Department of Computer Science and Technology

PhD in Computer Science

Course Information for Applicants

UNIVERSITY OF CAMBRIDGE

Welcome to the Postgraduate Studies Open Day.

We hope that this brief guide will be of some help but if it you have further questions you are welcome to ask us, Lise Gough, Joy Rook and Marketa Green, the Course Administrators, by email cst-graduate-admissions@cst.cam.ac.uk.

Postgraduate Education Team

Contents

1. DEPARTMENT OF COMPUTER SCIENCE AND TECHNOLOGY

The Department of Computer Science and Technology was founded in 1937 as the Mathematical Laboratory on the part of the New Museums Site now occupied by the Arup Building. The name was changed to Computer Laboratory in 1969 and the Computing Service was created in 1970 as part of the same department. With effect from 1 October 2017, the name changed to the Department of Computer Science and Technology.

Professor Sir Maurice Wilkes was the Head of Department from 1946 until 1980 when he was succeeded by Professor Roger Needham. In 1996, Roger was appointed Pro-Vice Chancellor of the University. Subsequent heads have been Professor Robin Milner, Professor Ian Leslie, Professor Andy Pitts and currently Professor Andy Hopper.

In 2001 we moved into purpose-built facilities in West Cambridge. Our address is:

> Department of Computer Science and Technology
> The Computer Laboratory
> William Gates Building
> 15 JJ Thomson Avenue
> Cambridge, CB3 0FD

The Department of Computer Science and Technology and is part of the School of Technology along with Engineering, Chemical Engineering and Biotechnology and the Judge Business School. See http://www.tech.cam.ac.uk/Graduate/aboutgrad

The department occupies the ground, first floor and most of the second floor of the William Gates Building. The large central entrance corridor is known as The Street. MPhil students use Teaching Rooms SW01, FS07 and FS09 and the Teaching Laboratory SW02. The Intel Lab in SW11 is a large computer room for undergraduate students.

Research students are typically allocated a desk in a room with two or more other research students or post-doctoral staff near their supervisors during their studies. Rooms are allocated for a period of around three-and-a-half years after which time a student may be moved to the writing-up area if the student has not submitted a PhD dissertation.
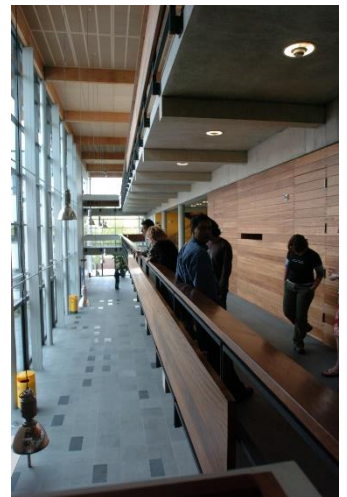
Other facilities include a small café on the ground floor which is open 09:30-16:00 Monday to Friday excluding public holidays, and small kitchens around the department. There is also a cafe in the Hauser Forum at the end of JJ Thomson Avenue south of the West Cambridge site. A Sainsbury's supermarket is a ten-minute bike ride away in the new Eddington site, and there is a state-of-the-art Sports Centre on the West Cambridge site.

The Basics

The PhD in Computer Science is a three-year programme of individual research on a topic agreed by the student and the Laboratory, under the guidance of a staff member as the student's supervisor.

All research students are admitted to read for the PhD Degree on a probationary basis and most will be registered for the Certificate of Postgraduate Study (CPGS) in the first instance. During this year students may do some additional coursework and will write a research report that is likely to form the foundation of the eventual PhD dissertation.

The CPGS

- Research Skills training
- Practical work
- Research report of no more than 10,000 words
- Attendance at research workshops and research seminars.

The CPGS is used as an end of first year assessment exercise. At the end the third full term of the first academic year, a formal assessment of progress is conducted by two independent assessors who make a recommendation about whether a student may be registered, retrospectively, for the PhD Degree. The assessment is based on consideration of the first-year report and thesis proposal, in the form of a single document, and an interview with the assessors. The document is principally a **PhD Proposal** that demonstrates a clear path from the candidate's current position to a complete PhD dissertation at the end of the third year. The document has two purposes:

i.   to help the candidate to reflect on and plan their research project and

ii.   to allow the Computer Laboratory to assess the student's progress and planned research.

A student who is not recommended to be registered for the PhD will, normally, be awarded the CPGS alone and will leave the University before submitting a PhD dissertation.

Students are expected to complete the substance of their research by the end of their third year, submitting their thesis then or within a few months.

The Ph.D. examination

The examination for the Ph.D. degree normally consists of two parts:

(1) Scrutiny of a thesis by two Examiners appointed by the Degree Committee, normally one Internal to the University (but not the Supervisor) and one External;
(2) An oral examination involving both examiners and the candidate.

Doctoral degrees are awarded to those who have demonstrated all of the criteria below:

1. a significant contribution to the field of study through the creation and interpretation of new knowledge, connection of previously unrelated facts or the development of new theory or revision of older views;

2. submission of work of a quality in whole or in part of a standard to merit publication (whether or not subsequently published);

3. provides evidence of the acquisition of knowledge and a detailed understanding of applicable techniques for research and advanced academic enquiry;

4. is of a quality and quantity to reflect three years of full-time postgraduate study.

Research Skills Programme

All students in their first year of research studies will be required to successfully complete the Research Skills Programme. Other courses in the undergraduate Tripos and M.Phil in ACS may also be recommended by the supervisor.

The Research Skills Programme is designed to provide advice on and training in a variety of practical skills required for research. The skills learnt will be useful in the student's individual project, other research-led modules, and in the student's future career.

All students are required to take 12 units in total which includes the core units and a number of optional units.

Core Units

There are 4 - 5 mandatory core units covering topics such as Academic English; Academic Writing; How to prepare a research presentation.

Please note that students who previously took the MPhil in Advanced Computer Science are not required to complete the Core Units.

Optional Units

Students choose units that are most relevant to their research plans, and supplementary to their previous experience. Optional units will not generally require coursework to be

completed or submitted beyond participation in the session itself. Some options will involve practical work, which will be carried out during the session. This will provide an opportunity for students to practice specific skills, but will not be formally assessed.

Examples of units offered in current and previous years are:

- Academic Writing in UK HE
- How to prepare a research presentation
- How to write a good abstract
- CV writing workshop
- Research ethics and GDPR
- Introduction to qualitative research methods
- Correctness proofs of distributed systems with Isabelle/HOL
- How (not to) lie with statistics
- Applications of Blockchains to Decentralised Finance, Markets, Art, and Beyond
- Buzzwords surrounding data science
- How to Write a Research Paper
- Intellectual property and commercialisation
- Entrepreneurship; how to start a company and other routes to exploit your research
- Motion Capture for Experimental Robotics Research
- How to work with artists and designers

3. APPLYING FOR THE PHD

Applications

Formal application for admission for the PhD degree must be made via the applicant portal https://www.postgraduate.study.cam.ac.uk/application-process/applicant-portal-and-self-service-account. The deadline for all applications is 30 June. However, if you are applying for funding support, please see the Funding competitions section below for the relevant deadlines. Those who are applying for one of the Computer Laboratory's PhD studentships should use the deadline published on the individual job listing.
After starting an application, the supporting documentation and research proposal must be uploaded within 7 days. Please note that your application can only be considered by the department once it is complete.

Prerequisites

Applicants are expected to have met the following prerequisites:

- a very good degree (in the UK a First Class Honours degree) in Computer Science or a related subject;

- a masters-level degree (or other post-graduate work) is increasingly desirable; some PhD applicants may find prior study of our MPhil in Advanced Computer Science useful;

- a Research Proposal;

- A good IELTS or TOEFL score is also required where an English Language qualification is necessary.

Research Project Proposal

Students are not assigned to pre-specified projects. They are expected to propose an area or topic, and will be accepted only if an appropriate and willing supervisor is available.

Applicants should therefore prepare a statement of proposed research of no more than 3000 words (in addition to the usual personal statement) indicating their intended topic and research strategy. This should:

- show an understanding of existing work in the field,

- identify an area for new work,

- have concrete goals and deliverables for the first year, and

- indicate that you know how to achieve them.

This could be drafted in collaboration with the intended supervisor and candidates are invited to make informal contact with the Computer Laboratory, either through individual staff members or the Postgraduate Education Manager, before submitting a formal application. Staff members belong to one or more research groups and may be contacted by email in the first instance.

Funding Competitions

Applicants wishing to be considered for funding competitions should check their eligibility on the University-wide Sources of Funding web page. The deadlines for the Postgraduate Funding competitions can be found on webpage
https://www.postgraduate.study.cam.ac.uk/funding

It is worth noting that full funding must be secured before starting a course at Cambridge. You will need sufficient funding to cover the University Tuition Fee, and at least the minimum maintenance for three years.
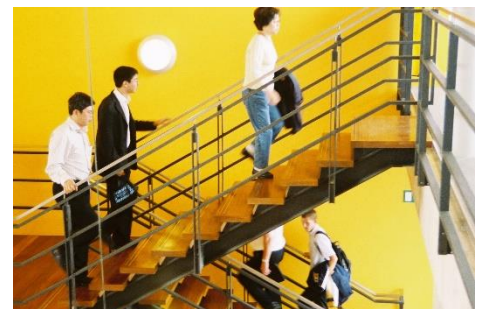
4.   RESEARCH THEMES

Students are integrated into the research culture of the Department by joining one of the research groups. Students are expected to attend the Department's and research theme's programme of research seminars.

Algorithms and Complexity Theme

Algorithms are fundamental objects of study in computer science. Algorithmic processes are not only executed in digital electronic computers but occur everywhere in the world around us. The Algorithms and Complexity research theme focuses on the mathematical modelling and analysis of algorithmic processes.

Computer Architecture Theme

Computer Architecture has been at the heart of the Department's research since it was first created – work on mechanical calculators and analogue computers drove the Lab's founders, which led to the development of EDSAC, the world's first practical stored-program computer in 1949.

Nowadays, research on Computer Architecture considers traditional general-purpose CPUs, GPUs, and accelerators for areas like machine learning, artificial intelligence, scientific computing and data processing. We have strong links with security through the CHERI project, machine learning and artificial intelligence, and programming language research via compilers and binary modification tools.

Through collaboration, we undertake complete system designs from gates through to applications with everything in between: processors, accelerators, compilers, linkers, run-times, operating systems, applications and verification at many levels.

Graphics, Vision and Imaging Science Theme

The areas of computer graphics, computer vision and imaging science address creating, capturing, rendering, and analyzing visual information in the forms of 2D/3D images, geometry, appearance, deformation, and motion models.

The tasks of computer graphics and vision are profoundly related. While computer graphics considers the forward problem of generating images and video from a description of a scene, computer vision considers the inverse problem of recovering and understanding scene properties from images and video. We utilize machine learning to exploit this duality and develop effective systems for digitizing and interacting with the visual world.

We build tools involving novel software and hardware components to tackle some of the fundamental problems of computer graphics, vision, and imaging. Our research often involves working with capture and display technologies, such as motion capture sensors, cameras, prototype displays, augmented and virtual reality headsets, or humanoid robots.

Human-Centred Computing Theme

The goal of human-centred computing is to create technologies that better meet human needs, through studying the needs of humans. Using diverse research methods from social

science, experimental psychology, cognitive science and other disciplines, we address grand challenges such as social and emotional interaction with robots, or crossing the perceptual line between interaction with virtual and real worlds. We work with AI, machine learning and data science methods to build intelligent tools for digital life, supporting business and engineering, artistic expression and enquiry, and enabling collaborative design processes that address global challenges. Through addressing human priorities with a commitment to cross-disciplinary rigour, we make research contributions in core fields of computer science such as human-computer interaction, computer graphics, visualisation, and display technologies. Members of the group are also leaders in emerging specialist fields including affective computing, computer music, human-robot interaction, diagrammatic reasoning, computational photography, end-user programming and ubiquitous computing.

Machine Learning and Artificial Intelligence Theme

The goal of our research in artificial intelligence and machine learning is to understand, represent, model, learn and reason about problems in the real world. We create AI technologies that benefit society and increase social awareness. The theoretical methods we develop and employ span all varieties of deep learning, classical statistical learning, computational biology, knowledge representation, Bayesian inference, causal modelling, logical reasoning, probabilistic reasoning, visual reasoning, stochastic processes, human-like computing, and natural language processing. We apply these methods and approaches in numerous settings such as personalised medicine and education, automated theorem proving, policy work and data, systems applications, sensor networks, and end-to-end solutions in the African context.

Mobile Systems, Robotics and Automation Theme

Research in Mobile Systems, Robotics and Automation encompasses the fundamental challenges introduced by systems that either move autonomously or are made mobile by human movement through wearable technology. The research spans issues related to how to make these systems more efficient, how to design algorithms that control and coordinate autonomous mobility and communication, and how to devise suitable machine learning models to analyze the data produced by them. This thrust also involves the investigation of security and privacy aspects and the interfaces between devices/robots and users.

Applications of the research include mobile health, industrial automation, transport and logistics, to name a few.

Natural Language Processing Theme

The aim of Natural Language Processing is to develop computational models for analysing and generating human language. Research in the Department encompasses many areas of NLP, ranging from fundamental theory to real-world applications.

The models we develop are mainly based on modern machine learning techniques. On the theoretical side, we seek to understand the structure needed to represent language, how language is learned and processed by people, and how language varies between people and over time. On the application side, the ALTA institute develops technology to support second language teaching and assessment. Other researchers work on automated fact checking, dialogue systems, document summarisation and scientific text processing, as well as interdisciplinary work in various domains such as healthcare and cybercrime.

Programming Languages, Semantics and Verification Theme

Research in the Programming, Logic, and Semantics group is centred around the study of programming languages, logics, and mathematical models, addressing hardware, software, and networks. It spans a wide range of applied and theoretical work: programming language design, compilers, and program analysis; the development of interactive theorem provers and automatic proof procedures; the formal verification of computational systems; and semantic models using techniques such as structural operational semantics, type systems, domain theory, category theory, finite model theory and linear logic. Work is in progress on the underlying mathematical structures of these, and on their application to the study of higher-order typed programming languages; object-based languages; low-level machine languages; foundational languages for concurrent, distributed and mobile computation; hardware description languages; security and networking problems; database theory; and computational complexity.

Security Theme

Computer security has been among our research interests for many years, along with related topics such as privacy, safety and maintainability. We research the technologies used by security engineers including access controls, protocols, cryptology, formal methods, hardware design, biometrics and usability; we also study the dependability of whole systems, which involves the economics of information security and spills over into policy.

We have established groups collecting data on cybercrime and abuse for use by researchers worldwide (the Cambridge Cybercrime Centre); developing novel vulnerability-mitigation mechanisms that are now starting to appear in commercial CPU designs (the CHERI project); and studying hardware tamper-resistance and emission security (the Tamper Lab).

Systems and Networking Theme

The Systems Research Group is one of the largest groups in the Department, undertaking research and teaching into all aspects of computer systems, broadly conceived, including computing and communications hardware and software, operating systems, distributed and mobile systems, and the legal and policy implications of future computing systems. The group has a strong tradition of design, implementation, and deployment of working platforms.

Systems research has been at the heart of the Department since its inception. Past systems developed and deployed here include the EDSAC (1949), the Titan operating system (1966), the Cambridge Ring (1974), the CAP (1976), and the Cambridge Distributed Computing System (1982).

More recent work includes the Desk Area Network (1991), the Tempest distributed network control system (1996), the Nemesis operating system (1999), the Xen hypervisor (2003), NetFPGA (2008), and the MirageOS unikernel system (2013).

Successful recent platforms include Xen, NetFPGA, and MirageOS.

5.   STUDENT REPRESENTATION

PhD Students are represented on the **Faculty of Computer Science and Technology** by a Junior Member. Elections for members are held in the November of each academic year. The Faculty receives the Minutes of the Staff Student Consultative Forum, the Postgraduate Education Committee, the Teaching Committee, and the Forum of Directors of Studies, and itself reports to the General Board of the University. The Faculty Minutes are sent to the Secretary General of the Faculties, the members and to Officers in the department.
The junior members attend the first part of each meeting during which unreserved business is discussed - that's the bulk of the business and includes things like the Head of Department's annual report, accreditation matters, examiners' reports, teaching matters related to the Tripos and M.Phil courses, the use of calculators in exams, new proposals for courses, etc.

Reserved business covers matters referring to named members of staff (e.g. promotions and leave of absence), and such things as the appointment of Examiners and the Form and Conduct of examinations.
Whilst the faculty representative elections are formally independent of the Graduate Union, under the terms of the GU Constitution (which has the approval of the University Council) the elected postgraduate representative is also a voting member of the GU governing council. Further information about the GU Council is available at
http://www.gradunion.cam.ac.uk/gradunion/council/

Faculty meetings are fairly formal and reasonable dress is required!

PhD students are also represented on the **Staff Student Consultative Forum** and the **Postgraduate Students' Forum.** Both of these groups are relatively relaxed occasions and provide the opportunity for student and staff representatives to exchange comments about facilities and teaching.

> The **Postgraduate Students' Forum** is made up of research student representatives from research students and the M.Phil course, the Postgraduate Students Coordinator and a member of the Student Administrative team. The Forum has the opportunity to suggest courses and activities that fall within the remit of the Transferable Skills allocation as well as issues that are particularly relevant to research students in the Faculty. Meetings are held at lunch time once a term and the minutes are received by the Postgraduate Education Committee and Degree Committee.

> The **Staff Student Consultative Forum** (SSCOF) is made up of student representatives from every year of the undergraduate course, a M.Phil student, a research student, and members of the academic, support and Student Administration team. Meetings are held at lunch time twice a term.

Postgraduate Students also have a representative on the **Postgraduate School of Technology Committee.**

6.   WOMEN@CL

The purpose of the women@CL network is to put in place a positive action programme for women in computing research, with a particular focus on interdisciplinary research, leadership and enterprise.

The programme consists of career development activities including regional and national workshops, mentoring and networking, with long term goals of:

- providing support for women in computing research;
- stimulating new research by bringing diverse viewpoints and expertise to bear;
- increasing the recruitment and retention of women in computing research careers;
- encouraging and supporting women to aim for early leadership roles;
- increasing women's understanding and participation in entrepreneurial ventures;
- contributing to a positive public perception and image of computer science;
- increasing public engagement in computer science;

The programme consists of a variety of local activities such as women@CL lunch talks that provide role models to our students and early career women, and our national and international activities include events like career development workshops at major conferences, regional technical meetings, and senior women leadership summits. We forge formal connections with existing bodies with similar goals. We also promote successful women and projects by placing articles, profiles and interviews in all forms of media.

women@CL events are open to all, women and men. For more information on the meetings and resources for and about women in computing, please visit the *women@CL* webpage http://www.cst.cam.ac.uk/women.

For more information please email women-at-cl-admin@cst.cam.ac.uk

7. GETTING TO THE LAB

Students at the University of Cambridge are not permitted to have cars except under very special circumstances.

Walking or cycling

The William Gates Building is 2 km (1.3 miles) west of the city centre. From the city centre go west on Garret Hostel Lane, Burrell's Walk (past the University Library), Adams Road, the Coton Cycle-path, and then turn right into Clerk Maxwell Road then left beside the Centre for Applied Photonics and Electronics to the William Gates Building.

Map of West Cambridge site
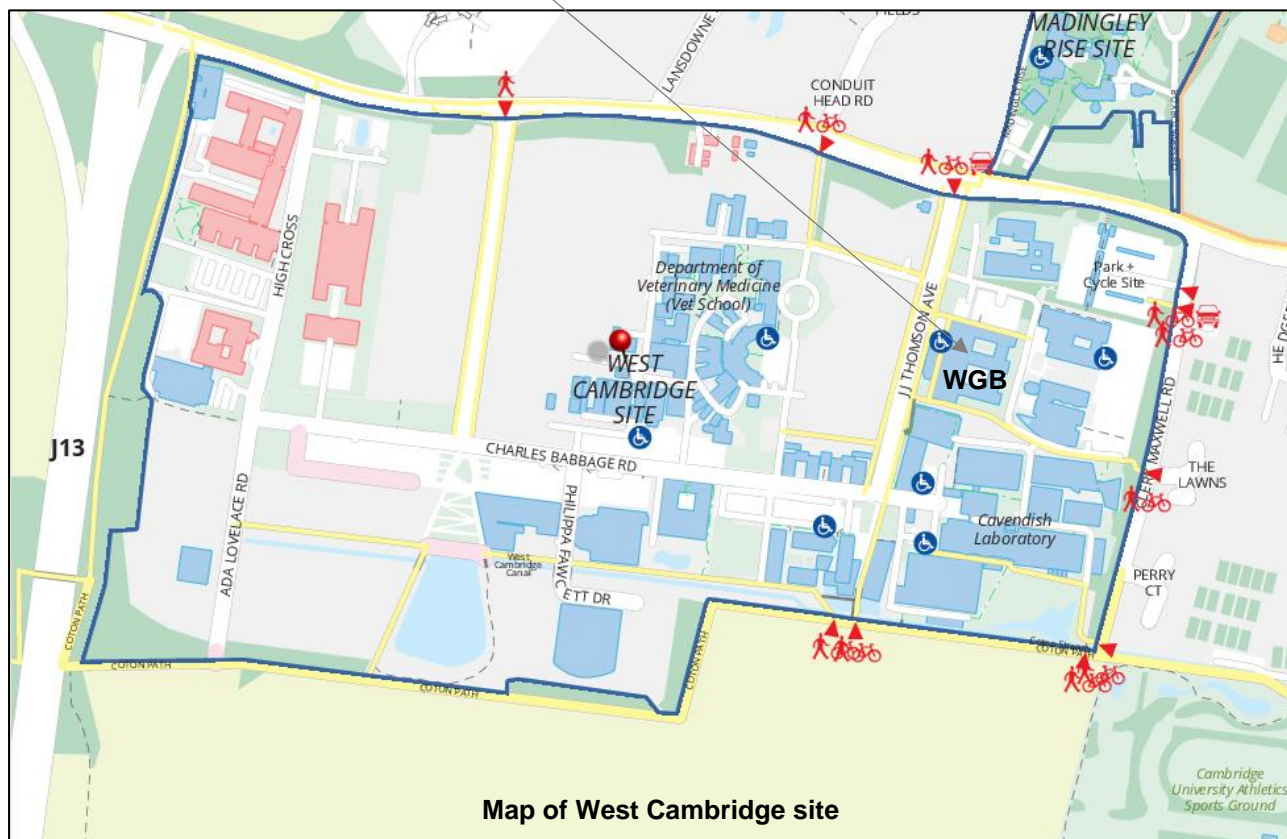
If you are cycling, please take care. The EMBS has a useful website for cyclists, old and new, at http://www.admin.cam.ac.uk/offices/embs/travel/cycle/. We also strongly recommend purchasing a strong D-lock.

Buses

Buses **Universal** (substantially reduced fares for University Card holders) and **Citi 4** run from the city centre to the West Cambridge Site. Both buses stop on the West Cambridge Site itself. In the city centre they stop on Silver Street (on the west side of Silver Street Bridge) and Trumpington Street (near the Fitzwilliam Museum and near Pembroke Street). Anyone planning to make three or more journeys in a day on Stagecoach buses (other than the Universal or Citi 4) will find it cheaper to purchase a Dayrider ticket, which can be used on any Stagecoach route within the city.

For more information about these services, see the links from the Bus Services page (http://www.admin.cam.ac.uk/offices/embs/travel/bus/index.html) which is maintained by the Estate Management and Building Service.

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