Machine Learning in Agri-Food and Nuclear Reactors

Dr Georgios Leontidis
Director, Interdisciplinary Centre for Data and AI
Vice-Principal's Office
Reader in Machine Learning (affiliated with the School of Natural and Computing Sciences)
University of Aberdeen
georgios.leontidis@abdn.ac.uk

In Aberdeen since March 2020 -

Previously *@University of Lincoln* - *@IBA Dosimetry GmbH, Germany* - *@University of Lincoln* - and *@Cardiff University*

- Background in *foundations* of Machine Learning (learning from multimodal data, domain adaptation, variational inference, (capsule) neural networks, privacy-preserving ML, Computer Vision) - (~50% of my research time and ~4 PhD students)

- As PI/Co-I (across several funders and industry), past and present applications (~50% of my research time, ~4 PhD students, and RAs/RFs) include:

  - Healthcare and Medical Imaging **(12 partners - MSCA FP7 REVAMMAD, ended 2016);**
  - Environmental Data Imputation **(Lincoln and CEH – *NERC, ended 2020*);**
  - Soft Fruit and Tomato Yield forecasting, and Agri-Food Data Sharing **(*EU-ERDF, BBSRC-CTP with BerryGardens, Data Lab & Angus Soft Fruits, Innovate UK – most are ongoing*);**
  - Enhancing Agri-Food Transparent Sustainability **(4 partners – *EPSRC, starting 1/1/2022 for 3 years*);**
  - Nuclear Reactor Anomaly Detection **(19 partners - *EU-H2020, ended 2021*);**
  - Siemens Gas turbine availability and Predictive Emissions Monitoring System **(*Siemens Energy & iCASE EPSRC, ongoing*)** and
  - Intelligent Retail Refrigeration Systems **(*Tesco & Innovate UK, ended 2019*)**

Aberdeen 2040 Challenges/Centres

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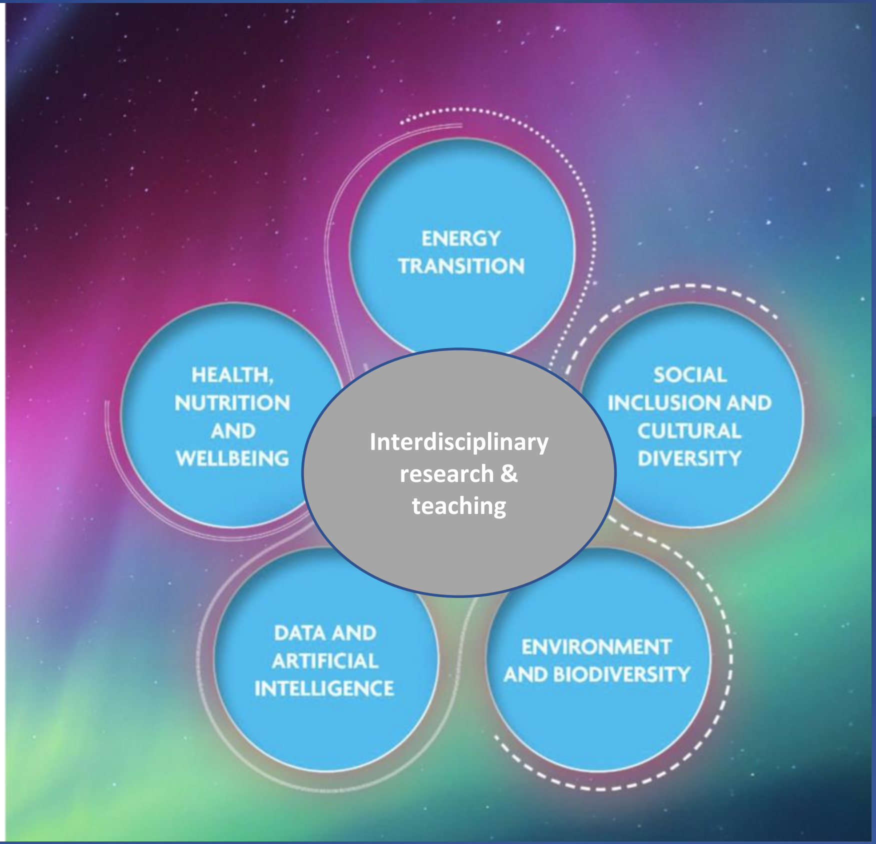
Our Interdisciplinary Challenges

Our pursuit of truth is grounded in the service of others. Working together, we will address five interdisciplinary challenges of our time. These urgent and wide-ranging problems require complex solutions, which draw on both theoretical and applied knowledge.

We have the expertise to face these particular challenges, which speak directly to our region, our society and our century. We will engage with them collaboratively, combining ideas and approaches across our areas of excellence. As we work, we will also look ahead and identify new challenges for the future.



Stakeholder and industry engagement key to addressing these challenges – attracting businesses, local government (city and shire) and industry at regional, local and national level is one of our main objectives

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Responding to Scotland's AI Strategy, National AI strategy, UKRI AI Review and AI Council Roadmap

*Five Core Thematic Areas **

- ***Fair, Accountable, Responsible and Ethical AI – FARE***
  (NCS, Law, DHP, others)
  Algorithmic/Data Bias, legal implications of AI, discrimination, etc.

- ***Privacy, Policy, & Cybersecurity***
  (NCS, Law, SMMSN, others)
  Privacy preserving, policy and governance, (cyber)secure systems, etc.

- ***Machine Learning***
  (Engineering, NCS, SMMSN, others)
  Reinforcement learning, multimodal processing, Big Data, etc.

- ***Robotics & Trustworthy Autonomous Systems***
  (Engineering, NCS, Psychology, others)
  social/service robots, bio-inspired, cognitive systems, etc.

- ***Digital Transformation (linking with industry as well)***
  (all schools and VP for Regional Engagement and Regional Recovery)
  end-to-end systems, real-life applications, etc.

*Cross-cutting themes **

- ***Environmental Data Science***
  (Environment & Biodiversity) – SBS, NCS, Geosciences, others

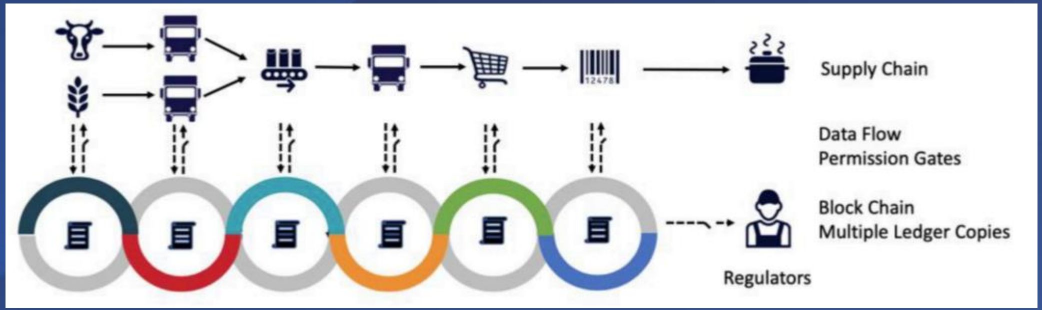
- ***Society 4.0***
  (Social Inclusion and Cultural Diversity) – Social Sciences, Business

- ***Digitilisation in Energy***
  (Energy Transition) – NCS, Engineering, others

- ***AI-driven Healthcare and Imaging***
  (Health, Nutrition and Wellbeing) – NCS, SMMSN, Engineering

****Working Draft***

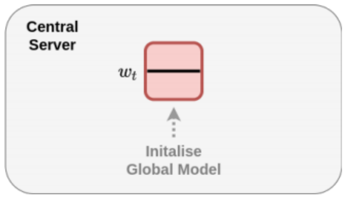
Agri-Food: from Farm to Fork



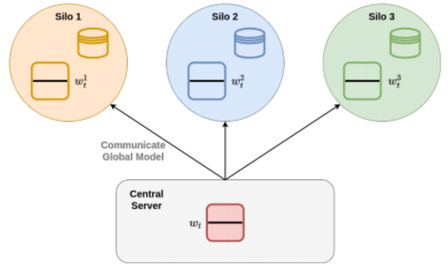
- Boost productivity for enhancing financial and environmental sustainability
- Rethinking supply chains (net zero targets – agriculture responsible for ~10% of all greenhouse gas emissions)
- Blockchain for traceability
- Data sharing (Intellectual property issues)
- Machine Learning technologies for optimisation

Agri-Food: from Farm to Fork: Example

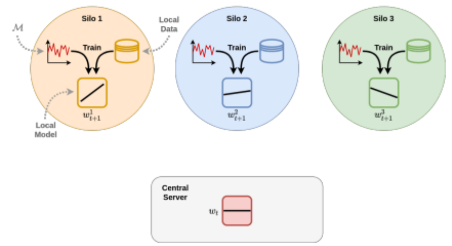
Federated Learning



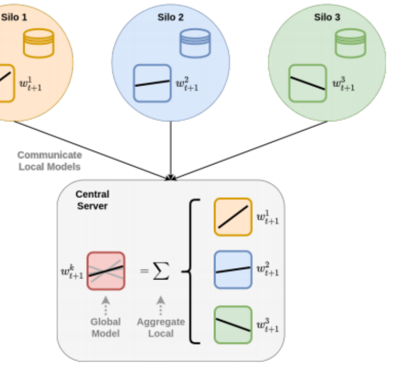
(a) Central node initializes the model paramters.



(b) Each client receives the initialized global model from the central server.



(c) Each client trains its copy of the global model on its own local data to produce an updated local model. In the local deferentially private setting this involves some addition of noise.



(d) The clients send their local models to the central server where they are aggregated to produce an updated global model. Steps b-d repeat for a number of communication rounds.

The Role of Cross-Silo Federated Learning in Facilitating Data Sharing in the Agri-Food Sector

Aiden Durrant[a,b], Milan Markovic[b], David Matthews[d], David May[c], Jessica Enright[a], Georgios Leontidis[b,*]

[a] *School of Computing Science, University of Glasgow, G12 8RZ, Glasgow, United Kingdom*
[b] *Department of Computing Science, University of Aberdeen, AB24 3UE, Aberdeen, United Kingdom*
[c] *Lincoln Institute for Agri-food Technology, University of Lincoln, LN2 2LG, Lincoln, United Kingdom*
[d] *Upton Beach Consulting Limited*

- *Collective intelligence*
- *Digital transformation of the sector*
- *Meeting net zero targets*
- *Resilience of the sector*
- *For instance Strawberry Yield forecasting, predicting harvestable crop in 1-, 2-, 3- weeks ahead*

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Agri-Food: from Farm to Fork: Example

Responsible development of autonomous robotics in agriculture

Despite the potential contributions of autonomous robots to agricultural sustainability, social, legal and ethical issues threaten adoption. We discuss how responsible innovation principles can be embedded into the user-centred design of autonomous robots and identify areas for further empirical research.

David Christian Rose, Jessica Lyon, Auvikki de Boon, Marc Hanheide and Simon Pearson

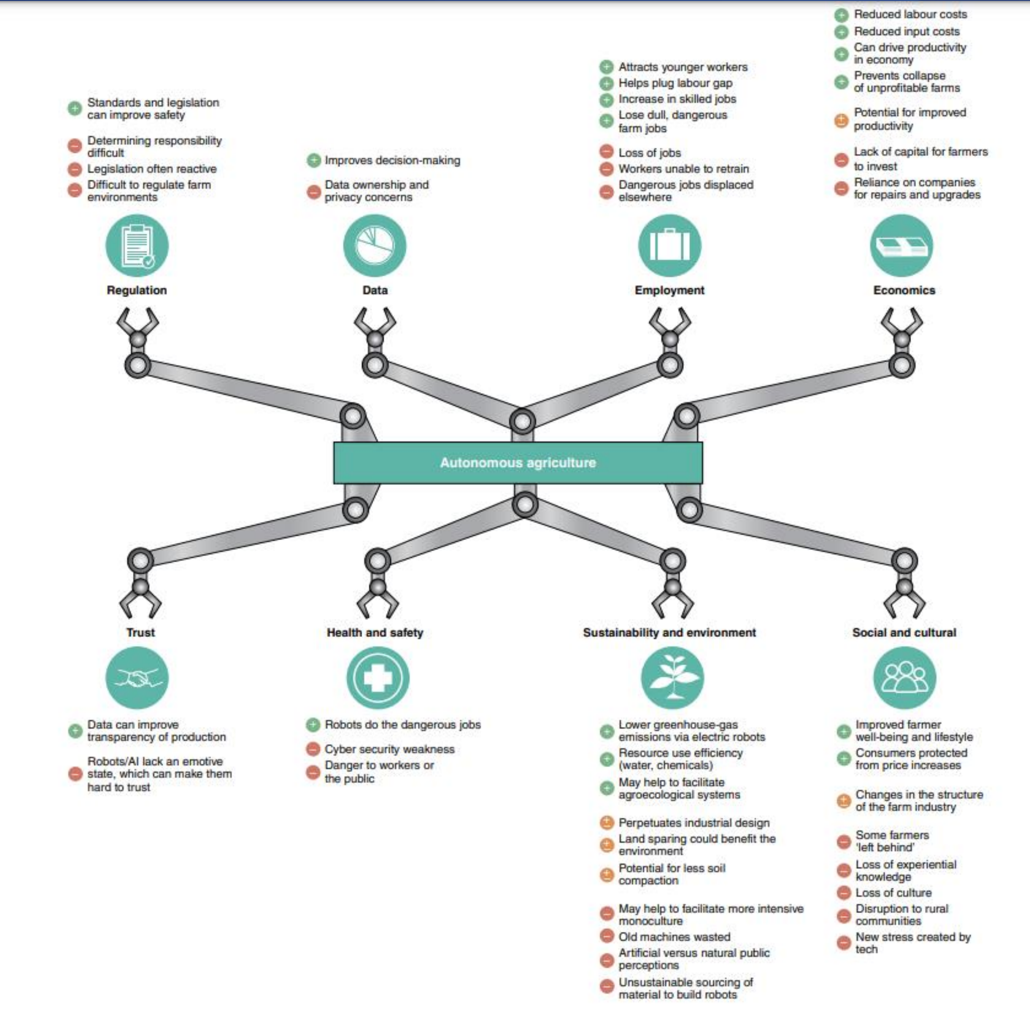


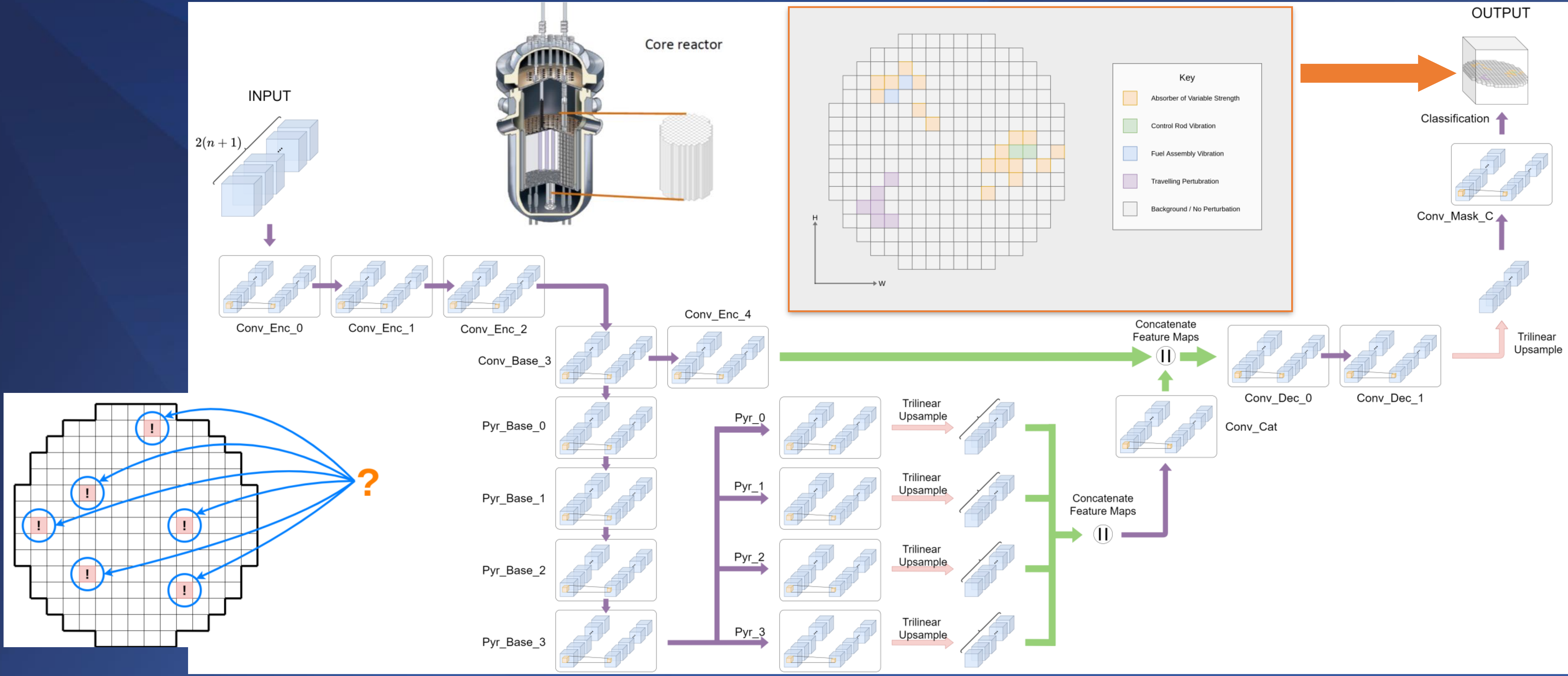
Fig. 1 | Overview of challenges, opportunities and potential consequences of autonomous agriculture. Positive (+), negative (-) and uncertain (+/-) consequences are indicated. Positive consequences denote opportunities to be harnessed, whereas negative consequences denote challenges to be overcome concerning the operationalization, adoption and/or deployment of innovations (see refs. [4,5] for more detail).

ANS M&C 2021 - The International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering · Raleigh, North Carolina · October 3–7, 2021

DETECTION AND LOCALISATION OF MULTIPLE IN-CORE PERTURBATIONS WITH NEUTRON NOISE-BASED SELF-SUPERVISED DOMAIN ADAPTATION

A. Durrant[1], G. Leontidis[1], S. Kollias[1], L. A. Torres[2], C. Montalvo[2], A. Mylonakis[3], C. Demazière[3], P. Vinai[3]

Energy-related examples: Nuclear reactor anomaly detection



Energy-related examples: Nuclear reactor anomaly detection

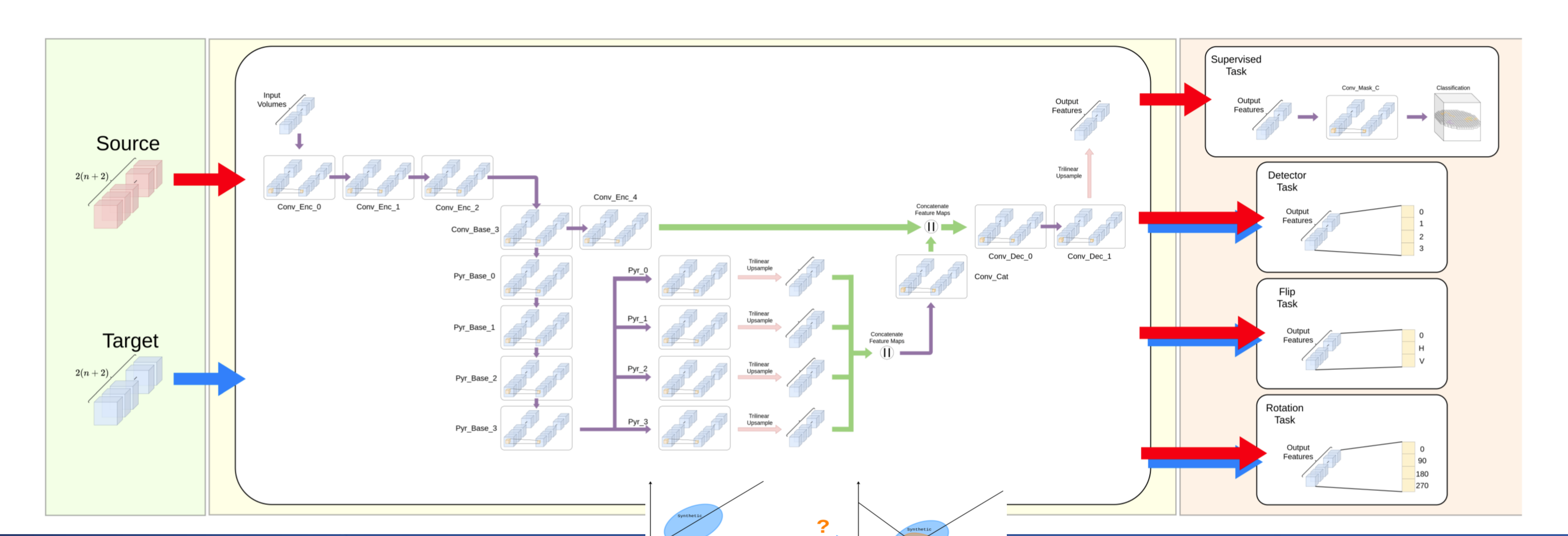
Towards a Deep Unified Framework for Nuclear Reactor Perturbation Analysis

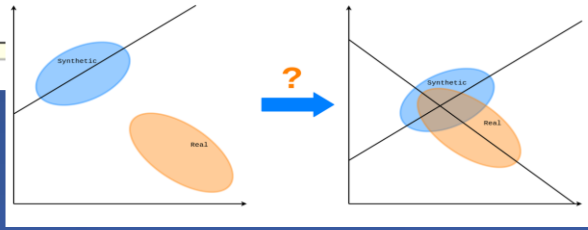
Fabio De Sousa Ribeiro* and Francesco Calivá* University of Lincoln, UK {fdesousaribeiro,fcaliva} @lincoln.ac.uk *Both authors contributed equally

Dionysios Chionis and Abdelhamid Dokhane Paul Scherrer Institute Villigen, Switzerland {dionysios.chionis, abdelhamid.dokhane}@psi.ch

Antonios Mylonakis and Christophe Demazière Chalmers University of Technology, Sweden {antmyl,demaz} @chalmers.se

Georgios Leontidis and Stefanos Kollias University of Lincoln Lincoln, UK {gleontidis,skollias} @lincoln.ac.uk





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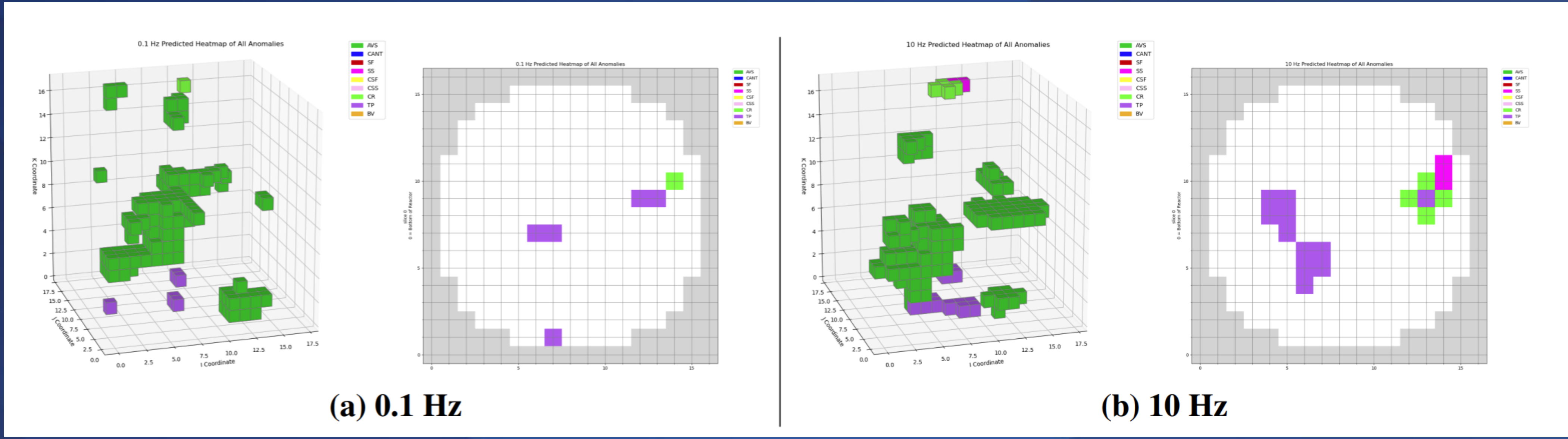
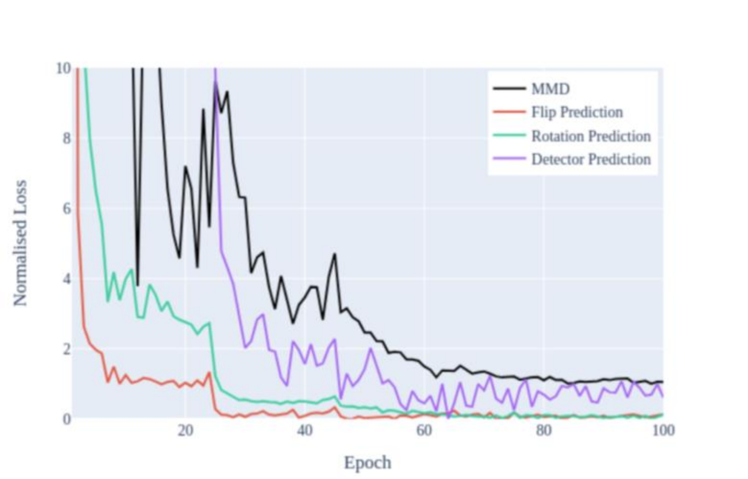
Energy-related examples: Nuclear reactor anomaly detection



(a) 0.1 Hz (b) 10 Hz

Predictions made by our network for real measurements of an operational German pre-KONVOI reactor. These results, although yet to be fully validated given the inability to acquire ground truth values, show the potential of our method to make on-line predictions of core anomalies in operational reactors.



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Thanks for Listening

Any Questions?