For prospective students

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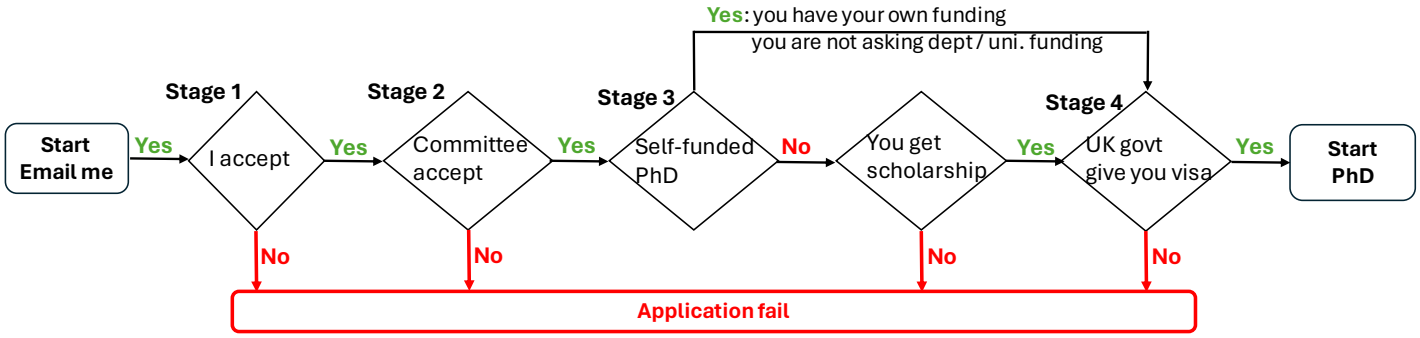
Doing a PhD requires lots of reading. If you can't even finish reading this document, it gives me a negative impression that you don't have reading skill.

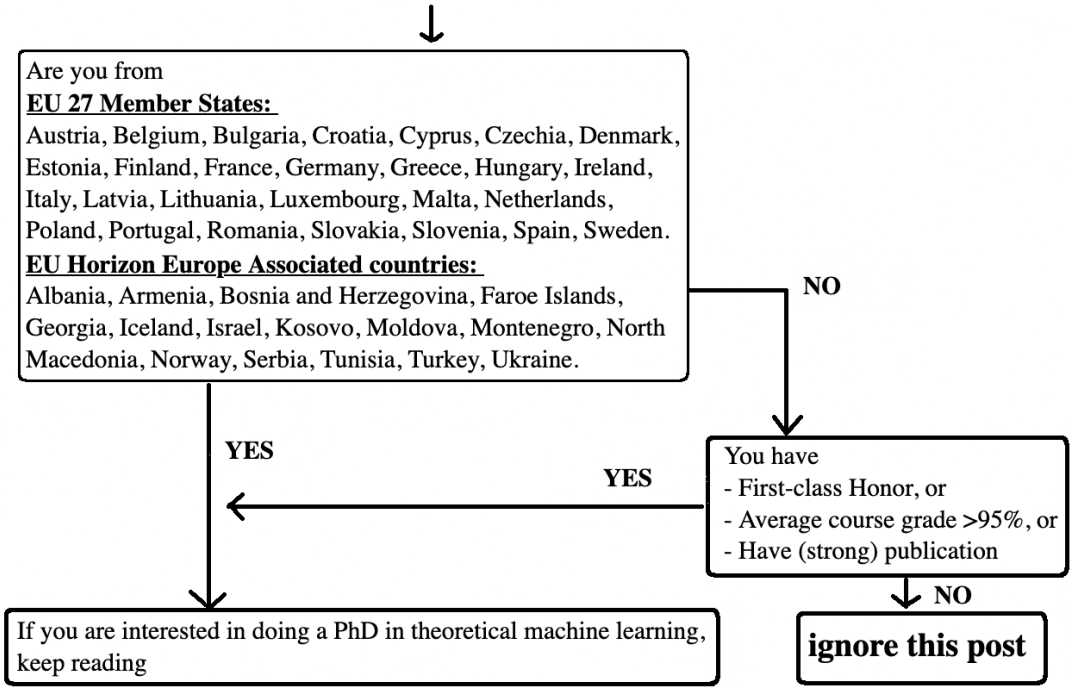
General information

- Four PhD scholarships available for Theoretical Machine Learning
- We are seeking highly qualified candidates for doctoral positions on the research of Machine Learning (ML).
  - We are looking for a MSc in applied mathematics, computer science, operations research, statistics, engineering, mathematics, or a related discipline with strong theoretical training.
- The project focuses on the theory, algorithms and applications for ML based on generalised nonconvex low-rank models. The goals include designing faster algorithm, understanding the working principle behind ML, applying ML to solve application problems.
  - This research is a mathematics-heavy project, it is not just about "applying method X on data Y". You are expected to learn, understand, and develop theory to prove that "why method X will work", "when will method X work" and "how fast will method X converge".
  - I instantly reject projects like "I want to apply deep learning method X on data Y". Unless you are proposing something interesting like "Using algebraic geometry to study the theory of deep learning".
- You will have the flexibility to choose a topic within the range of this project.
  Area/ Topics:
  - Nonsmooth Nonconvex Optimisation
  - Nonsmooth optimisation on manifold
  - Analysis of optimisation algorithm by differential equations
  - Submodularity and Combinatorial Optimisation
  - Graph-theoretic machine learning
  - Numerical Analysis / Numerical Linear Algebra
  - Tensor-based signal processing
  - Optimal transport for machine learning
  - Foundation of machine learning via Clifford-Grassmann algebra
  - Foundation of machine learning via Subtropical algebra
  - Quantum optimization algorithm
- What we offer
  - High quality training to do theoretical machine learning
  - Exciting theoretical research topics
  - Flexible research environment
  - Full PhD scholarships (£18622 per year for 3.5-4 years) number for 2024
  - £1400 per year for conference
- Requirement
  - good mathematical skills
  - good programming skills in a numerical language (such as MATLAB, Python, or Julia)
  - good communications skills, both written and oral, in English
- Before you make a decision, go to angms.science for more information.
  Contact Andersen Ang (`andersen dot ang at soton dot ac dot uk`) to discuss any details of the project.

1 Your application has 4 stages



On funding The finance people will be "more flavourable" towards the following students.



Send your complaints to the UK government if you think this is unreasonable / unfair.

2 Basic information

- PhD entry requirements (from the university)
  - 1st / upper-2nd class honours degree or equivalent
  - English: IELTS $\geq$6.5 overall & $\geq$6.0 each item — On English level requirements
- What you will get
  - PhD program: PhD in Computer Science
  - You will have two supervisors, one is me.
  - Standard PhD scholarship length: 3.5 years
  - Money numbers: £90000 (local student) and £180000 (international student)
    - Tuition fee: £4700 - £5000 (local student), £25500 (international student) **per year**
    - Your stipend (your take home salary): £18622 - £20000 (**tax free**) **per year**
    - You have £1400 for conference travel, books, course, computer **per year**
    - **Summary**: in 3.5 years, you get salary £65177, £4900 for conference, computer and training

3 Procedure for PhD applications

Professors do not directly admit students. You apply through the university.

Steps

- **Step 0** You (the student) contact me (the proposed supervisor) & send me the following
  - CV, Academic transcript (to date) & degree certificate (if graduated) — no page limit
    These tell me about your academic background
  - Personal statement — 0.5 - 1 page
    This explains your motivation
  - Research statement / research proposal — 1 - 2 pages
    This explains your research interest & how it aligns to mine, and your understanding of the field
  - 2 reference letters in official letter head — 1 - 2 pages each

  THEN I read your file. IF I am interested, I will reply your email and arrange an online meeting. After the meeting, IF I agree to accept you as a PhD student, go to step 1a.

- **Step 1a**. The student make a formal application to the university
  - put my name on the application
  - say in the application how you plan to fund your studies: you are looking for funding from
    - Internal scholarship (Scholarship within University of Southampton)
      - University scholarship
      - Faculty funding / School of ECS funding: DTP/ECS studentships
      - Right now I have no my own fund but **I am prioritized for ECS funding**, see Section 4
    - External scholarship (Scholarship outside University of Southampton)
      - UK Government scholarship
      - Government scholarship from your country
      - Other external funding
      - UK government loan — Not recommended

- **Step 1b** The faculty sends me your application, I accept, go to step 2. — No promise of funding at this stage

- **Step 2** Funding
  - IF {you look for funding from me} AND {I have funding}:
    - IF I say yes THEN go to step 3.
    - IF I say no THEN go back to step 2.
  - IF you look for university / faculty funding, the application goes to a committee that will decide on funding.
    - Each application can only be considered twice by the committee.
      I.e., if you failed twice, you will never be considered again.
    - More change for stronger student: good degree / achievement / research experience / publication record.
      Contact me, I will look at your application material and advise how to improve.

  After you have finalized the funding, go to step 3.

- **Step 3**. University send you an offer letter / conditional offer letter.
  - Apply for student visa (`https://www.gov.uk/student-visa`) — (English test / ATAS)
  - We decide the exact starting date of your PhD study.
  - You look for accommodation (Section 8) and start preparing.

4 Faculty / Department funding for PhD (PGR) students

ECS has funding for several PhD students and **I am prioritized for the funding**. That means,

- if you are from UK/EU **and you are strong**, I have a high chance to have a fund from ECS to support you.
- if you are from oversea but **you are very strong**, I have a high chance to have a fund from ECS to support you.
- Terminology
  - home/local: UK students, EU or HE-associated
  - oversea: non-UK students
  - PGR: postgradusate research
  - ECS: School of Electronics and Computer Science
- Priority of PGR funds goes to home student, if overseas student need other funds to cover extra international fees, see Section 2.
- (I will do these) Before a student can be considered for funding
  - they are required to undergo an interview with at least two academic staffs
  - read paragraphs 13 and 14 of the PGR Code of Practice
  - Complete Postgraduate Application Form, ask me for the form
  - Complete forms 3 (I will do it)
  - Complete ECS PhD Studentship Application Form 4 (I will do it)

5 Documents you need

- Readable academic transcript (to date) and degree certificate (if any) in English — no page limit
- CV — no page limit
- Personal statement — Max 1 page
- Research statement — Max 2 pages (you can put figure /chart)
- 2 reference letters — Max 2 pages each
- English language certificate (if needed) — for student visa
  Make sure your English certificate is recognised by UKVI (UK Visas and Immigration)
- If you apply for ECS scholarships
  - Form 2, Form 3, ECS PhD Studentship Application Form (form 4) — ask me for these forms
- ATAS certificate and UK student VISA, see Section 7 — apply after you get the offer

If your documents are not in English, they need to be translated into English. You either get the official English version of the document, or you pay for certified translation service (those regocnized by UKVI[1]) to translate your document to English.

[1] UK Visas and Immigration `https://www.gov.uk/government/organisations/uk-visas-and-immigration`

6 Some tips and links

- **Don't send me your research proposal before knowing what I do.**
  - An immediate reject: you didn't even do research on knowing what my research is.
  - Explain why you want to work with me
  - Explain what topics within my expertise interested you
  - Elaborate your understanding of the research field
- Online resources
  - Apply for a research degree `https://www.southampton.ac.uk/study/postgraduate-research/apply`
  - Write a PhD CV `https://uk.indeed.com/career-advice/cvs-cover-letters/phd-cv`
- Scholarships
  - Southampton PhD Scholarships
    `https://www.southampton.ac.uk/doctoral-college/presidential-scholarships.page`
  - Southampton funding opportunities
    `https://www.southampton.ac.uk/doctoral-college/funding-opportunities.page`
  - Postgraduatesearch.com
    `https://www.postgraduatesearch.com/funding`
  - PROSPECTS (scholarship search)
    `https://www.prospects.ac.uk/postgraduate-study/funding-postgraduate-study`
  - British Council (Search for UK courses and scholarships)
    `https://study-uk.britishcouncil.org/scholarships-funding`
  - Look for industrial scholarship
  - Look for government scholarship from your country

7 After you get the university offer: UK VISA

1. Information from the university
   `https://www.southampton.ac.uk/studentservices/visa-and-immigration/index.page`
2. UK government page
   `https://www.gov.uk/browse/visas-immigration/student-visas`
   - English requirement
     `https://www.gov.uk/student-visa/knowledge-of-english`
     This is the government's requirement, not the university's requirement (and they can be different)
   - About brining your partner and children
     `https://www.gov.uk/student-visa/family-members`
   - Academic Technology Approval Scheme (ATAS)
     `https://www.gov.uk/guidance/academic-technology-approval-scheme`

8 After your VISA is successful: prepare your PhD life

- Apply for a UK bank online before the trip.
  UK banks have low efficiency, it may take few weeks or even a month to open your bank account.
- Prepare a UK sim card
- Prepare some £, I recommend £1500 - £2000 for your first month bills, rents and living expenses.
  (Some landlords may ask you to pay for 3 months of rent in advance.)
- Plan your finance: your PhD stipend (£18622 - £20000) is tax free. Your salary each month is £1541 - £1666.
- Cost of living
  - Accommodation

  - ∗ Student accommodation in Southampton — recommended
  - ∗ VITA student — high-end, only if affordable
  - ∗ unihomes
  - ∗ rightmove

  The first two options will lump everything together into one single cost and free yourself from dealing with electricity bill, gas bill, water bill, internet bill, phone bill, TV bill, etc.
- Local transportation: £2 per bus trip or £360 for one year bus pass (infinite many bus trips)
- Personal advice: do not put more than $35\% - 40\%$ of your salary on rent (excluding bills). That is about £600 - £750.
- For lower rent, you can look for house share in rightmove.

- In UK all adults have to pay Council Tax. PhD students are exempt from paying Council Tax. However, if you are moving with your partner, your partner may need to pay council tax. See Southampton City Council.
- Familiarize yourself with Southampton map, zip code, and important locations
  - post office (apart from mail, UK post offices also deal with bills, phone, ID card, internet, currency exchange)
  - hospital
  - bank

9 Work expectation

- Flexible 40 hours of work per week — 8 hours each day Mon-Fri
  Flexible, lunch time / sport time counted in working hours
- A year has 52 weeks, so in theory you have 2080 work hours. In practice you have 1500-1600 work hours.
- A course takes < 50 hours. For a "intro-intermediate-advanced" 3-unit course structure, it takes 150 hours to master a subject.
- Counting half of the time to study (other half go to research), you need to master at least 8 subjects.

10 My view about PhD study

- PhD should be about theoretical frontier, not on application.
  PhD focusing too much on a particular application should be considered "industrial practioner".
  I am not saying you should do no application, I am saying you shouldn't do no theory.
- Math is important. No math, no PhD.
  Math is the queen of science. Math is a formal language system for doing research. All researcher has to master at least TWO FIELDS of maths (not two topics, two areas, but two fields).
- Depth is important. No depth, no PhD.
  In the future all shallow things will be replaced by artificial intelligence. People with no in-depth skills have no competitiveness.
- Breath is important. No breath, no PhD.
  I believe maths is not invented but discovered. You make discovery by connecting the dots. To connect dots you have to know at least TWO DOTS, hence you have to know at least TWO FIELDS of maths.
- My minimum requirement for PhD
  - Math genius? Not necessary.
  - Good at math? Not necessary.
  - Good math grade? Not necessary.
  - Good at coding? Not necessary.
  - Good at English? Should.
  - Good at reading? Should.
  - Good at writing? Should.
  - Good at presenting? Should.
  - Hardworking? Must.
  - Willing to learn? Must.
  - Motivated to learn? Must.
  - Ambitious? Must.

11 Lists of things I am interested (not in any order)

Optimization

- Nonlinear optimization
- Nonsmooth optimization and subdifferential
- Optimization algorithm design
- Convergence analysis of optimization algorithm
- Acceleration of optimization algorithm
- Block-coordinate descent
- Nonconvex optimization
- Convex analysis for optimization
- Inexact proximal gradient method
- Trust-region methods
- Nonproximable optimization and proximal average
- Differential equation technique for optimization
- Proximal bundles
- Manifold for optimization on non-Eucledian space
- Zeroth order method
- Semi-smooth Newton's method
- Semidefinite optimization
- Randomization for optimization

Linear algebra

- Nonnegative matrix factorization
- Nonnegative tensor factorization
- Numerical Linear Algebra
- Randomized Linear Algebra

Graph topics

- Spectral graph theory
- Sum-of-norms clustering

Expository topics

- Multi-level/scale/grid methods for optimization
- Fractional derivative for optimization
- Exterior algebra and derivative for optimization
- Wasserstein metric
- Matorid
- Complex derivative for optimizaton on $\mathbb{C}$
- Pseudospectrum
- Pseudomatrix

Applied pure mathematics

- Algebraic geometry for optimization
- Differential geometry for optimization
- Convex geometry for optimization
- Algebraic topology for optimization
- Functional analysis for optimization
- Abstract algebra for optimization
- Combinatorics for optimization
- Probability for optimization

Applications

- Identifiability
- Signal processing
- Blind source separation
- Hyper-spectral imaging
- Text mining
- Bioinformatics
- Snake / active contour model
- Sparse optical flow

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