UNIVERSITY OF CAMBRIDGE
Department of Computer Science and Technology

Laboratory or Department?
Exploration and Creation in Computer Science and Technology

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Department of Computer Science and Technology

“The Computer Lab”

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85 years of history of the Department/Computer Laboratory

In two minutes…

- Founded in 1937 as the “Mathematical Laboratory” to provide a computing service to the University.
- Originally proposed name was “Computer Laboratory” (but committees …)
- Name changed to “Computer Laboratory” 30 years later.
- University Computer Services created in 1970, eventual complete split from the department.
- Formally became “Department of Computer Science and Technology” in 2017 (but still often called the Computer Lab).
- Lots more in Haroon Ahmed’s book (2013), pdf freely downloadable from the Department’s website.

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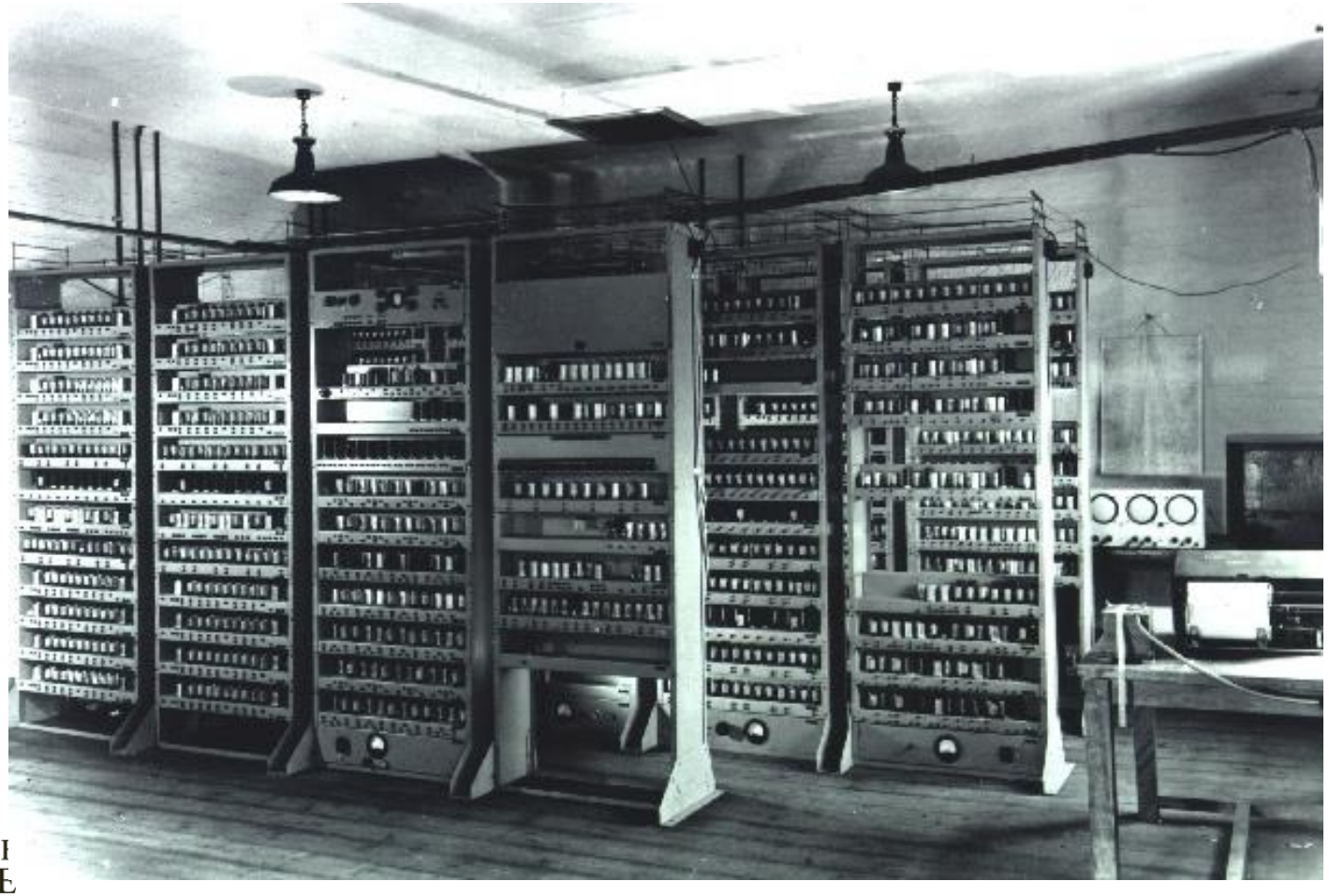
EDSAC



EDSAC

- EDSAC became operational in 1949: the first practically usable stored program computer.
- Built by a team led by Maurice Wilkes, with David Wheeler chiefly responsible for programming.
- Development of many aspects of computer science and scientific computing.
  - e.g., David Wheeler's code for the Fast Fourier Transform in late 50s
- EDSAC and EDSAC 2 enabled scientific research that would otherwise have been impossible (three Nobel prize winners acknowledged it in their lectures: Kendrew, Huxley, Ryle).

Fast Fourier Transform for radio astronomy (Ryle and Neville 1962)

As an alternative method of computation, the surface brightness of the sky may be determined at points on a cartesian-coordinate lattice (X, Y), where in this case the X-axis was chosen parallel to $\alpha = 03^{h}\,00^{m}$ with the origin at the North Pole; the observed data were converted by an interpolation process to points on a cartesian-coordinate lattice (x, y), where the axes x, y were chosen to be parallel to the axes X, Y. The computation then reduces to the form:

$$T(X,Y) = \sum_x \sum_y \left[z(x,y)\, e^{\frac{2\pi i}{\lambda}(Xx - Yy)} \right] \equiv \sum_x e^{\frac{2\pi i}{\lambda} Xx} \left[\sum_y z(x,y) e^{\frac{-2\pi i}{\lambda} Yy} \right].$$

Since the summation can now be done in two parts the total computing time is reduced by a factor of about $\sqrt{N}$, where N is the total number of data points. This method was used for the second survey (1961 June).

That's all there is!

Acknowledgments.—We are indebted to Dr M. V. Wilkes, F.R.S., Director of the University Mathematical Laboratory, for permission to use EDSAC II, to Dr D. J. Wheeler, for help in the design of the programme, and to Mrs Elizabeth Waldram for dealing with the photographic output. We should also like to thank Dr A. Hewish for many helpful discussions throughout this work, and Dr P. F. Scott for assistance with the observational programme.

Wheeler acknowledged but not a co-author.

The Lab

Developing Computer Science to support science

- Focus of work on EDSAC and EDSAC2 was building reliable machines: Wilkes avoided making innovations when he didn't absolutely have to.
- The hardware was central, but everything round it had to be created too: programming (e.g., the subroutine), the system by which programs were submitted and output obtained, the training material (the one-year Diploma course started in 1953).
- Exploration and creation in a collaboration between the scientists and the engineers: co-creation of code and ideas.
- Difficult transition once computer hardware became a commodity and the split between computer services and the Department became inevitable.

Computer Science evolves as an academic discipline

splitting away from science …

- Abstract view of computation: development of computer science as a general subject.
- Immensely powerful abstraction which has allowed the development of computer science as a separate field.
- Assumption: scientists learn how to program (usually as part of their science degrees), write their own programs and run them on general purpose computers.
- **But** as CS developed and diverged, limited transmission of:
  - modern computer science ideas – e.g., advanced machine learning and its associated methodology.
  - modern CS approaches, especially in software engineering.
  - Ideas from sciences into CS. e.g., concepts from Physics relevant to machine learning.
- Whole field of computational modelling not well understood by most scientists **or** computer scientists (recent rebranding as "digital twin").
- Scientists' needs sometimes turn out to be general needs - World Wide Web developed at CERN.

Bringing science back into computer science?

How do we build an environment for genuine interdisciplinarity?

- Huge scope for accelerating scientific discovery with modern machine learning approaches.
- Better scientific software means more reliability and perhaps credibility.
- The climate and biodiversity emergencies makes it essential to deploy scientific resources as effectively and rapidly as possible.
- Mixed approaches needed: collaboration, education, software engineering assistance …
- Huge desire to do this, perhaps especially from students and junior researchers.
- Issues:
  - Finding the right collaborations and the right funding and the right support is really complicated.
    e.g., Research software engineers are essential, but don't fit well in University career structures.
  - Interdisciplinary collaborations are often high-risk high-gain: many researchers are understandably risk averse.
  - Doing things that work vs getting publications?
  - Lots of boundary busting required!

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Accelerate Programme for Scientific Discovery

Advancing scientific discovery with machine learning

- Supported by a donation from Schmidt Futures, the Accelerate Programme will provide young researchers with specialised training in AI techniques
- Data Science for Science Residency Programme for PhD students across the University
  - Courses so far have trained students from chemistry, biochemistry, physics, engineering, medicine, veterinary medicine and psychology.
- Four Departmental Early Career Academic Fellows (DECAFs)
- Four PhD students
- Led by Prof. Neil Lawrence and Jess Montgomery
- https://acceleratescience.github.io///about.html

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Institute of Computing for Climate Science

Supporting the work of climate scientists through computer science research

- Computational modelling is key to climate science.
- Models are becoming increasingly complex as we seek to understand our world in more depth and model it at higher fidelity.
- Collaboration between Cambridge Zero, the Departments of Computer Science and Technology, Applied Mathematics and Theoretical Physics, and University Information Services
- Led by Professor Emily Shuckburgh (Cambridge Zero and CST), Dr Dominic Orchard (CST), Dr Chris Edsall (UIS), Professor Colm-cille Caulfield (DAMTP)
- Part of a Virtual Institute for Scientific Software (VISS) established by Schmidt Futures addressing the growing demand for software engineers with backgrounds in science, complex data and mathematics who can build dynamic, scalable, open software to facilitate accelerated scientific discovery across fields.

SCHMIDT FUTURES

CAM ZERO $_2$

UNIVERSITY OF CAMBRIDGE
Institute of Computing for Climate Science

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Cambridge Centre for Carbon Credits

How do we verify that deforestation solutions are working?

- Launched in November 2021
- Aim: to scale up the supply of deforestation avoidance carbon credits in order to halt tropical deforestation as soon as possible
- Funding by a research grant & donation by the Tezos Foundation, with additional further donations
- Working on a prototype of a trusted nature based marketplace
- Plan to support University travel offsets very soon.
- Supports students and faculty members conducting foundational research in the relevant areas of computer science, environmental science, and economics.
- Director Anil Madhavapeddy with David Coomes (Conservation Research Institute), S Keshav (CST) and Andrew Balmford (Department of Zoology)

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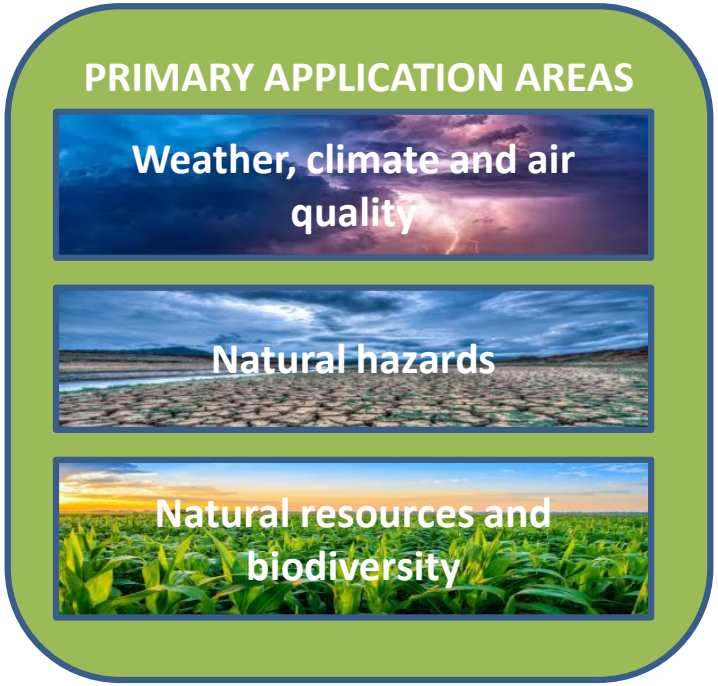
Application of AI to the study of Environmental risk

Centre for Doctoral Training supported by industry, government & NGOs

- Aims:
  - Attract and train researchers to develop and apply leading edge computational approaches to address global environmental challenges.
  - Develop a new generation of leaders in the application of AI to the most pressing environmental risks facing the planet.

- 43 students are currently enrolled on the programme (11 in Computer Science and Technology) working on projects spanning renewable energy, climate, air pollution, remote sensing, biodiversity and ecology.
- Bringing together academics from 14 Departments in the University and the British Antarctic Survey as well as over 40 partner organisations.



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UKRI Engineering and Physical Sciences Research Council

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

AI4ER

Networked across the University

Involved in many networks and CDTs

CAMBRIDGE LANGUAGE SCIENCES

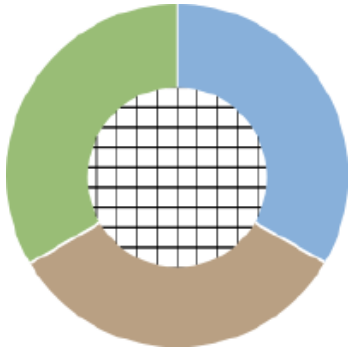
C2D3

SENSOR CDT

Agri FoRwArdS
EPSRC Centre for Doctoral Training in Agri-Food Robotics

CAMBRIDGE GLOBAL CHALLENGES

CAMBRIDGE NEUROSCIENCE



AI for Environmental Risk

CAMBRIDGE | ESRC
DOCTORAL TRAINING PARTNERSHIP

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Some other interdisciplinary research projects and collaborations

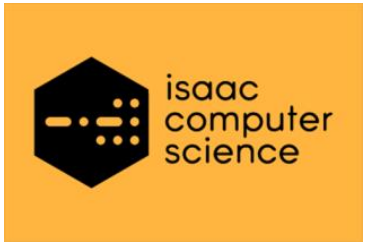
Medicine, education, linguistics, psychiatry, law …

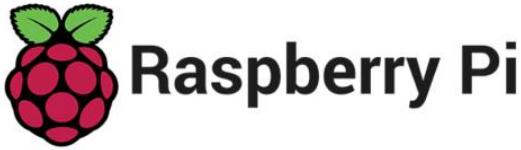
- **Centre for Mobile, Wearable Systems and Augmented Intelligence** - Cecilia Mascolo in collaboration with Nokia Bell Labs
- **Alta institute - Institute for Automated Language Teaching and Assessment** – Paula Buttery and Mark Gales (Engineering) in collaboration with Cambridge University Press and Assessment
- Pietro Lio and Mateja Jamnik work at the intersection of AI and Medicine, collaborating with clinicians e.g. **Mark Foundation Institute for Integrative Cancer Medicine and Cambridge Centre for AI in Medicine**
- **Affective Intelligence and Robotics Laboratory** have explored the use of robots to assess mental wellbeing in children – Hatice Gunes in collaboration with the Department for Psychiatry
- **Cybercrime Centre** – Alice Hutchings

Computer Science Education

The Lab has a long history in Computer Science education: the Diploma was the world's first full-year taught Computer Science course, starting in 1953. It was aimed at students with a first degree in science or maths.

- Current initiatives include two educational collaborations with Raspberry Pi:
  - Isaac Computer Science, a free online platforms for teaching and learning to support GCSE & A Level students. This followed on from Isaac Physics, a collaboration between the University and the Department for Education
  - Raspberry Pi Computing Education Research Centre, which carries out research to help increase our understanding of what works in the teaching and learning of computing





Where we're going: Department **and** Laboratory

- Foundations – similar principles to 1949:
  - Doing things that work …
  - Busting boundaries …
  - Collaborations!
  - Educating …
- Computer Science and Technology has become all-pervasive, but other disciplines still need us, perhaps more than ever.
- Balancing between teaching, progress in research, doing things that matter now, doing things that will matter in 40 years.
- And make sure it's exciting!

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