Machine Vision and 21stCentury AI – Our Responsibilities for The Planet

IEEM 2023
19.12.2023

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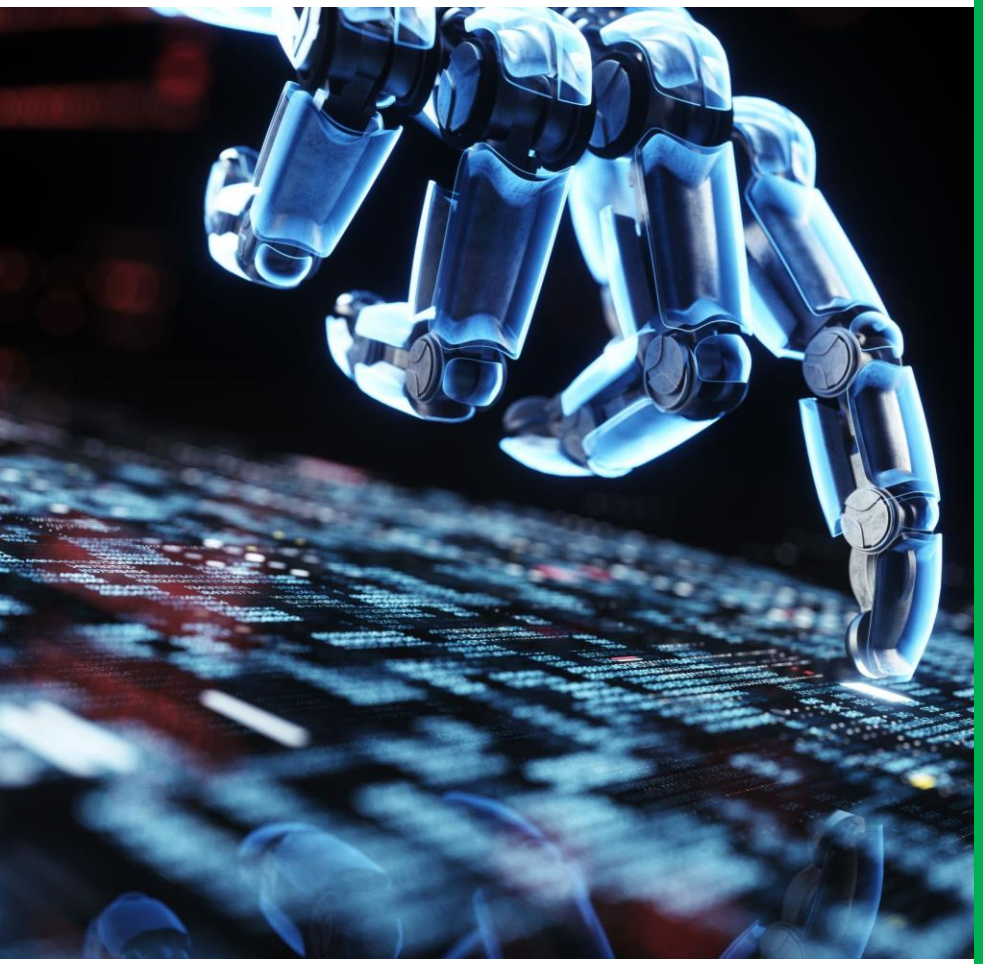
Melbourne, Australia

FAIR AI is an initiative by researchers in AI, Optimisation and Pattern Recognition Group

Our location at University of Melbourne, Australia

Ranked 1st in Australia and within top 50 in the world



- Machine Vision and 21st Century AI –What to expect?
  - Fakes and Real – how would we know the difference?
  - AI Applications changing the world
- FAIR AI: Socially Responsible AI
- Visualisation – a key aspect of FAIR AI
- Examples from Health, Automation

The planet will look very different in 100 years…..

"**With climate change, overdue asteroid strikes, epidemics and population growth, our own planet is increasingly precarious,"**
Stephen Hawking

https://www.cnbc.com/2018/03/15/stephen-hawking-predictions-human-extinction-to-global-warming.html#:~:text=Hawking%20said%20humans%20will%20need,a%20BBC%20documentary%20last%20year.

- **Climate change-**
  Earth should not become a harsh environment for humans and other species
  - Clean water
  - Healthy oceans
  - Biodiversity
  - Weather and natural disasters
- **Human made disasters**: wars, refugees
- **Extreme health emergencies**

Would we have a livable world for humans in 2123?

The planet will look very different in 100 years…..

Imagine a world where every machine can see, process information, and communicate with other machines and humans.

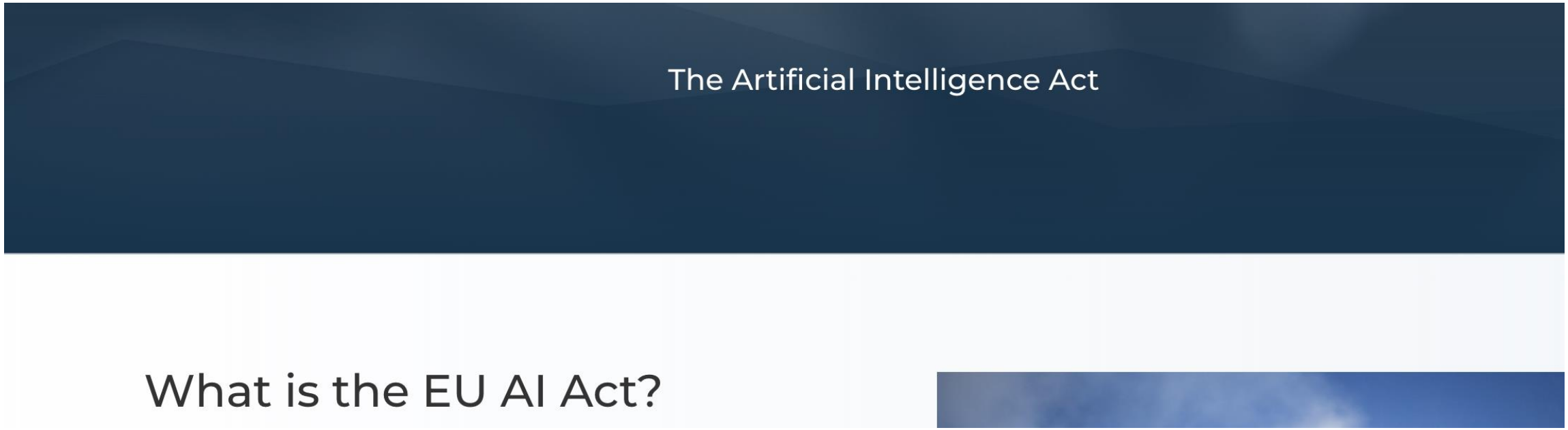
a million ways machine vision and AI can help…..
but a million ways to make it worse too…

How can machine vision and AI positively interact with industrial Eng/Eng management to achieve this target?

Would we have a livable world for all species in 2123?

As an engineer, I love machines, but I love humans more!

AI MUST BE REGULATED!



What type of AI Future we do not want?

ARE OUR ACTIONS SUPERIOR TO ANY PERCEIVED AI SINGULARITY?

Is there nothing? No imagination - no innovation than killing humans to resolve a conflict in 2023

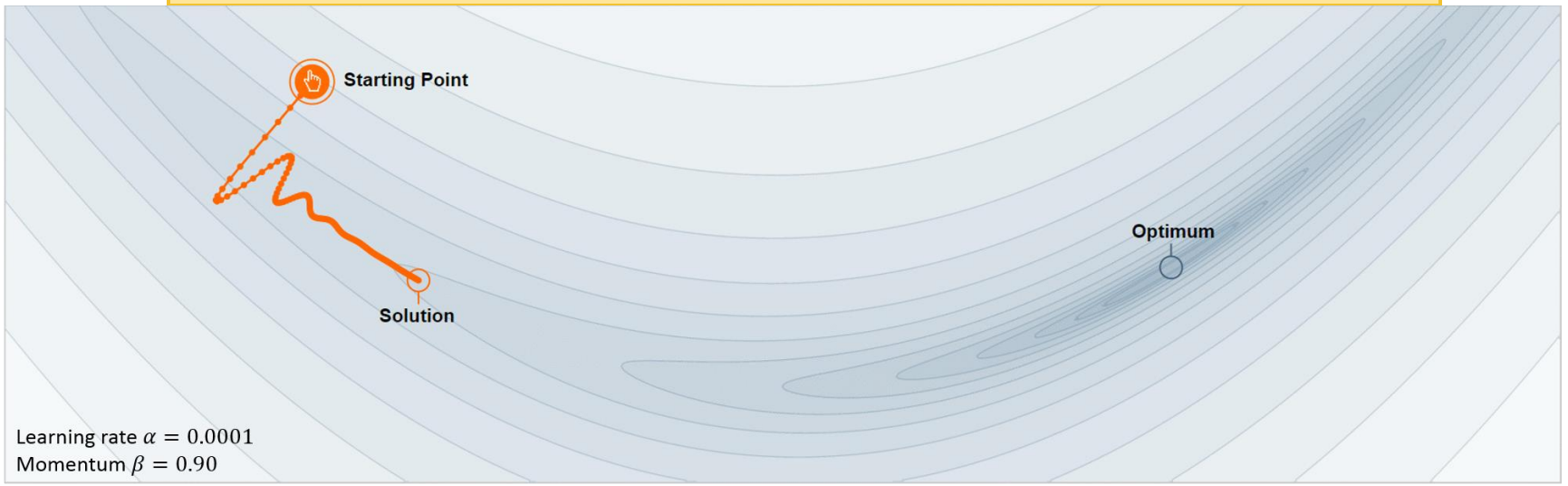
AI that cannot explain its action

AI that is secretive/not transparent

AI that cannot learn continuously

AI that can harm humans/world

AI that can go out of control



Img src: why momentum works

Generative Models

"What I cannot create, I do not understand." — Richard Feynman

Human faces generated by style generative adversarial nets [1]
Img src: https://thispersondoesnotexist.com/
Refresh this page, you'll get a different face each time!

https://commons.wikimedia.org/wiki/File:Ambigram_Real_Fake_animated_%281%29.gif

Generative models learn to approximate the sample generation process

Generative models are widely used in AI for Engineering applications today

In a future world can we recognize fake humans (humanoids) through such technology? Even if they are mixed with real humans?

Vision Transformers
Diffusion Models

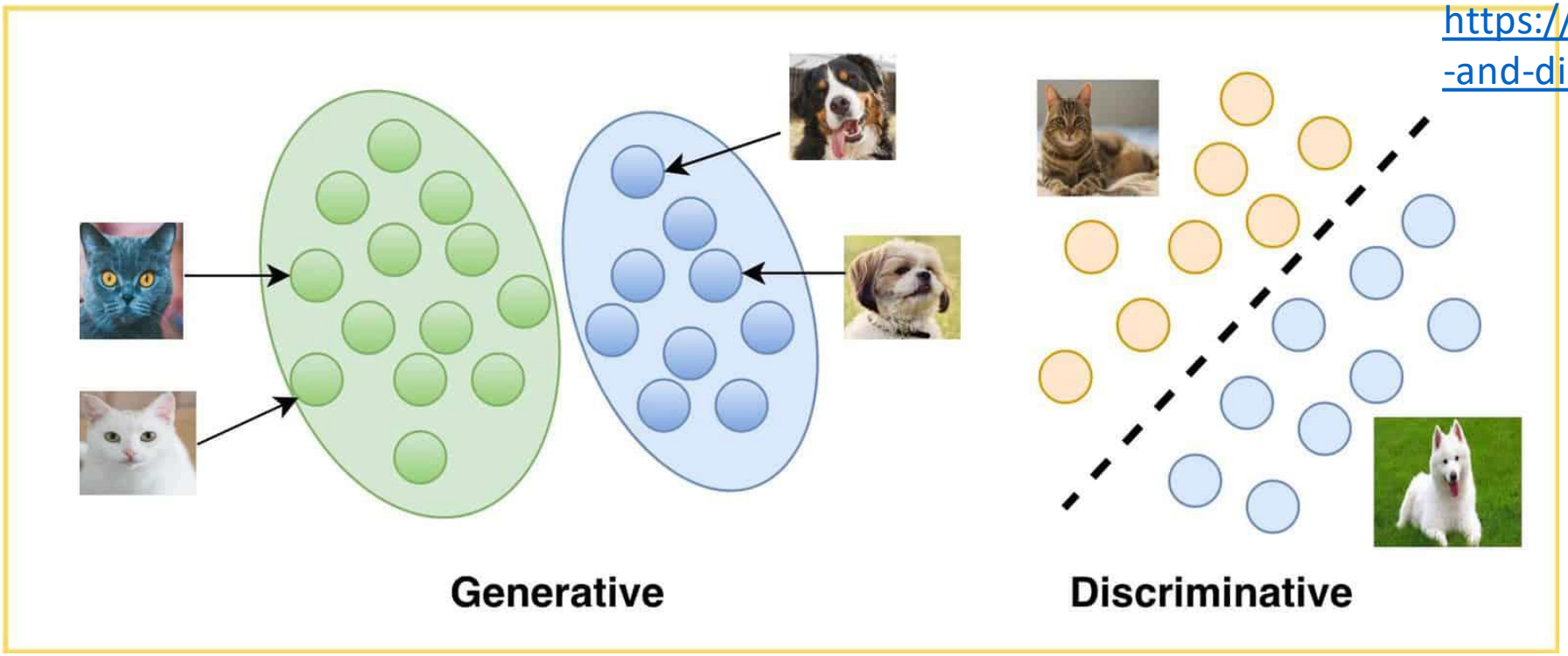
Generative Models

Explicit means “clearly/directly expressed”
Implicit means “not directly expressed”

If probability density function P_data(x) distribution CANNOT BE EXPLICITLY LEARNED what do we do?

Without explicitly defining P model(x)

Can we IMPLICITLY learn to sample from a P_model(x)



https://learnopencv.com/generative-and-discriminative-models/

https://commons.wikimedia.org/wiki/File:Ambigram_Real_Fake_animated_%281%29.gif

Paper available in

Arxiv

Undercover Deepfakes: Fakes are mixed with real ones –
Publication in October 2023
ICCV-W France

https://arxiv.org/abs/2305.06564

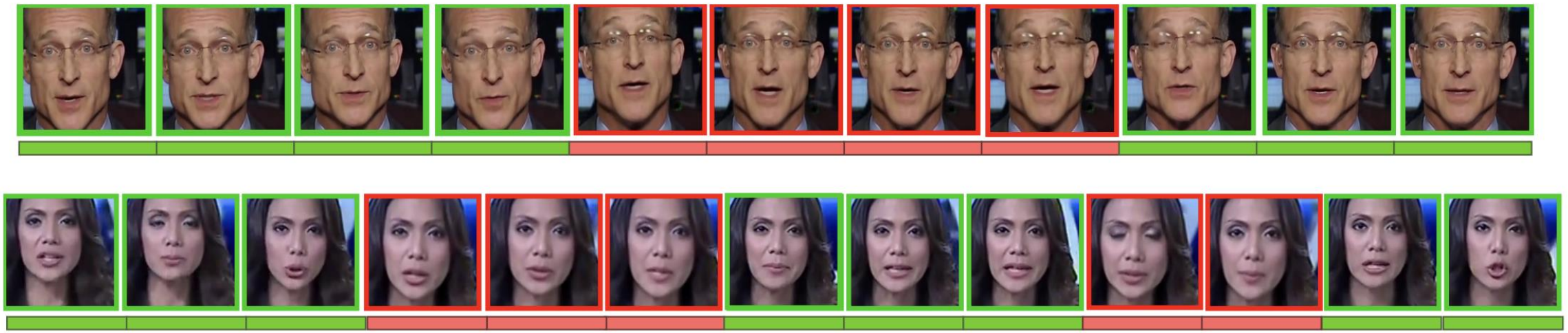
Undercover Deepfakes: Detecting Fake Segments in Videos

Several members of my group are co-authors of this anonymous submission in collaboration with NUS – Singapore.

Our Contributions

Newly introduced benchmark dataset for temporal deepfake segment detection

- Simplified illustration of sample videos from the newly introduced benchmark dataset for temporal deepfake segment detection.



ANSAC: A deep learning framework for classifying breast cancer whole-slide images based on Tumor Infiltrating Lymphocytes and slide-level labels.

Rashindrie D. Perera[1,2], Peter Savas[2,3], Damith A. Senanayake[1], Roberto Salgado[2,4], Heikki Joensuu[5], Sandra O'Toole[6], Jason Li[1,2], Sherene Loi1[2,3], Saman K. Halgamuge[1]

[1] School of Electrical, Mechanical and Infrastructure Engineering, University of Melbourne, Melbourne VIC 3010, Australia.
[2] Division of Cancer Research, Peter MacCallum Cancer Centre, Melbourne VIC 3000, Australia.
[3] Sir Peter MacCallum Department of Medical Oncology, University of Melbourne, Parkville VIC 3010, Australia.
[4] Department of Pathology, GZA-ZNA Ziekenhuizen, Antwerp, Belgium
[5] Helsinki University Hospital and University of Helsinki, Helsinki, Finland.
[6] The Garvan Institute of Medical Research and The Kinghorn Cancer Centre, Sydney, NSW 2010, Australia.

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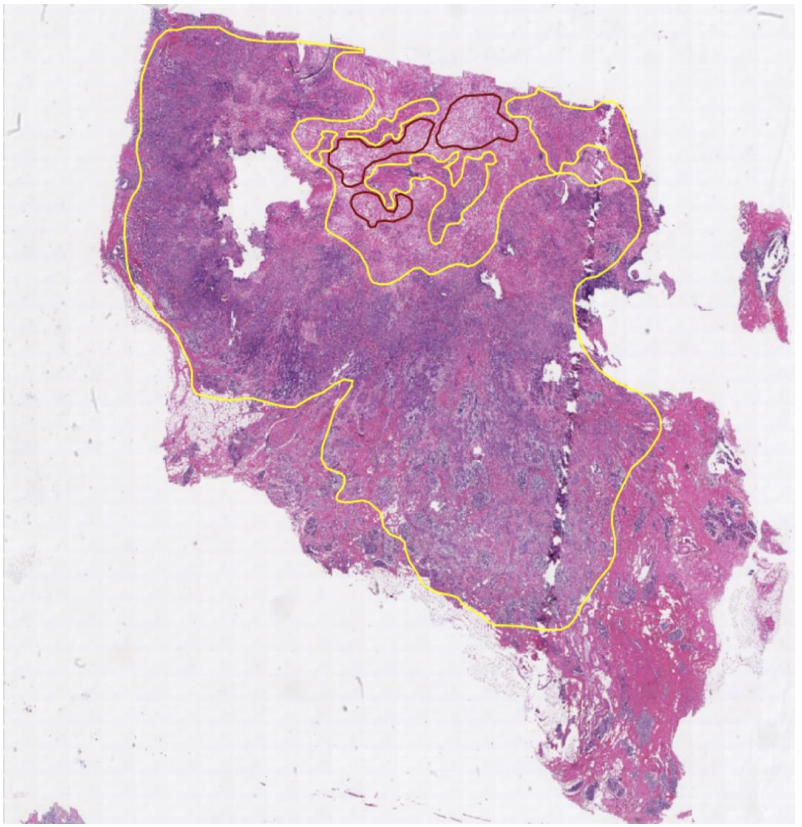
PAPER WILL BE AVAILABLE

Bioarxiv December 2023

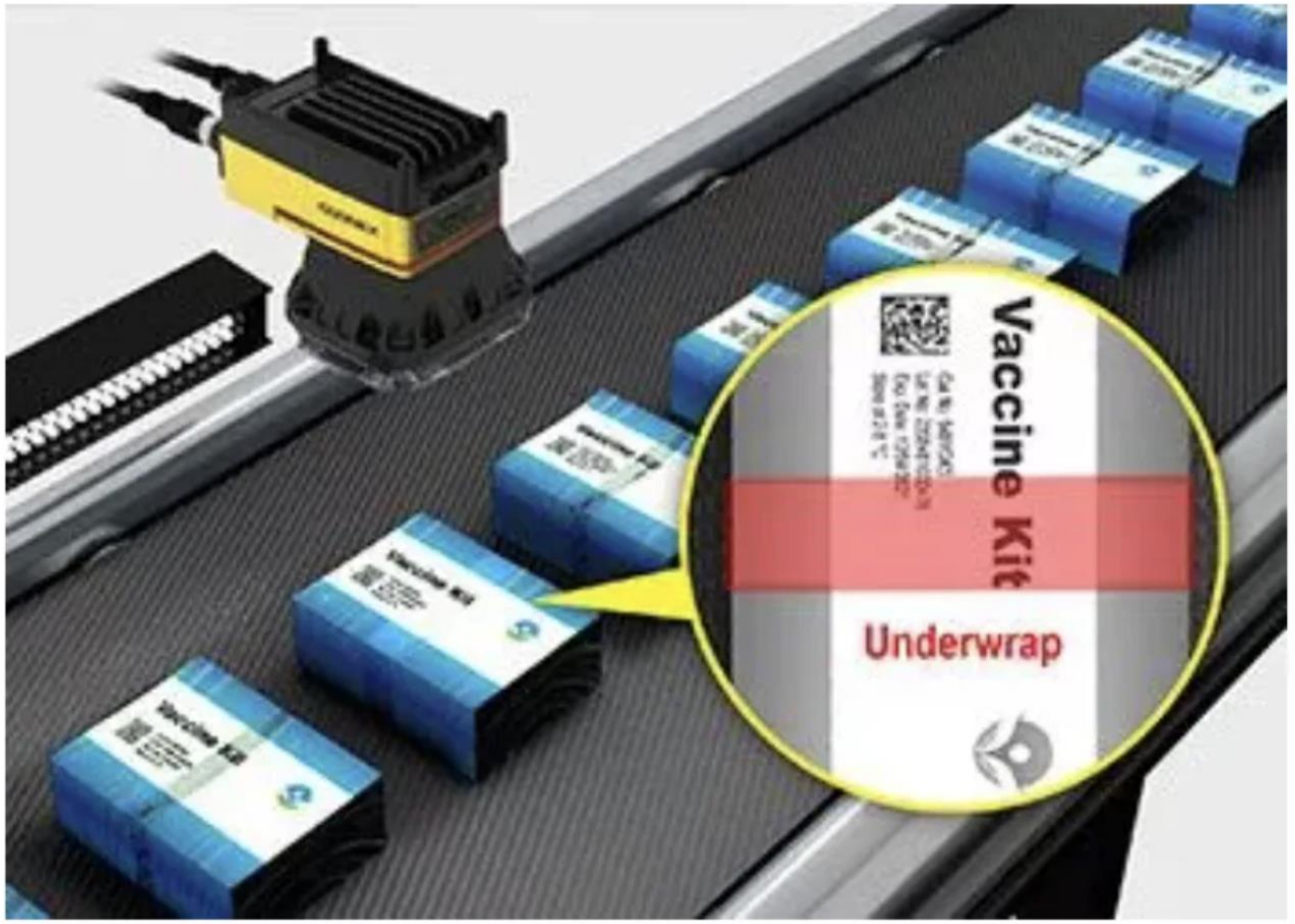


Expert annotations of tumor (yellow border) and stroma (red border) regions

A socially responsible application of AI

Common applications in manufacturing and automation

- Quality Control
- Packaging
- Assembly
- Resource management
- …..



Detecting problematic products

https://www.edlitera.com/en/blog/posts/computer-vision-edge-computing

Smart warehousing with a machine vision supported swarm of robots

- A “symphony” between humans and machines

With Semi-automation, they achieved what cannot be achieved with

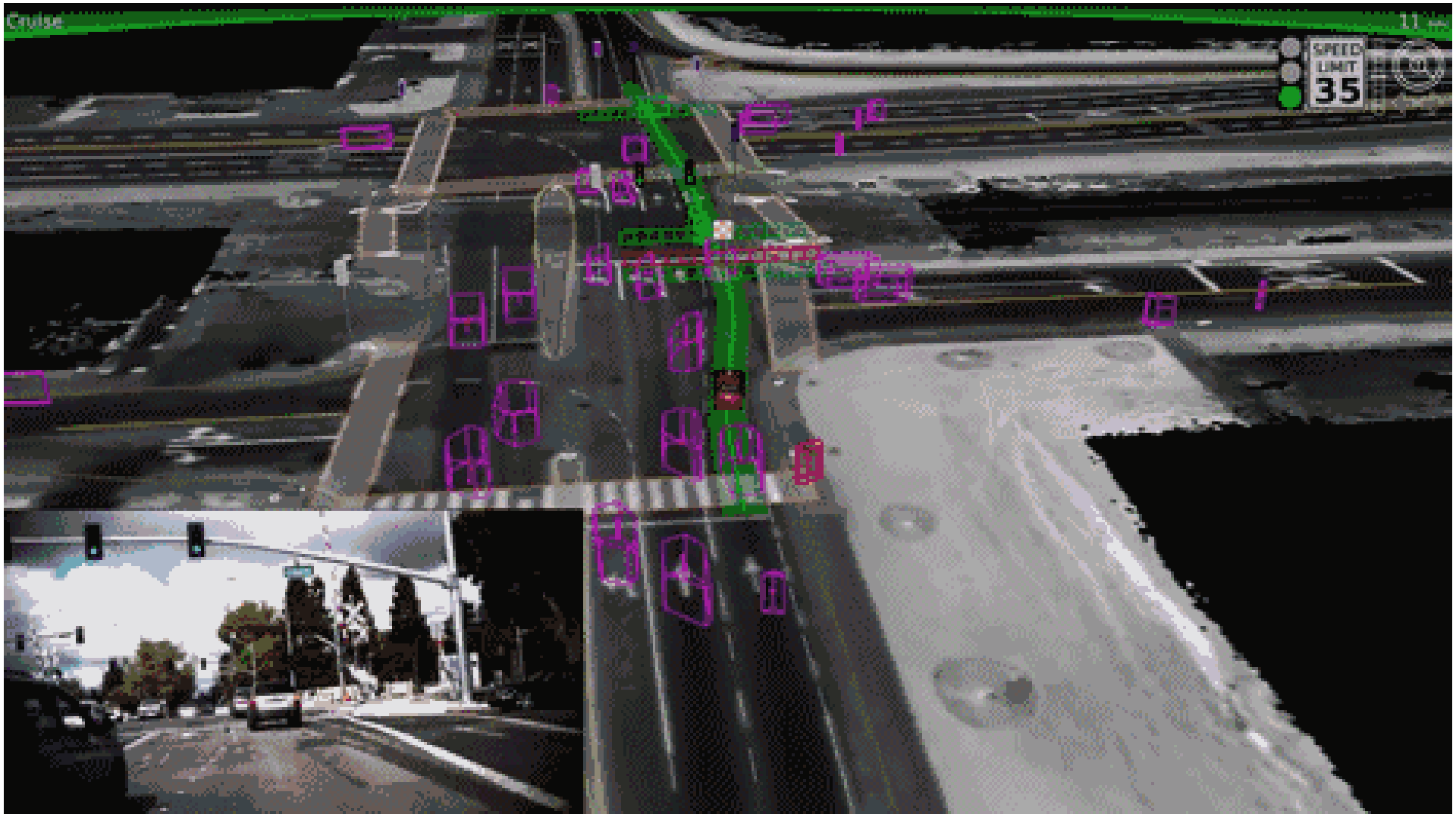
- full automation or
- full manual operation

Courtesy: Amazon, US where my former PhD student and Mechatronic engineer Dr Ken Steer works

Machine Vision Applications …

https://analyticsindiamag.com/9-computer-vision-trends-that-will-dominate-the-industry-in-2021/

Machine Vision Applications …



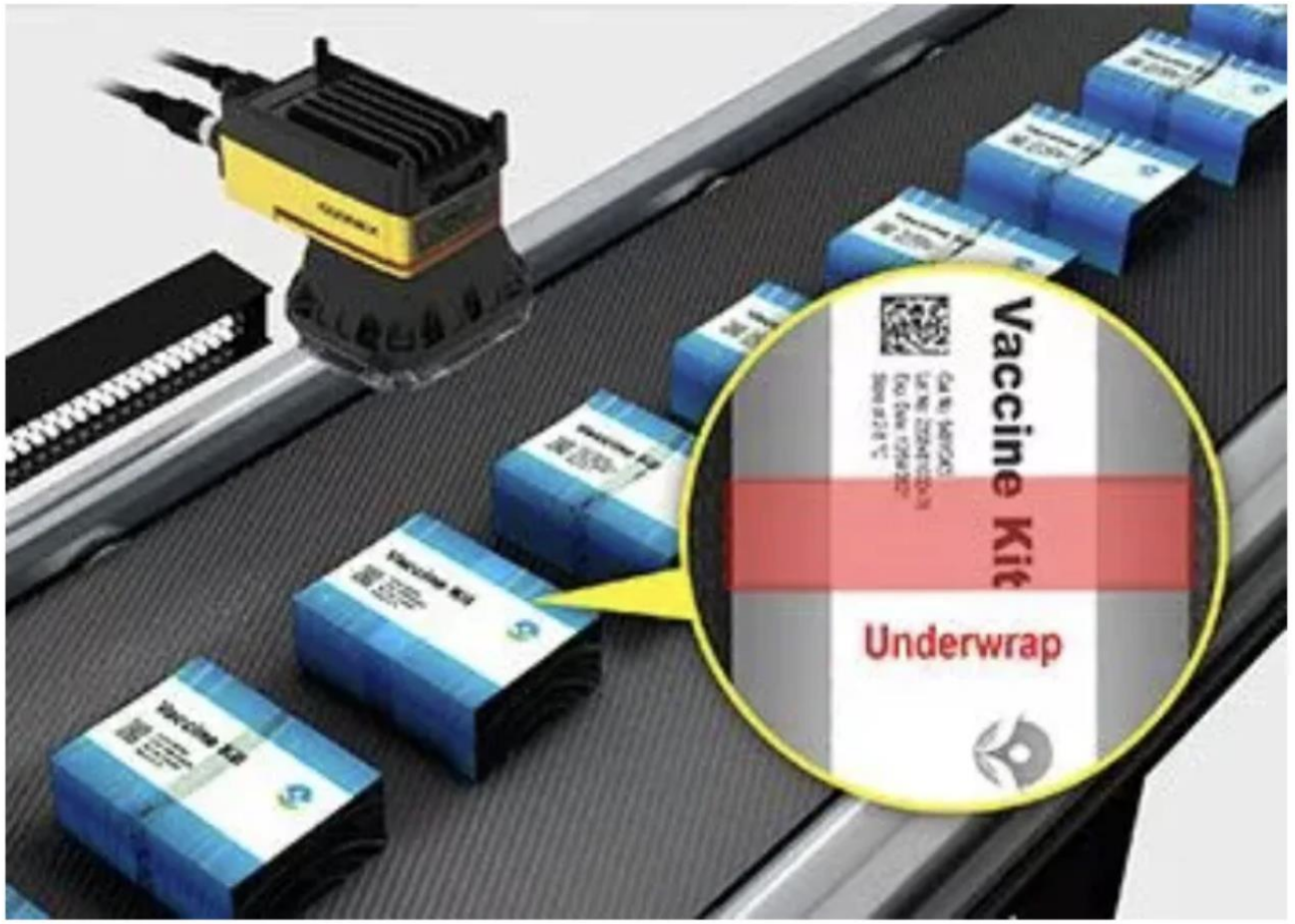
https://gifer.com/en/9kas

Is AI another tool or a disruptive technology (Computing ++)?

https://analyticsindiamag.com/9-computer-vision-trends-that-will-dominate-the-industry-in-2021/

Common applications in manufacturing and automation

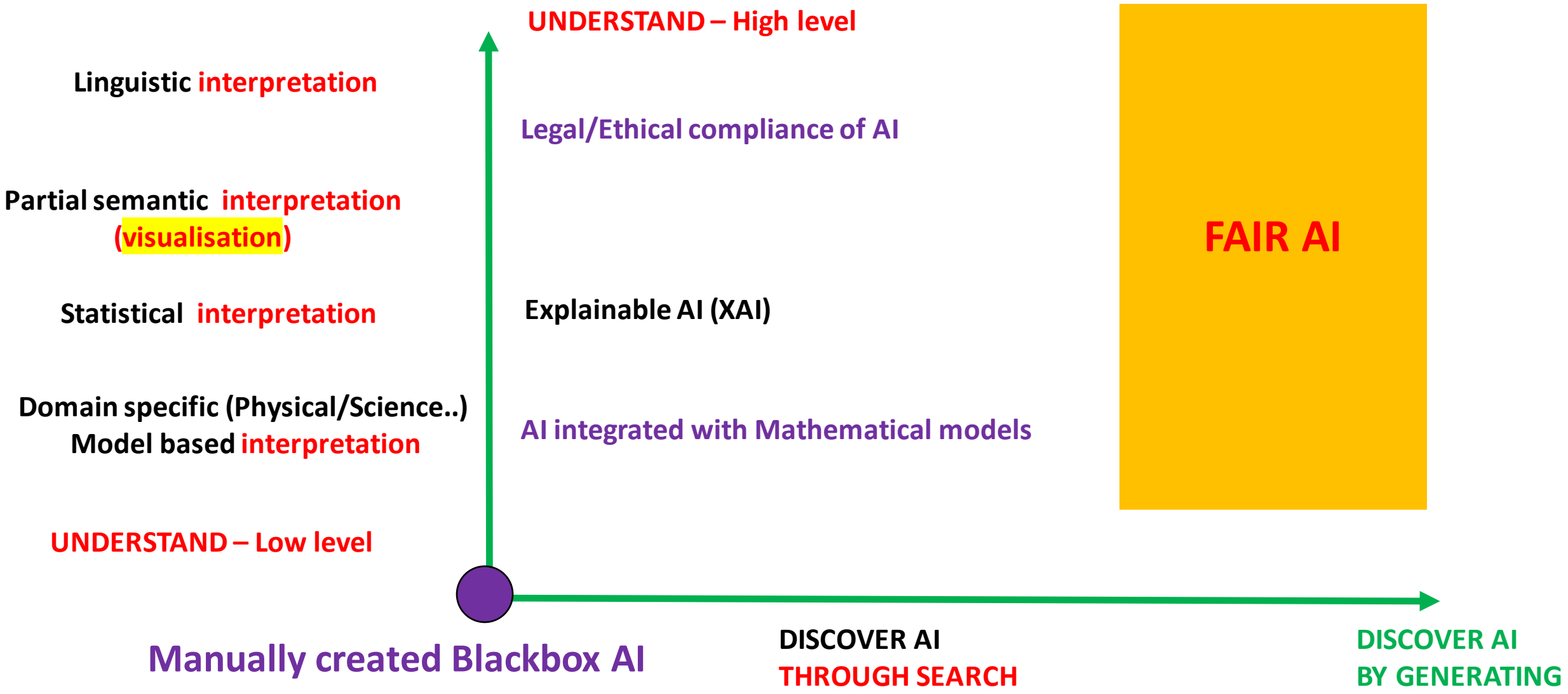
- Quality Control
- Packaging
- Assembly
- Resource management
- …..



Detecting problematic products

https://www.edlitera.com/en/blog/posts/computer-vision-edge-computing

Socially responsible AI or FAIR AI : Fair Accessible Interpretable and Reproducible AI

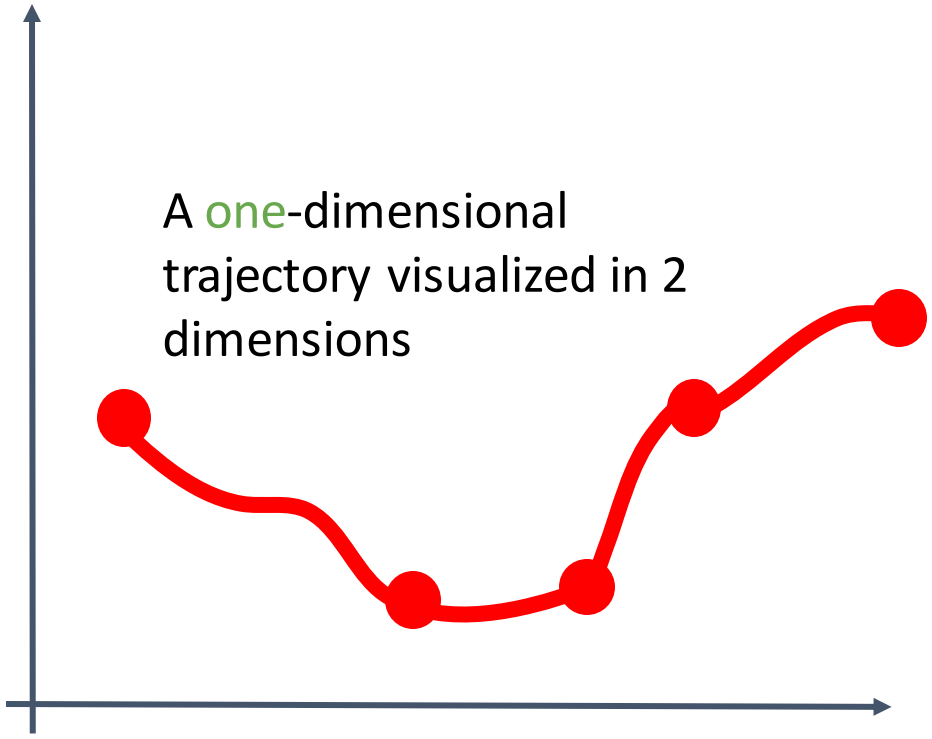


Visualisation - a form of XAI

IDEAL

Y axis : an observation we can visualise

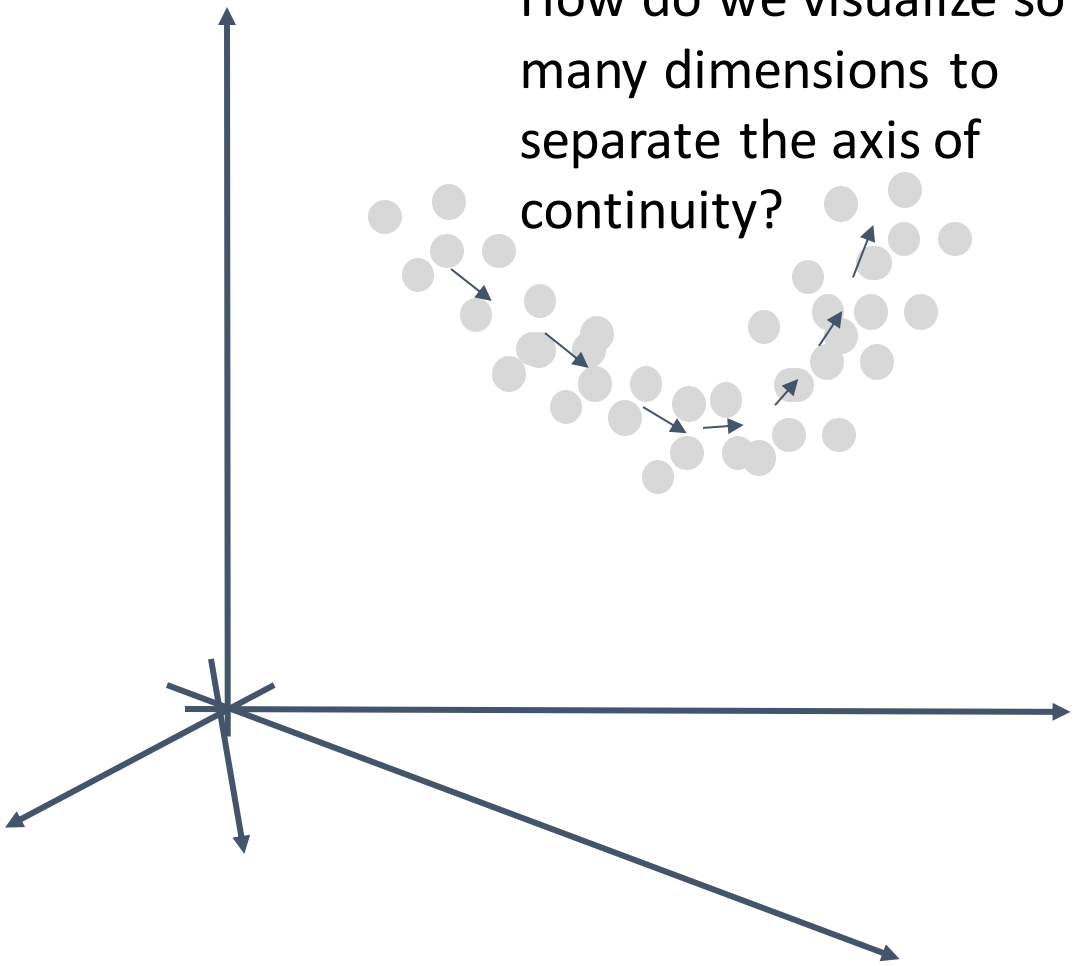
A one-dimensional trajectory visualized in 2 dimensions



X axis- some form of continuum (e.g.time)

REALITY…

How do we visualize so many dimensions to separate the axis of continuity?

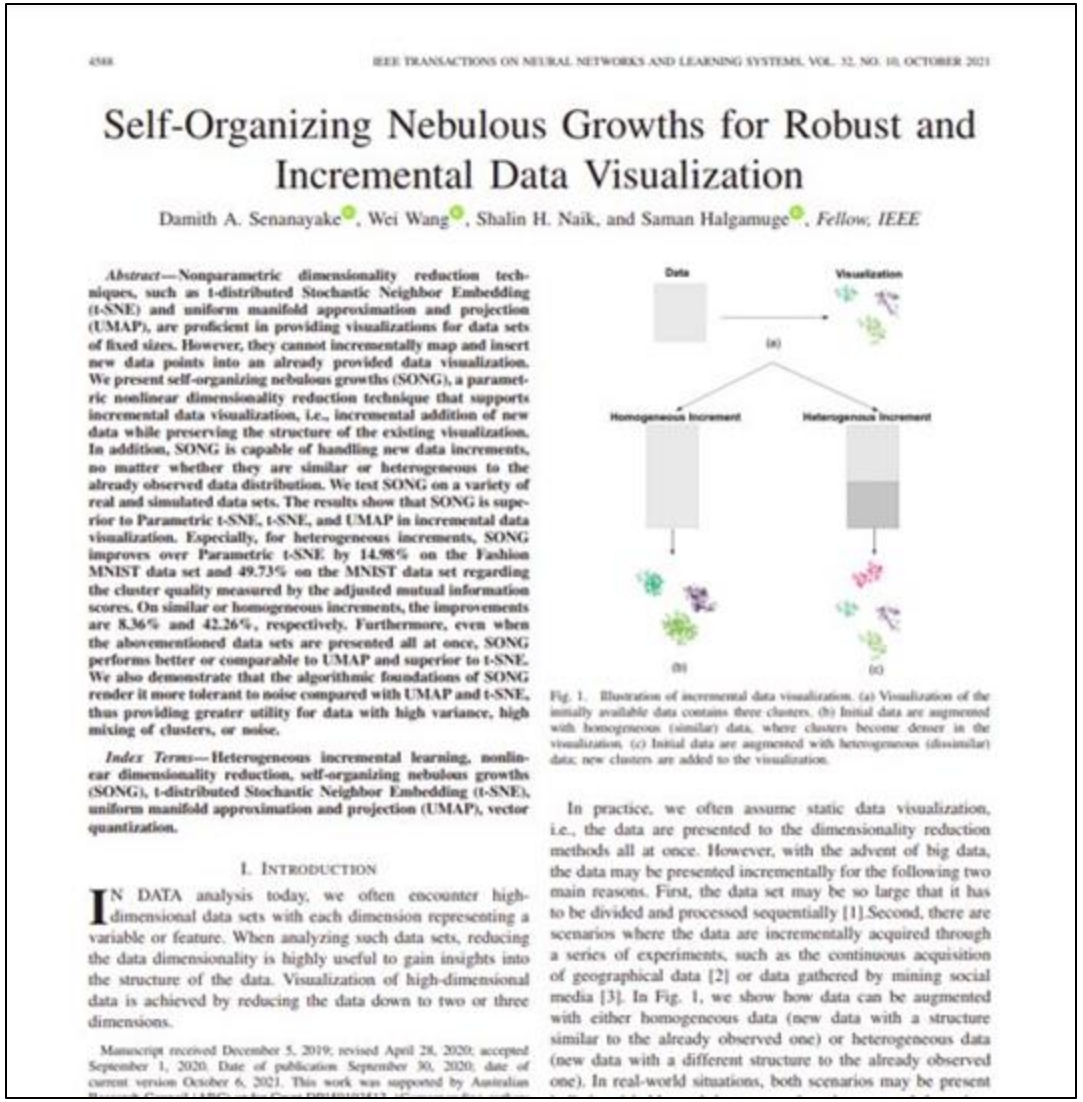


SONG: Self Organizing Nebulous Growths (2021)

- *Senanayake, D.A., Wang, W., Naik, S.H. and Halgamuge, S., 2020. Self-organizing nebulous growths for robust and incremental data visualization. IEEE Transactions on Neural Networks and Learning Systems, 32(10), pp.4588-4602.*

An algorithmic foundation for identifying hidden continuums in data with incremental visualization

A challenge posed by a completed NHMRC project led by Shalin Naik (WEHI)



4588 IEEE TRANSACTIONS ON NEURAL NETWORKS AND LEARNING SYSTEMS, VOL. 32, NO. 10, OCTOBER 2021

Self-Organizing Nebulous Growths for Robust and Incremental Data Visualization

Damith A. Senanayake, Wei Wang, Shalin H. Naik, and Saman Halgamuge, *Fellow, IEEE*

***Abstract*—Nonparametric dimensionality reduction techniques, such as t-distributed Stochastic Neighbor Embedding (t-SNE) and uniform manifold approximation and projection (UMAP), are proficient in providing visualizations for data sets of fixed sizes. However, they cannot incrementally map and insert new data points into an already provided data visualization. We present self-organizing nebulous growths (SONG), a parametric nonlinear dimensionality reduction technique that supports incremental data visualization, i.e., incremental addition of new data while preserving the structure of the existing visualization. In addition, SONG is capable of handling new data increments, no matter whether they are similar or heterogeneous to the already observed data distribution. We test SONG on a variety of real and simulated data sets. The results show that SONG is superior to Parametric t-SNE, t-SNE, and UMAP in incremental data visualization. Especially, for heterogeneous increments, SONG improves over Parametric t-SNE by 14.98% on the Fashion MNIST data set and 49.73% on the MNIST data set regarding the cluster quality measured by the adjusted mutual information scores. On similar or homogeneous increments, the improvements are 8.36% and 42.26%, respectively. Furthermore, even when the abovementioned data sets are presented all at once, SONG performs better or comparable to UMAP and superior to t-SNE. We also demonstrate that the algorithmic foundations of SONG render it more tolerant to noise compared with UMAP and t-SNE, thus providing greater utility for data with high variance, high mixing of clusters, or noise.**

***Index Terms*—Heterogeneous incremental learning, nonlinear dimensionality reduction, self-organizing nebulous growths (SONG), t-distributed Stochastic Neighbor Embedding (t-SNE), uniform manifold approximation and projection (UMAP), vector quantization.**

I. Introduction

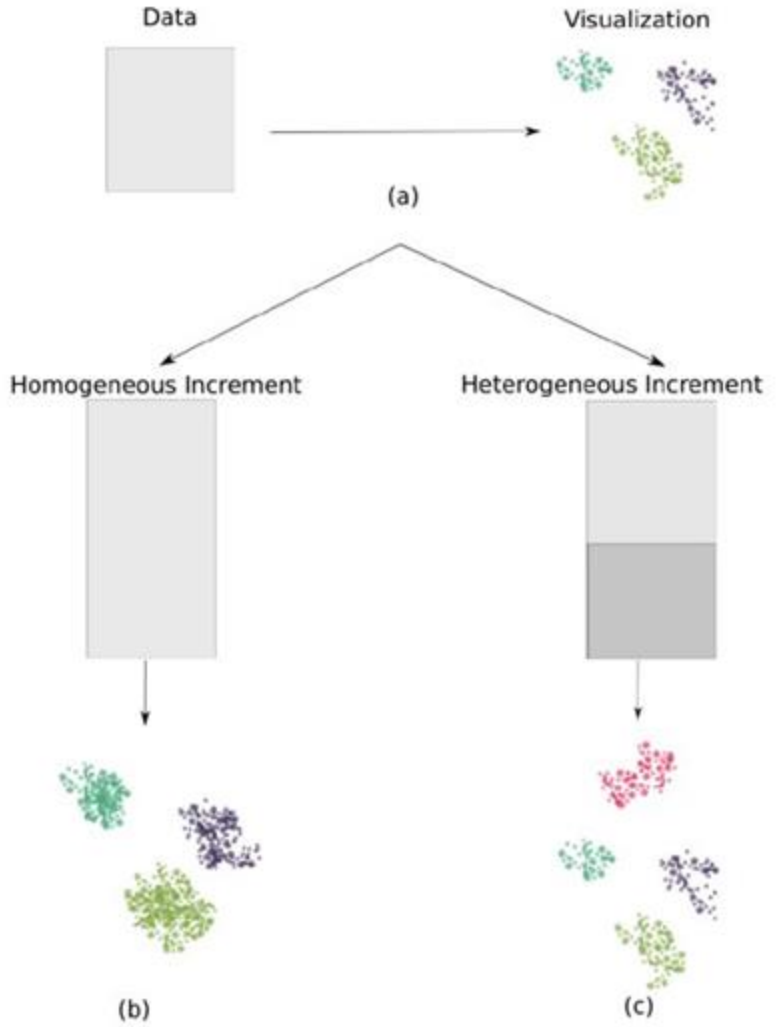
IN DATA analysis today, we often encounter high-dimensional data sets with each dimension representing a variable or feature. When analyzing such data sets, reducing the data dimensionality is highly useful to gain insights into the structure of the data. Visualization of high-dimensional data is achieved by reducing the data down to two or three dimensions.

Manuscript received December 5, 2019; revised April 28, 2020; accepted September 1, 2020. Date of publication September 30, 2020; date of current version October 6, 2021. This work was supported by Australian

Fig. 1. Illustration of incremental data visualization. (a) Visualization of the initially available data contains three clusters. (b) Initial data are augmented with homogeneous (similar) data, where clusters become denser in the visualization. (c) Initial data are augmented with heterogeneous (dissimilar) data; new clusters are added to the visualization.

In practice, we often assume static data visualization, i.e., the data are presented to the dimensionality reduction methods all at once. However, with the advent of big data, the data may be presented incrementally for the following two main reasons. First, the data set may be so large that it has to be divided and processed sequentially [1].Second, there are scenarios where the data are incrementally acquired through a series of experiments, such as the continuous acquisition of geographical data [2] or data gathered by mining social media [3]. In Fig. 1, we show how data can be augmented with either homogeneous data (new data with a structure similar to the already observed one) or heterogeneous data (new data with a different structure to the already observed one). In real-world situations, both scenarios may be present

SONG: Self Organizing Nebulous Growths (2021)

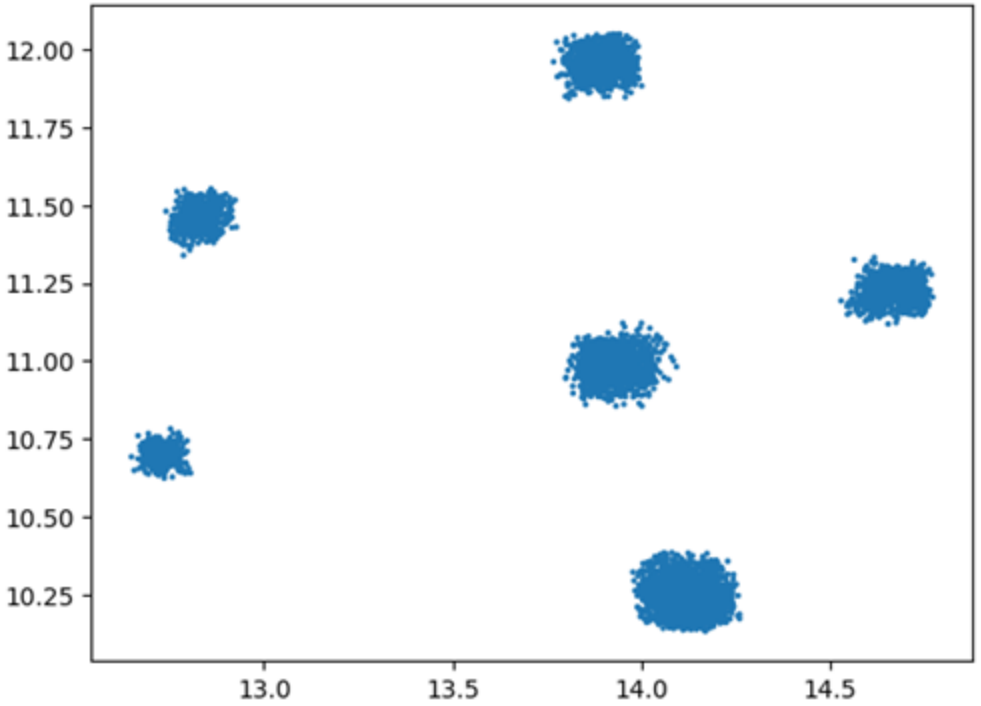


Homogenous Increments where the clusters are proportionally augmented

Heterogenous Increments where the clusters are vastly different from increment to increment

SONG: Self Organizing Nebulous Growths (2021)

- Based on Vector Quantization and Self-Organization
- **NEW**: outperforms all other dimensionality reduction methods when incorporating heterogeneous increments
- **BETTER**: Has Comparable/Better Visualization Quality to t-SNE / UMAP
- **FASTER**: Can act as a heuristic initialization for UMAP thus speeding up UMAP operation



Visualization of hand-written digits dataset (MNIST) when you add one class at a time

SONG: Application examples

1. Integrating large, high dimensional datasets into a single reference atlas (single cell transcriptomics)

Trick: Continuum here is not the time!

A completed NHMRC Project grant led by Shalin Nail at WEHI and a current ARC DP I hold.

2. Using SONG visualizations to track the developmental progression of brain organoids by visualizing their electrophysiological characteristics

Continuum here is indeed the time!

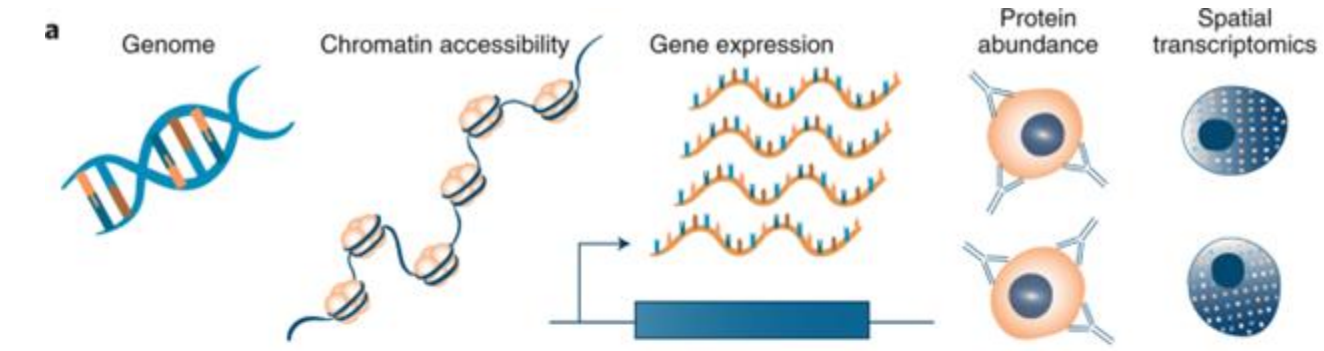
A completed Dementia Australia-Yuligbar Foundation grant led by Jagadish (ANU), MND grant and a current US DoD Biomedical Research grant – both led by Lezanne Ooi at UoW

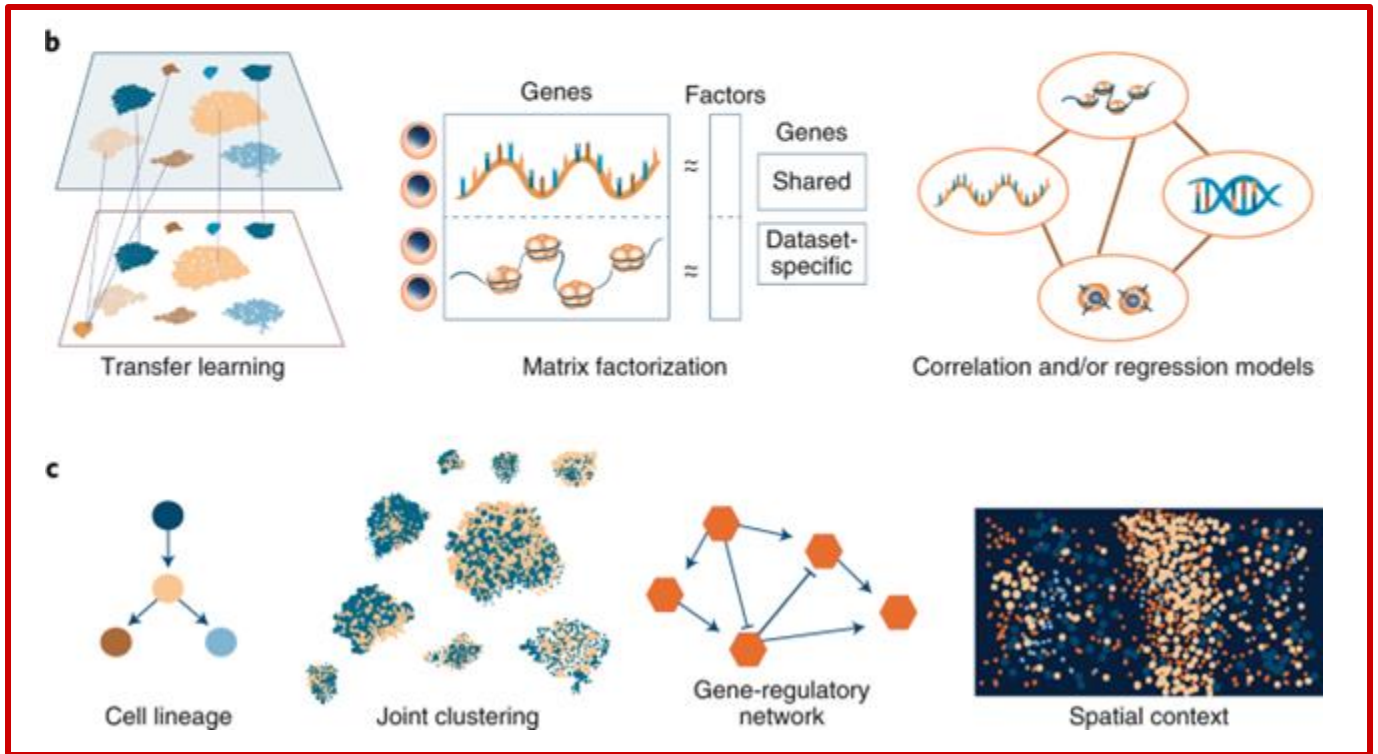
SCEATLL: Application 1 of SONG

- Single-Cell biology has evolved a lot over the last decade, providing a high-resolution view into the cellular dynamics
- Laboratories from across the world produce single-cell data from various tissues/donors/species!
- Integrating them for better insights/confidence is computationally intractable…

Until now!

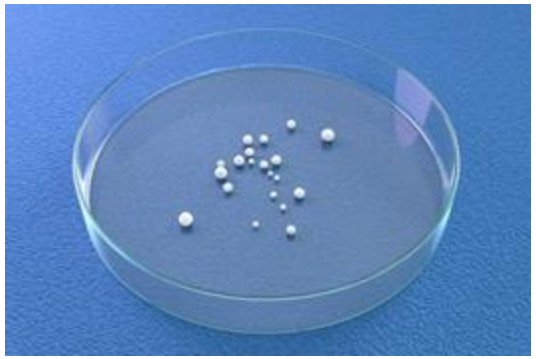
Trick: Continuum here is not the time!



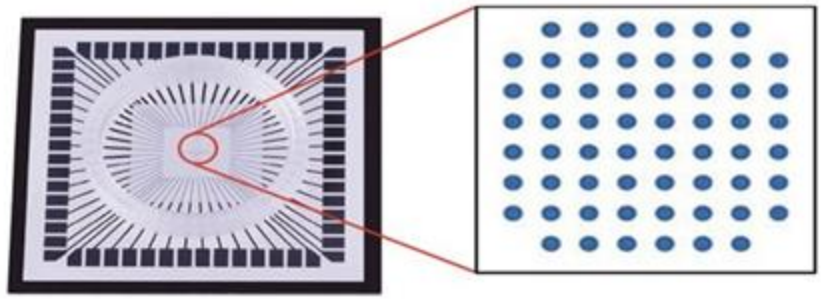


IL-VIS: Application 2 of SONG

- IL-VIS (Incrementally-Learned Visualization) (2022, bioRxive)
- **Brain organoid**-based **longitudinal study**
- Brain organoids (mini brains) are tiny tissue cultures
  - Derived from human stem cells
  - Mimics the functionality of the brain
- Many neurological diseases, including **Alzheimer's disease (AD)**, are being studied using brain organoids to test the effects of potential drugs.
- **Electrophysiological properties** of these organoids can be studied using **Multi-Electrode Arrays (MEA)**
- MEAs contain multiple electrodes that record the extracellular activities of the neurons in the organoid



Brain Organoids [1]



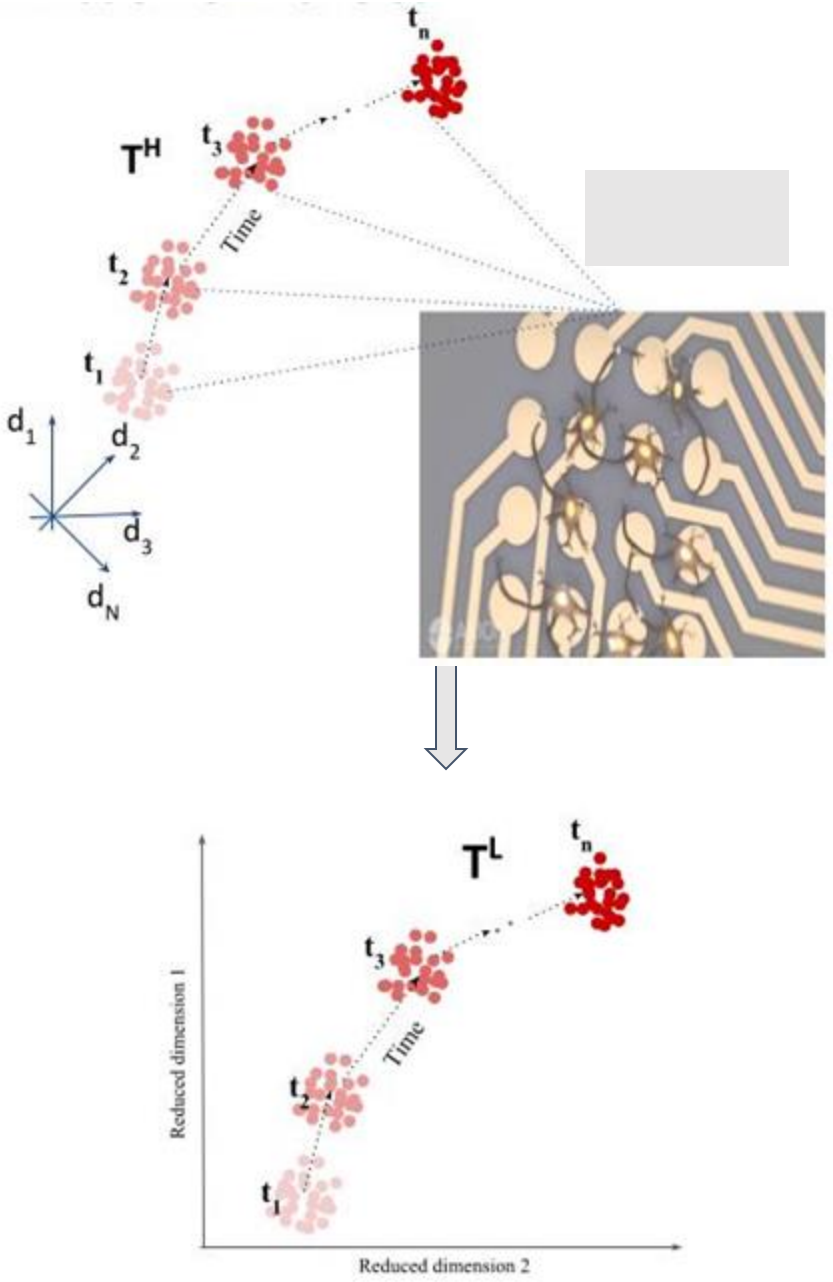
An MEA plate [2]

[1] https://www.popularmechanics.com/science/health/a42916548/are-brain-organoids-conscious

[2] https://hsci.harvard.edu/news/improved-human-brain-organoids-boost-neurologicl-disease-research

IL-VIS

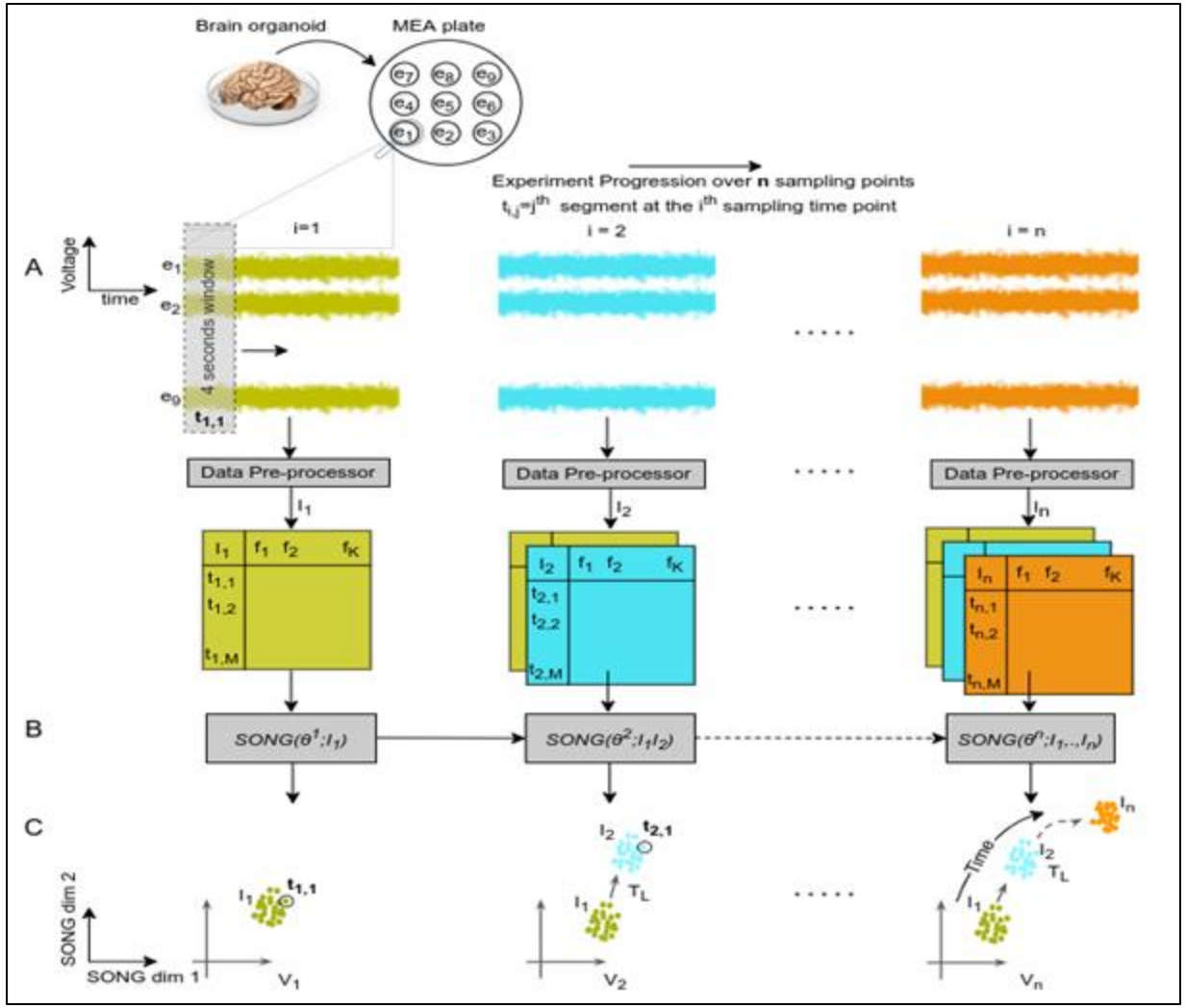
- MEA recordings are obtained from an organoid over a period of time at different sampling time points
  - t_1 , t_2 … t_n
- We hypothesize that the progression of the electrophysiological properties of an organoid could be represented as a **trajectory** embedded in the **high-dimensional MEA data**
- Our goal is to **visualize this trajectory in a 2D space** while keeping the complex relationships between electrodes and organoids (when modeling multiple organoids) intact



A schematic representation of the MEA signals recorded from an organoid at different sampling time points

IL-VIS: Approach

- We propose **IL-VIS (Incrementally Learned Visualizer)**, a machine-learning pipeline that visualizes the longitudinal progression of the electrophysiological properties of an organoid

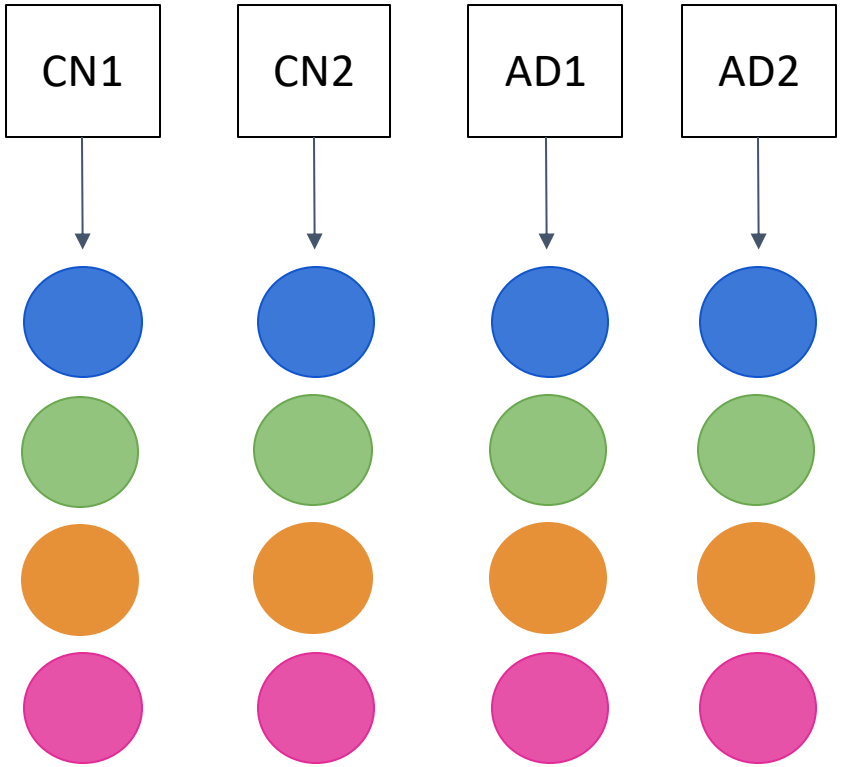


A schematic diagram of IL-VIS

IL-VIS: Findings on Experimental Data

- The dataset contains MEA data obtained from brain organoids derived from:
  - two AD patients **(AD1 and AD2)**
  - two healthy controls **(CN1 and CN2)**

- Four organoids are derived from each cell line exposed to one of the following four treatments
  1. Untreated
  2. Quinolinic Acid (QUIN) : a metabolite known to play a role in many neuroinflammatory diseases including AD
  3. Quinolinic Acid Antibody (QUIN Ab) : a blocking antibody of QUIN
  4. Both QUIN and QUIN Ab added.



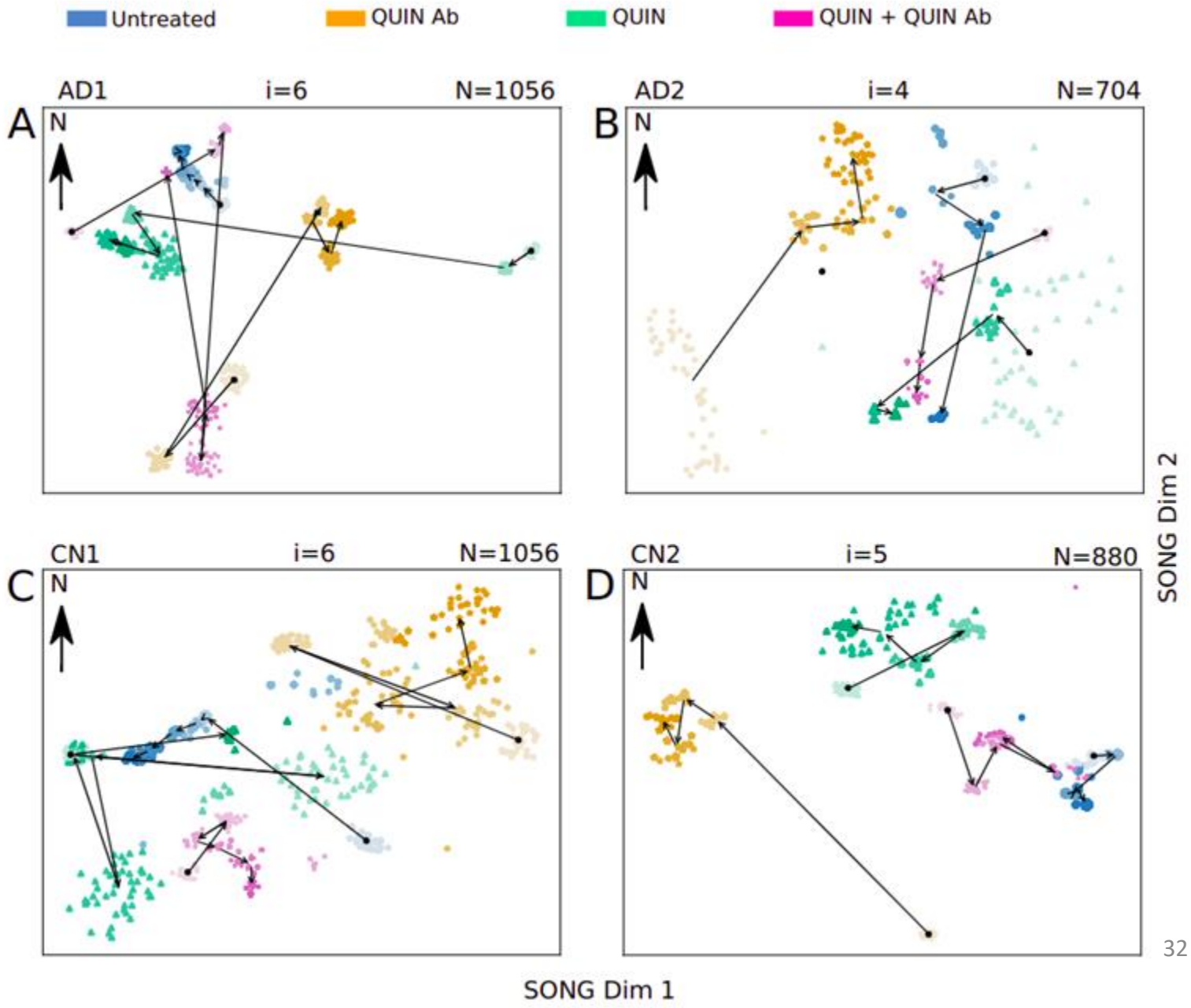
IL-VIS: Findings on Experimental Data

- We test the ability of QUIN Ab to reduce the harmful effects of QUIN

Organoid age	Treatment time (t)	CN1	CN2	AD1	AD2
5 months	-	I_1	-	I_1	
6 months (Drugs added)	t=0	I_2	I_1	I_2	I_1
6 months & 1 Day	t=1 day	I_3	I_2	I_3	-
6 months & 1 Week	t=1 week	I_4	I_3	I_4	I_2
6 months & 1 Month	t=1 month	I_5	I_4	I_5	I_3
6 months & 3 Months	t=3 months	I_6	I_5	I_6	I_4

IL-VIS: Findings on Experimental Data

- **QUIN Ab-treated** organoid trajectory deviates from the other three conditions in all four cell lines
- Our findings support the evidence of **QUIN Ab's capability in reducing the harmful effect of QUIN** which is of greater importance to the field of neurobiology



Will Bedowes (PhD student)

- **Kenya -** *71.4% Electrification*
- **Uganda -** *41.5 % Electrification*

Co-supervisors:
Dr Elizabeth Ratnam (ANU)
Dr Julian de Hoog
Funding:
Australian Research council

AI applications in developing countries

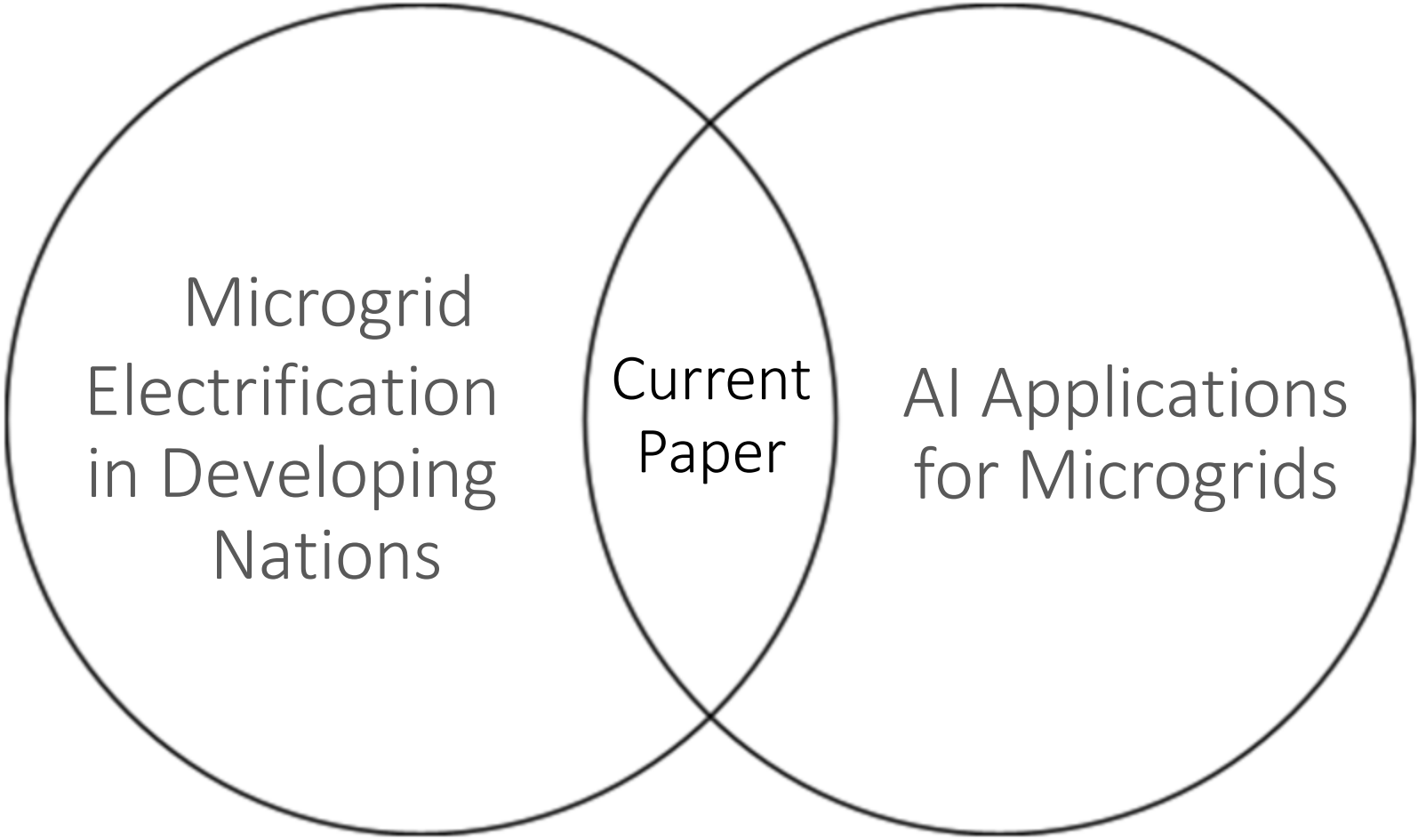
Image Source: Repairing a power line (Kampala, Uganda)

Leveraging Artificial Intelligence for Enhancing Renewable Energy Adoption in Developing Countries: An Industry Focused Review

A comprehensive review of challenges facing developing countries and suggestion for future research. To appear:

Accepted:

Sustainable/Renewable Energy Reports



orbike, www.zem.bo:

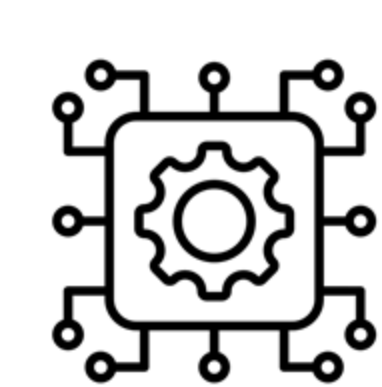
Rural electrification, one STEP at a time.

Social

- Education
- Awareness
- Adoption

Technical

- Resources
- Knowledge
- Applications



Economic

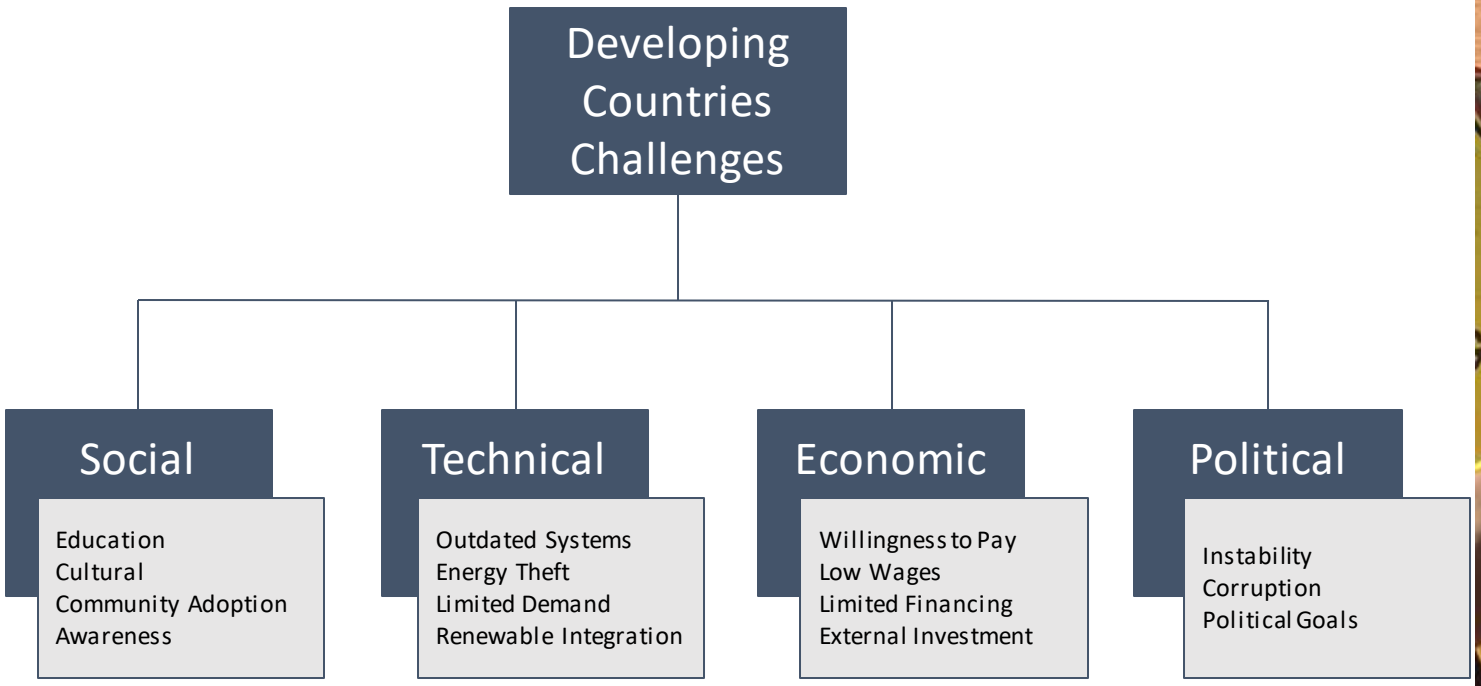
- Financing
- Investment
- Poverty

Political

- Policy
- Incentives
- Corruption

Source: Afful-Dadzie, Anthony, Alexandra Mallett, and Eric Afful-Dadzie. 2020. "The Challenge of Energy Transition in the Global South: The Case of Electricity Generation Planning in Ghana." Renewable and Sustainable Energy Reviews 126 (July): 109830.

Leveraging Artificial Intelligence for Enhancing Renewable Energy Adoption in Developing Countries: An Industry Focused Review



PhD student Will Bedowes in Uganda

Power Quality of Existing mini grids in DRC

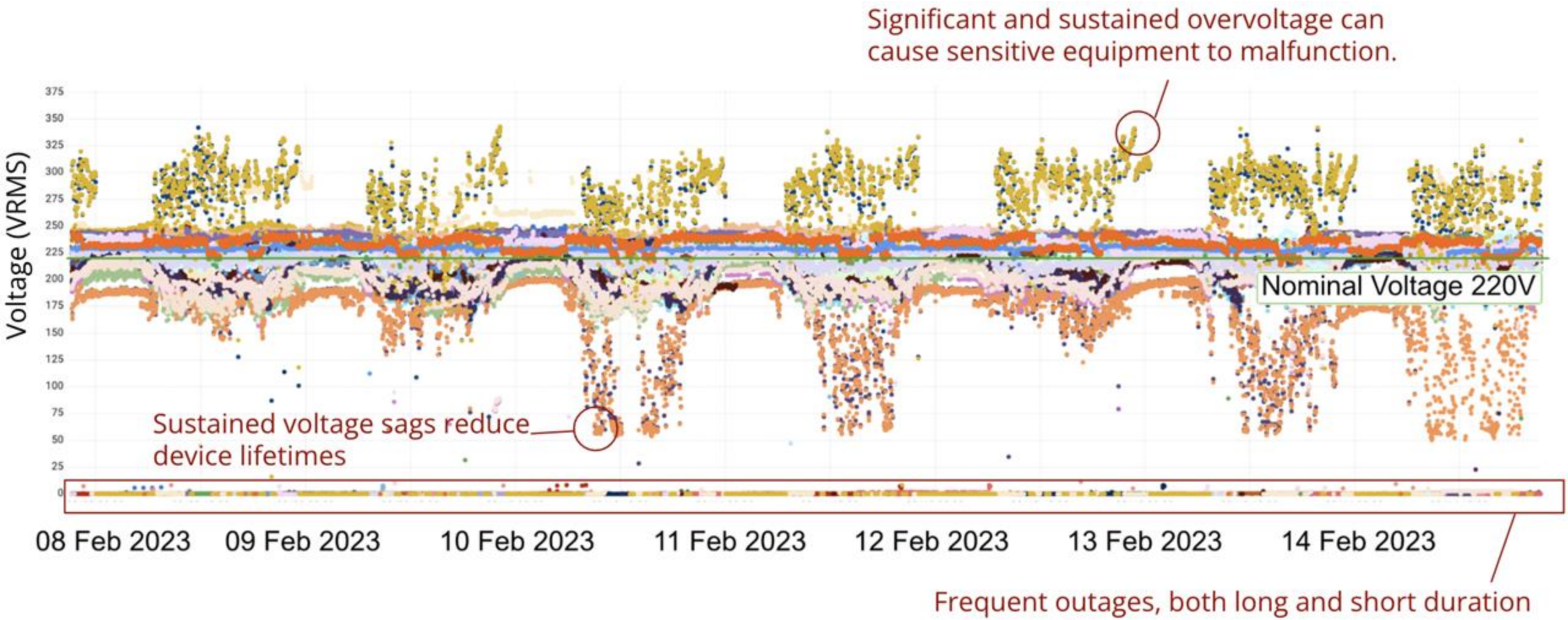
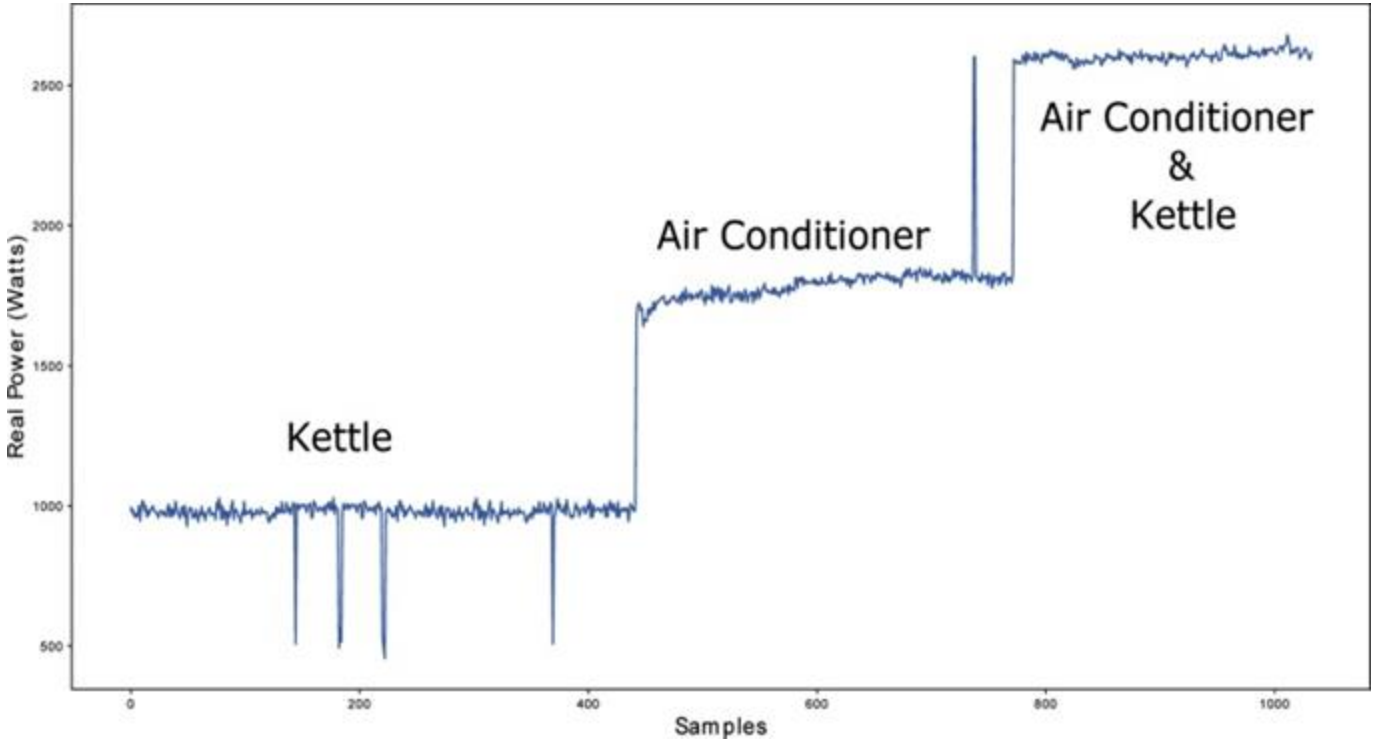


Image Source: nLine Power Watch Sensors

Non Intrusive Load Monitoring (NILM)

NILM uses classifiers including AI models to desegregate different loads based on electrical signal.



NILM AI Models:

- LTST-RL
- CNN
- SVM
- Random Forest
- CALM
- DNN
- HMM

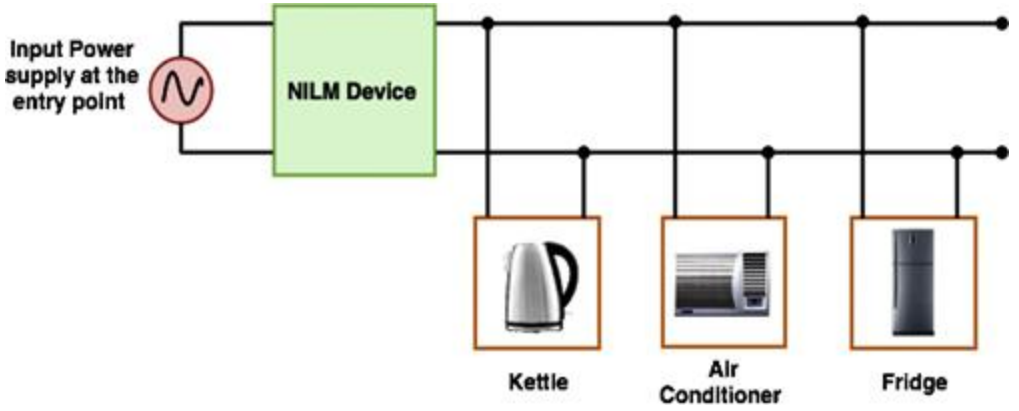


Image Source: Lee, K. (2023). Expanding Access to Electricity in Kenya. In: Madon, T., Gadgil, A.J., Anderson, R., Casaburi, L., Lee, K., Rezaee, A. (eds) Introduction to Development Engineering. Springer, CAM

Applying AI to improving electrification rates

Biofuel cooking is the leading cause of carbon emission in developing Africa.

Biofuel based cooking **contributes 2% of all global greenhouse gasses** and **causes nearly 500,000 deaths annually,** impacting women and children disproportionately. **In Uganda, 92% of the population** does not have access to cleaner cooking.

Image Source: Acumen.org

New project….

Objective: To increase payback of microgrids and rural electrification by

- introducing electric cooking, and
- validating its use for carbon credit payback.

Industry backing: Energrow, StemaCo

Image Source: https://www.clasp.ngo/wp-content/uploads/2021/01/Accelerating-Microgrid-E-Cooking-Through-Business-and-Delivery-Model-Innovations.pdf

Role of Deep Learning/ Optimisation in Solar Power Forecasting

On going work (more information will be available on Arxiv in mid 2023):

- **Deep learning for cloud movement forecasting**
- **Forecasting regional solar generation using deep learning techniques**

Published work (available online):

- **Residential solar power forecasting across multiple time resolutions and horizons**
  - Perera, M., De Hoog, J., Bandara, K., & Halgamuge, S. (2022). Multi-resolution, multi-horizon distributed solar PV power forecasting with forecast combinations. Expert Systems with Applications, 117690.

How can accurate solar power forecasts help?

Grid operators can better plan and manage the energy supply - forecasts can help reduce the uncertainty associated

Consumers can manage their energy storage systems and better plan their energy demand

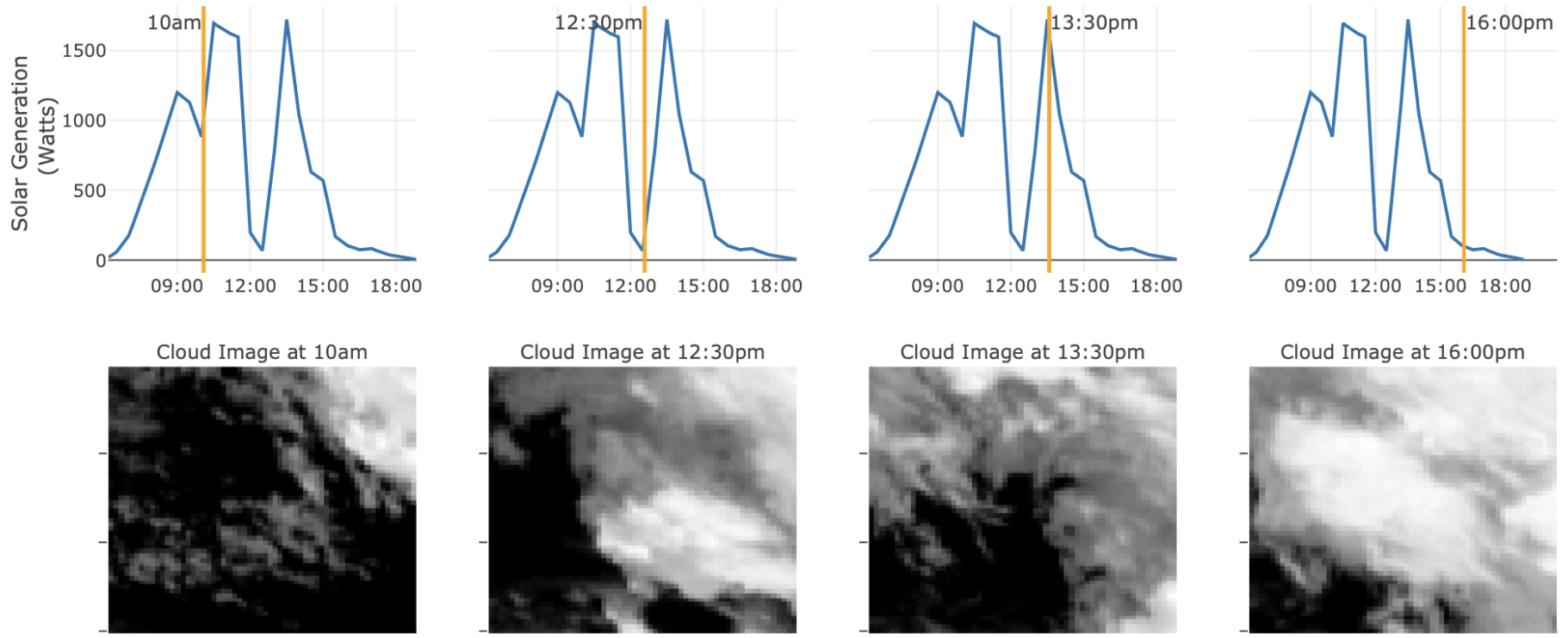
(Brancucci Martinez-Anido, et al. 2016, Erdener et al. 2021)

- Estimating and forecasting regional distributed solar generation
  - De Hoog, J., Perera, M., Bandara, K., Senanayake, D., Halgamuge, S. "Solar PV Maps for Estimation and Forecasting of Distributed Solar Generation". In: ICML 2021 Workshop on Tackling Climate Change with Machine Learning, 2021.
- Improving solar power forecasting using seasonality models
  - De Hoog, J., Perera, M., Ilfrich, P., & Halgamuge, S. (2021). Characteristic profile: improved solar power forecasting using seasonality models. ACM SIGENERGY Energy Informatics Review, 1(1), 95-106.

PhD thesis submitted by Maneesha Perera

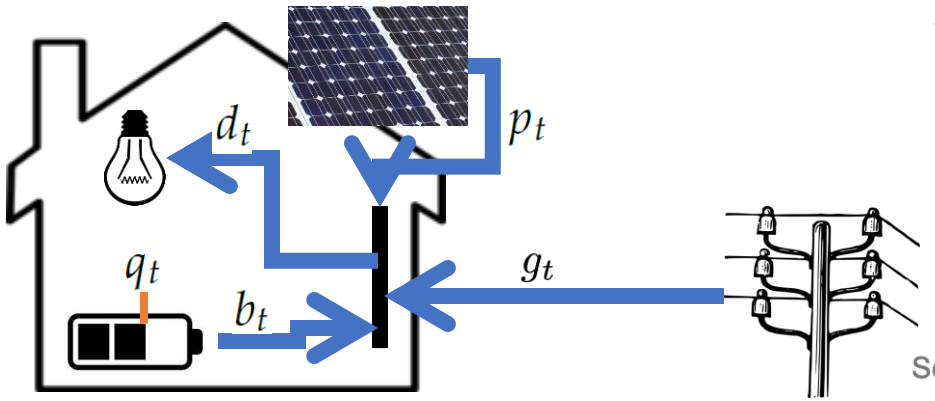
Perera, M., De Hoog, J., Bandara, K., & Halgamuge, S.

All you need to know are in clouds?



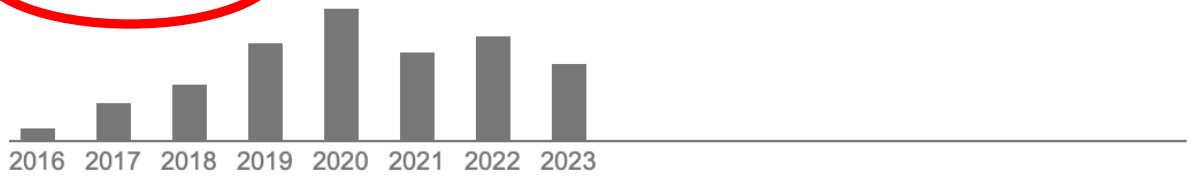
Journal paper: M. Perera, J. De Hoog, K. Bandara, S. Halgamuge,
"Distributed solar generation forecasting using attention-based deep neural networks for cloud movement prediction"

2018 IEEE Transactions
PhD student Khalid Abdulla
(graduate of Manchester Uni)
IBM internship in parallel to the
PhD scholarship



Optimal Operation of Energy Storage Systems Considering Forecasts and Battery Degradation

Authors	Khalid Abdulla, Julian De Hoog, Valentin Muenzel, Frank Suits, Kent Steer, Andrew Wirth, Saman Halgamuge
Publication date	2018
Journal	IEEE Transactions on Smart Grid
Publisher	IEEE
Description	Energy storage systems have the potential to deliver value in multiple ways, and these must be traded off against one another. An operational strategy that aims to maximize the returned value of such a system can often be significantly improved with the use of forecasting - of demand, generation, and pricing - but consideration of battery degradation is important too. This paper proposes a stochastic dynamic programming approach to optimally operate an energy storage system across a receding horizon. The method operates an energy storage asset to deliver maximal lifetime value, by using available forecasts and by applying a multi-factor battery degradation model that takes into account operational impacts on system degradation. Applying the method to a dataset of a residential Australian customer base demonstrates that an optimally operated system returns a lifetime value which is 160% more, on average …
Total citations	Cited by 192



Scholar articles

Optimal operation of energy storage systems considering forecasts and battery degradation
K Abdulla, J De Hoog, V Muenzel, F Suits, K Steer… - IEEE Transactions on Smart Grid, 2016
Cited by 192 Related articles All 3 versions

How to write a great survey paper and WHY?

Nanduni – a former PhD student and a graduate from Sri Lanka wrote this paper in her first year of PhD in 2020

A Survey of Algorithms for Distributed Charging Control of Electric Vehicles in Smart Grid

Authors	N. I Nimalsiri, C. P. Mediwaththe, E. L. Ratnam, M. Shaw, D. B. Smith, S. K. Halgamuge
Publication date	2020/11
Journal	IEEE Transactions on Intelligent Transportation Systems
Publisher	http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8855113&isnumber=4358928
Description	Electric vehicles (EVs) are an eco-friendly alternative to vehicles with internal combustion engines. Despite their environmental benefits, the massive electricity demand imposed by the anticipated proliferation of EVs could jeopardize the secure and economic operation of the power grid. Hence, proper strategies for charging coordination will be indispensable to the future power grid. Coordinated EV charging schemes can be implemented as centralized, decentralized, and hierarchical systems, with the last two, referred to as distributed charging control systems. This paper reviews the recent literature of distributed charging control schemes, where the computations are distributed across multiple EVs and/or aggregators. First, we categorize optimization problems for EV charging in terms of operational aspects and cost aspects. Then under each category, we provide a comprehensive discussion on algorithms for …
Total citations	Cited by 155

Scholar articles	A survey of algorithms for distributed charging control of electric vehicles in smart grid NI Nimalsiri, CP Mediwaththe, EL Ratnam, M Shaw… - IEEE Transactions on Intelligent Transportation …, 2019 Cited by 155 Related articles All 5 versions

Social Optimisation – a new cool idea

Chathurika – a former postdoc and a graduate from Sri Lanka wrote this paper with Marnie – a former postdoc and a graduate of University of Melbourne in 2020

An Incentive-compatible Energy Trading Framework for Neighborhood Area Networks with Shared Energy Storage

Authors	Chathurika Prasadini Mediwaththe, Marnie Shaw, Saman Halgamuge, David Smith, Paul Scott
Publication date	2020/1
Journal	IEEE Transactions on Sustainable Energy
Volume	11
Issue	1
Publisher	IEEE
Description	Here, a novel energy trading system is proposed for demand-side management of a neighborhood area network (NAN) consisting of a shared energy storage (SES) provider, users with non-dispatchable energy generation, and an electricity retailer. In a leader-follower Stackelberg game, the SES provider first maximizes their revenue by setting a price signal and trading energy with the grid. Then, by following the SES provider's actions, the retailer minimizes social cost for the users, i.e., the sum of the total users' cost when they interact with the SES and the total cost for supplying grid energy to the users. A pricing strategy, which incorporates mechanism design, is proposed to make the system incentive-compatible by rewarding users who disclose true energy usage information. A unique Stackelberg equilibrium is achieved where the SES provider's revenue is maximized and the user-level social cost is minimized …
Total citations	Cited by 97

Customer benefits in getting the charging and discharging property right…

Nanduni, Chathurika and young staff member Elizabeth 2020 publish this work in 2021

Coordinated charging and discharging control of electric vehicles to manage supply voltages in distribution networks: Assessing the customer benefit

Authors	Nanduni I Nimalsiri, Elizabeth L Ratnam, Chathurika P Mediwaththe, David B Smith, Saman K Halgamuge
Publication date	2021/6/1
Journal	Applied Energy
Volume	291
Pages	116857
Publisher	Elsevier
Description	Increased worldwide uptake of Electric Vehicles (EVs) accentuates the need for developing coordinated EV charging and discharging methods that mitigate detrimental and sustained under-voltage and over-voltage conditions in distribution networks. In this paper, a centrally coordinated EV charge-discharge scheduling method is proposed, referred to as Network-aware EV Charging (and Discharging) N-EVC(D), that takes into account both EV customer economics and distribution grid constraints. Specifically, N-EVC(D) is designed to maintain quasi-steady-state feeder voltages within statutory power quality limits, while minimizing EV customer operational costs associated with: (1) purchasing (or otherwise being compensated for delivering) electricity on a time-of-use tariff; and (2) battery degradation due to frequent charging and discharging. The optimization problem for N-EVC(D) is formulated as a quadratic …
Total citations	Cited by 41

Scholar articles

Coordinated charging and discharging control of electric vehicles to manage supply voltages in distribution networks: Assessing the customer benefit
NI Nimalsiri, EL Ratnam, CP Mediwaththe, DB Smith… - Applied Energy, 2021
Cited by 41 Related articles All 5 versions

Other AI work in my lab: e.g.

Continuous Learning

Led by postdocs Tamasha Malepathirana and Damith Senanayake

- Similar to humans, artificial neural networks suffer from **"catastrophic" forgetting** of old knowledge as they acquire new knowledge.
- **Continual learning** aims to develop mechanisms to overcome forgetting
- CAN WE CREATE methods that can continually gain new knowledge **without storing or reusing old data?**

NAPA-VQ: Neighborhood-Aware Prototype Augmentation with Vector Quantization for Continual Learning

Accepted by International Conference on Computer Vision (ICCV 2023)

Anonymous ICCV submission

Paper ID 11387

Abstract

Catastrophic forgetting; the loss of old knowledge upon acquiring new knowledge, is a pitfall faced by deep neural networks in real-world applications. Many prevailing solutions to this problem rely on storing exemplars (previously encountered data), which may not be feasible in applications with memory limitations or privacy constraints. Therefore, the recent focus has been on Non-Exemplar based Class Incremental Learning (NECIL) where a model incrementally learns about new classes without using any past exemplars. However, due to the lack of old data, NECIL methods struggle to discriminate between old and new classes causing their feature representations to overlap. We propose NAPA-VQ: Neighborhood Aware Prototype Augmentation with Vector Quantization, a framework that reduces this class overlap in NECIL. We draw inspiration from Neural Gas to learn the topological relationships in the feature space, identifying the neighboring classes that are most likely to get confused with each other. This neighborhood information is utilized to enforce strong separation between the neighboring classes as well as to generate old class representative prototypes that can better aid in obtaining a discriminative decision boundary between old and new classes. Our comprehensive experiments on CIFAR-100, TinyImageNet, and ImageNet-Subset demonstrate that NAPA-VQ outperforms the State-of-the-art NECIL methods by an average improvement of 5%, 2% and 4% in accuracy and 10%, 3% and 9% in forgetting respectively. Our code will be made available.

dependently and identically distributed (IID) [21]. This assumption may not hold in real data owing to various factors such as the addition of new classes of data, the removal of old data due to memory or availability constraints, and the changes in the data-generating phenomena (concept drift). As a result, neural networks may experience catastrophic forgetting where the network forgets the previously learned knowledge upon acquiring new knowledge [25].

"Continual Learning" is a field of research pursuing mechanisms to mitigate this forgetting [13]. In this manuscript, we focus on one paradigm of continual learning, named Class Incremental Learning (CIL) [37]. In CIL, a neural network is trained over a series of tasks and at each task, the network learns a new set of classes. At any given time, the network should classify between all learned classes thus far. Among the techniques proposed for CIL, rehearsal-based methods have demonstrated promising results in mitigating forgetting by storing exemplars (old samples) and reusing them while learning new tasks [37, 5, 35]. However, such storage is not always possible due to memory limitations and privacy constraints [44]. Therefore, we focus on Non-Exemplar based CIL (NECIL), a more pragmatic yet challenging scenario, which attempts to preserve the old knowledge without storing any exemplars [56, 57].

The unavailability of old data causes NECIL methods to struggle with overlapping old and new class representations, resulting in catastrophic forgetting [56]. While prototypes of old classes in the deep feature space are a viable alternative to reusing exemplars [56, 55], if not properly generated, the class boundaries refined using such pro-

Acknowledgement

Funding:
Australian Government: 19 ARC and 3 NHMRC grants, Australia Indonesia Centre
Philanthropy/Foundations: Yuligbar Foundation, Rowden White Foundation, MND Foundation
Industry: Your Gene BioSciences (UK), Google (USA), IBM (Australia), Robert Bosch (Germany), POSCO (South Korea), US Department of Defence (Biomedical Research Program)
University of Melbourne: 50 PhD scholarships, Internal grants
Australian National University: Internal grants
Data 61: PhD scholarships

External collaboration: Howard Florey Institute, Peter Mac Cancer Centre, WEHI, Tongji and Hebei Universities (China), Academia Sinica (Taipei), CUHK (HK), Oxford (UK), Uni Southampton (UK), Uni Wollongong (Aus), NTU and NUS Singapore, Tutte Institute (Canada), Cambridge (UK)
Contact: saman@unimelb.edu.au

Thank you