Artificial Intelligence for Real World Problems

by

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@

North East Finance Leaders' Group Event

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Agenda

1. **What are the AI Tools?**
   (scope)
2. **What problems do they solve?**
   (domain)
3. **How do they solve problems?**
   (algorithms)

What you want to know

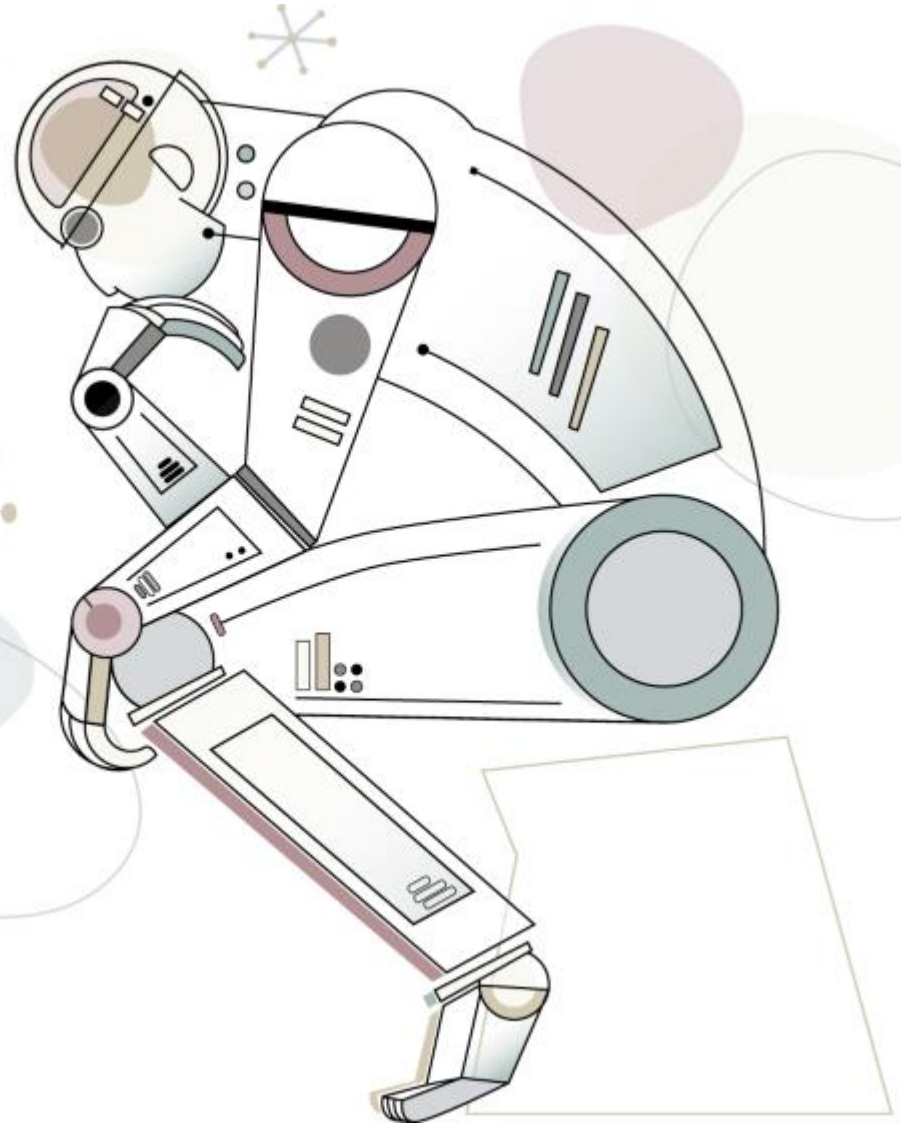
1. **to understand the data**
   (data collection, processing, and modelling)
2. **to make some prediction**
   (forecasting)
3. **to optimize some systems**
   (discovering appropriate parameters, variables, and settings)

Artificial Intelligence

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

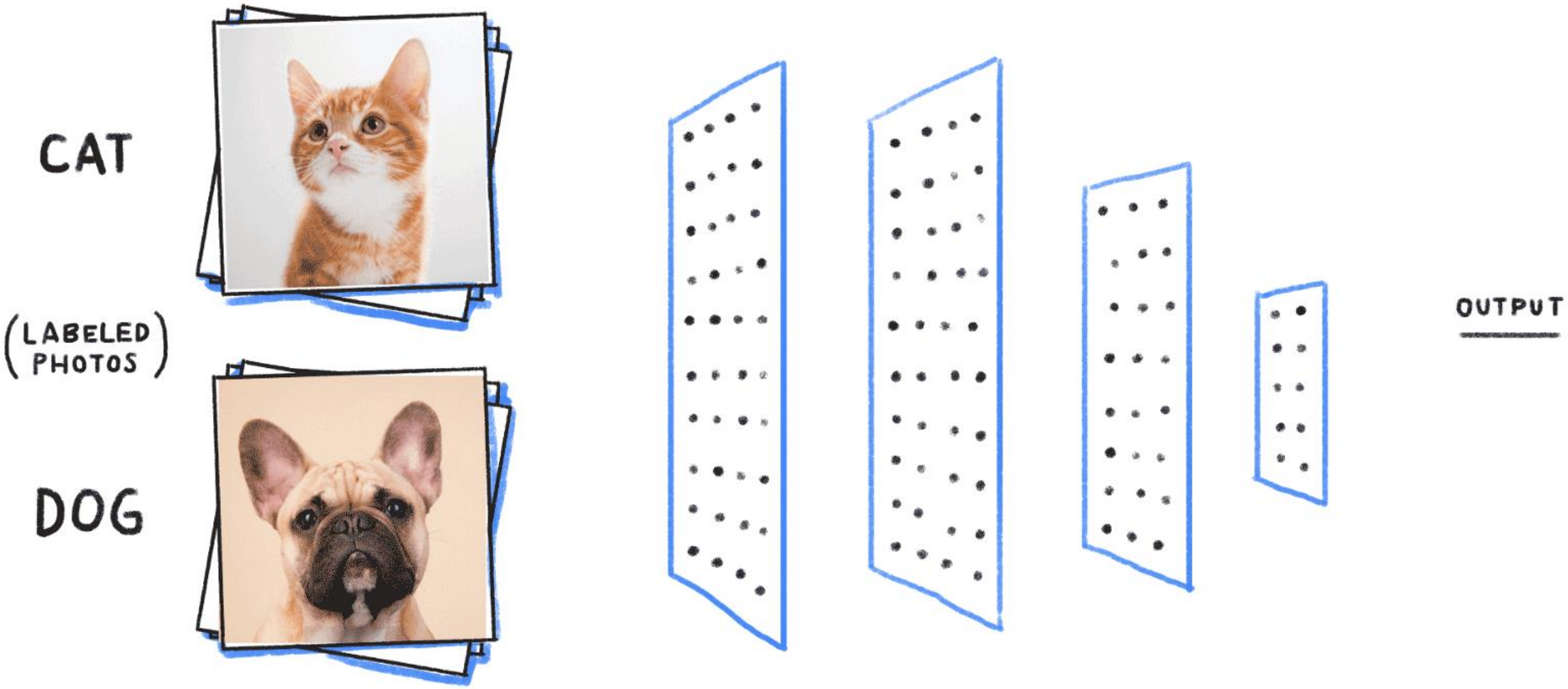
Machine Learning

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

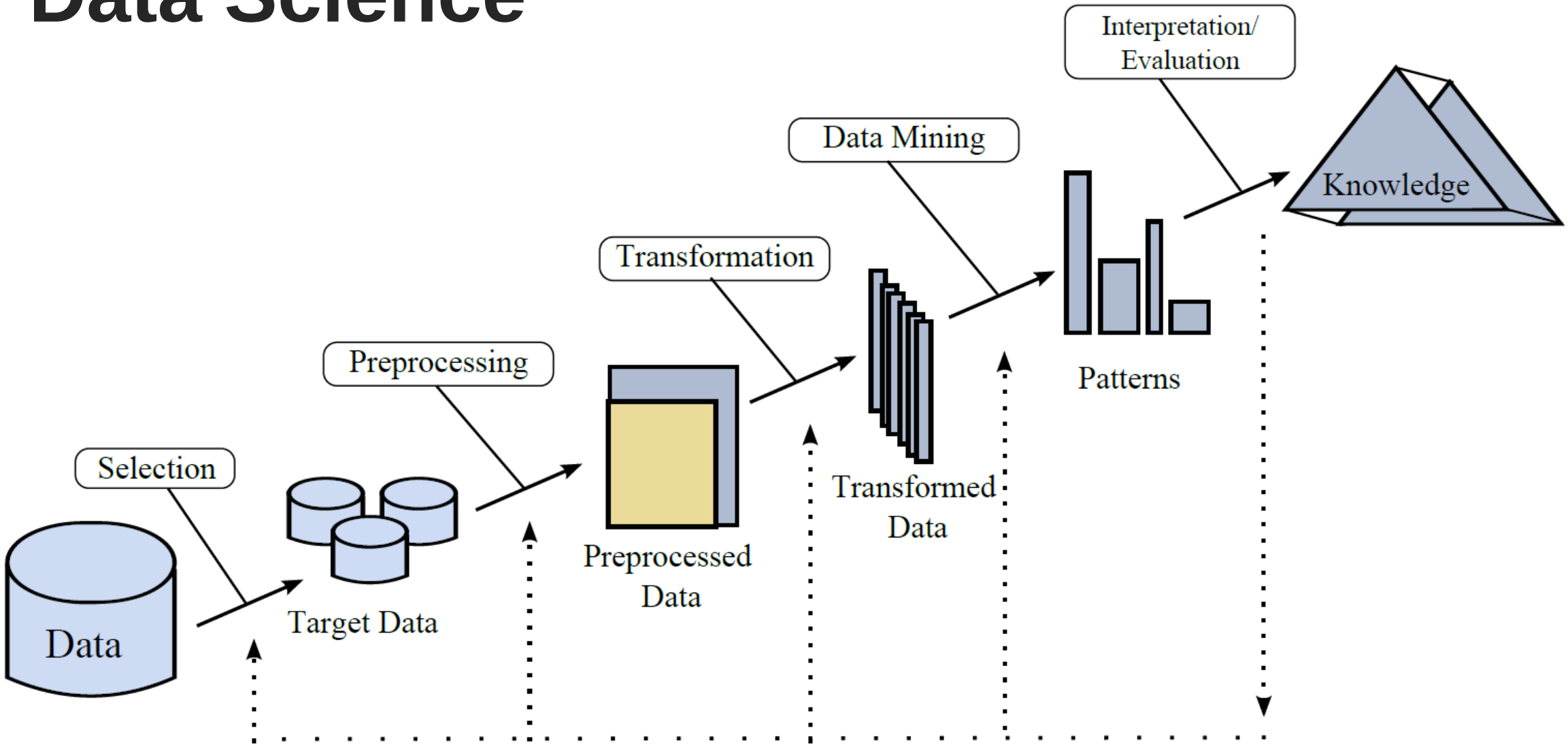


Deep Learning

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



Data Science



AI in Real World

1. Engineering
2. Pharmacy & Drugs
3. Environment (Physiology & Architecture)
4. Civil Engineering
5. Physics
6. Biology
7. Hydrology

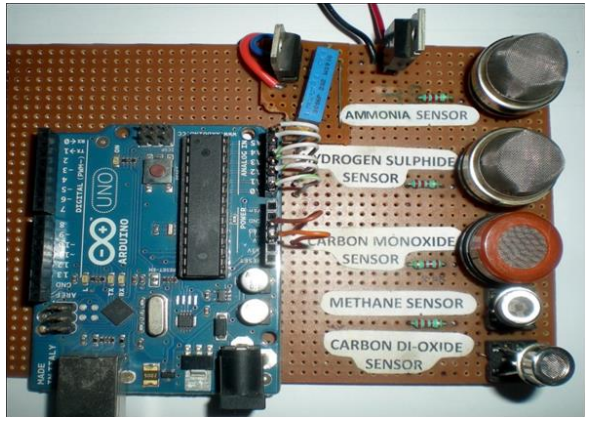
Electronics Engineering

Protection of health and life of sewer pipeline workers

Pattern Recognition

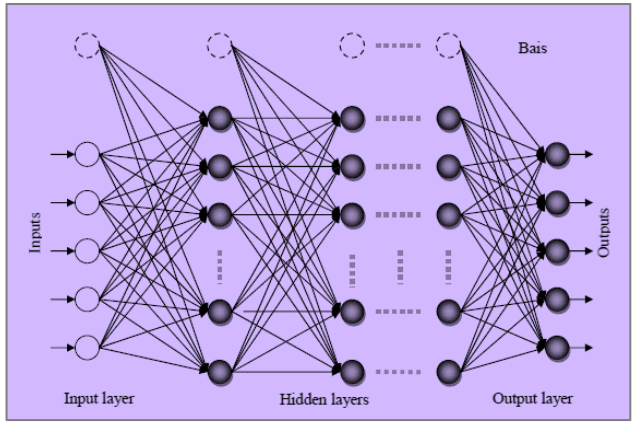
Intelligent recognizer for the component analysis of toxic mixture of (sewer) gases

Gas mixture collection



Sensor array formation

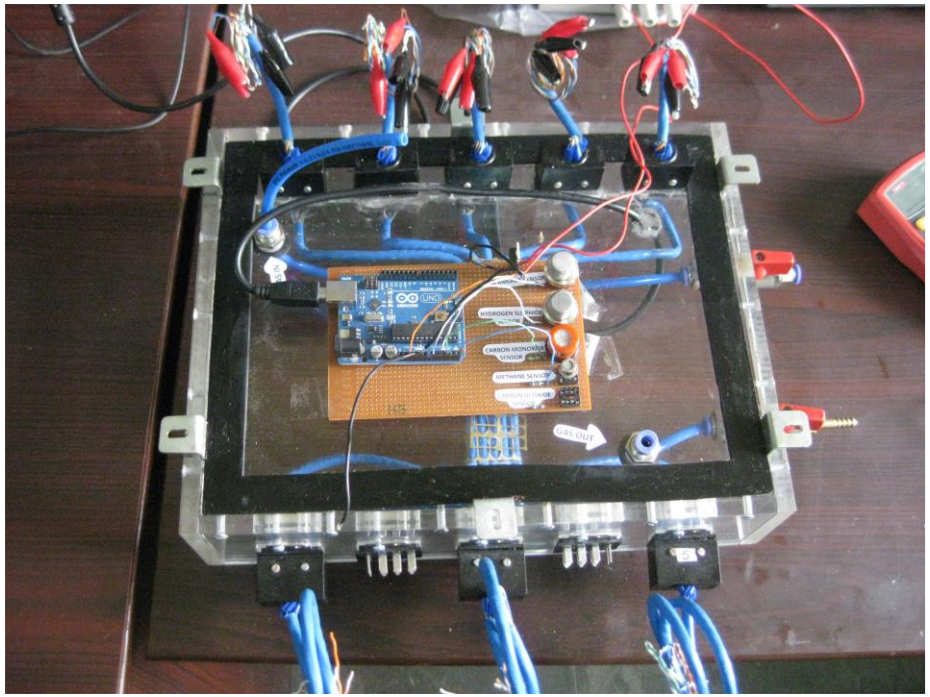
Data collection and simulation



Pattern Recognition

Prototype of Intelligence Sensor

This was the objective ☺



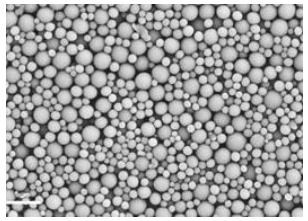
We managed to get this one nonetheless! (2011-2013)

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)

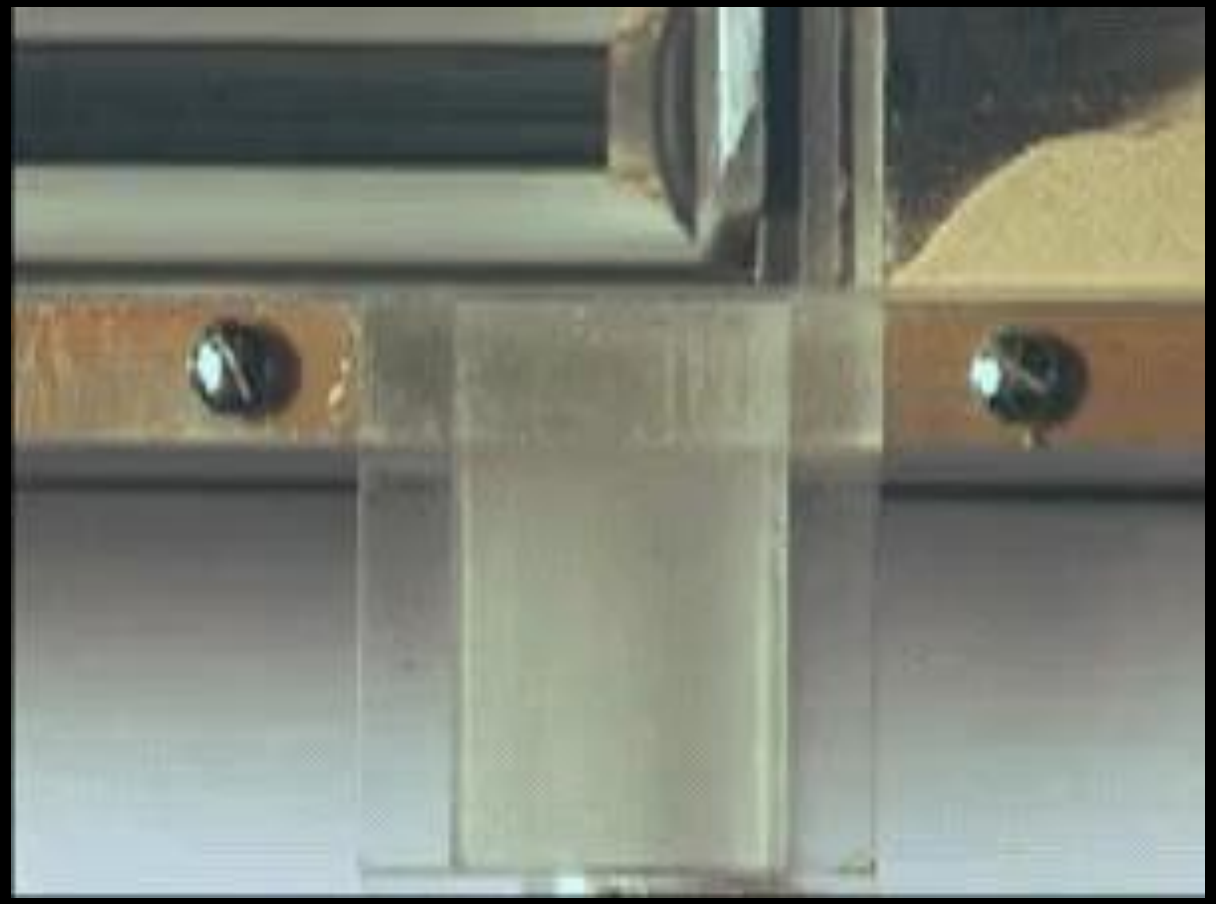
Tablet Properties

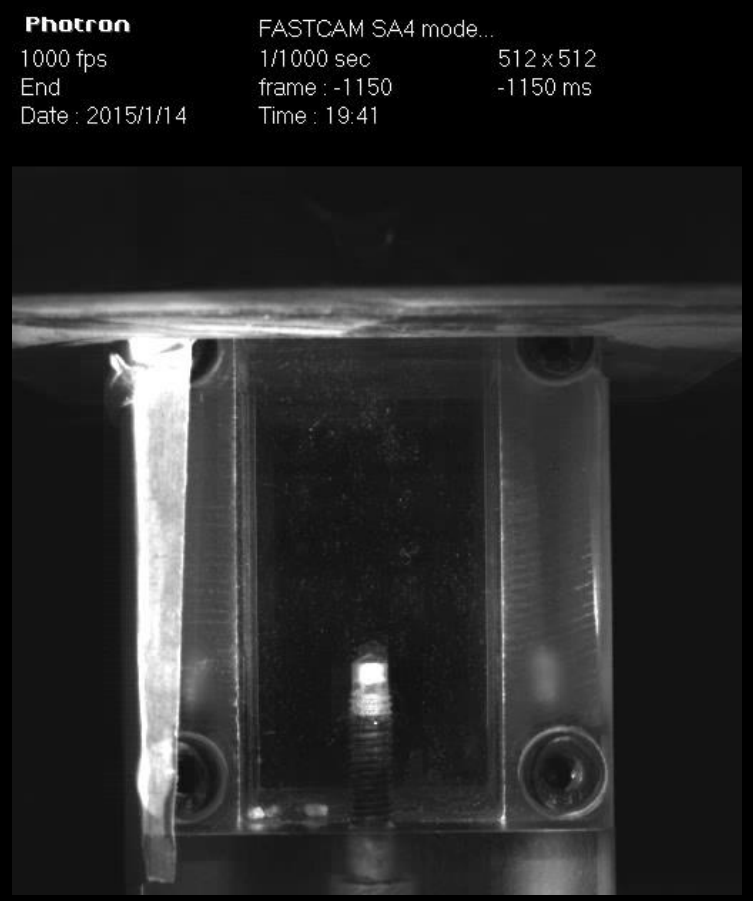
(Compressibility)

Ojha et al. (2017) *Neural Computing and Applications*. https://arxiv.org/abs/1709.04318

Variable Identification of Pharmaceutical Industrial Processes

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*
https://doi.org/10.2147/IJN.S71847

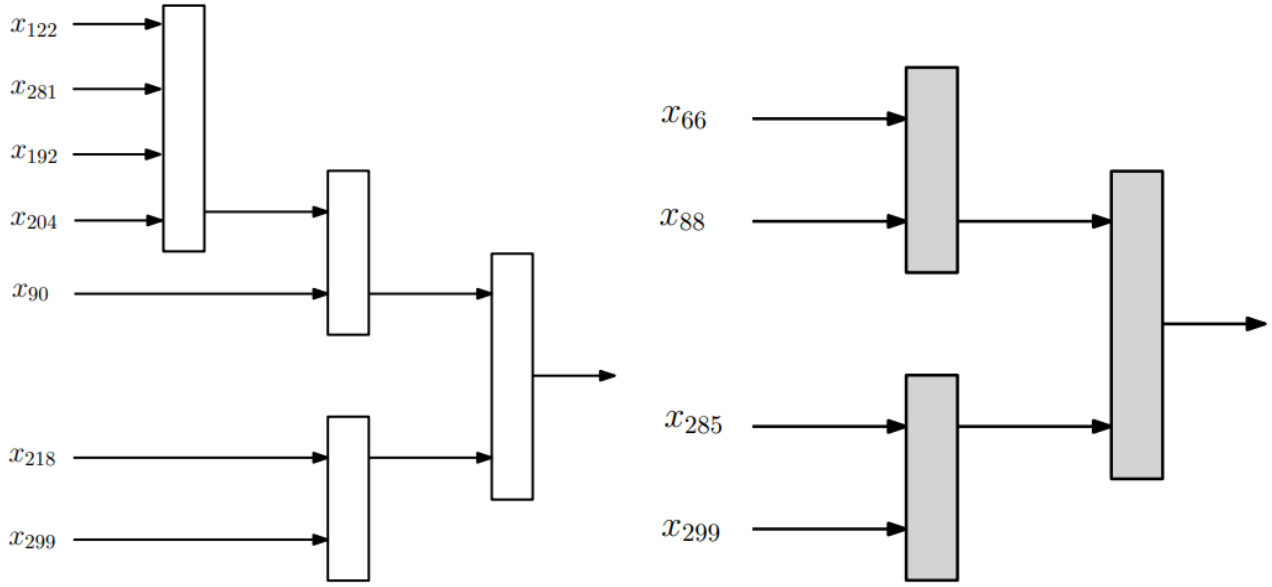
Balancing Prediction and Feature Selection

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*
https://arxiv.org/abs/1705.05769

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**

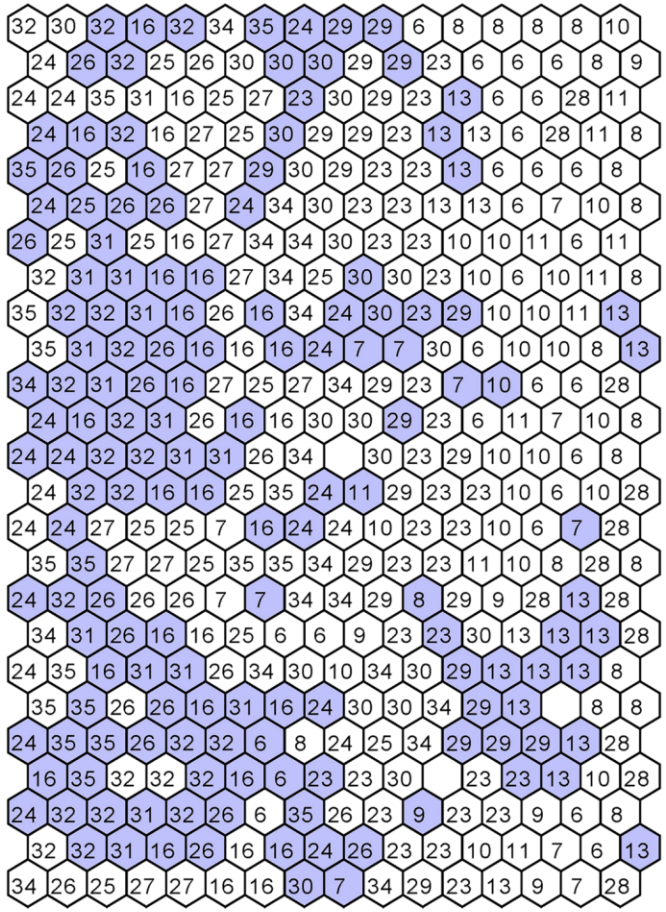
Ojha et al. (2018) *IEEE Transactions on Fuzzy Systems*
https://arxiv.org/abs/1705.05769

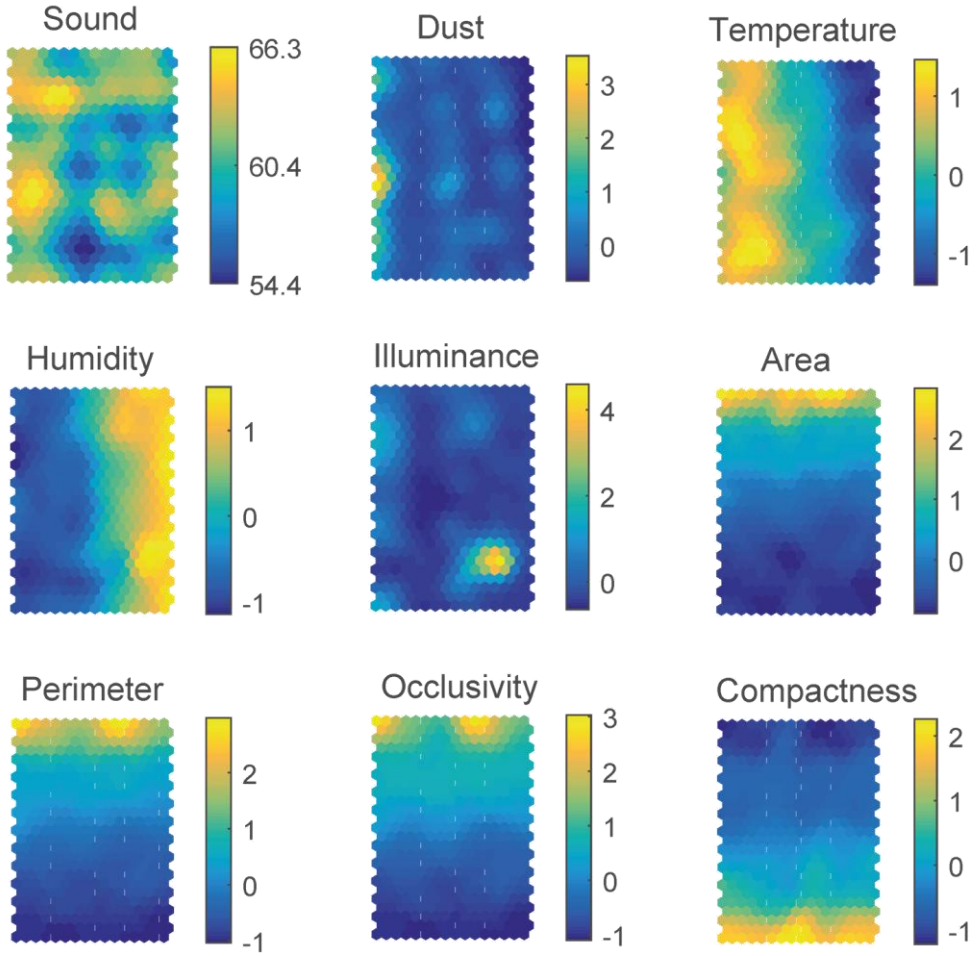
Environment and Build Architecture

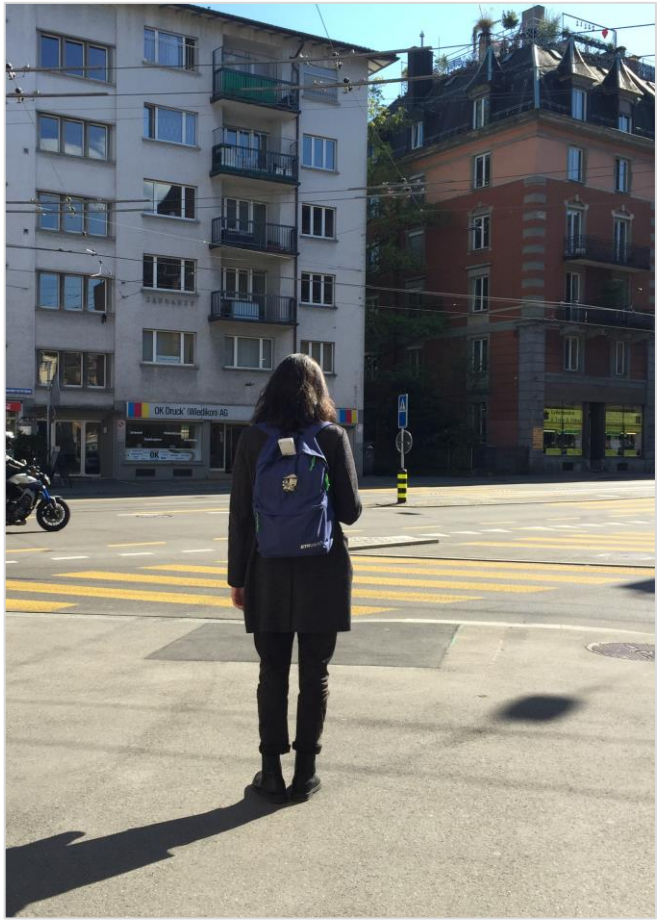
Understanding impact of environment and urban dynamics on humans

Perception of the Environment

Perceptual Experience







Ojha et al. (2019) *Information Sciences* | Buš & Ojha (2017), *ETH Zurich*
https://arxiv.org/abs/1812.06128

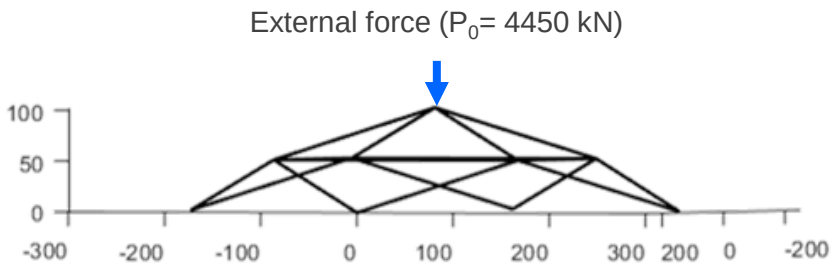
Civil Engineering

Structure buckling analysis

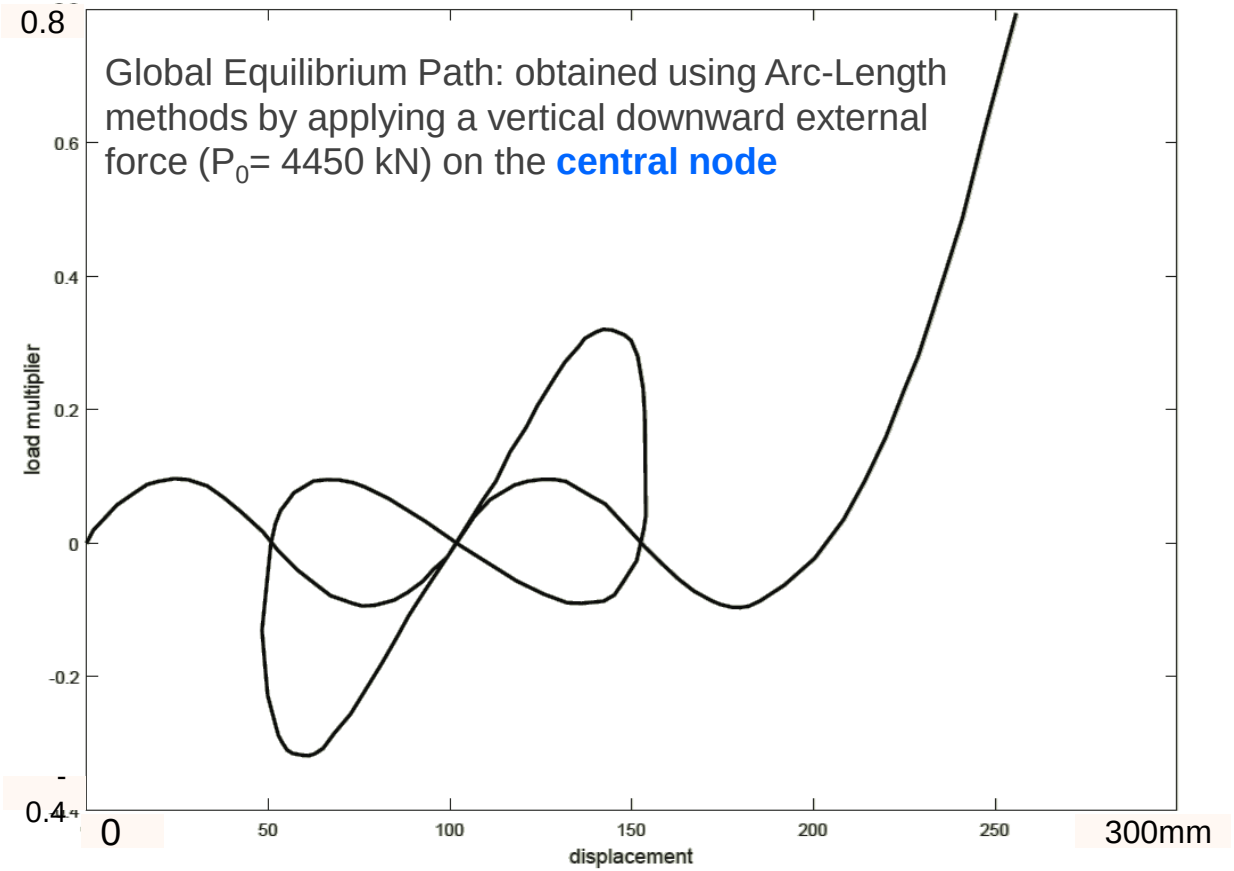
Civil Engineering Problem

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

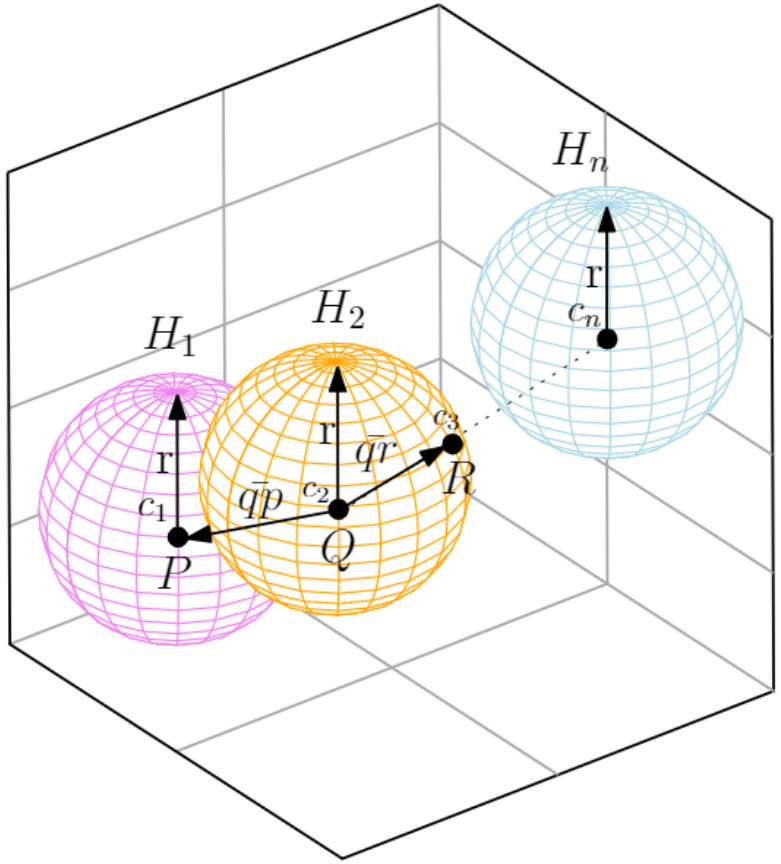


Fig A. Adaptive Hypersphere Search Algorithm for Structural Static Analysis

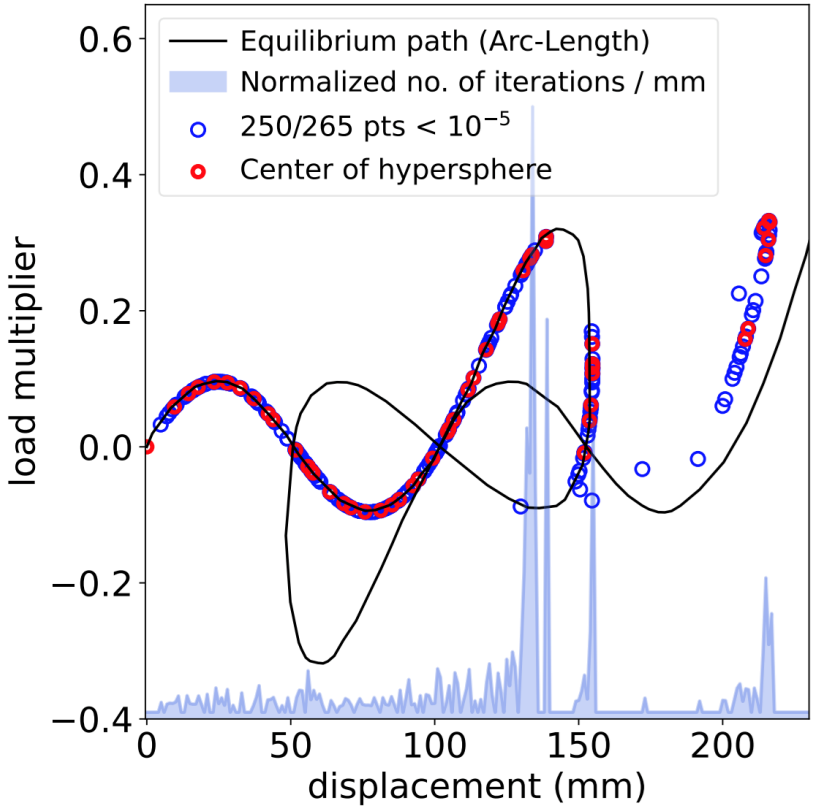
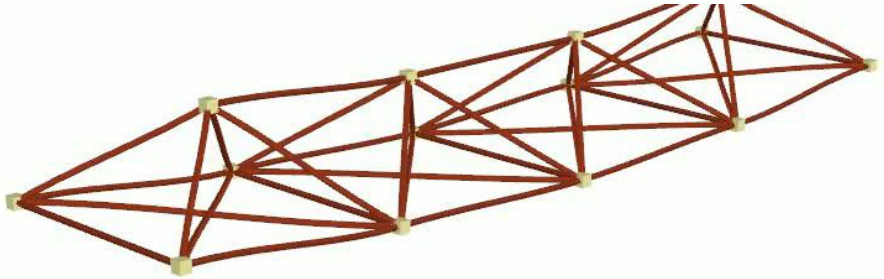


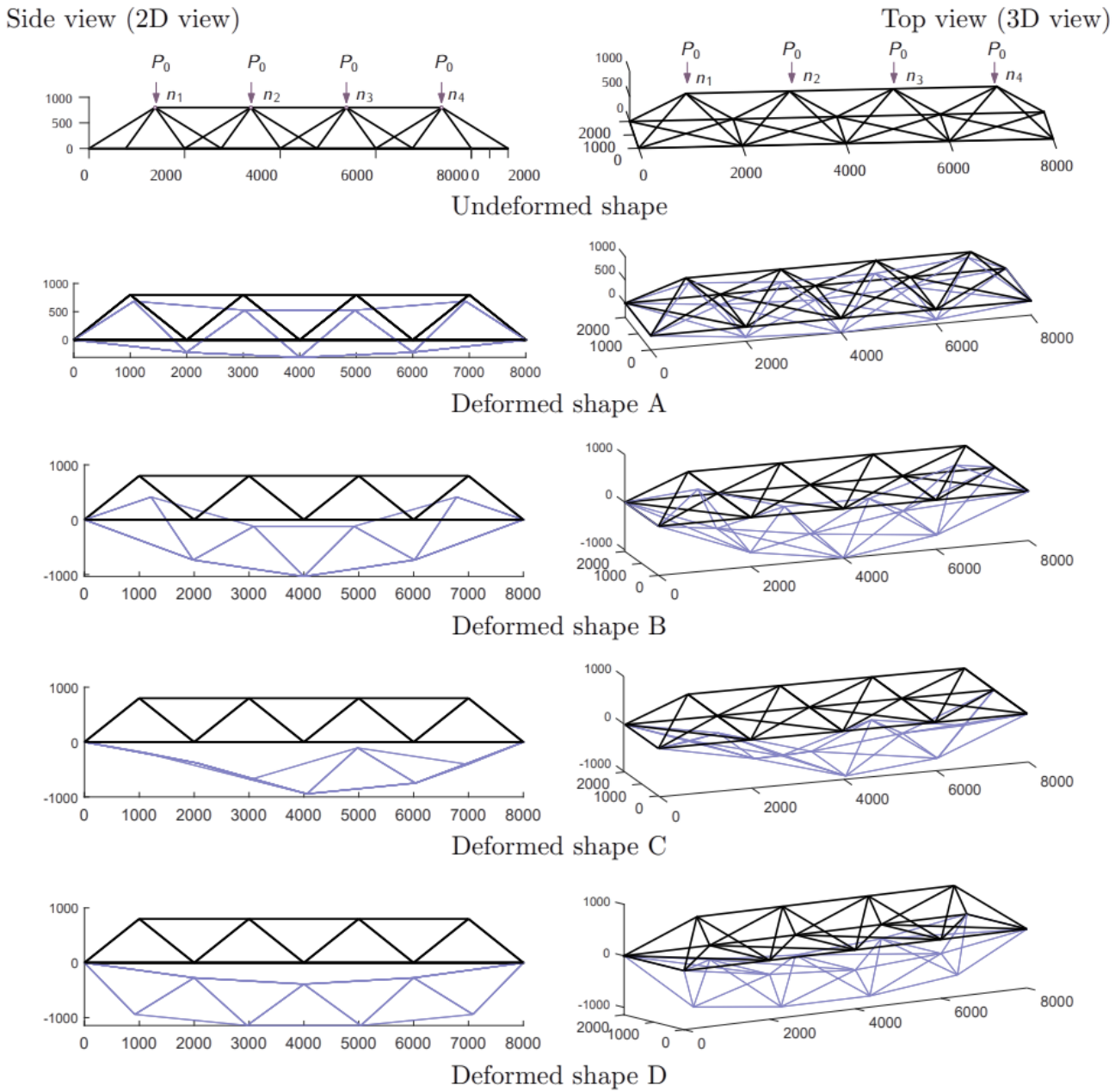
Fig B. Equilibrium Path traced using Adaptive Hypersphere Search Algorithm

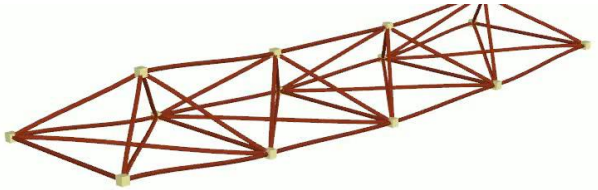
Ojha et al (2022), *Engineering Application of Artificial Intelligence*
https://arxiv.org/pdf/2211.07519.pdf

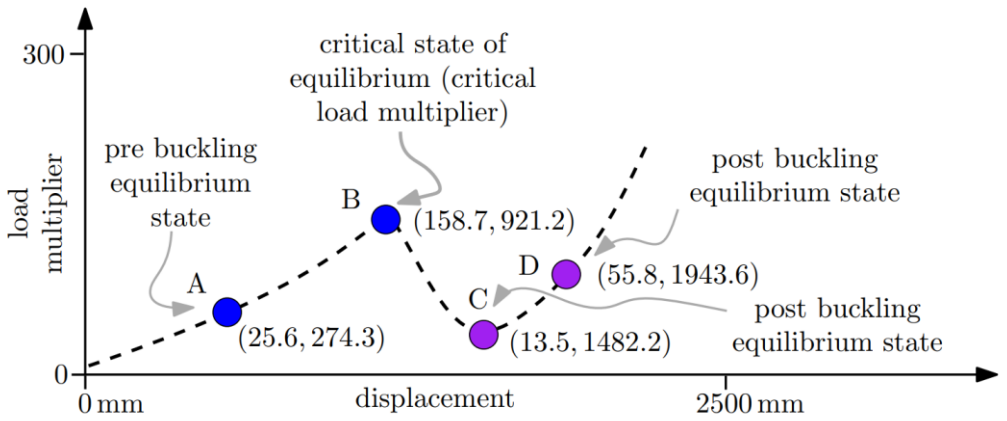
Prediction of the Collapse



Ojha et al (2022), *Engineering Application of Artificial Intelligence*
https://arxiv.org/pdf/2211.07519.pdf


Side view (2D view)
Top view (3D view)
Undeformed shape
Deformed shape A
Deformed shape B
Deformed shape C
Deformed shape D

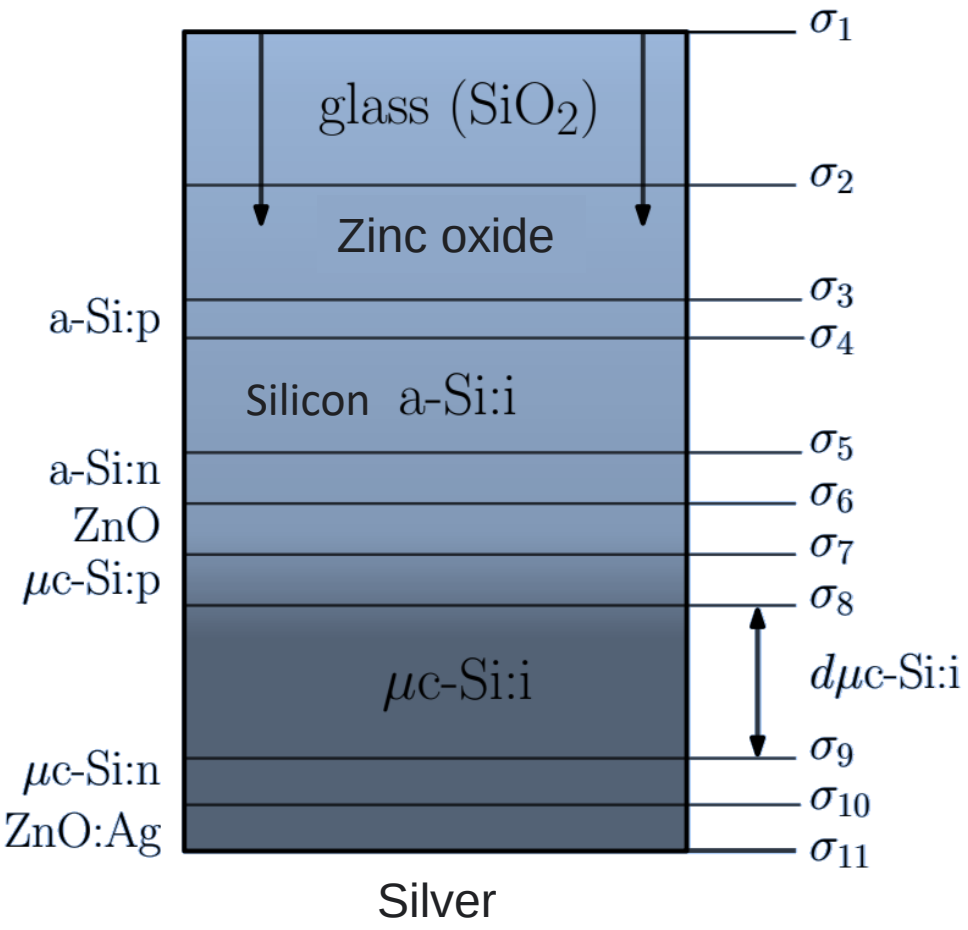


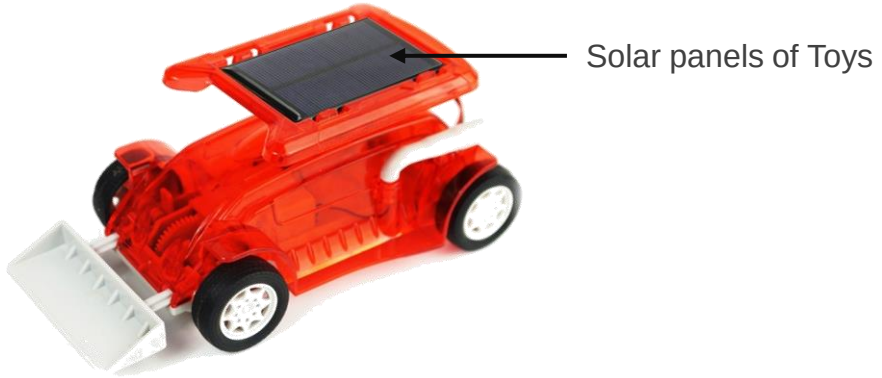

300
0
load multiplier
critical state of equilibrium (critical load multiplier)
pre buckling equilibrium state
post buckling equilibrium state
post buckling equilibrium state
A
B
C
D
(25.6, 274.3)
(158.7, 921.2)
(13.5, 1482.2)
(55.8, 1943.6)
0 mm
displacement
2500 mm

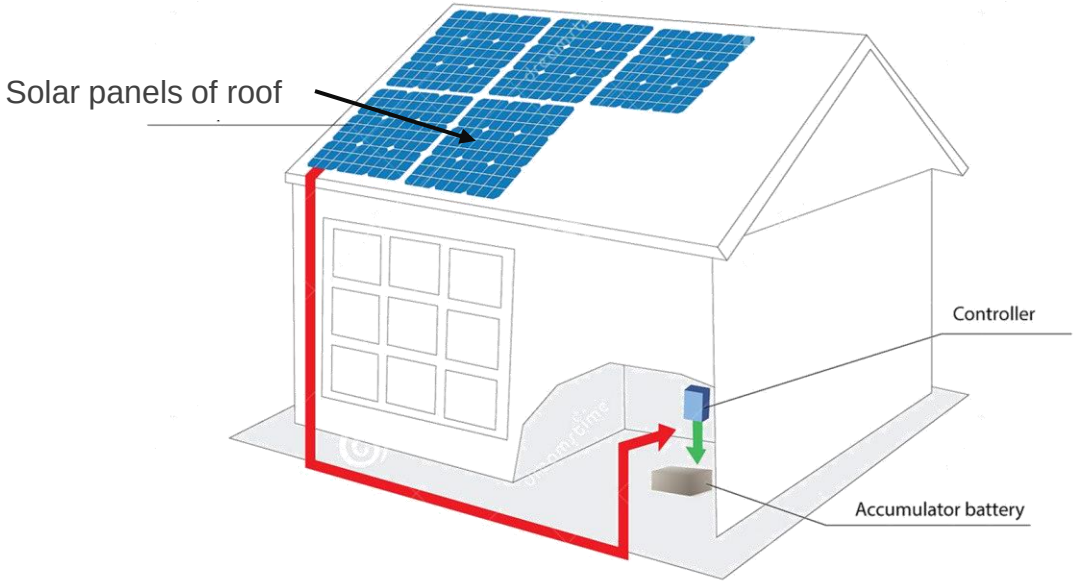
Physics

Solar cell design and characterization

Solar Cell – Energy Optimization



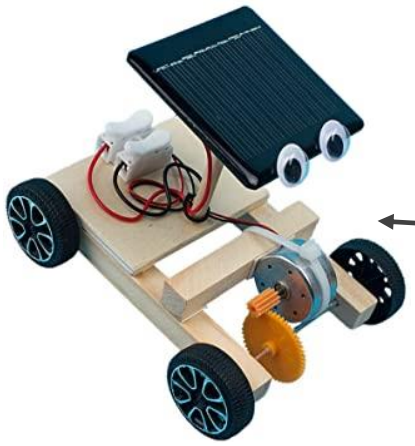


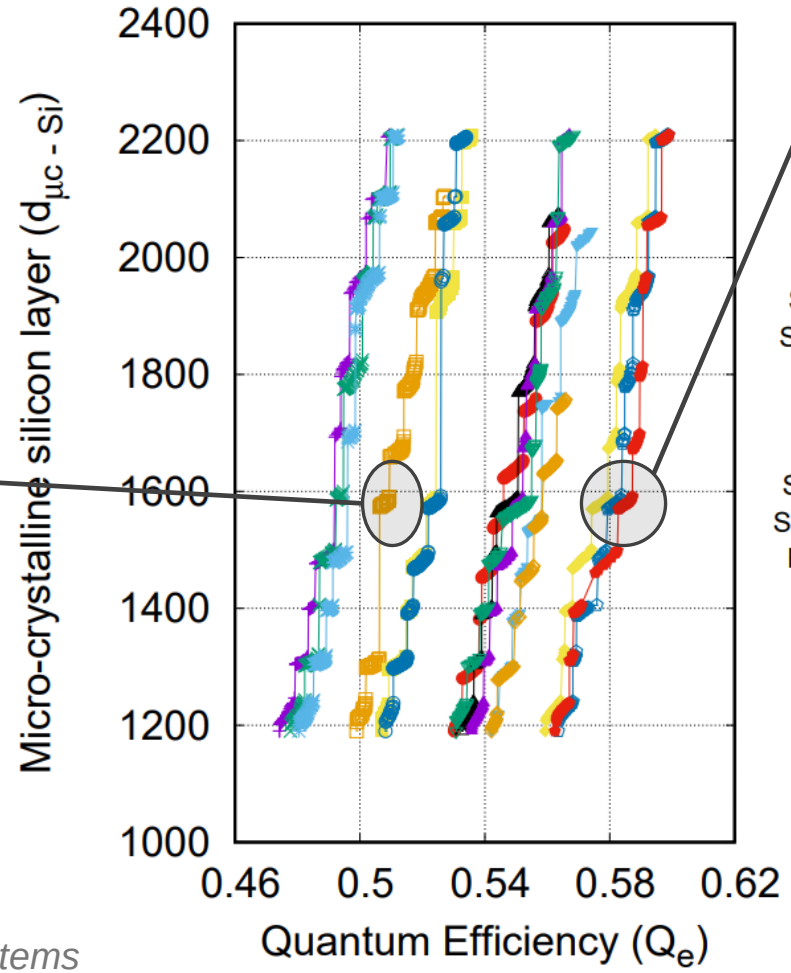


Ojha et al. (2021) *Energy Systems*
https://arxiv.org/abs/2109.07279

Solar Cell

Cost and Efficiency Trade-offs for its Usage





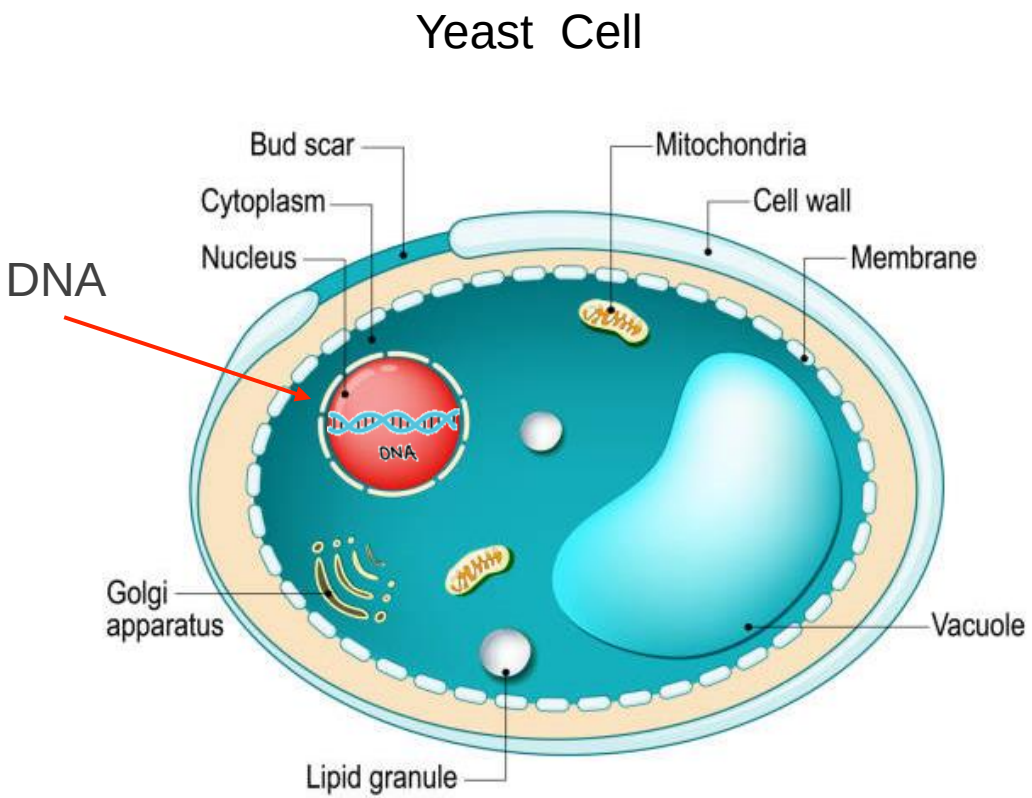
Smooth back reflector Al, Not Doped ZnO
Rough back reflector Ag, Not Doped ZnO
Smooth back reflector Ag, Not Doped ZnO
Smooth back reflector Al, Lowly Doped ZnO
Smooth back reflector Ag, Lowly Doped ZnO
Rough back reflector Ag, Lowly Doped ZnO
Smooth back reflector Al, SnO2
Smooth back reflector Al, Normally Doped ZnO
Smooth back reflector Ag, Normally Doped ZnO
Rough back reflector Ag, Normally Doped ZnO
Smooth back reflector Ag, SnO2
Rough back reflector Ag, SnO2
Smooth back reflector Al, Optimally Doped ZnO
Smooth back reflector Ag, Optimally Doped ZnO
Rough back reflector Ag, Optimally Doped ZnO

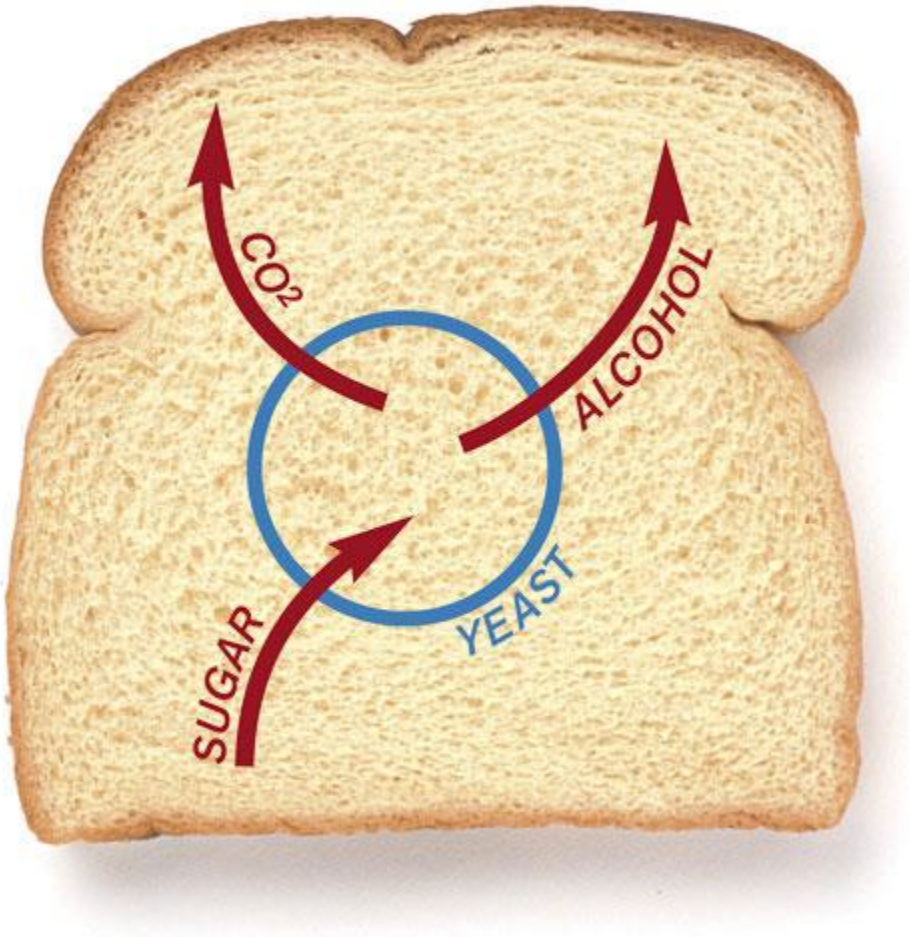
Ojha et al. (2021) *Energy Systems*
https://arxiv.org/abs/2109.07279

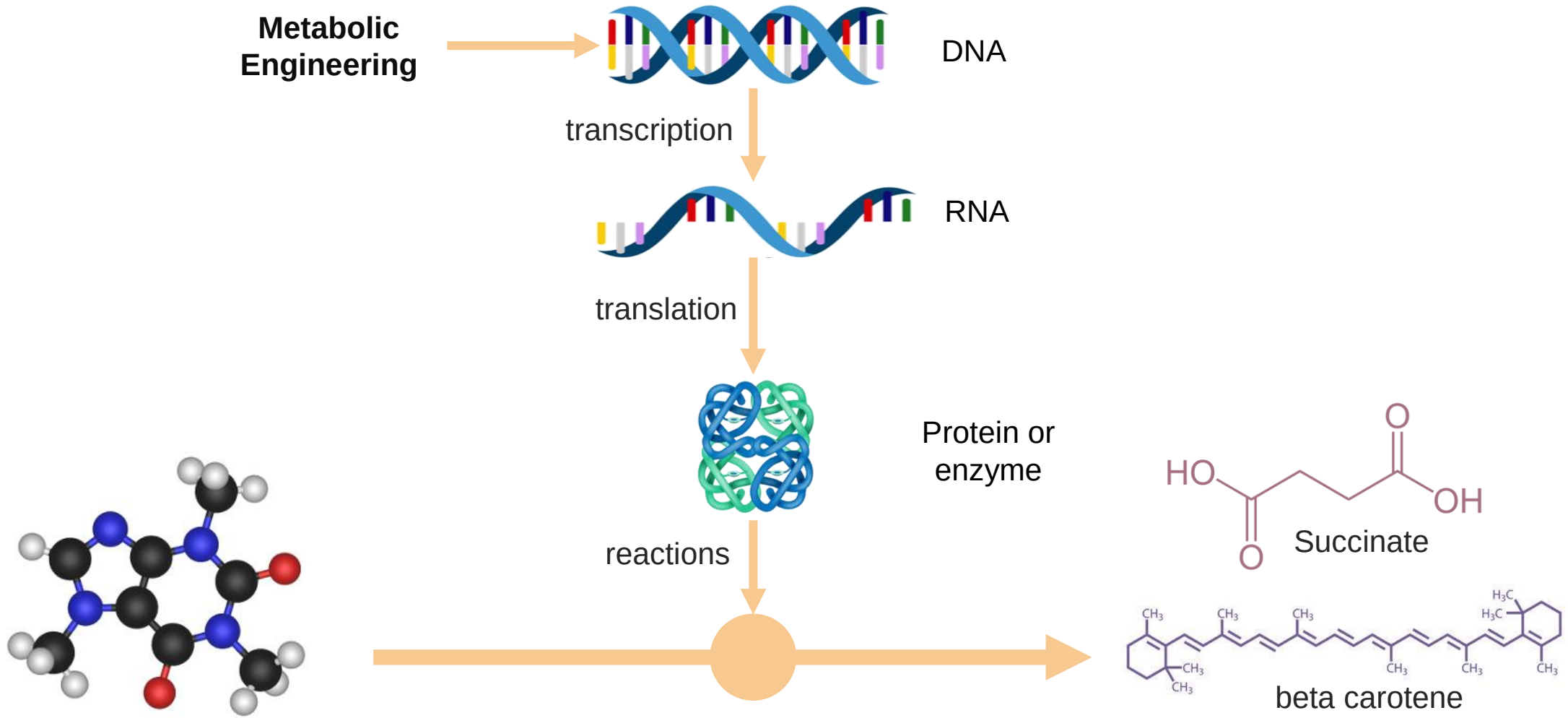
Biology

Metabolic engineering (searching for best strains)

Role of Yeasts in Food Production

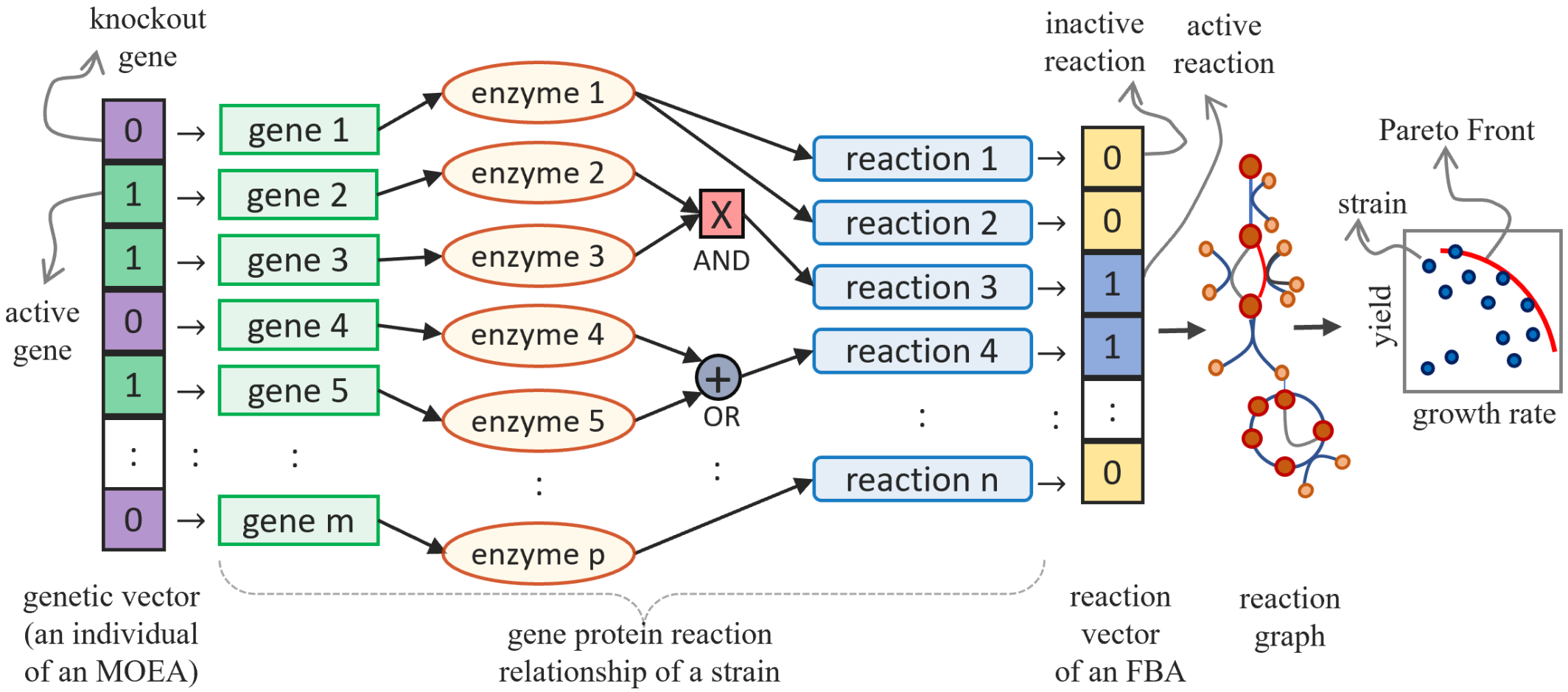




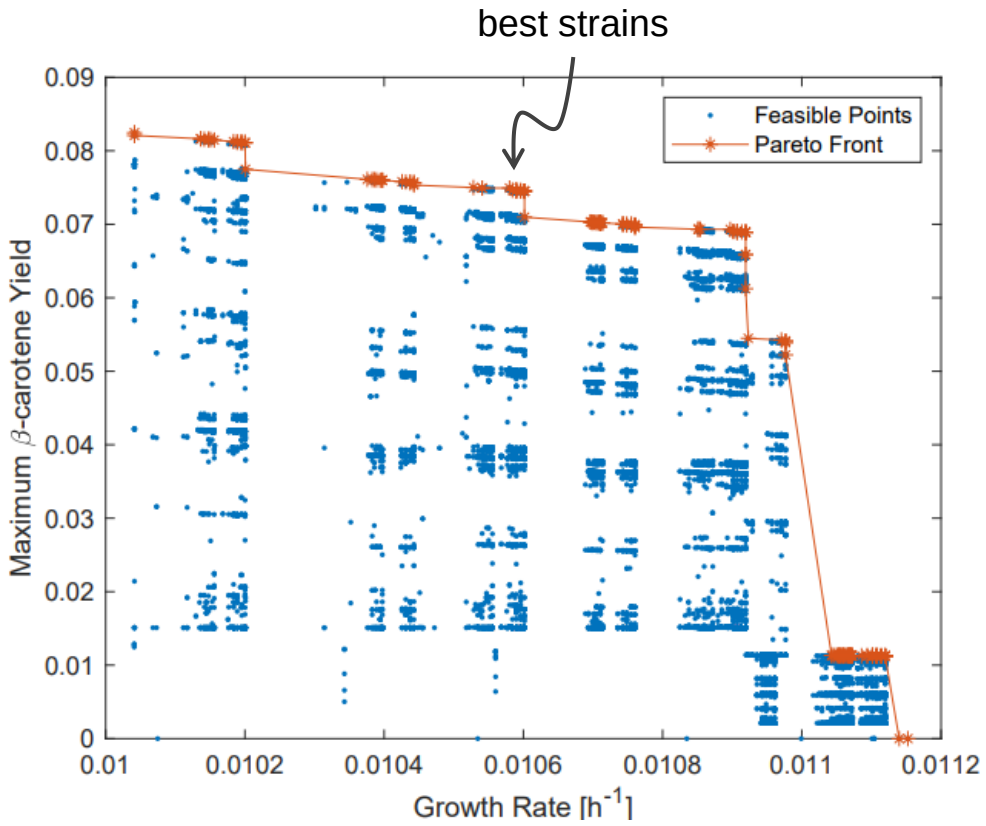


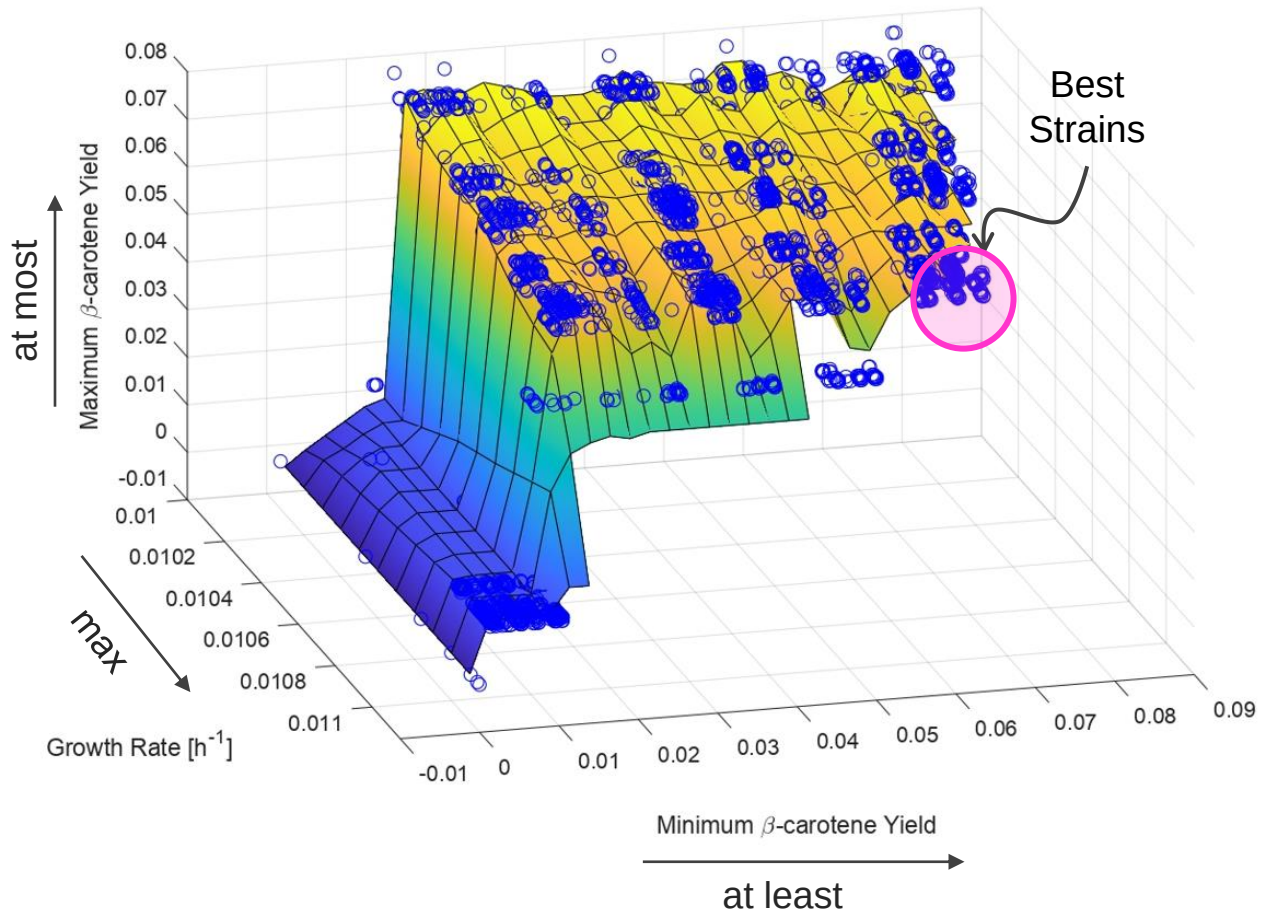
Ojha et al. (2022) *Bioengineering & Biotechnology* *https://doi.org/10.1002/bit.28103*

Metabolic Engineering for Chemical Production



Optimal Strains of Yeast





Hydrology

Prediction of flood events

Hydrology: Flood Event Prediction

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

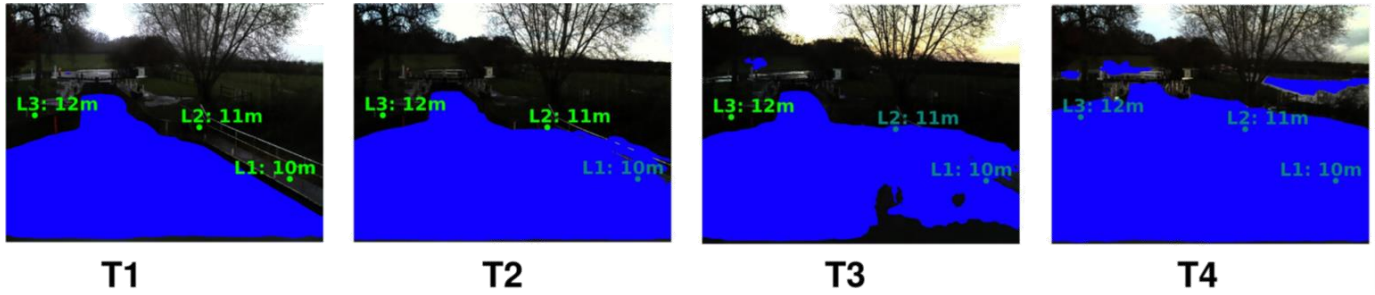


Fig. Time-series sequence of images of river. Blue pixels are water segmentation by using deep learning models

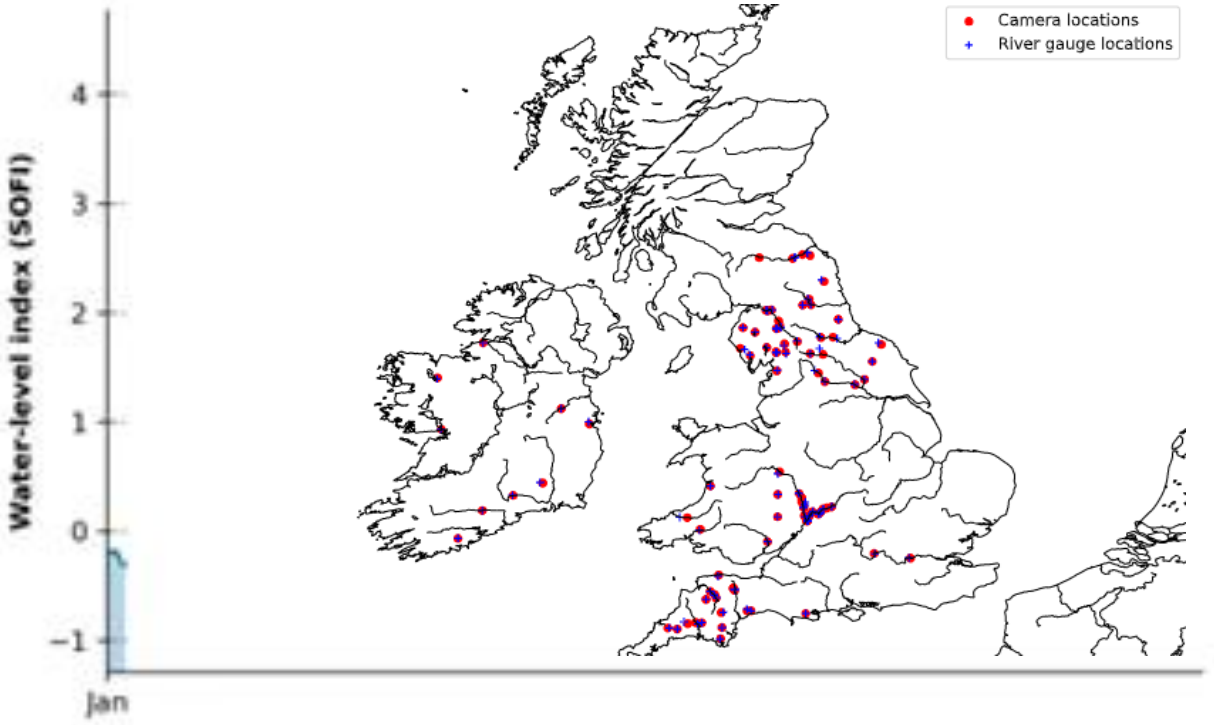
Credit: Farson Digital Watercams
https://www.farsondigitalwatercams.com/locations/keswick_greta

Vandaele, Dance, and Ojha, (2020), *GCPR*
https://doi.org/10.1007/978-3-030-71278-5

Edge AI for Flood Tracking and Monitoring

Fusion of Environmental Agency Data Edge Data (CCTV Cameras) across UK & Ireland

Our research help automat tracking and monitoring of flood saturation



We achieve 94% accuracy in correctly predicting real flood events on the Avon and Severn rivers.

Source: Ojha et al (Newcastle)

Trash screen monitoring

Trash screens prevent debris from entering critical parts of river networks but debris buildup can lead to floods Clean trash screen Blocked trash screen

Clean trash screen

Blocked trash screen

54 trash screens with CCTV camera feed: 80,452 images downloaded over 10 months

Input Video

Output Video

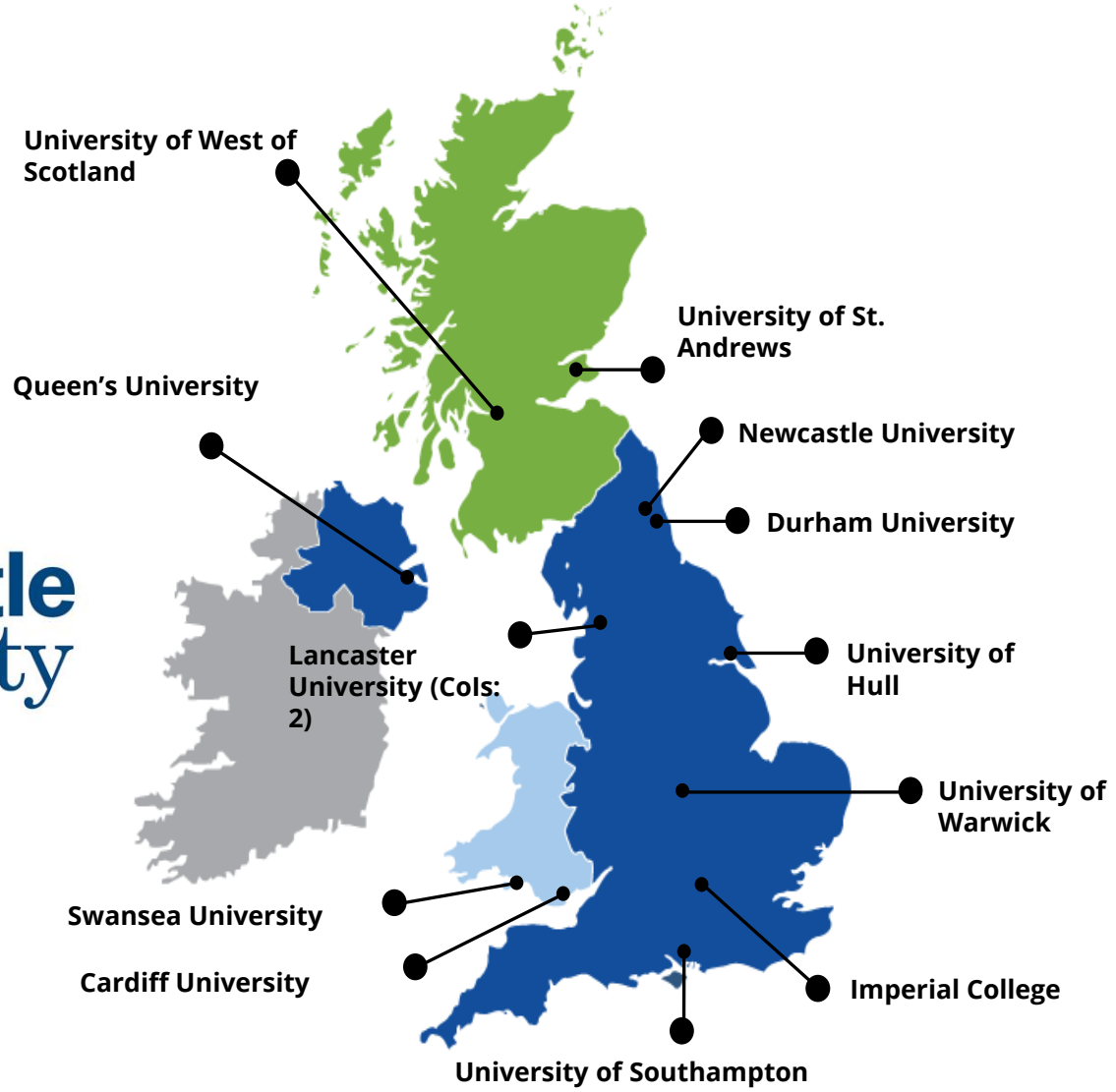
Jaikumar P et al. (2020) ISDA, https://centaur.reading.ac.uk/98569/

Engineering and Physical Sciences Research Council

National Edge AI Hub

12 m GBP Investment

Newcastle University



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  Neural Computing Application, 28(6), 1343–1354. Springer(2016)
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- Machine learning approaches to understand the influence of urban environments on human's physiological response
  Information Sciences, 474, 154–169. Elsevier. (2019)
  Ojha VK, Griego D, Kuliga S, Bielik M, Bus P, Schaeben C, Treyer L, Standfest M, Schneider S, Konig R, Donath D, Schmitt G
- Pareto Optimal Metabolic Engineering for the Growth-coupled Overproduction of Sustainable Chemicals
  Biotechnology and Bioengineering, Wiley (2022)
  Amaradio MN, Ojha V, Jansen G, Pappalardo X, Costanza J, Nicosia G
- Deep learning for automated river-level monitoring through river camera images: an approach based on water segmentation and transfer learning
  Hydrology and Earth System Sciences 25(8) 4435–4453 (2021)
  Vandaele R, Dance SL, Ojha V
- Deep Learning for Automated Trash Screen Blockage Detection Using Cameras: Actionable Information for Flood Risk Management
  Journal of Hydroinformatics, (2024)
  Vandaele, R., Dance, S L, & Ojha, V
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  Energy Systems, 1–28. Springer (2021)
  Ojha V, Jansen G, Patanè A, Magna AL, Romano V, Nicosia G
- Predictive modeling of die filling of pharmaceutical granules using the flexible neural tree
  Neural Computing Application 29(7), 467–481. Springer (2016)
  Ojha VK, Schiano S, Wu C, Abraham A, Snášel V