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Mission

- To achieve synergies between applied mathematics and statistics by solving real-world problems in clinical imaging (neuro, cancer and cardiovascular)

- To establish deep collaborations between mathematics, engineers, physicists, biomedical scientists and clinicians

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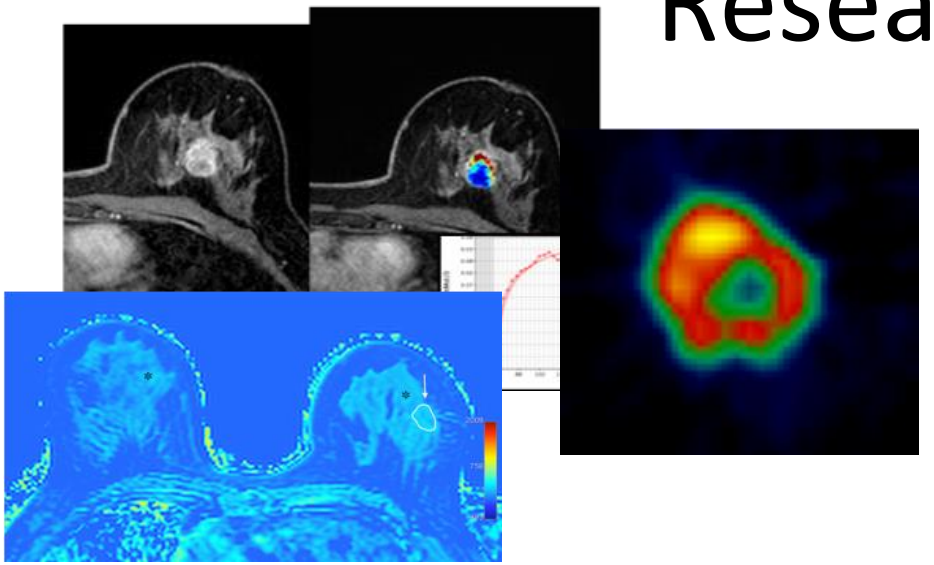
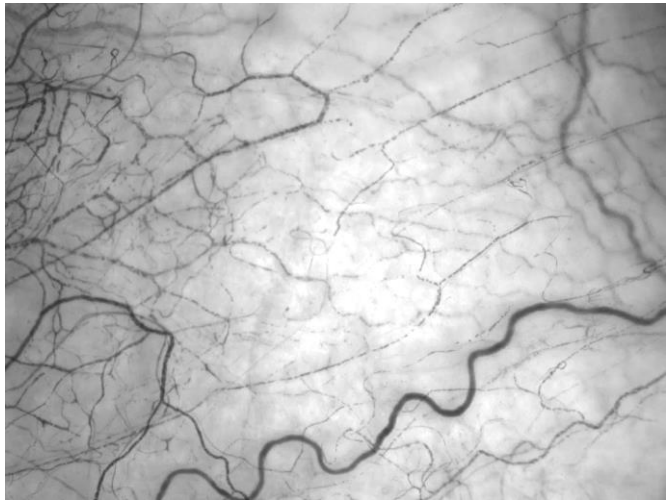
Research Themes



Multimodal and spectral imaging



Dynamic imaging

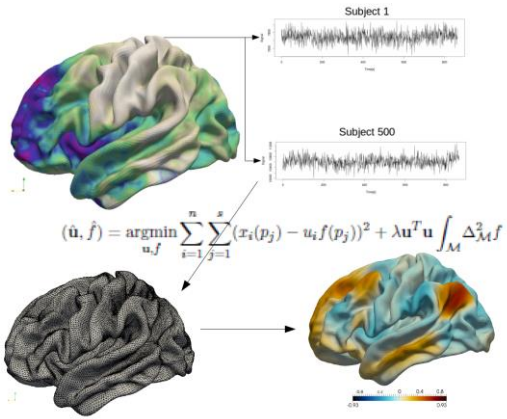


Image analysis on non-flat geometries

- Image reconstruction, registration, segmentation, classification
- Mechanical modelling of physiological processes (e.g. cardio)
- Novel imaging technologies

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CMIH Management

Carola Schönlieb,
CMIH Director,
DAMTP

James Rudd,
Clinical Lead
Department of Medicine

Rachel Furner,
CMIH Coordinator

John Aston,
Statistical Lead,
DPMMS

Stefanie Reichelt,
Imaging Clinic,
CRUK-CI

Bogdan Roman,
Imaging Clinic,
DPMMS

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Investigators

James Rudd, Clinical Lead, Department of Medicine

Carola Schönlieb, CMIH Director, DAMTP

John Aston, Statistical Lead, DPMMS

Martin Graves, Department of Radiology

Raj Jena, Department of Oncology

Ed Bullmore, Department of Neuroscience

Sarah Bohndiek, Department of Physics

Thanasis Fokas, DAMTP

Richard Samworth, DPMMS

Stefanie Reichelt, CRUK-CI

Graham Treece, Department of Engineering

Fiona Gilbert, Department of Radiology

Guy Williams, Wolfson Brain Imaging Centre

Anders Hansen, DAMTP

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Industrial Collaborators

SIEMENS Healthineers

Microsoft Research

AstraZeneca

CCI LTD

TOSHIBA MEDICAL

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Cambridge University Hospitals NHS
NHS Foundation Trust

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CMIH Postdocs

Parham Hashemzadeh
Applied Mathematics

Bogdan Roman
Computer Science

Yu Wang
Computer Science and Statistics

Pan Liu
Applied Mathematics

Yuan Huang
Medical Engineering and Radiology

Angelica Aviles-Rivero
Applied mathematics

Jingjing Zou
Statistics

Milana Gataric
Applied Mathematics and Statistics

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Internal Advisory Board

Biochemistry
University of Cambridge

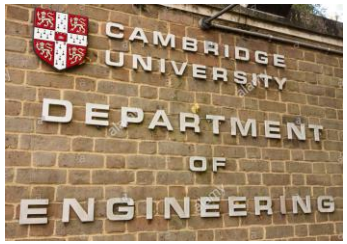
Kevin Brindle

MRC Cognition and Brain Sciences Unit

Richard Henson

Franklin Aigbirhio
Adrian Carpenter

David Spiegelhalter



Roberto Cipolla
Joan Lasenby
Richard Prager (chair)

CANCER RESEARCH UK | CAMBRIDGE CENTRE

Simon Tavare

Andy Parker

UNIVERSITY OF CAMBRIDGE
Cavendish Laboratory

UNIVERSITY OF CAMBRIDGE
Department of Psychiatry

John O'Brien

MRC Biostatistics Unit

Sylvia Richardson

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External Advisory Board

Thomas Nichols

UNIVERSITY OF OXFORD

Simon Arridge (Chair)

UCL

CMIC Centre for Medical Image Computing

Hongtu Zhu

THE UNIVERSITY OF TEXAS MD ANDERSON CANCER CENTER *Making Cancer History®*

Yale University

Richard Carson

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Kate Reading

WESTFÄLISCHE WILHELMS-UNIVERSITÄT MÜNSTER

Martin Burger

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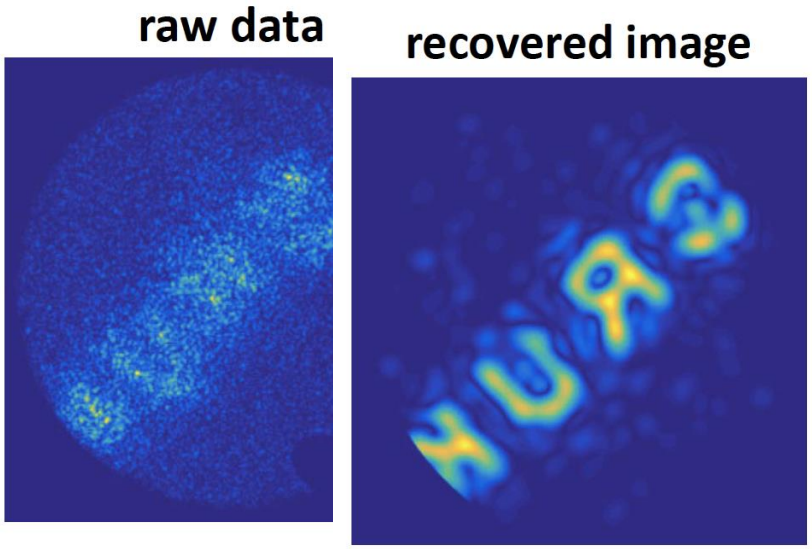
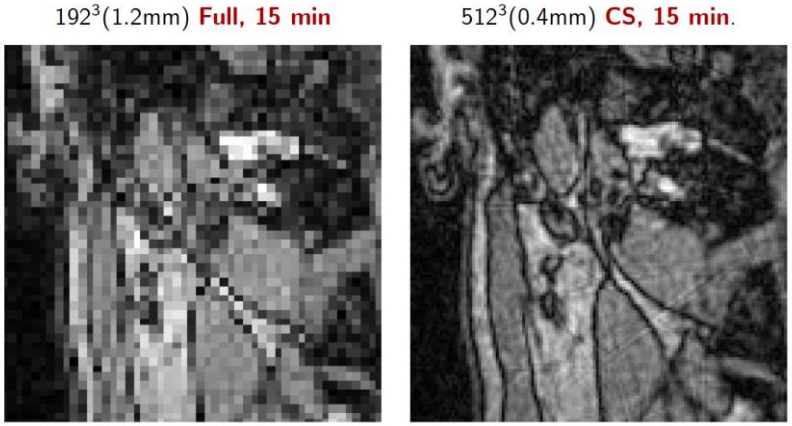
Some Research Highlights

Optimising acquisition and reconstruction in imaging





High-resolution MRI (Graves, Roman)

Adcock, B., Hansen, A. C., Poon, C., & Roman, B. (2017). Breaking the coherence barrier: A new theory for compressed sensing. In *Forum of Mathematics, Sigma* (Vol. 5). Cambridge University Press.

Endoscopy (Bohndiek, Gataric)

Gataric, M., Gordon, G., Bohndiek, S., Phase and polarisation reconstruction from data acquired by a MCF endoscope, in preparation

- Fast MRI (Aviles-Rivero, Graves, Schönlieb, Williams) accepted for ISMRM 2018
- Motion enhanced reconstruction (Burger, Schönlieb), to appear in SIIMS 2018

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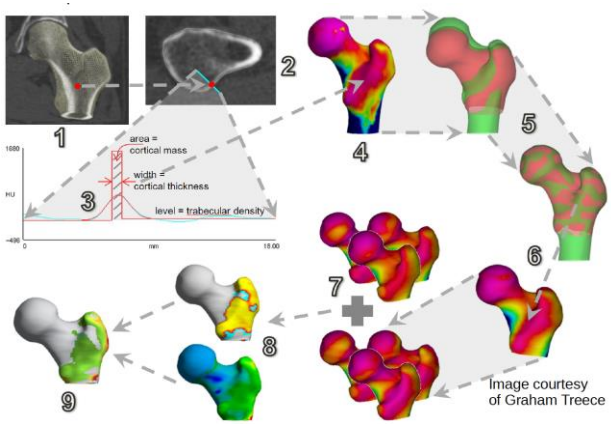
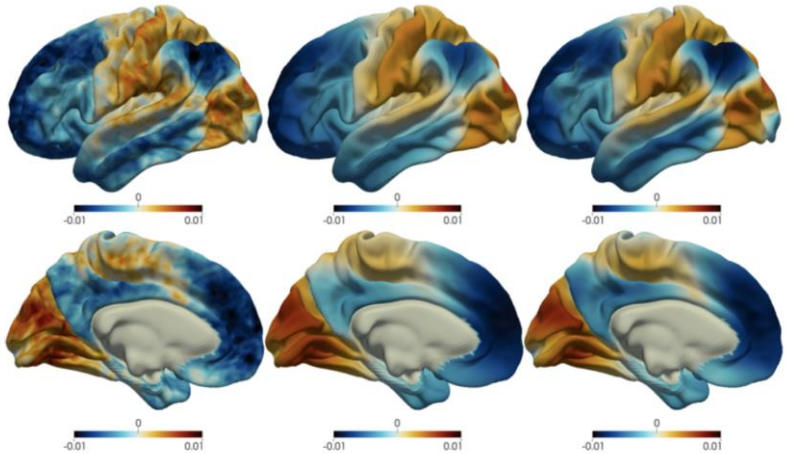
Some Research Highlights

Statistical analysis and numerical modelling for hybrid analysis of imaging data





Joint analysis of surface texture and shape for femoral cortex analysis (Treece,Aston,Lila)

Gee, A. H., G. M. Treece, and K. E. S. Poole. "How does the femoral cortex depend on bone shape? A methodology for the joint analysis of surface texture and shape." *Medical Image Analysis* (2018)

Statistical analysis on manifolds for tensor-valued imaging (Aston, Lila, Zou, Williams)

Lila, Eardi, John AD Aston, and Laura M. Sangalli. "Smooth Principal Component Analysis over two-dimensional manifolds with an application to Neuroimaging." *The Annals of Applied Statistics* 10.4 (2016): 1854-1879.

Lila, E., & Aston, J. A. (2017). Functional and Geometric Statistical Analysis of Textured Surfaces with an application to Medical Imaging. *arXiv preprint arXiv:1707.00453*

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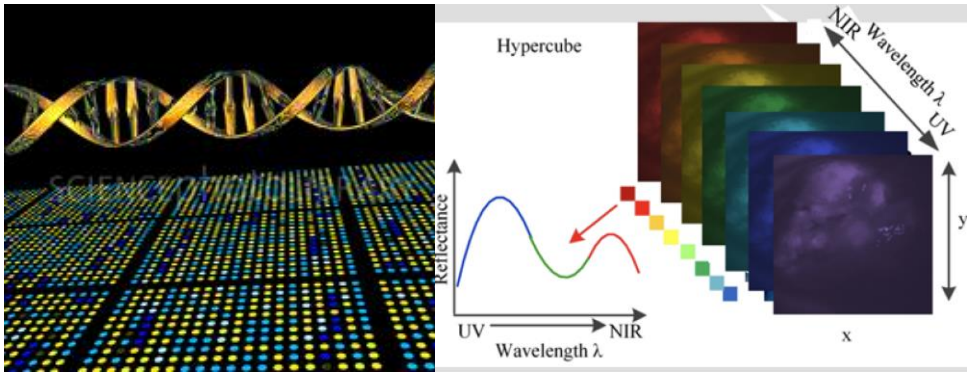
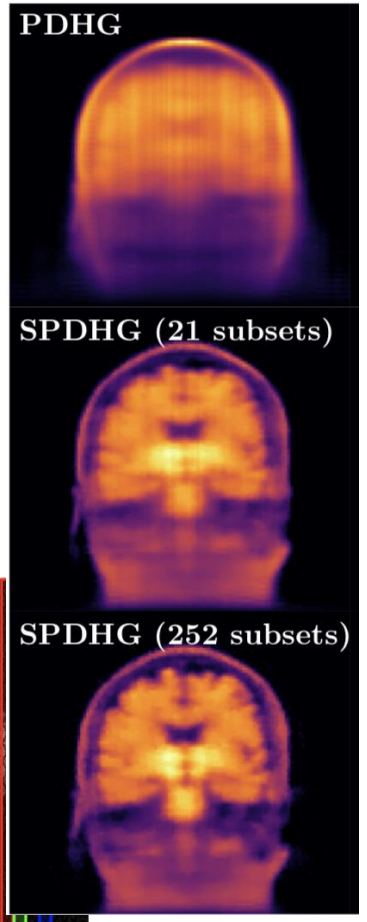
Some Research Highlights

Handling large-scale and high-dimensional imaging data - A pathway to clinical implementation



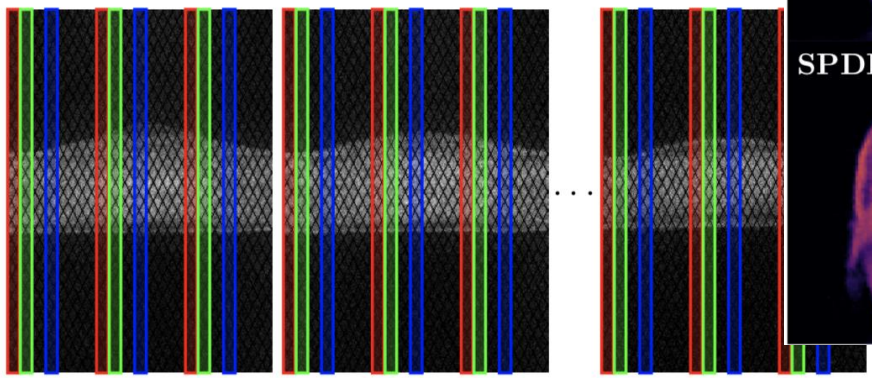
Fast PET reconstruction (Ehrhardt, Schönlieb)

Ehrhardt, M. J., Markiewicz, P., Chambolle, A., Richtárik, P., Schott, J., & Schönlieb, C. B. (2017, August). Faster PET reconstruction with a stochastic primal-dual hybrid gradient method. In *Wavelets and Sparsity XVII* (Vol. 10394, p. 103941O). International Society for Optics and Photonics



Sparse PCA for high-dimensional data such as spectral imaging data (Gataric, Samworth)

Gataric, M., Wang, T., & Samworth, R. J. (2017). Sparse principal component analysis via random projections. *arXiv preprint arXiv:1712.05630*.



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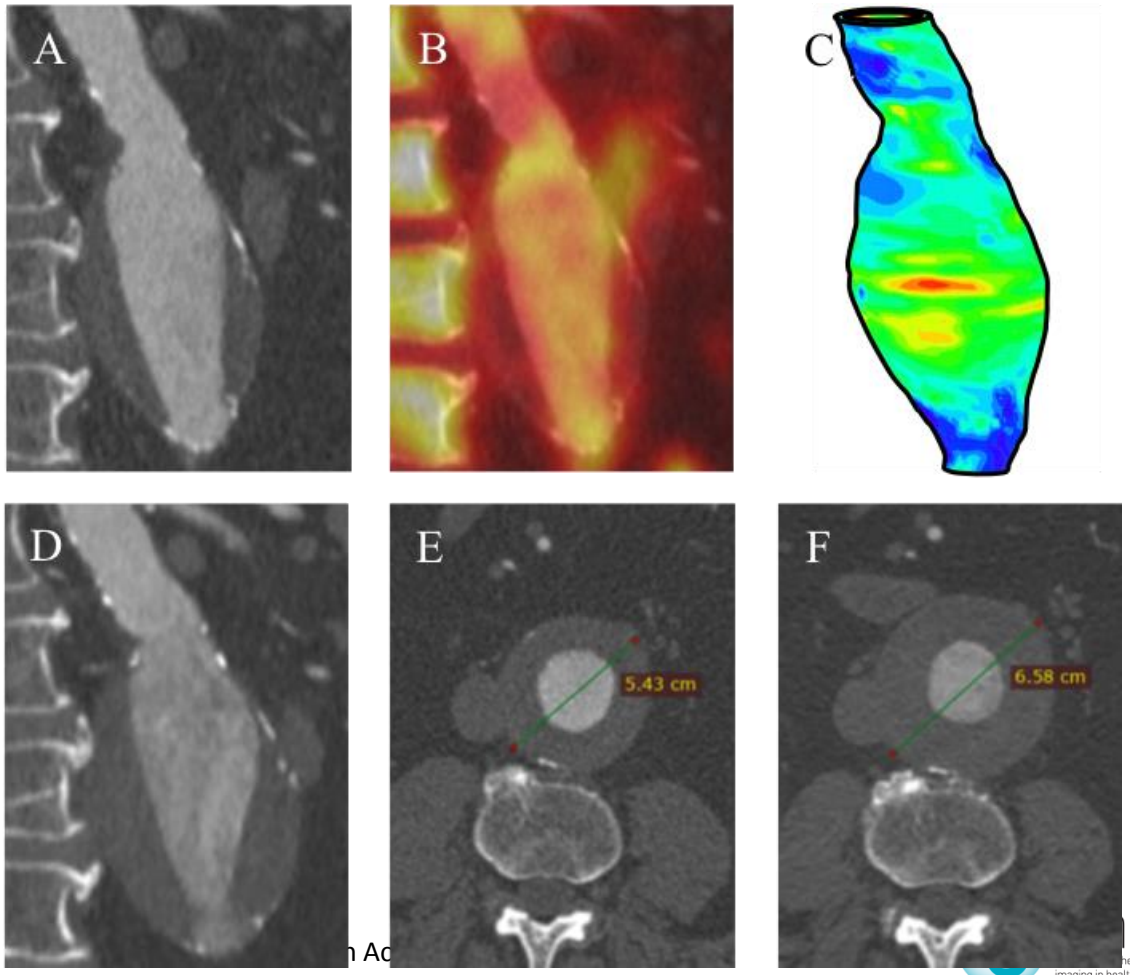
Some Research Highlights

Numerical modelling and multi-modal imaging for studying the cardiovascular system

Assessing the rupture risk of abdominal aortic aneurysm based on multi-modal clinical imaging (Aston, Huang, Rudd)



Huang, Y., Teng, Z., Elkhawad, M., Tarkin, J., Joshi, N., Boyle, J., Buscombe, J., Fryer, T., Zhang, Y., Park, A., Wilkinson, I., Newby, D., Gillard, J. and Rudd, J. (2016). High Structural Stress and Presence of Intraluminal Thrombus Predict Abdominal Aortic Aneurysm 18 F-FDG Uptake: Insights From Biomechanics. *Circulation: Cardiovascular Imaging*, 9(11), p.e004656.

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Some Research Highlights

Machine learning for clinical decision support

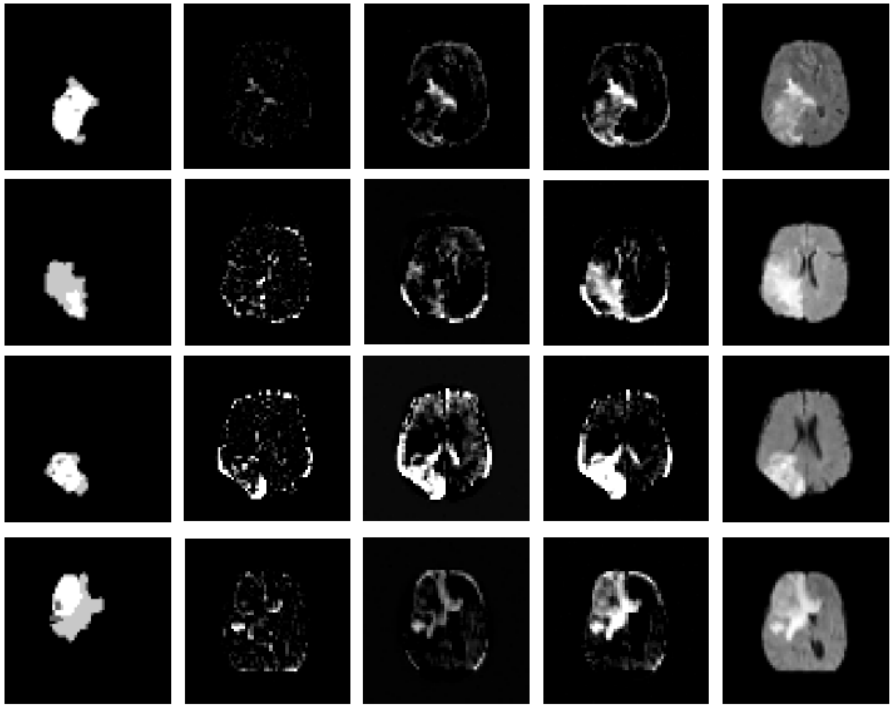
- Deep learning for clinical decision support (Aston, Gilbert, Grah, Huang, Rudd, Schönlieb)

  Spin-off ATI project on personalised breast cancer screening

- Automated Classification of Osteoarthritis with Textural Analysis of Magnetic Resonance Images (Kaggie-GSK, Tovey, Schönlieb)

  Kaggie, J. D., Tovey, R., MacKay, J., et al. (submitted). Automated Classification of Osteoarthritis with Textural Analysis of Magnetic Resonance Images, submitted to

  IEEE Transactions on Medical Imaging



Unsupervised abnormality detection (Aston, Yu)

Dai, B., Wang, Y., Aston, J., Hua, G., & Wipf, D. (2017). Green Generative Modelling: Recycling Dirty Data using Recurrent Variational Autoencoders, *Conference on Uncertainty of Artificial Intelligence (UAI)*

Wang, Y., Aston, J. & Wipf, D. (2017). Sparse Bayesian Multitask Learning for Subspace Segmentation, *Women in Computer Vision Workshop in, IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*

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Upcoming CMIH seminars

4th May, 2pm: **Bill Jagust**, UC Berkeley School of Public Health

Imaging the Molecular Pathology of Alzheimer's disease

25th May, 1pm: **Miguel Rodrigues**, UCL

1st June 2pm: **Audrey Repetti**, Heriot-Watt University

Optimisation methods for Bayesian inference: Application to high dimensional inverse problems

15th June 2pm: **Ferdia Gallagher**, University of Cambridge

Methods to model and segment novel metabolic imaging in humans

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Upcoming Conferences

- Cambridge Imaging Festival, 15th May
- 2nd Cambridge Representational Similarity Analysis and Advanced Computational Methods Workshop (RSA2018), 21st - 22nd May
- CMIH - connecting with Industry, 17th October
- NIHR & CMIH workshop: AI in Imaging, 6th November
- CMIH – Connecting with Academia, Spring 2019, date tbc

TGM Turing Gateway to Mathematics

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Partnership fund

We have an open call for funding a variety of projects through the partnership fund, with a number of suggested applications, this has supported many of the aforementioned activities, as well as many others;

- Sabbatical support for academics outside of the CMIH to spend time at the centre
- International visitor programme, with support for visitors to spend time at other UK research centres alongside visiting the CMIH
- Internship opportunities for Post Doctoral Research Associates to spend time in industrial/clinical settings
- Industrial/clinical secondments into the CMIH
- Funding for workshops
- Scoping (pump priming) projects to build new collaborations between academics and industry in the field of mathematics of clinical imaging

More information at https://tinyurl.com/cmih-fund

2nd Cambridge Representational Similarity Analysis Workshop: Theory, Application and Practice in Cognitive and Clinical Neuroimaging (RSA2018)

PMP and Surop Summer placement projects

Conference travel for affiliated students

Tamara Grossman internship

Computing facilities for project predicting the site of tumour progression in the invasive margin of glioblastomas

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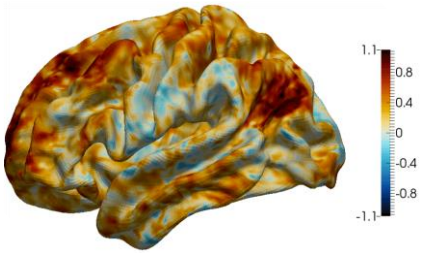
Imaging Clinic

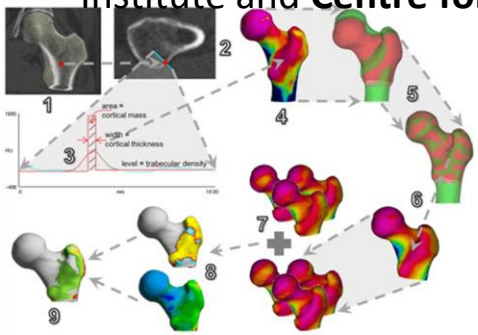
Do you have a specific question about an imaging modality, or wondering what analysis technique is most appropriate for your data?

Or do you have a project on which you are keen to collaborate with an imaging expert?

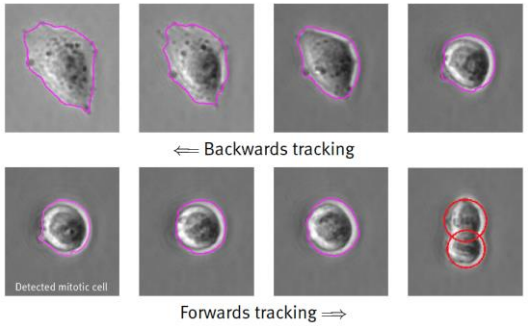
The CMIH now hosts a regular imaging clinic, offering a free, walk in consultation service for imaging related projects.



- **Fortnightly** during term time & roughly monthly outside of term
- **Wednesdays 4:00-5:30**
- Location alternates between the **cafe at CRUK** Cambridge Institute and **Centre for Mathematical Sciences**



Easter 2018 clinic dates
Wed, May 9th, 4:00 – CRUK Cafe
Wed, May 16th, 4:00 – CMS, MR3
Wed, June 6th, 4:00 – CRUK Cafe
Wed, June 20th, 4:00 – CMS, MR 3



For further information email imagingclinic@maths.cam.ac.uk, or visit our website

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Thank you so much for your attention!

We hope you will have an interesting rest of the day

https://www.cmih.maths.cam.ac.uk

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