University of BRISTOL

Centre for Doctoral Training in Interactive Artificial Intelligence

2019/20

Programme Structure, Unit Descriptions & Funding details

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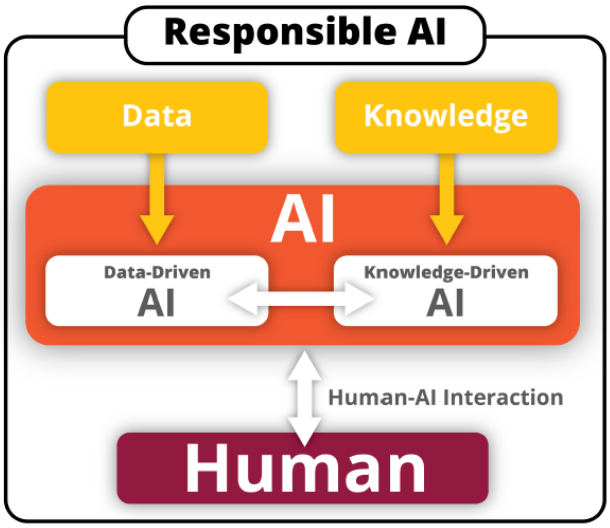
PHD PROGRAMME STRUCTURE

This four-year PhD programme comprises a one-year innovative taught component and a three-year research project. Its mission is to deliver cohorts of highly-trained PhD graduates with the skills to design and implement complex interactive AI pipelines solving societally important problems. Our Interactive AI doctoral training programme has been designed from the ground up to train the next generation of research leaders who will address this challenge in innovative ways.



After the taught first year, covering foundational topics in data-driven AI, knowledge-driven AI, human-AI interaction and responsible AI, you will undertake a 3-year research project, supervised by one of the 60 academics in the supervisory network and in close collaboration with one or more external partners. The Centre partners with a wide range of external organisations including Microsoft Research, Amazon, Dyson, Thales, QinetiQ, EDF Energy, and Adarga.

		Core Strands			Cross-Cutting Themes	
		Data-Driven AI	**Knowledge-Driven AI**	**Human-AI Interaction**	**Responsible AI**	**Interactive AI in Context**
Y1	TB1	Machine Learning Paradigms	Uncertainty Modelling	Human-Computer Interaction	Responsible Innovation & Enterprise	Group Project – set up Group Project – dive in
	TB2	Applied Data Science	Computational Logic for AI	Dialogue & Narrative	Responsible AI	Group Project – wrap up Advanced Topics in AI
	TB3	Summer Project(s)				
Y2-Y4		PhD Project *Research visits and internships, data/hackathons, workshops, conferences, summer/winter schools, reading groups, professional development*				

TAUGHT COMPONENT STRUCTURE - YEAR ONE

Teaching Block 1 (TB1, September to January) – Mandatory Units

Unit Code	Unit Title	Credit Points	Strand
COMSM0025	Machine Learning Paradigms	10	Data-Driven AI
EMATM1120	Uncertainty Modelling for Intelligent Systems	10	Knowledge-Driven AI
COMSM0036	Human-Computer Interaction	10	Human-AI Interaction
INOVM0013	Innovation, Entrepreneurship and Enterprise	10	Responsible AI

Teaching Block 2 (TB2, January to June) – Mandatory Units

Unit Code	Unit Title	Credit Points	Strand
COMSM0017	Applied Data Science	10	Data-Driven AI
COMSM0022	Computational Logic for Artificial Intelligence	10	Knowledge-Driven AI
COMSM0023	Dialogue and Narrative	10	Human-AI Interaction
COMSM0027	Responsible AI	10	Responsible AI
COMSM0028	Advanced Topics in AI	10	

All Year/Summer Units – Mandatory Units

Unit Code	Unit Title	Credit Points	Notes
COMSM0026	Interactive AI Group Project	30	Sept to Jun
COMSM0024	Summer Project	60	Jun to Sept

Previous study

- If you have previously studied any of these units at the University of Bristol, then you will be given the opportunity to take an optional unit instead.
- If you have previously studied the curriculum of these units at another institution, then you can apply for Recognised Prior Learning. More information on this process is available on this webpage - http://www.bristol.ac.uk/university/governance/policies/admissions/prior-learning.html

Overall Credit Points

	TB1	TB2	All Year (TB4)	Research Project	Total
Credit Points	40	50	30	60	180

PART-TIME APPLICATIONS

Requests to complete this programme on a part-time basis will be considered if an applicant has compelling reasons. This will be on a 50 per cent basis and requires daytime (9 am to 6 pm), weekday (Monday to Friday) attendance in the first year.

TRANSFERABLE AND TRANSLATIONAL SKILLS DEVELOPMENT

As a PhD researcher the CDT is a privileged place to be. The programme is established as a complete package to support each individual student into being a leader in their field. It is not purely about working on a research project (although that is obviously the primary focus). The following is an indication of the CDT skills development programme. Additional training is provided as required, in collaboration with the student cohort and via the Bristol Doctoral College.

Programme Year	Skills and Personal Development
Year One	• Introduction to Project Management • Confidence at Conference • Skills for Interdisciplinary Research • Introduction to Public Engagement
Year Two	• Alan Turing Institute Masterclasses • Open access and Research data management • Communicating Research
Year Three	• Industrial Placement
Year Four	• How to write thesis • Viva Survivor • Thesis requirements
Open to all years	• Winter & Summer Schools • Research Seminars, Symposiums and Workshops • Career Planning • Industry Symposia (every four years)

EXPECTATIONS WE HAVE OF OUR STUDENTS

We expect our students to seize the unique opportunity that the CDT provides and challenge themselves for self-improvement. Our full expectations are laid out in the 'CDT Supervisor Student Charter' (available on request), this includes:

- To embrace the transferable skills opportunities.
- To submit and present a paper to at least one national conference and one international conference during the PhD.
- To aim to submit at least two peer-reviewed journal papers before PhD completion.
- To volunteer for cohort activities, *e.g.* to act as student representative as well as respond to requests from student reps.
- To participate in at least one public engagement event, over the course of the PhD.

UNIT DESCRIPTIONS

This list below gives more information on the units as they are in 2019-20. It is possible that the information for future academic years may change due to developments in the academic field. Full descriptions of other units that can be audited in later years are available online – http://www.bris.ac.uk/unit-programme-catalogue/

COMSM0025 Machine Learning Paradigms

Unit Description

This unit gives an in-depth overview of Machine Learning, exploring both unity and diversity among different ML paradigms and why this diversity is needed and how it can be exploited. The paradigms covered include: Introduction: tasks, models and features; Tree and Rule models; Linear and Distance-based models; Probabilistic models; Model ensembles; Deep learning. The unit will provide students with a solid analytical and practical framework for further work in data-driven AI.

Teaching details

20 lectures; problem classes; unsupervised lab sessions.

Assessment Details

Coursework involving a significant comparative study of performance of different learning algorithms on a provided real-world data-set. This will be assessed through a written report (2,000 words + appendices). (50%)

Reading and References (indicative only)

Machine Learning: The Art and Science of Algorithms that Make Sense of Data. Peter Flach. Cambridge University Press. September 2012.

EMATM1120 Uncertainty Modelling for Intelligent Systems

Unit Description

This unit will explore the techniques and methodologies developed within Artificial Intelligence to represent and reason with information which is uncertain, imprecise or fuzzy. The unit will provide an overview of a range of different approaches explaining both the mathematics and the underlying philosophy and investigating practical applications.

Aims:

- To provide students with an overview of uncertainty modelling techniques and formalisms
- To provide students with an in-depth study of the mathematics and philosophy underlying these techniques
- To provide a detailed analysis of the application of uncertainty modelling in intelligent systems.

Teaching details

Lectures

Assessment Details

2-hour written examination: 100% (all learning outcomes)

Reading and References (indicative only)

- Probabilistic Reasoning in Intelligent Systems, Judea Pearl, Morgan Kaufmann.
- The uncertain reasoner's companion – a mathematical perspective, Jeff Paris, Cambridge Tracts in Theoretical Computer Science.
- Modelling and Reasoning with Vague Concepts, J. Lawry, Springer
- A first course in fuzzy logic, Hung T. Nguyen and Elbert A. Walker

COMSM0036 Human-Computer Interaction

Unit Description

This unit introduces and explores systematic approaches to human factors in computer science. Human-computer interaction is a key issue to consider in the design and development of software, and in the evolution of technology policy and procedure. This unit considers a range of subjects in the field from user

interface design to usability testing methodologies. We will address the design process, explore how to study user behaviour, and look at how others have produced theories to fit behavioural observations. Topics will include: the paradigmatic history of human-computer interaction; theories and frameworks of technology use; methods, methodologies and analysis techniques for studying people; techniques for graphical user interfaces and beyond; an interface's usability and universality. Tools and technologies supporting interaction design.
Aims: This unit introduces systematic approaches to human factors in computer science. It explores how to understand users, and then provides techniques to apply that understanding appropriately in design.

Teaching details
20 Lectures and additional seminars

Assessment Details
100% Coursework

Reading and References (indicative only)
Alan Dix, Janet Finlay, Gregory D. Abowd, and Russell Beale (2003), Human-Computer Interaction, 3rd Edition. Prentice Hall, 2003. ISBN:0-13046-109-1

INOVM0013 Innovation, Entrepreneurship and Entreprise

Unit Description
The world of work is changing rapidly; new technologies are creating not only new companies but new ways of working. Small companies are disrupting established businesses and permanent jobs in many sectors are being discarded in favour of flexible contractors and freelancers. Even established old companies are furiously trying to innovate new products, services, and markets to keep up and avoid being disrupted out of business.
To succeed in this emerging economy, you'll need to not only embrace technology but be enterprising and entrepreneurial in your behaviour to spot and seize opportunities for yourself and for the companies you'll work for. Entrepreneurial thinking is not just the preserve of Silicon Valley, it's a way of searching for and executing on business ideas that is relevant to anyone trying to create value for themselves and others.
The aim of this unit is to develop your understanding, abilities and skills in all aspects that are essential to set up or be part of a successful entrepreneurial venture.
You will work in a team, with mentor advice, to develop a business plan and give a presentation to potential investors. You will need to generate a business idea that is sustainable in both senses of the word; firstly, it is economically viable for the ongoing future and, secondly, the impact of the business to the planet's resources has been thought through and mitigated.
We're also interested in how your idea developed; and one part of the assessment specifically asks you to document the process through which your team and idea developed.
The broadest view of entrepreneurship is taken in the unit - the entrepreneurial venture could take one of several forms, for example:

- A commercial start-up company which is solely economic growth/profit oriented
- An initiative concerned with social entrepreneurship or a not-for-profit enterprise which combines economic sustainability with some form of social impact

Lectures and workshops will cover examples and latest thinking in several generic areas related to entrepreneurship. However, groups will be expected to identify and engage with a wider range of material, both of an academic and business nature, as required by their particular venture.

Teaching details
Lectures, Group meetings, Workshops

Assessment
Business Plan Assessment (70%); Presentation (30%)

Reading and References (indicative only)

- The lean startup: how constant innovation to creates radically successful businesses - Eric Ries, 2011
- Value proposition design - Alexander Osterwalder, Yves Pigneur, Gregory Bernarda, Alan Smith, 2014
- Business model generation: a handbook for visionaries, game changers, and challengers - Alexander Osterwalder, Yves Pigneur, dawsonera, 2010
- The innovator's method: bringing the lean startup into your organization - Nathan Furr, Jeff Dyer, BusinessNews Publishing Ltd, dawsonera, date of publication not identified

- The new business road test: what entrepreneurs and executives should do before launching a lean start-up - John W. Mullins, dawsonera, 2013
- Blue ocean strategy: how to create uncontested market space and make the competition irrelevant - W. Chan Kim, Renée Mauborgne, c2005

COMSM0017 Applied Data Science

Unit Description

This unit introduces key data science concepts and their application to support data-driven approaches to problem solving.
The aim of this unit is to allow students to acquire fundamental skills covering the full data science pipeline, including the pre-processing, manipulation, integration, storage, exploration, visualisation and privacy. Students will study techniques to transform raw data into advanced representations that will enable a deeper understanding of the original data:

- Data ingress and pre-processing
- Data storage and data management
- Data transformation and integration
- Data exploration and visualisation
- Data sharing, privacy and anonymisation

The students will also gain practical skills in handling structured and unstructured data, gaining hands-on experience of software tools widely used in real-world settings.

Teaching details

This unit involve lectures that will cover the recent advances in applied data science. The topics are addressed from a practical point of view, following the emphasis of a hands-on point of view. This will enable students from different backgrounds to be able to understand the fundamentals of the data science techniques that they will implement in the coursework.
In addition, there will be weekly Q&A sessions in which students can get help, advice and feedback on their current progress with the coursework.

Assessment Details

100% coursework (10% presentation: 90% project)
Assessment will be through a significant data science project, which will be carried in groups of 4-5 students. The projects will be on the basis of real-life data provided by a number of domain experts. Groups will need to pitch for 2 projects after which the allocation is made. The groups do their software development on a platform such as Github and can request formative feedback on their progress up to three times before the final submission, at a time of their choosing. 1-2 weeks before the final submission there will be a workshop where all groups present their proposed solution to the entire cohort and the domain experts and therefore will be able to incorporate any further formative feedback into their final submission. This final submission is due at the end of the teaching block and will be summatively assessed on all intended learning outcomes as they correspond to different stages of the data science pipeline.

Reading and References (indicative only)

- Mining of Massive Datasets, Anand Rajaraman, Jeffrey David Ullman, Cambridge University Press, 2011.
- Principles of Data Mining, David J. Hand, Heikki Mannila and Padhraic Smyth, MIT Press, 2001.
- Information Visualization, Colin Ware, Morgan Kaufmann, 2012.
- Additional reading material in the form of research papers, online resources, etc.

COMSM0022 Computational Logic for Artificial Intelligence

Unit Description

This unit provides an introduction to knowledge-driven AI from the perspective of computational logic. It covers the basic principles of knowledge representation and automated inference by means of logic programming languages, which have pattern matching and backtracking search as primitive operations.
This then leads to more advanced methods in natural language processing and machine learning which exploit the representation and reasoning power of logic programming.

Teaching details

2 hours of lectures and 2 hours of unsupervised labs per week

Assessment
Programming assignment - students will be given a simple implementation (on one of the main voice-driven personal assistant platforms) of a conversational chatbot with basic reasoning capabilities, and asked to extend this in various ways (50%)
Viva/Oral Examination (50%)

Reading and References (indicative only)
Peter Flach. Simply Logical - intelligent reasoning by example. Interactive online copy at https://book.simply-logical.space

COMSM0023 Dialogue and Narrative

Unit Description
This unit presents the theoretical foundations for interactions that are narratively structured, reflecting the human bias towards organising our experiences as (language, logical and visual) narratives. Understanding the narrative structure requires a deep understanding of Natural Language Processing (NLP) components going from low-level text mining and segmentation to discourse-level analysis and summarisation. The unit builds upon these to teach core concepts in dialogue management, argumentation theory, and computational modelling of narratives.

Teaching details
This unit will be made up of a combination of taught lectures, problem classes and unsupervised lab classes.

Assessment Details
Coursework 50% which will involve implementing an interactive dialogue system using one of the presented interfaces (e.g., Alexa Skills).
Written examination, 2 hours.

Reading and References (indicative only)
Selected literature, references and online material will be provided at the start of the unit.

COMSM0027 Responsible AI

Unit Description
This unit gives a solid grounding in fairness, accountability, transparency, privacy and trustworthiness in AI, and related concepts relating to ethics, law and regulation. Using case studies we will present and analyse these concepts from the perspective of industry, academia and government. Wherever possible these case studies will be drawn from PhD projects from earlier-cohort CDT students or other PhD students in the school.

Teaching details
This unit will be made up of a combination of seminars and problem classes.

Assessment
The unit will be assessed through an essay (~ 2,000 words) drawing on literature study and selected case studies. (100%)

Reading and References (indicative only)
Selected literature, references and online material will be provided at the start of the unit

COMSM0028 Advanced Topics in AI

Unit Description
This seminar-style unit introduces advanced and state-of-the-art topics in AI. There will be a mix of presentations by academics and students. The goal of the unit is to both improve the breadth and depth of general AI knowledge and to learn how to process and present scientific material.
The selected topics are chosen to be practically applicable and make students reflect about future research directions. Some topics might not strictly AI but related; they are included to understand the wider context of

AI. Examples of topics to be covered in the first year include: Explainable and Interpretable AI; Reinforcement learning; Experimental design; Evaluation and psychometrics.

Teaching details
This unit will be made up of a combination of taught seminars and problem classes.

Assessment Details
The unit will be assessed through a presentation (talk) on one or more of the topics covered (30%) and a written report (2,000 words, 70%).

Reading and References (indicative only)
Selected literature, references and online material will be provided at the start of the unit

COMSM0026 Interactive AI Group Project

Unit Description
The aim of the group project is to integrate and consolidate knowledge from the different components and it serves to put in practice the skills learnt in other units, whilst focusing the workload and strengthening the cohort. Students will work in groups (3-5 students with defined roles mimicking an industrial setting). Each group project will be supervised by one academic and one industry partner, who will act as a stakeholder. Y2 students will act as mentors, thus building up leadership skills. The group will deliver a working Interactive AI system combining a particular set of AI topics, which will change from year to year, adapting to students' interests, suggestions from industry partners and recent progress in AI. Topic sets suggested by our partners include {Information Retrieval, Text Mining and Natural Language Processing} and {Personalisation, Recommender Systems and Networks}. In practice, the project consists of three stages.

1. Set up. The students are presented with a set of best practices as provided by our industry partners to realistically recreate an AI team. This involves discussions on software design, code reviews, agile development and continuous integration. Additionally, the students will be introduced to the computational and data infrastructure
2. Dive in. The students plan and estimate the duration of the tasks and work together as a team. Additionally, the students learn about the targeted AI topics
3. Wrap up. This stage involves the final testing and deployment. The students present the project and get feedback from the stakeholder – that can still be incorporated into the final report.

Teaching details
Taught classes, group meetings and progress meetings

Assessment Details
Presentation (talk) involving the whole group, detailing the work done, way of working and break-down of tasks - 30%
Group Project Report, 20,000 words - 70%

Reading and References (indicative only)
Dependent on project

COMSM0024 Summer Project

Unit Description
The project offers two possible itineraries. For students with a clear project/supervisory team in mind, this sets the scene for the PhD thesis to be developed in Years 2 to 4. The main purpose of this initial phase is to compile the literature review and analyse the feasibility, social impact and any ethical issues. It will deliver a small proof-of-principle implementation and also a report, including the outline plan of the subsequent project. The project will be presented in the form of a poster in the next Summer School. For students that need to further explore the field, they will be allowed to undertake two smaller projects involving up to two supervisory teams, such that one of them will develop into the subsequent thesis. This flexibility in how to shape the Summer project was strongly recommended by our project partners.
Between TB1 and TB2, a Winter School will be organised involving all CDT cohorts, industry partners and potential supervisors. The aim of the Winter School is to showcase the range of research being done in the CDT, and to help prepare Y1 students to choose their Summer project and PhD topics.

Teaching details
All projects will be supervised by an academic. After an initial introduction to the problem, students will manage their own activities, with weekly supervisory meetings.

Assessment
Poster Presentation - 10%
Project Report, about 30,000 words - 90%
For students doing two smaller projects assessment will be pro-rata (two project reports of about 15,000 words, each worth 45% of the overall mark; two poster presentations, each worth 5% of the overall mark).

Reading and References (indicative only)
Dependent on individual project selection

UNIVERSITY OF BRISTOL CDTS - DIFFERENCES AND SIMILARITIES

If you are interested in the Interactive AI CDT then you may also be looking at the other CDTs at the University of Bristol and weighing up which best fits your interests. The following is intended to give a summary of the principles and visions of each CDT that are in a similar academic field.

Interactive Artificial Intelligence CDT (UKRI)
Based in the Department of Computer Science, this 4-year PhD programme trains the next generation of innovators in responsible, data-driven and knowledge-intensive human-in-the-loop AI systems. The training programme will deliver cohorts of highly trained PhD graduates with the skills to design and implement complex AI pipelines in which responsible interaction between AI and humans takes centre stage.

Artificial Intelligence, Machine Learning and Advanced Computing CDT (UKRI)
Based in the School of Physics, this CDT offers PhD opportunities across the areas of particle physics and astronomy, biological and health, and mathematical and computer sciences. Training in AI, high-performance computing (HPC) and high-performance data analytics (HPDA) plays an essential role, as does engagement with external partners, which include international companies, locally based start-ups and SMEs, and government and Research Council partners.
The CDT is built upon research and training collaborations between the universities of Aberystwyth, Bangor, Bristol, Cardiff and Swansea.

Digital Health and Care CDT (EPSRC)
Based in the Department of Electronic and Electrical Engineering, this CDT offers a multidisciplinary PhD programme that brings together students from health and life sciences, computer science, design and engineering. Its vision is to create a generation of innovators who understand how smartphone apps, wearables & smart homes can support decision-making by health professionals and help a patient manage their own health.

Future Autonomous and Robotic Systems CDT (FARSCOPE, EPSRC)
As a collaboration between the University of Bristol and UWE, the FARSCOPE's vision is *ubiquity* – robots everywhere – looking at the richness with which robots interact with their surroundings. *Ubiquity* promotes consideration of contextual impact beyond the machine, including social and societal considerations that are common to robotics deployments in any scenario; extreme and challenging environments, next-generation manufacturing, autonomous transport and health and social care.
Their programme is designed to get students' thinking beyond a robot's technology and about its environment. This requires multidisciplinary thinking, as enabling technologies of computer science and engineering interface with questions of natural and life sciences, policy, ethics, law and more.

Computational Statistics and Data Science CDT (COMPASS, EPSRC)
Based in the School of Mathematics, this 4-year PhD programme focuses on statistical and computational techniques of data science. The programme trains graduates in modeling, uncertainty quantification, prediction and decision making skills. Their PhD research topics range from statistical theory and methods to collaborations with experimental scientists and businesses.

FUNDING

The Interactive AI CDT offers a number of fully-funded 4 year PhD studentships covering:

- tuition fees at UK/EU student rates
- tax-free stipend of £20,500 per year for living expenses and
- a research budget to support research related activities, travel, equipment etc.

We are governed by the EPSRC Student Eligibility rules - epsrc.ukri.org/skills/students/help/eligibility/ - and can therefore only offer funding to UK/EU students who have ordinarily been resident in the UK for at least 3 years prior to the start of the studentship.

Candidates from EU countries other than the UK are generally eligible (subject to their eligibility on grounds of academic qualifications) for awards restricted to the payment of tuition fees only; no Revised May 2018 19 maintenance award will be payable. In order to be eligible for a fees-only award, a candidate must be ordinarily resident in a member state of the EU, in the same way as UK candidates must be ordinarily resident in the UK.

For outstanding candidates, the CDT may choose to provide open eligibility for up to 10% of the students starting in an academic year without the normal residency eligibility restrictions applying. The CDT cohort can, therefore, include EU students who would have received a fees-only award in other circumstances, or international students.

Applicants who do not meet the criteria listed above are welcome to apply, however they will be required to find funding from other sources. These funds must cover the tuition fees, living costs and research training support costs. The University's Funding Database may help with this search - http://www.bristol.ac.uk/fees-funding/search/.

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