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Deciphering True Emotions:
Micro-Expression Detection and Recognition using Deep Nets

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Deciphering True Emotions:
Micro-Expression Detection and Recognition using Deep Nets

A dissertation submitted in partial fulfilment of the requirements for the degree of

Doctor of Philosophy
in
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by

Madhumita Abhijeet Takalkar

under the supervision of

A/Prof. Dr. Min Xu and **Dr. Zenon Chaczko**

to

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Certificate of Original Authorship

I, *Madhumita Abhijeet Takalkar* declare that this thesis is submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy, in the *School of Electrical and Data Engineering*, *Faculty of Engineering and Information Technology* at the University of Technology Sydney, Australia.

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.

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Abstract

Micro-expressions are anticipated as the outcome of deliberate manipulation or involuntary repression of emotions when an individual feels emotion but tries to conceal the facial movements. The micro-expression interpretation tends to recognise a person's deceit and actual mental state. Therefore, micro-expression detection and recognition has significant opportunities for emotion analysis in psychotherapy, forensics, border protection, and negotiations, among others. Since such gestures are quick and hard to spot with the naked eyes, the inclination towards automated micro-expression recognition is an obvious step forward in the domain. Micro-expression research has drawn various interests within the computer vision field notable in localisation, magnification and recognition. Earlier studies primarily implemented single handcraft descriptors and classifiers for recognising micro-expressions. Modern techniques emphasise on deploying Convolutional Neural Networks (CNNs) or hybrid strategies that integrate handcraft descriptors and CNNs. Owing to the existence of a few datasets, the recognition of micro-expressions is still a concern. Nevertheless, efficiency is often influenced by the feature selection and training approach.

Our work, presented in this thesis, introduces various approaches that we have developed to detect and recognise facial micro-expressions using deep networks. In the initial stages of this work we design a dual-stream model with attention networks for the task of micro-expression detection from images. We implement Local- and Global-level Attention Networks (LGAttNet) to concentrate on local facial regions as well as full face to boost the chances of extracting relevant micro-expression features. Unlike previous detection methods where frame difference is calculated to detect micro-expressions, our framework uses attention network to focus on various parts of a face to identify the presence of the micro-expression. We developed LGAttNet to be a supervised detection framework where a traditional Artificial Neural Network (ANN) is trained as a binary classifier. LGAttNet is a novel documented approach that utilises attention network for micro-expression detection from image and video frame sequence.

The next stage of this thesis focuses on recognising micro-expression from an image using CNN. We propose to implement a CNN network by performing fine-tuning on a pre-trained CNN network. Fine-tuning is carried out to retrain the last convolutional layer of the CNN network to be able to learn appropriate micro-expression features and predict the micro-expression classes accurately. This fine-tuned CNN network gained acceptable accuracy for recognising micro-expressions from image frames. Thirdly, we extend the outcome of this stage to be implemented on video data; hence we explore the

approach of combining handcrafted descriptors with the CNN derived features. Local Binary Pattern-Three Orthogonal Planes (LBP-TOP) and VGGFace CNN network are combined in late fusion technique to extract a comprehensive feature representation of the video. Softmax and SVM are trained for classification. The employed hybrid approach is one of the first attempts to implement handcrafted descriptors and deep features for micro-expression recognition.

Finally, we consider the factor of gender affecting the tendency to express micro-expressions. We have built a multi-task learning architecture with two streams extracting different features to achieve the same task of micro-expression recognition based on gender, GEME. We incorporated a dynamic image concept to convert a video into a single frame, and gender features and micro-expression features are added at each level and given to the micro-expression stream. Inclusion of the gender features with the micro-expression features elevates the feature details respective to the individual participant, and the network learns unique gender features while extracting micro-expression features.

Concisely, we have introduced four novel concepts for micro-expression detection and recognition. The work described in this thesis establishes a connection between computer vision and psychotherapy, and aids to expedite the micro-expression analysis process for quick assessment wherever necessary.

Dedication

In memory of my father, to whom I promised to dedicate this thesis before he left this world...

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List of Publications

Related to the Thesis :

1. **Madhumita A. Takalkar**, Min Xu, Qiang Wu, Zenon Chaczko, *A survey: facial micro-expression recognition [J]*, Multimedia Tools and Applications (MTA) 2017. (***Published***)

2. **Madhumita A. Takalkar**, Min Xu, *Image based facial micro-expression recognition using deep learning on small datasets [C]*, In 2017 International Conference on Digital Image Computing: Techniques and Applications (DICTA), IEEE. (***Published***)

3. **Madhumita A. Takalkar**, Haimin Zhang, Min Xu, *Improving Micro-expression Recognition Accuracy Using Twofold Feature Extraction [C]*, In 2019 International Conference on Multimedia Modeling, Springer, Cham. (***Published***)

4. **Madhumita A. Takalkar**, Min Xu, Zenon Chaczko, *Manifold Feature Integration for Micro-Expression Recognition [J]*, Multimedia Systems (MS) 2020. (***Published***)

5. **Madhumita A. Takalkar**, Selvarajah Thuseethan, Sutharshan Rajasegarar, Zenon Chaczko, Min Xu, John Yearwood, *LGAttNet: Automatic Micro-expression Detection using Dual-Stream Local and Global Attentions [J]*, Knowledge-Based Systems (KBS). (***Under Review***)

6. Xuan Nie, **Madhumita A. Takalkar**, Mengyang Duan, Haimin Zhang, Min Xu, *GEME: dual-stream multi-task GEnder-based Micro-Expression recognition*, Neurocomputing. (***Under Review***)

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