Computational Intelligence Methods for Optimising Airport Security Process

A Thesis Submitted for the Degree of
Doctor of Philosophy

By
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in

School of Computer Sciences
UNIVERSITY OF TECHNOLOGY SYDNEY
AUSTRALIA
13/02/2022

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Mohamad Naji declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Computer Science/Faculty of engineering IT at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by the Australian Government Research Training Program.

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The undersigned hereby certify that they have read this thesis entitled "**Computational Intelligence Methods for Optimising Airport Security Process** " by **Mohamad Naji** and that in their opinions it is fully adequate, in scope and in quality, as a thesis for the degree of **Doctor of Philosophy**.

Dated: 13/02/2022

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_____
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Acknowledgements

I am greatly indebted to my supervisor, Madhu Goyal for her continuous encouragement, advice, help and invaluable suggestions. She is such a nice, generous, helpful and kindhearted person. I feel really happy, comfortable and unconstrained with her during my PhD study. I owe my research achievements to her experienced supervision. Many thanks are also due to my co-supervisor, Ahmed Al-Ani for his valued suggestions and constant support, and for the numerous conversations with him. I gratefully acknowledge the useful discussions with Paul Kennedy, Ali Anaissi, and Ali Braytee. I appreciate the travel support for attending the international conferences which I received from the School of Computer Science. I would like to thank my wife, Maha and my children, for their understanding and assistance. This thesis could not have been completed without the support and encouragement of my parents-in-law, and my sisters.

To the soul of my father and mother who instilled in me the virtues of perseverance and commitment. To my wife Maha, whose sacrificial care for me and our children enabled the hours of research, contemplation, and writing necessary to complete this thesis. To my children Ali, Zahraa, Houssein, Fatima and Mahdi you are my greatest achievement, and you will always be my blessings from God. To my sisters thanks for your support as usual. All together we have managed to survive throughout this challenging journey. I love you all.

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Abstract

Airport security screening processes are essential to ensure the safety of both passengers and the aviation industry. Security at airports has improved noticeably in recent years through the utilisation of state-of-the-art technologies and highly trained security officers. However, maintaining a high level of security can be costly to operate and implement. It also lead to delays for passengers and airlines. Nowadays, research is focused to build efficient and effective systems to reduce the congestion caused by the security screening process while maintaining a high level of safety for passengers and the aviation industry. Two open security challenges motivates this thesis: optimize and design the security process at airport, and build an effective intelligent system to detect anomalies in X-ray images.

This thesis proposes a series of novel using queuing theory and machine learning models to handle the aforementioned challenges. Particularly, this thesis addresses the issues related to passengers congestion at the waiting area and improve the performance of the security detection system to ensure the safety of both passengers and the aviation industry.

There are four contributions in this thesis. Contribution 1 proposes queueing theory method to optimise the security screening process with multi-servers operating in parallel to serve a different number of passengers during different seasons, such as

Christmas, Easter and school holidays, and time of the day, as this strongly influences the number of passengers. Contribution 2 proposes a novel method based on queueing theory augmented with particle swarm optimisation (QT-PSO) to predict passenger waiting time in a security screening context and to determine the required number of servers and security officers. Contribution 3 propose a tensor-based learning approach to extract the informative latent features that will be used as an input to build a one-class model for anomaly detection. Contribution 4 proposes a federated learning (FL) approach for anomaly detection in X-ray security imaging using OCSVM. The innovative machine learning approach can train a centralized model on data generated and located on multiple airports without compromising the privacy and security of the collected data. The performance of all novel methods in this these is evaluated in the context of Sydney airport dataset, synthetic data, and public datasets for X-ray images. Further, all the results of the novel methods are compared to the state-of-the-art methods. The experimental results shows that our proposed methods in the contributions outperform the state-of-the-art and produce promising results.

Publications

Below is the list of journal and conference papers associated with my PhD research:

Naji, M., Anaissi A., Braytee A. & Goyal, M. (2021, April). Anomaly Detection in X-ray Security Imaging: a Tensor-Based Learning Approach. In 2021 International Joint Conference on Neural Networks (IJCNN) (pp. 1-8). IEEE

Anaissi, A., Suleiman, B., & Naji, M. (2021, April). Intelligent Structural Damage Detection: A Federated Learning Approach. In International Symposium on Intelligent Data Analysis (pp. 155-170). Springer, Cham.

Naji, M., Al-Ani, A, Braytee A., Anaissi A, Goyal M. & Kennedy, P. (2020, March). Design of Airport Security Screening Using Queueing Theory Augmented with Particle Swarm Optimisation. Journal of Service Oriented Computing and Applications.

Naji, M., Braytee A., Anaissi A., Sianaki, O. & Al-Ani, A, (2019, March). Optimizing the Waiting Time for Airport Security Screening using Multiple Queues and Servers. In CISIS 2019.

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