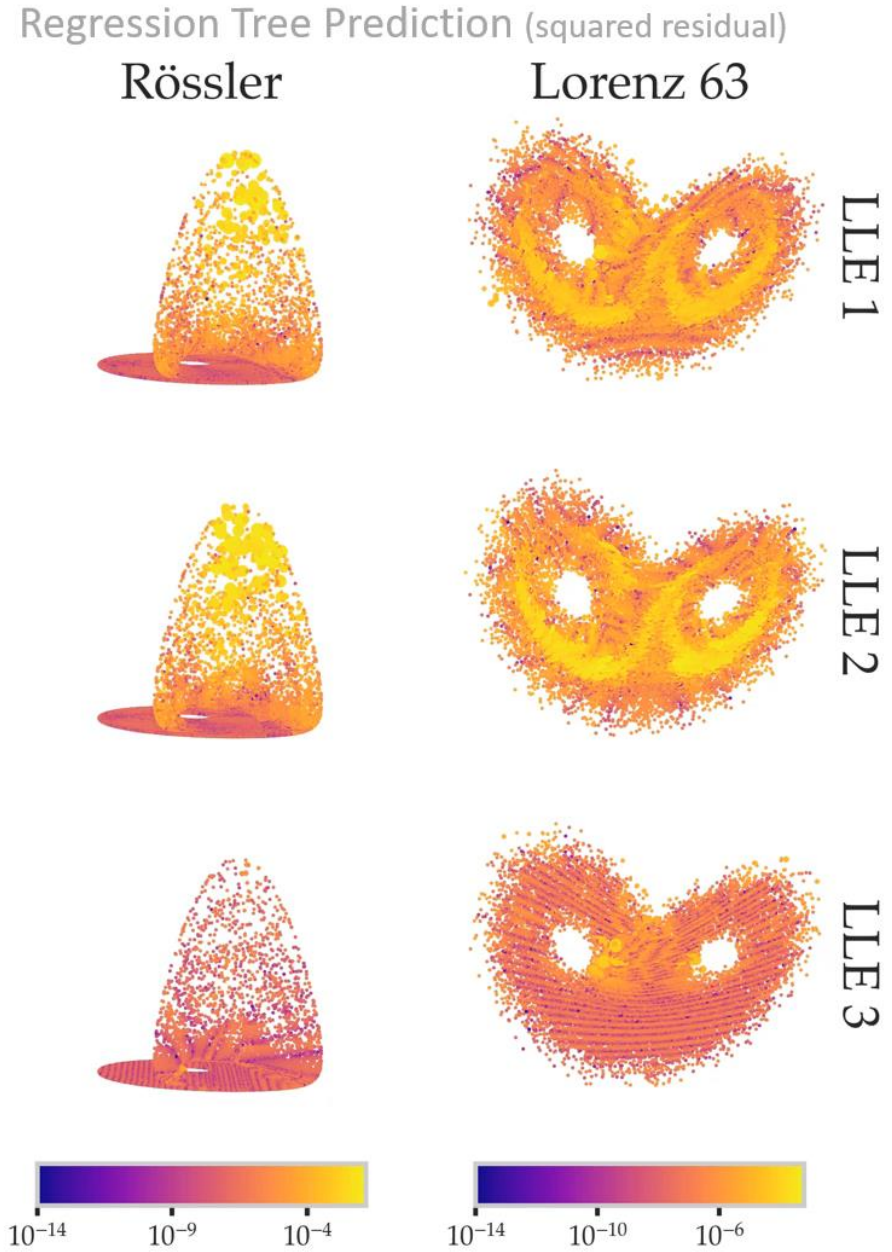
Climate Science

Prediction using previous 6 time-steps:

- Very good prediction LLE3
- Good prediction LLE1
- LLE3 is more difficult to predict

Impact: Supplements Physical Models

This prediction can be useful in real-time decision making whether to increase/reduce spatio-temporal resolution, increase/reduce ensemble size or locate/remove observations



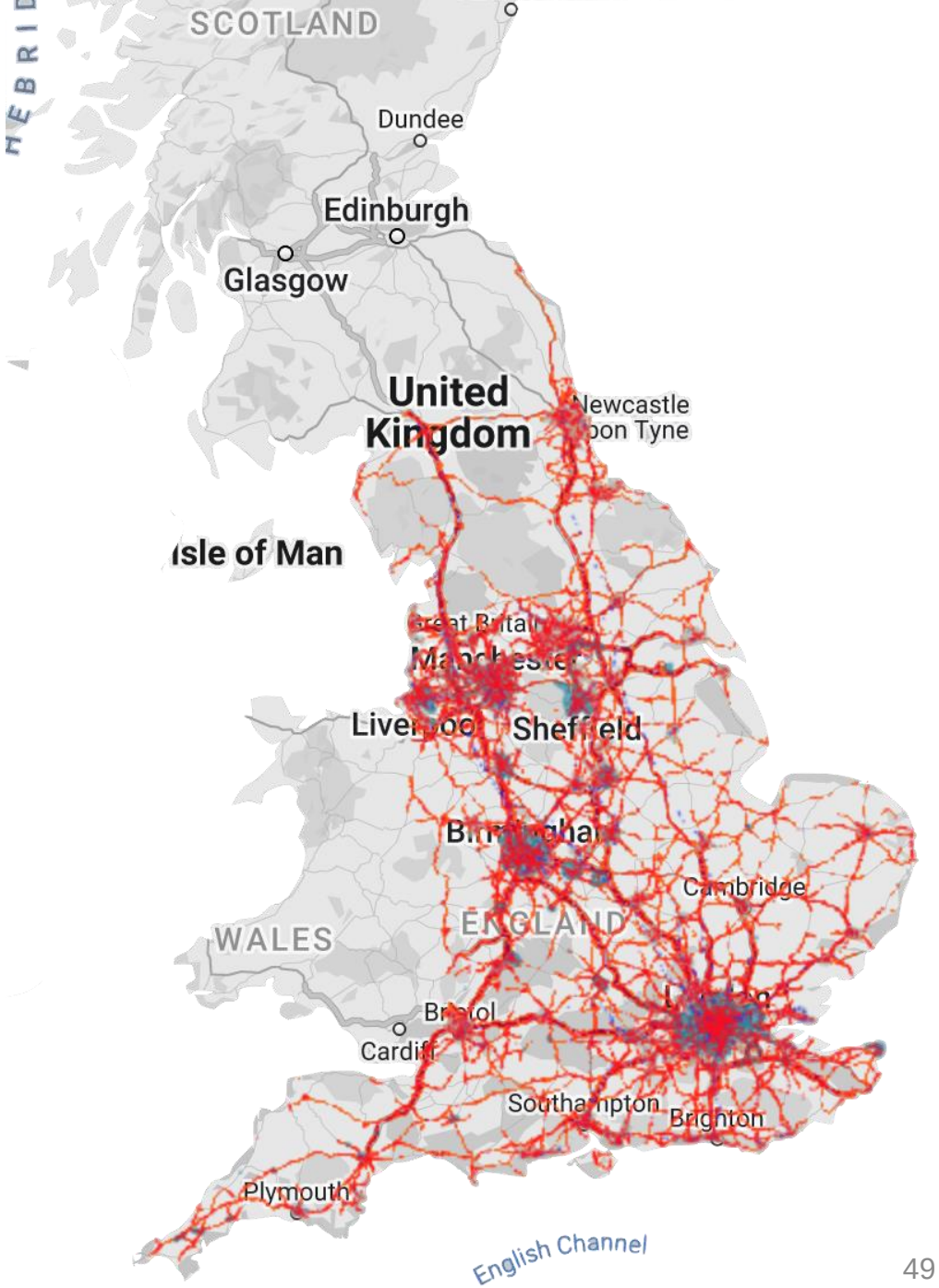
Computer Science

Final year student projects

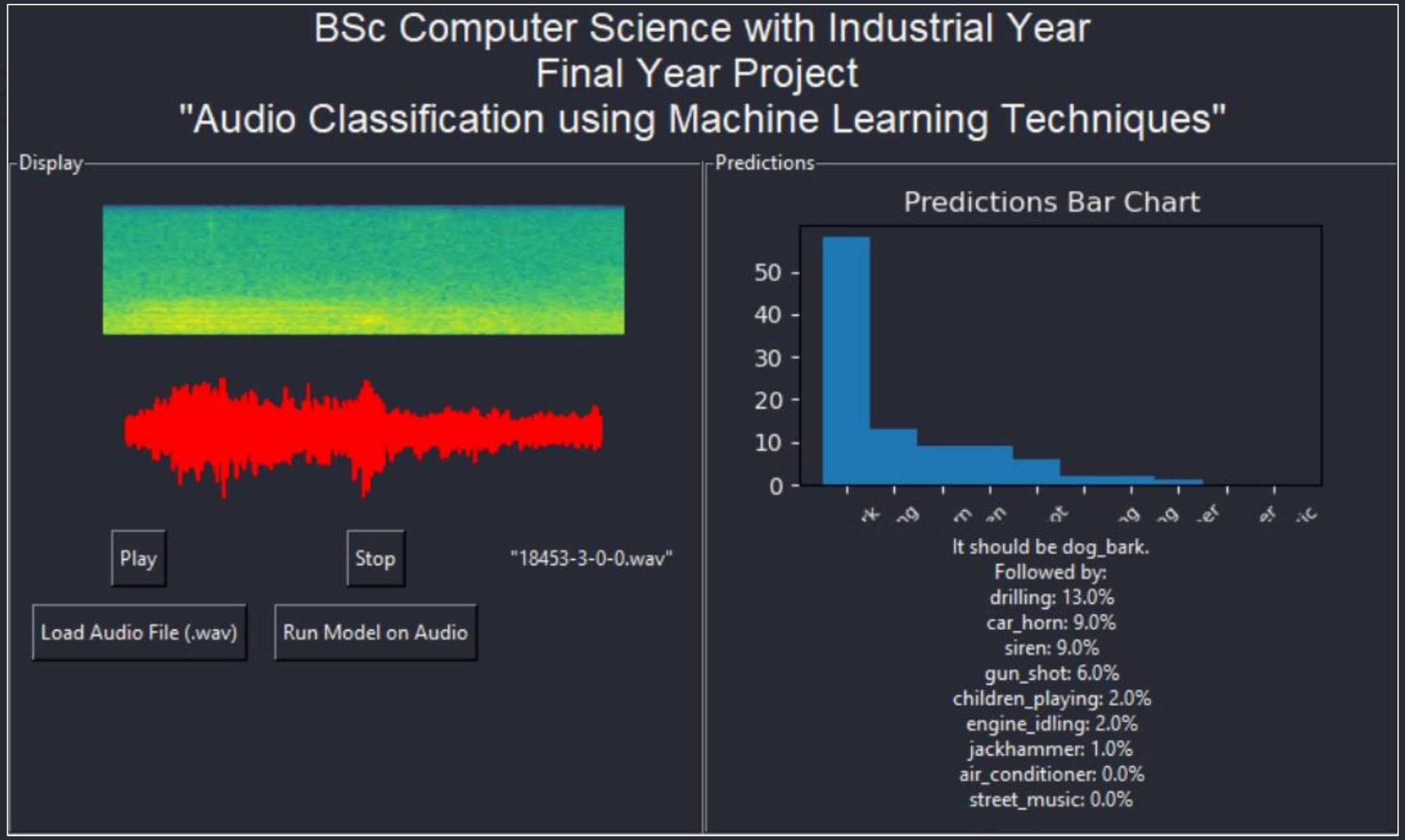
Can We Detect Noise Pollution?

e.g., traffic noise in England

Source: http://www.extrium.co.uk/noiseviewer.html



BSc Computer Science with Industrial Year
Final Year Project
"Audio Classification using Machine Learning Techniques"

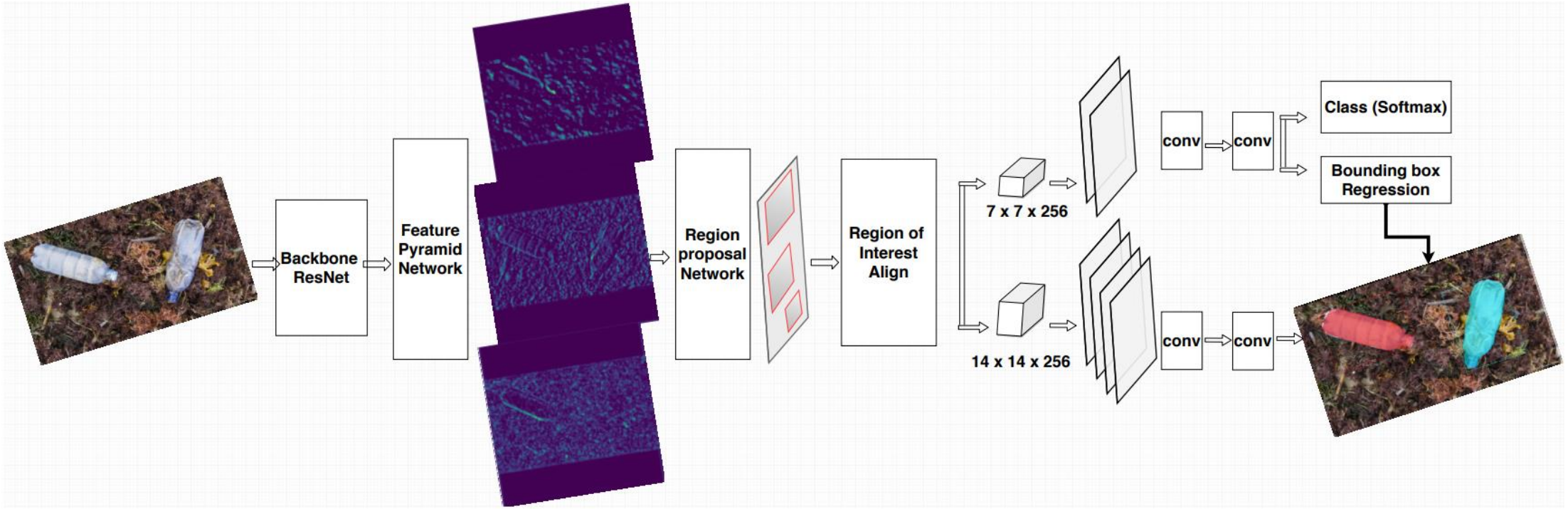


Credit: Student Project @ UoR Computer Science, A Taemur (2021)

Can We Detect Plastic Pollution?

Jaikumar P et al. (2020) ISDA

Waste Plastic Bottle Identification



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Input Video

Output Video

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v.k.ojha@reading.ac.uk