UNIVERSITY OF BIRMINGHAM | COLLEGE OF ENGINEERING AND PHYSICAL SCIENCES

Theme 2

Data Analytics and Computer Vision for Image Datasets on Many Scales

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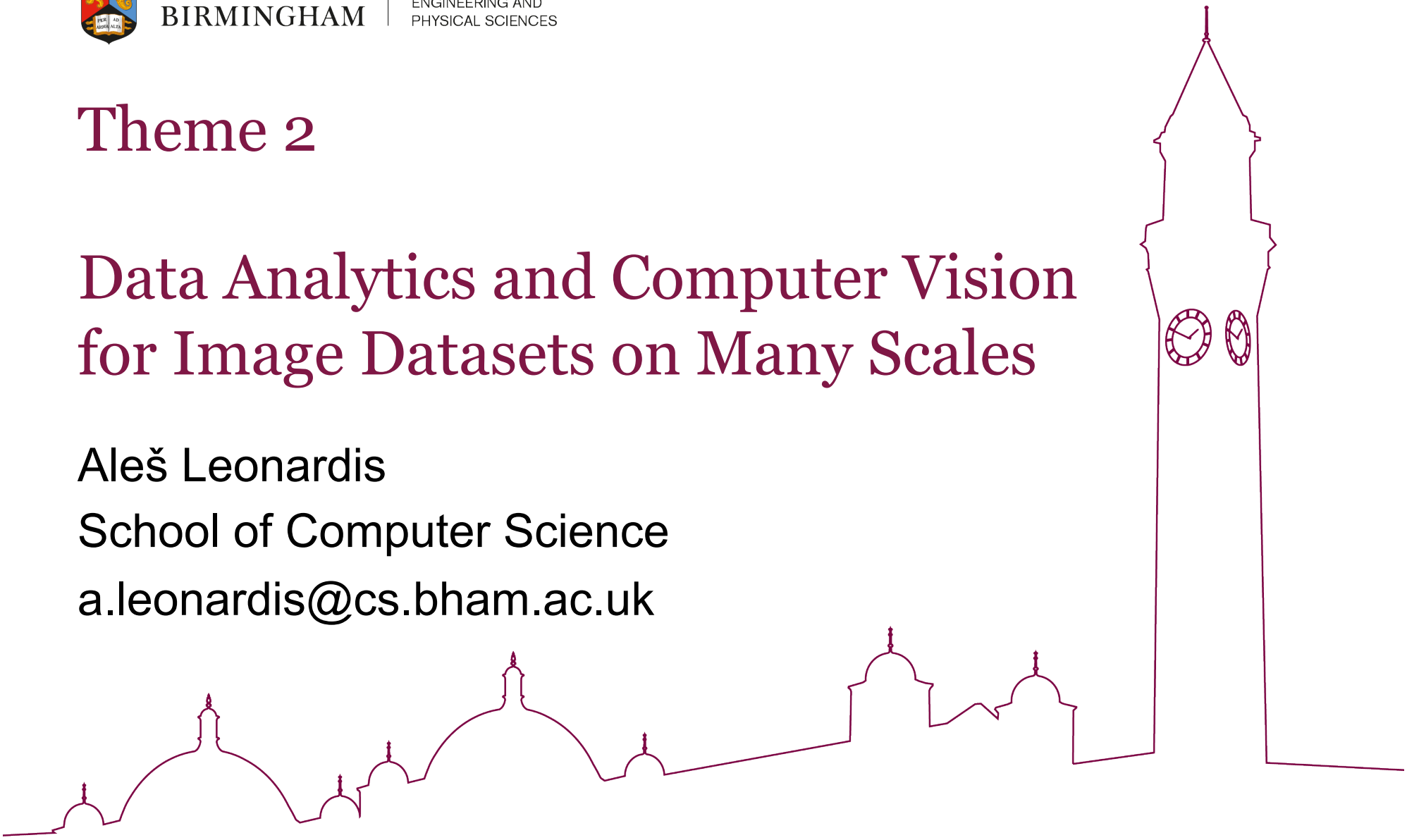
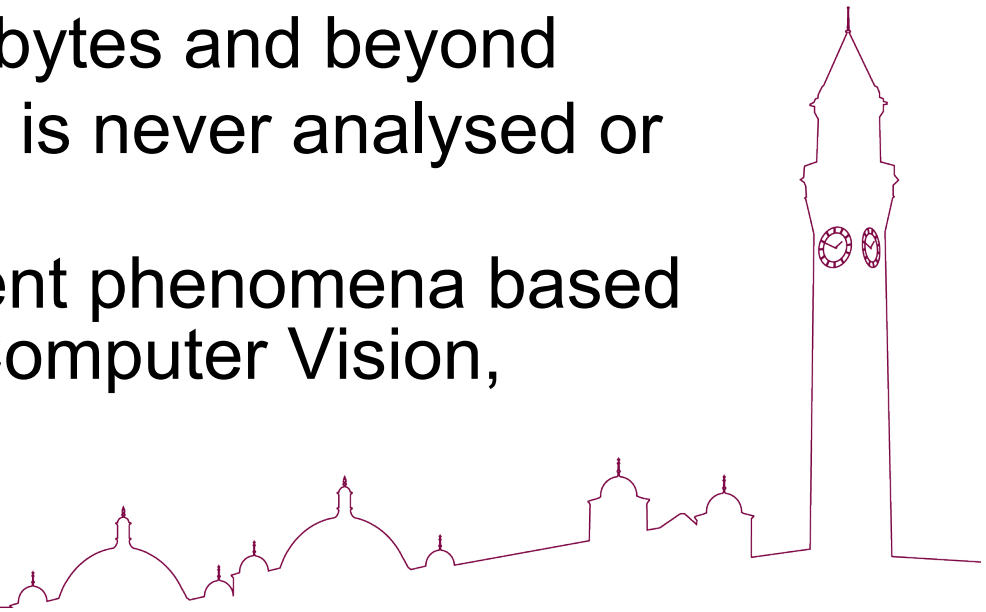


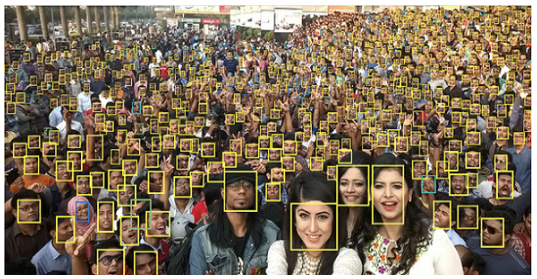
Data Analytics and Computer Vision for Image Datasets on Many Scales

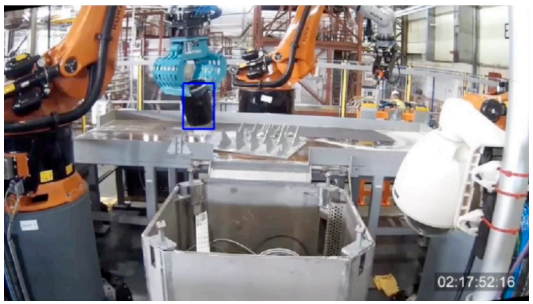
- Datasets
  - images
  - videos
  - *multidimensional complex spatio-temporal signals*
- Sizes of datasets >> Terabytes and beyond
- A large portion of the data is never analysed or inspected
- New understanding of latent phenomena based on these datasets using Computer Vision, Machine Learning and AI

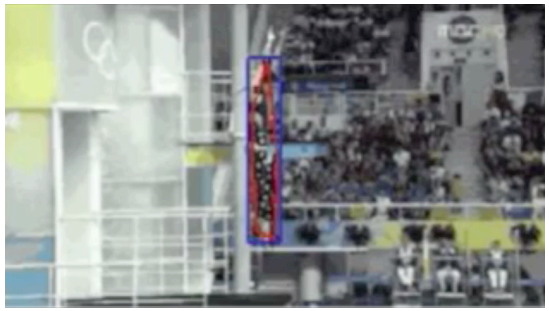


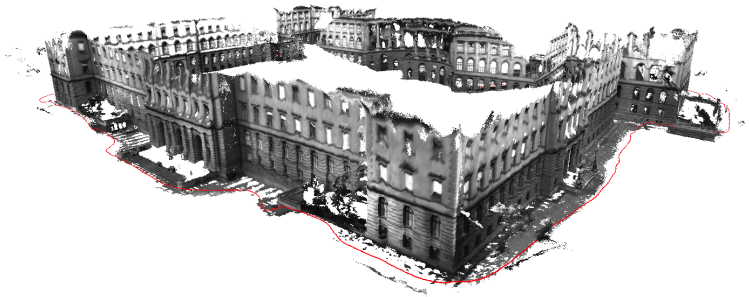
A few examples (on a macro scale)

- face detection and recognition
- vehicle tracking, autonomous driving
- understanding social interactions
- inspection of urban infrastructure



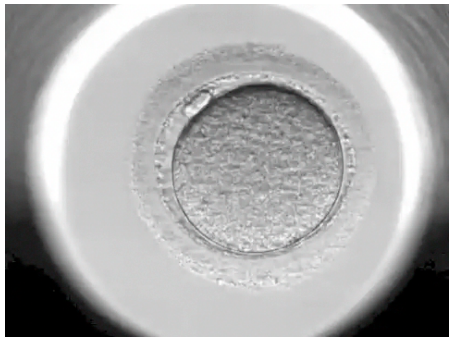






Extraordinary span of spatial and temporal scales

- particle physics, molecular imaging of proteins
- tracking blood cells and early growth of cancer
- understanding brain functions
- detection of aquifers from satellites using quantum technology sensors
- discovering planets, detecting black holes millions of light years away



Dividing cells (Arri Coomarasamy)

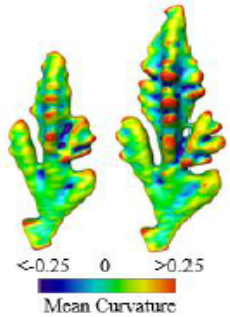
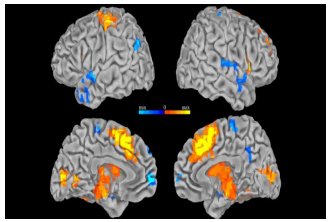
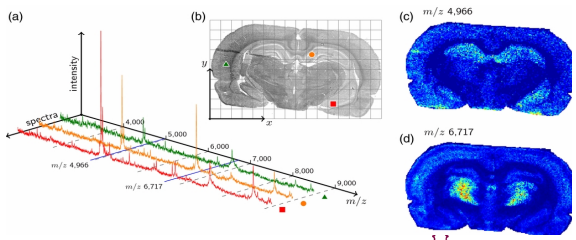


Fig. 1. A growing dendritic crystal

4D tomography of growing crystals (Biao Cai)



Analysing FMRI



Mass spectra

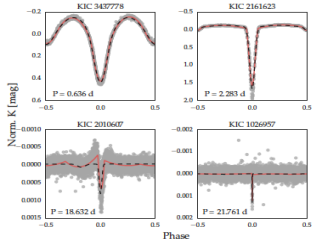
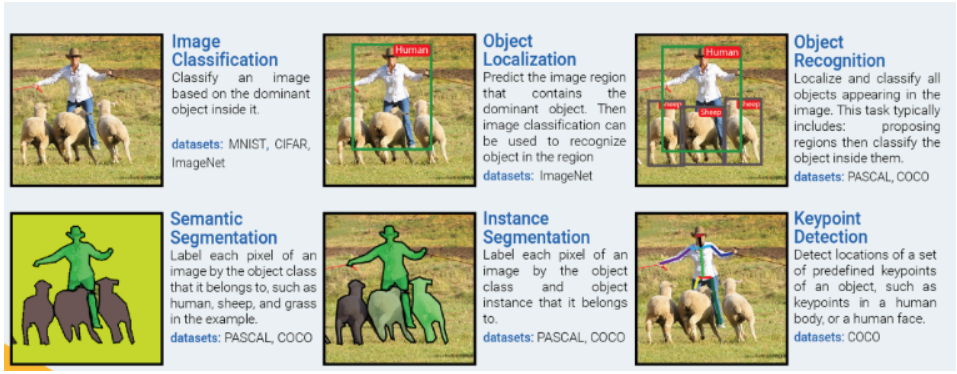


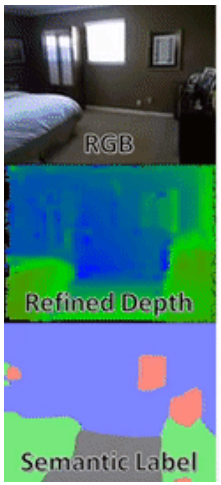
Fig. 1. Several examples of *Kepler* light curves and their respective model fits with *polyfits* and *two-Gaussians*. The plots show the observed *Kepler* light curve (grey dots) in normalized *Kepler* (*K*) magnitude, *polyfit* model (solid red line) and *two-Gaussian* model (dashed black line). Magnitudes are obtained from the *Kepler* detrended flux and normalized to a reference value of 0 out of eclipse.

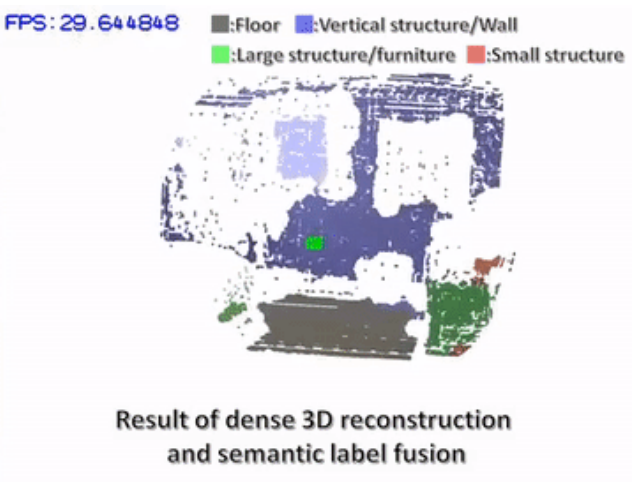
Fluxes of binary stars

Common operations

- Classification, detection, semantic segmentation, tracking, 3D reconstruction, etc.





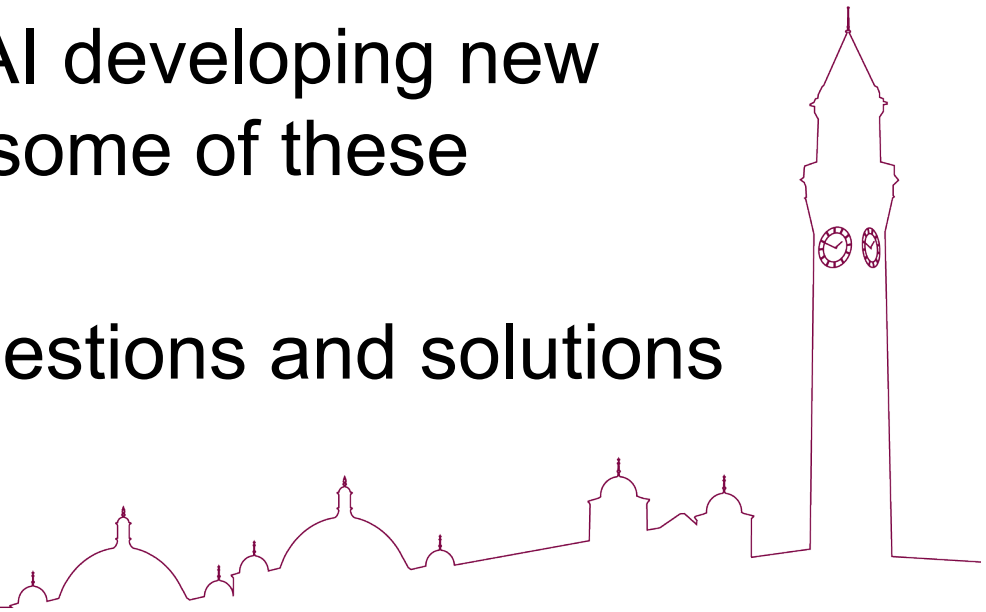


Result of dense 3D reconstruction and semantic label fusion

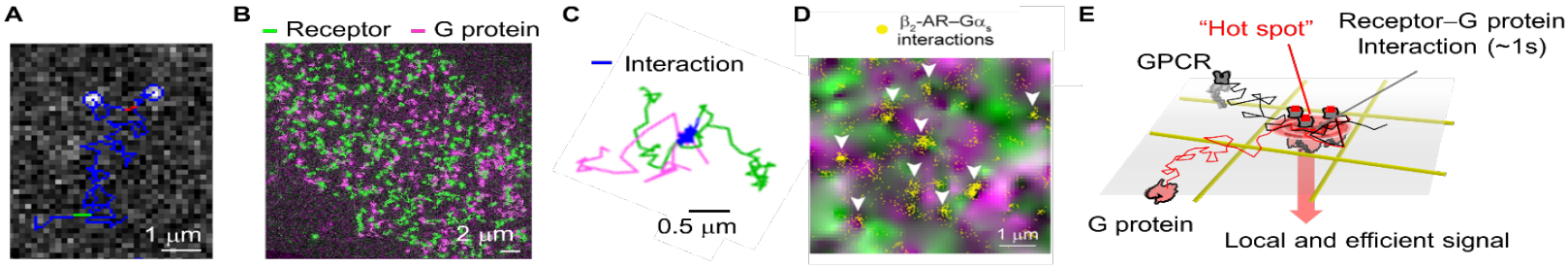
However

Key to success: Interdisciplinarity

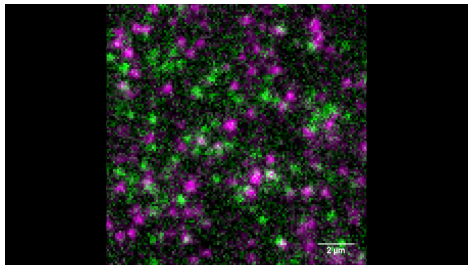
- Close collaboration between
  1. domain experts asking scientific questions, providing hypotheses (models) and
  2. experts in CV, ML, AI developing new methods to answer some of these questions
  3. Iterate on refined questions and solutions

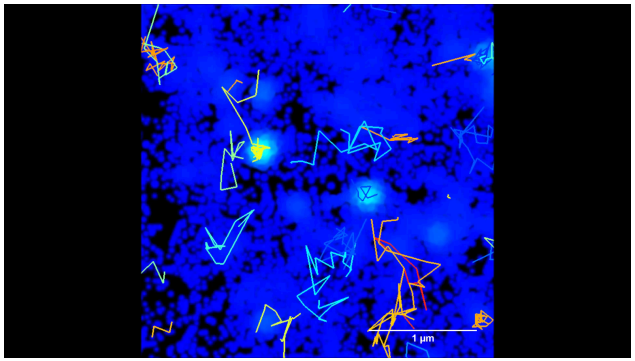


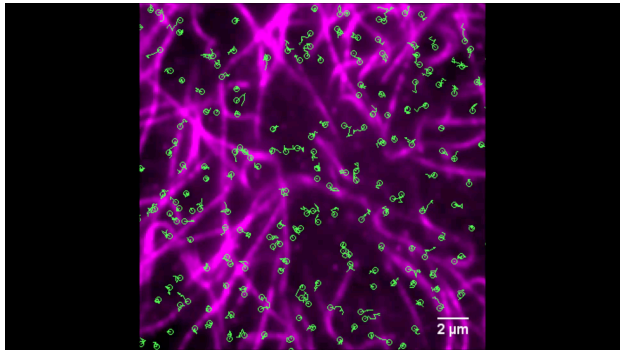
Tracking diffusing proteins

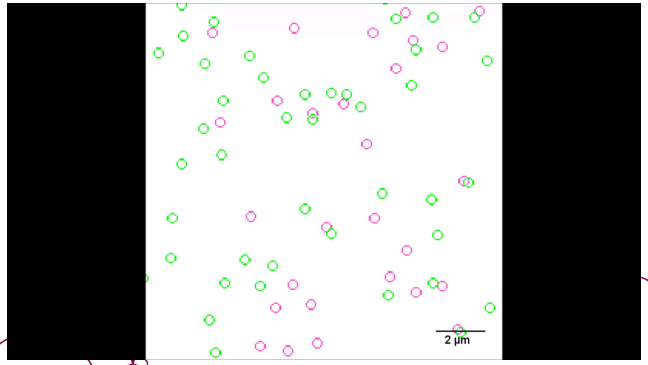


(Davide Calebiro, Iain Styles)







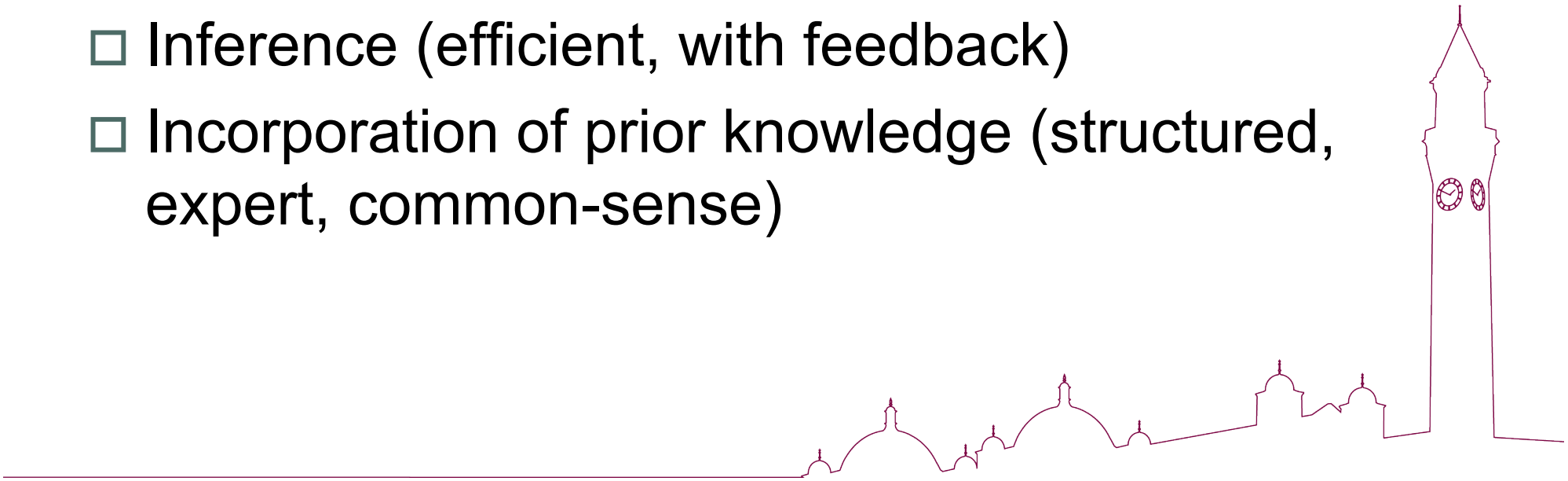


Overarching approach

- Modelling and learning on complex multi-scale spatial-temporal data, to produce novel interpretable models.
- The approach is about combination of domain knowledge with statistical learning in a model-based way.

Challenges

- Representations (scalable, hierarchical, compositional, interpretable)
- Learning (supervised, unsupervised, reinforcement, online, lifelong, from small data)
- Inference (efficient, with feedback)
- Incorporation of prior knowledge (structured, expert, common-sense)



Alan Turing Institute

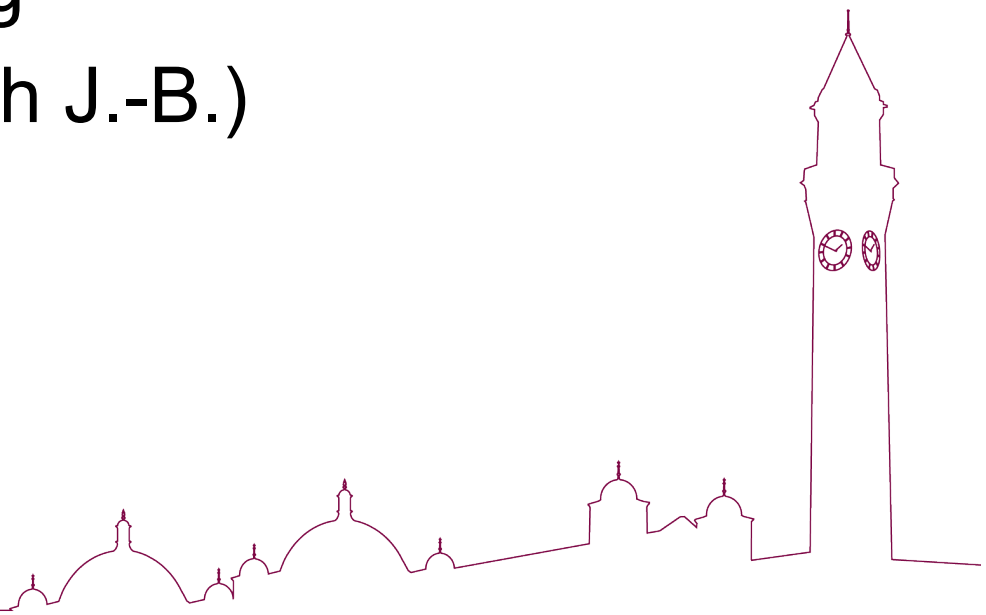
Research Programmes:

- Data Science for Science
- Artificial Intelligence
- Data-centric Engineering
- Health (collaboration with J.-B.)

Turing Data Study Groups

Workshops

PhD studentships



DSAI at UoB

- Infrastructure (storage, compute)
- Data management, computational frameworks (e.g., Tensorflow, PyTorch), visualisation tools
- Internal seminars
- Joint projects

Thank you

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