

How I do Research

1 Why Research?

"Life isn't worth living if you have not found out the one thing it's worth dying for." - Lee Child

This section highlights my beliefs and ideas towards research and why it is essential from an academic standpoint. The discussion provided here follows a philosophical tone so please feel free to skip it if in the interest of time.

People have a reason and a liking to do the things they do. Some people like to cook, so they become chefs. Some people like to play, so they become athletes. Some people like music, so they become musicians. Along similar lines, some people like to *solve problems*. And these people become *scientists*.

My interest in academic research is built on the firm belief of making other people's lives better while I do what I like the most. A scientist forms a theory, conducts experiments and contributes to the community not because his day job asked him to, but because it brings him solace in the fact that his work will make a difference to other people's lives. Thomas Edison invented the light bulb not because his manager asked him to. He invented the light bulb to make his family's life better by removing the need for harmful candescent material. Thus, a researcher invents novel technologies *not for the sake of a better appointment, but for the sake of a better tomorrow*.

2 The Pandemic

The COVID19 pandemic has affected a lot of us and our progress as a research community. My Masters research was indirectly impacted by the pandemic. This section highlights the four measures I took to combat this hindrance.

- 1) While most of my reinforcement learning research team was let go, I made sure to be my own advisor. In order to continue my research, I devised a self-study plan highlighted in [section 4](#) which allowed me to stay disciplined towards my research.
- 2) Although my advisors worked in areas different from my research, namely unsupervised learning and computer vision, I made sure to reach out to other people in my research community. This allowed me to get a sense of direction and effective collaboration towards my projects.
- 3) Due to the depletion in computational resources, I found it difficult to train my models. To alleviate this issue, I subscribed to a personal Amazon Web Services (AWS) account and additionally gained access to the Department of Computer Science (DCS) servers.
- 4) The later half of 2020 made it increasingly challenging for me to work from home. To address this issue, I used the Gerstein Library's personal study spaces from 9 AM to 6 PM for a total of 6 months. This was carried out while complying to the social distance measures imposed by the Government of Canada.

3 The Ramification-based Approach

Academic research requires structure and concreteness from the learning perspective. To this end, I strictly follow a self-constructed plan which allows me to stay focussed towards novel ideas. My research methodology is based on the below listed 3 fundamental aspects of learning a new skill. These correspond to my self-study schedule which I follow on a day-to-day basis. [section 4](#) explains them in detail.

- **Daily Study-** Review theoretical concepts and implement programs everyday.
- **Reading-** Read 2 papers every week.
- **Writing-** Write 1 paper summary every week.

In addition to self-study, **I work towards a top-tier publication once every 6 months**. The reason behind this large time duration is my constant belief to improve our current methods and ideas. I firmly believe that a contribution which can make a significant impact on our research community is convalescent to 2-3 moderately rated papers.

4 Self Study

Independent research requires discipline and commitment towards a rigorous study schedule. Towards this goal, I constructed a self-study scheme which allows me to incorporate all the necessary components of research and build on my ideas simultaneously. [Table 1](#) presents my self-study scheme for independent research.

Table 1: Self-study scheme for independent research

| Day | Description | Tasks |
|-----------|-------------|-----------------------|
| Monday | project day | study |
| Tuesday | reading day | study + reading |
| Wednesday | project day | study |
| Thursday | reading day | study + reading |
| Friday | project day | study |
| Saturday | writing day | study + writing |
| Sunday | review day | study + weekly review |

4.1 Daily Study

As highlighted in [section 3](#), my concept study involves **learning new theoretical concepts and techniques every day of the week**. Concepts are reviewed and learned from literature in the form of review papers, textbooks, course notes and video lectures. While most of the study centers around theory from textbooks, I additionally solve exercise problems in the form of derivations and proofs. Following is a list of rigorous book concept studies completed from their respective resources-

- Data Structures & Algorithms- whole book ([notes + solutions](#))
- Pattern Recognition & Machine Learning (PRML)- Chapters 8-13
- Reinforcement Learning: An Introduction- whole book

- Neuro-Dynamic Programming- Chapters 1-6 ([notes](#))
- Abstract Dynamic Programming- Chapters 1-2 ([notes + solutions](#))
- Machine Learning: A Probabilistic Perspective- Chapters 21-28 ([notes](#))
- Convex Optimization- whole book ([notes + solutions](#))
- High-Dimensional Statistics: A Non-Asymptotic Viewpoint- whole book ([notes](#))
- Optimizing Algorithms on Matrix Manifolds- whole book ([notes](#))
- Programming Robots with ROS- Chapters 1-10 ([practice scripts](#))

As highlighted in [section 3](#), my implementations involve *building up on an idea for one month*. This process consists of understanding a large code base, redesigning the program by implementing my own ideas, carrying out experiments and evaluating my scheme while I build on the code. The central goal of projects is to **maximize the novel contributions while maintaining consistency with predefined programs**. Following is a complete list of projects undertaken during my self study-

- Evolution Strategies ([code](#))
- Deep Eligibility Traces ([code](#))
- Lua Classics ([code](#))
- Pybullet envs ([code](#))
- Viz Matrix Games ([code](#))

4.2 Reading

As highlighted in [section 3](#), my self study consists of **2 readings each week**. These readings consist of modern research papers in the broad field of Deep Learning. While I aim to center my paper selection towards Reinforcement Learning, my reading time frequently extends towards other areas such as Probabilistic Learning, Energy-based Learning, Bayesian Optimization, Computer Vision, Unsupervised Representation Learning. Occassionally, I read three papers a week depending on the availability of time. This section does not provide a complete list of papers I have read so far as there are simply way too many.

4.3 Writing

As highlighted in [section 3](#), my self study consists of **1 writing component each week**. The writing is a summary of one of the papers which I understood while doing my reading for a given week. In the interest of conciseness and quality, length of the summary is restricted to 1 page with its content focussing on the technical depth of the approach. My 70 writing summaries are available at [The Surreal 70 Samples](#).
