UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Engineering and Information Technology

# Common and Unique Feature Learning for Data Fusion

by

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A Thesis Submitted
in Partial Fulfillment of the
Requirements for the Degree

**Doctor of Philosophy**

Sydney, Australia

2020

# Certificate of Authorship/Originality

I, Sunny Verma declare that this thesis, is submitted in fulfilment of the requirements for award of Doctoral of Philosophy, in the School of Software, Faculty of Engineering and Information Technology at the University of Technology Sydney.

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

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

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

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Date: 02/03/2020

Sunny Verma

# Acknowledgements

First and foremost, I want to thank my supervisors Dr. Wei Liu and Dr. Chen Wang, for their support throughout my degree. The journey as a Ph.D. student is not for everyone. Only you know about the feeling of joy after acceptance of your work and the feeling of lost after a rejection. I could not have achieved half of what I have without strong supervision of my supervisors.

I would like to thank Prof. Liming Zhu and Data61, CSIRO for providing me the scholarship for this degree. I'm also thankful to my former supervisor Dr. Meng Hui Lim for the opportunity under his guidance in Hong Kong, and to many things beyond words.

I also appreciate the support and discussion with my friends, in particular, Dr. Abhinav Anand, Dr. Rajan Kashyap, Dr. Avinash Singh, and Yurui Ming. In a similar spirit, my colleagues at UTS and Data61, CSIRO have been a constant source of valuable moments I can remember.

Finally, I owe my family the irreversible time and patience they have had during all these years and thank Sau Kei Kwok for all her support.

Sunny Verma

Sydney, Australia, 2020.

# List of Publications

### Journal Papers

J-1. **Sunny Verma**, Chen Wang, Liming Zhu, and Wei Liu, "Attn-HybridNet: Enhancing Discriminablity of Features with Attention Fusion," *IEEE Transactions on Cybernetics*, **Under Review**.

### Conference Papers

C-1. **Sunny Verma**, Chen Wang, Liming Zhu, and Wei Liu, "DeepCU: Integrating Both Common and Unique Latent Information for Multimodal Sentiment Analysis, *IJCAI19*, Aug 2019. **Accepted.**

C-2. **Sunny Verma**, Chen Wang, Liming Zhu, and Wei Liu, "Towards Effective Data Augmentation via Unbiased GAN Utilization, *PRICAI19*, Aug 2019. **Accepted.**

C-3. **Quan Do**, **Sunny Verma**, Fang Chen, and Wei Liu, "Multiple Knowledge Transfer for Cross Domain Recommendation, *PRICAI19*, Aug 2019. **Accepted.**

C-4. **Sunny Verma**, Chen Wang, Liming Zhu, and Wei Liu, "HybridNet: Improving Deep Learning Networks via Integrating Two Views of Images, *ICONIP18*, Dec 2018. **Accepted. Accepted.**

### Conference Posters

P-1. **Sunny Verma**, Chen Wang, Liming Zhu, and Wei Liu, "A Compliance Checking Framework for DNN Models, *IJCAI19*, Aug 2019. **Accepted.**

P-2. **Sunny Verma**, Chen Wang, Liming Zhu, and Wei Liu, " Extracting Highly Effective Features for Supervised Learning via Simultaneous Tensor Factorization, *AAAI17*, Feb 2017. **Accepted.**

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# ABSTRACT


**Common and Unique Feature Learning for Data Fusion**

In today's era of big data, information about a phenomenon of interest is available from multiple acquisitions. Data captured from each of these acquisition frameworks are commonly known as modality, where each modality provides information in a complementary manner. Despite the evident benefits and plethora of works on data fusion, two challenging issues persist, 1) feature representation: how to exploit the data diversity that multiple modalities offer, and 2) feature fusion: how to combine the heterogeneous information for better decision making.

To address these challenges, this thesis presents a significantly improved model of two widely utilised fusion techniques, a) early fusion: combining features from multiple modalities for joint prediction, and b) late fusion: combining modality-specific predictions at the decision level. I illustrate how both these techniques have their own specific limitations, with late fusion unable to harness the inter-modality benefits, and the reliance of early fusion on a single model causing failure when information from any modality is futile. To overcome these drawbacks, I developed novel multimodal systems that performs feature extraction and feature fusion in a consolidated frameworks. Technically, I designed feature extraction schemes to capture both unique information from individual modalities and common information from multimode representations. I then combine these two kinds of information for supervised prediction, by designing efficient fusion schemes that enable this frameworks to perform information discovery and feature fusion simultaneously.

In this thesis, I also demonstrated the benefits of fusing both the common and unique information in supervised learning and validate the significance of the developed techniques on multimodal, multiview, and multisource datasets. The designed methods leverage the multimodal benefits by creating additional diversity, and ob-

tain a more unified view of the underlying phenomenon for better decision making.