Proc. 3rd International Conference on Advancements in Engineering Education (iCAEED2024)
20-23 Nov 2024, Sydney, Australia
ISBN: 978-1-7636843-3-1

Artificial Intelligence-based Regional Flood Modeling: Illustration of Learning Aspects by a Doctoral Student

Nilufa Afrin[1], Ataur Rahman[2], Farhad Ahamed [3], Ahmad Sharafati [4]

[1]PhD student, School of Engineering, Design and Built Environment, Western Sydney University, Kingswood, Penrith, NSW, Australia
[2]Professor, School of Engineering, Design and Built Environment, Western Sydney University, NSW, Australia
[3]Associate Lecturer, School of Social Science, Western Sydney University, NSW, Australia.
[4]Associate Professor, Department of Civil Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran

Corresponding author's E-mail: 19658243@student.westernsydney.edu.au

Abstract

Design flood estimation in ungauged catchments remains a persistent challenge in the field of hydrology. To address this challenge, the Regional Flood Frequency Analysis (RFFA) is a widely accepted method. Until now, the RFFA method has primarily relied on linear approaches, which are inept to capture the complexity of nonlinear hydrological processes. The advent of Artificial Intelligence (AI)-based techniques has demonstrated superior performance in addressing this limitation. Recently in RFFA, several studies have indicated the effectiveness of AI-based models compared to linear models. The advantage of AI-based techniques lies in their ability to learn from given datasets without adhering to predefined rules, contributing to more accurate predictions. However, application of AI to RFFA problem is not straightforward. This paper outlines the learning aspects that the first author gains in carrying out her PhD research applying AI-based techniques to RFFA problem to New South Wales flood and catchment data. It is found that learning the fundamentals of the AI-based techniques is relatively difficult. Although its application to a dataset using available software is relatively easy, the interpretation of results and understanding assumptions related to the model output need significant efforts. The findings of this study will benefit other students and researchers who would like to apply AI-based methods to RFFA problems in Australia and other countries.

Keywords: Ungauged Catchment, Regional Flood Frequency Analysis, Artificial Intelligence.

1. INTRODUCTION

The PhD study focuses on a deep learning experience and is expected to transform an individual into a researcher (Barnacle and Mewburn 2010). It is a journey for an individual with fear and excitement (Owler, 2010), which can feel like the opening verses of The Book of Beginnings, in the beginning. The earth was without form and void (Genesis 1:2, The Holy Bible: King James Version). Therefore, with effort and planning, things take shape.

With a high passion for becoming an independent researcher and expert as a consultant, the first author boarded on a three-year journey as a full-time student of a PhD research when she was also doing full-time work in a private engineering consultancy company and committed to a young family to take care which was an intimidating task for her. For the first author, in the beginning, the journey seemed like a harsh long road ahead. Still, advice from the supervisory panel and converting status from full-time

student to part-time status helped her to manage the PhD journey. The PhD journey can be different for each candidate, for example, the first author of this article changed her research topic one year after her candidature commencement as it was difficult to get necessary data for the topic (water sensitive urban design), and she had to take one year of annual leave for family reasons. After losing two years of candidature finally, she started her doctoral research journey in the regional flood frequency analysis (RFFA) field. While the process of doctoral education is challenging, only enthusiasm and skill development can work synergistically to ensure a well-managed doctoral education. The first author of this paper in her candidature moving through different stages from being a "novice" (no experience in research) to becoming an independent researcher under an expert supervisory panel in Western Sydney University (WSU) . The principal supervisor, the second author of the paper, is a well-known researcher in RFFA who already supervised over 25 doctoral students. He is a demanding person but finds enough time for a PhD student.

This paper contributes to elucidate on the process and steps of learning aspect that the first author experienced in carrying her doctoral research journey in applying artificial intelligence (AI)-based techniques to the RFFA modeling.

2. LEARNING ASPECTS AND CHALLENGES

The PhD provides the space for candidates to learn what it means to do research and learn how to perform as a researcher to investigate a new problem. To pursue a doctoral degree, especially in a scientific field like developing an AI-based model for RFFA, researchers should navigate through several fundamental steps as shown in Figure 1.

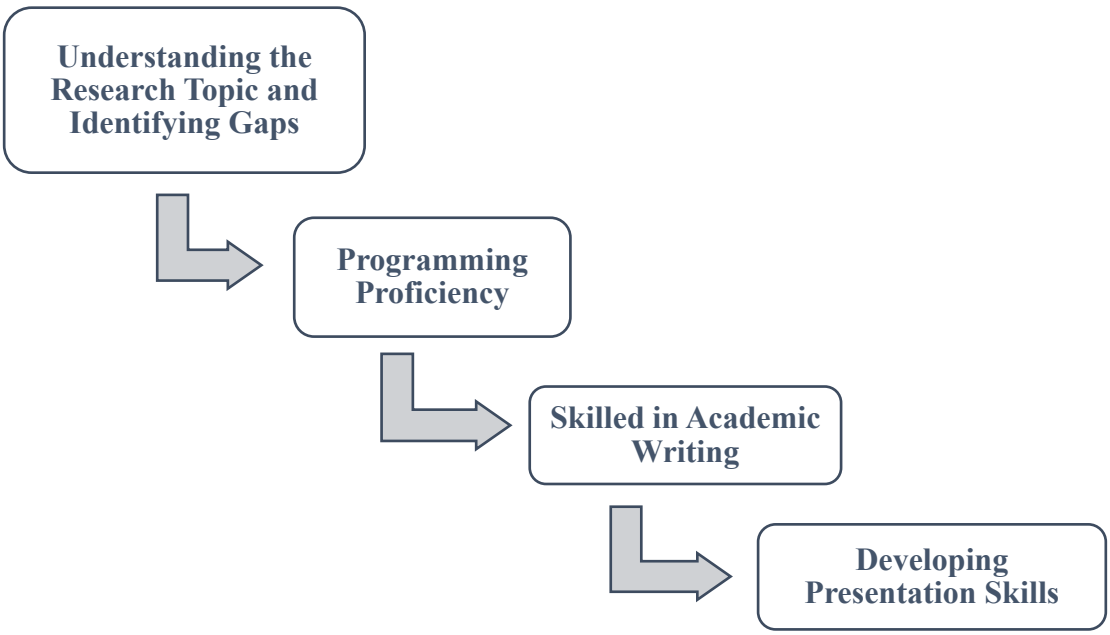

Figure 1: Steps to become an independent researcher through PhD journey

The experience of each step for the first author of this paper are described below.

a) Understanding the Research Topic and Identifying Gaps

It should be noted that reviewing ongoing research is crucial to understanding the state-of-the-art and pinpointing areas ripe for innovation. Therefore, any researcher needs to read and understand relevant publications. Until now, RFFA research involves different methodologies including linear and non-linear approaches. Each has its strengths and weaknesses depending on the application domain. Initially, the first author struggled to comprehend RFFA, its principles, and how catchment characteristics relate with flood data. This involves understanding how various hydrological and statistical parameters influence RFFA outcomes. The first author reviewed the Australian Rainfall and Runoff (ARR) suggested technique for RFFA, which was developed by the second author and his team (Rahman et al., 2019). For this reason, understanding its accuracy and limitations compared to other techniques was essential for benchmarking the ARR method. This analysis likely included the pros and cons of each technique, such as the effectiveness of kriging in stream catchments.

Understanding the current landscape of AI techniques being applied in RFFA and identifying gaps where existing methods may fall short is critical. Insights from AI applications in other fields provided valuable inspiration and benchmarks to the first author. Techniques that have proven effective elsewhere may offer new approaches or improvements for RFFA. AI-based techniques vary widely, from rule-based systems such as artificial neural networks (ANN) to modern approaches like deep learning and reinforcement learning. Each technique operates on different principles and is suited to different types of problems. AI is a rapidly evolving field where new techniques and methodologies constantly emerge. Staying updated with these advancements is crucial for developing state-of-the-art solutions in RFFA. Exploring AI applications across different sectors provided insights into adapting and optimising techniques like convolutional neural network (CNN) and ensemble machine learning (EML) for RFFA. This cross-pollination of ideas and methodologies from other fields helped innovate within the RFFA.

The first author contributed to the field by developing novel AI-based and EML-based methods for RFFA. This involved understanding different AI techniques (e.g., ANFIS, various ANN structures) and their applications in RFFA, each offering distinct advantages and requiring tailored interpretations for optimal results. The journey of the first author underscores the importance of deep domain knowledge, rigorous comparative analysis of existing techniques, and the leveraging AI and EML advancements to develop cutting-edge solutions for RFFA.

b) Programming Proficiency and applying AI

Proficiency in relevant programming languages is necessary for many hydrology research tasks. Depending on the research focus, languages like Python, R and MATLAB may be required. Before applying an AI-based technique for RFFA using any programming language, one needs to understand the principle of the technique, how it works and if the technique needs supervision or if it can be unsupervised. There are numerous free learning videos and websites online. The first author explored several books, learning videos, and websites to understand different AI-based techniques and principles when she was exploring the application of AI-based techniques in RFFA and other fields. This exploration found that AI-based techniques evolve with technological advancements such as once can integrating image, and speech with data easily and this gives better results to the researcher. Application of AI techniques is comparatively easy and language programmers of MATLAB, R and Python have already prepared a library for codes and apps to apply techniques effortlessly. The first author learned MATLAB and Python to apply AI-based techniques for RFFA by mainly using code and apps from libraries such as Matplotlib and Seaborn for Python and regression, clustering app, etc. for MATLAB. In applying codes and apps, she compared results with previous results to check their accuracy.

The first author also learnt to prepare meaningful graphs for statistical analysis and geographical information system to show the hydrometric station locations she is using for her research. Understanding statics to analyse and interpret results is key for many scientific research tasks or innovations, which acts as a benchmark to compare results with previous studies and give an indication for further research.

c) Skilled in Academic Writing

Academic writing skills are paramount for effectively communicating research findings. This includes maintaining coherence in writing, clearly presenting complex ideas, and accurately interpreting results using tables, graphs, and other visual aids. Maintaining a coherent structure in writing helps, readers follow the logical progression of ideas. The structure consists of clear introductions, transitions between paragraphs, and a well-defined conclusion that ties everything together. Effectively interpreting research results from tables, graphs, and visualizations is crucial as it enhances understanding and provides clear evidence to support research findings. To connect with a broader audience through writing needs to ensure that precise language has been used and jargon information is avoided. This transparency is especially important when explaining complex RFFA methodologies and AI techniques.

Initially, the first author struggled to capture academic writing style so she attended a few writing courses provided by WSU for HDR students. She then also followed other researchers' writing styles for each section such as from Introduction to Conclusion. She prepared her confirmation of candidature (COC) report, but on the first go it was not accepted by the supervisory panel. She then rewrote it and used more logical expression in the literature review and finally it was accepted. Under the guidance of her supervisory panel, recently her first journal paper has been published in a Q1 cohort journal; also, she submitted her second journal paper in another Q1 cohort journal. For the first author, writing was the hardest part to capture during her PhD journey. However, with time, practice, observation of other people's writing, peer review for writing and supervisors' comments helped the first author to improve her writing.

d) Developing Presentation Skills

Being able to present research findings cogently is vital for academic and professional success. Researchers must develop skills in structuring presentations, delivering engaging talks, and effectively conveying the significance of their research. Confidence in presenting one's research helps convey authority and credibility. Practice is key to improving presentation skills, whether through mock presentations, peer feedback, or attending workshops.

The first author attended iCAEED 2018 conference before she commenced her PhD and yearly three minutes presentation (3MT) organised by WSU since she confirms her candidature. In addition, she attended a half-yearly presentation, organised by her supervisory panel to present her research findings to her peers. She has also booked herself training for conference presentations organized by WSU to prepare herself for big conferences.

3. TEACHING ASPECT

The second author has supervised over 25 doctoral students. He faced several challenges in supervising these students: (a) few students took long time to master the art of scholarly writing; (b) few students struggled to learn computer programming, a vital part of doctoral research in statistical hydrology; (c) few students could not welcome criticisms in writing and data analysis; and (d) few students lost motivation and it was needed to encourage them frequently to continue to complete a doctoral degree. In the supervision of the first author, who did not complete her Master's degree before starting PhD, the second author found a significant improvement over the years in her candidature.

4. CONCLUSION

The PhD is a journey of becoming an independent researcher from a naive. This paper presents PhD journey of the first author and illustrates learning aspects of her research topic, which is AI-based model development for RFFA. With only a Bachelor of Science in Civil Engineering degree and several years of industry work experience, initially, she struggled to understand the process of becoming a researcher. From understanding RFFA methodologies to different types of AI-based techniques, learning

programming and applying AI, statistical evaluation and interpretation of results, connecting broader audience through publishing journals and finally presenting her research findings confidently to the audience is the process of training to become a doctorate holder. She is in her final year of PhD and she understands it is vital for any professional to become an expert in all these processes and one must go through these processes gradually, either as a full-time PhD student or as a part-time student. Furthermore, she understood technologies evolve rapidly, and new programming languages and frameworks emerge and as such, researchers in statistical hydrology should have the capacity to adapt and learn new programming languages as needed to stay at the forefront of their field.

REFERENCES

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia

Barnacle, Robyn, and Inger Mewburn. 2010. "Learning Networks and the Journey of 'Becoming Doctor'." Studies in Higher Education 35 (4): 433–44.

Owler, K. (2010). A 'problem'to be managed? Completing a PhD in the arts and humanities. Arts and Humanities in Higher Education, 9(3), 289-304.

Rahman, A., Haddad, K., Kuczera, G., & Weinmann, E. (2019). Regional flood methods. Australian Rainfall and Runoff: *A Guide To Flood Estimation. Book 3, Peak Flow Estimation,* 105-146.

The Holy Bible: King James Version