

2026-27 HIVE Summer Internship Project

Visualising Classical and Quantum Computing for Optimisation

Primary Academic Supervisor

Prof. Ryan Loxton

Project Background

The project will involve researchers from the Centre for Optimisation and Decision Science (CODS). CODS is a R&D consulting unit at Curtin that specialises in using data and mathematical models to optimise scarce resources and make better decisions. The team is a mix of mathematicians, data scientists, and engineers who have worked with a wide range of companies and government organisations across mining, agriculture, energy, and defence to solve real-world data problems.

The challenge with these problems is that the number of potential solutions grows extremely rapidly. This is because there are often multiple variables that can be controlled, and they all interact with each other; i.e., the variables are not independent, and changing one forces the others to change in non-trivial ways. The challenge is to choose the best values for the variables to optimise some measure of performance, such as maximising efficiency or minimising cost.

Consider, for example, the problem of choosing when to schedule maintenance activities for a large piece of infrastructure. There are typically hundreds of such activities, with constraints such as certain activities must occur before other activities, or certain activities must occur within certain time windows. If we have 100 activities and 20 work shifts in which to schedule, then there are at least $100 \times 20 = 2000$ variables, far too many to consider manually. These problems often become much larger and it's not uncommon for the number of potential solutions to exceed the number of atoms in the solar system!

The purpose of this project is to visualise this complexity and how quantum computing can be used as a potential remedy. Quantum computing is a

new computing approach based on quantum physics with the ability to explore multiple "computational paths" simultaneously, differing from classical computers that can only explore one path at a time. Interest in quantum computing is exploding with Google and IBM leading the charge.

Project Description, Expected Outputs, Possible Stretch Goals

The purpose of the project is to create a series of animations or short videos to visualise:

1. How optimisation challenges arise in real-world applications,
2. The complexity of optimisation challenges - how the number of variables and potential solutions grow rapidly (often reaching massive numbers that are difficult for humans to conceive),
3. How classical computers and quantum computers explore the search space in different ways to solve these problems.

The aim is to have visualisations suitable for a general audience, to help convey the challenges of real-world optimisation and the importance of having smart algorithms to address them. These algorithms typically exploit the mathematical structure of the problem. CODS specialises in this area.

The student does not need to have a background in optimisation or mathematics. The supervision team will provide this and explain how the algorithms work and the concepts we would like to see visualised. We envisage that there will be two-way exchange at the start of the project, with the CODS team providing an understanding of optimisation and data challenges, and the student providing advice on what visualisation options are available. The team will then work together throughout the project to explore different concepts for points 1-3 above.

Links to background reading and any relevant recent work in the field

- The project supervisor's LinkedIn page contains links and videos on applications of optimisation: <https://www.linkedin.com/in/ryan-loxton-257487a1/>
- Additional background information is available on the website of Gurobi, the world's most advanced optimisation engine (for classical computing): <https://www.gurobi.com/>

- Case studies on the CODS website: <https://www.optimisation-centre.com.au/>

What type of visualisation will the student develop or produce?

Mainly video content - short animations or videos as described in the previous section. For example, we have previously created a video of an expanding search tree, to show how the tree grows rapidly as the number of dimensions increases - this forms a good starting point for the types of visualisations we are expecting.

The VR, 3D models, graph visualisation options would also be interesting to explore - we would seek advice from the HIVE team should this project progress.

How will the visualisation contribute to your research outcomes?

CODS specialises in developing mathematical algorithms for solving optimisation and data science challenges. These challenges are highly technical and difficult to explain to a general audience. Having a polished set of visualisations/animations will help us reach additional industry and government partners, opening up new project opportunities. This is critical to sustaining the capability in CODS since the group is predominantly externally funded, and relies on grants to sustain the team.

If the project is successful, where would you consider publishing the results?

The results will be displayed on our website and be embedded within our presentations to industry and government. We could also use the results for outreach activities with high-school students.

Draft Project Timeline:

Week 1

Nov 16 - Full day HIVE induction

Nov 17 - Area and Project Induction with Primary supervisor

Develop project plan with HIVE and academic team

Literature and relevant project review

Project Familiarisation

Week 2

Review of background on optimisation and previous animations,

Brainstorming visualisation concepts

Week 3

Workshops with the supervision team and potentially HIVE team to decide on visualisations to pursue

Week 4

Produce animations - how optimisation arises in the real world

Week 5

Produce animations - how optimisation arises in the real world

Week 6

Produce animations - Computational complexity

Week 7

Produce animations - Quantum computing approaches

Week 8

Produce animations - Quantum computing approaches

Week 9

Focus on report writing and presentation (including demo) preparation

Week 10

Focus on report writing and presentation (including demo) preparation

5th Feb Final Showcase Day and final report due

Student Experience and Supervision:

How often will you meet with the student over the 10-week period?

At least once per week. Most likely multiple sessions in the first two weeks to provide sufficient background ideas and contribute to brainstorming.

Your work desk location and the location of student desk

Building 314, level 4, in the shared space with CODS researchers.

Student Attributes:

Please indicate any preference for student's academic discipline or field of study

NA. We would seek advice from the HIVE team.

What competencies are required to start this project

Intermediate - 2D art/editing

Intermediate - Video production/editing

Intermediate - AI Integrations (build tools to assist with custom workflows)

Do you have any other student attributes you think are important to the project?

NA