The University of Newcastle, Australia

Doctoral Thesis

Affective Analysis of Visual Scenes using Face Pareidolia and Scene-Context

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or the degree of Doctor of Philosophy in Computer Science

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Faculty of Engineering and Built Environment

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Statement of Originality

I hereby certify that the work embodied in the thesis titled, 'Affective Analysis of Visual Scenes using Face Pareidolia and Scene-Context' is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968 and any approved embargo.

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Date: 22/10/2020

Acknowledgement of Authorship

I hereby certify that the work embodied in this thesis contains published paper/s/scholarly work of which I am a joint author. I have included as part of the thesis a written declaration endorsed in writing by my supervisor, attesting to my contribution to the joint publication/s/scholarly work.

By signing below I confirm that Asad Abbas contributed to the paper/ publication entitled:

- **A. Abbas** and S.K. Chalup, "Affective Analysis of Visual Scenes using Face Pareidolia and Scene-Context", published in Neurocomputing, Volume 437, 2021, Pages 72-83, ISSN 0925-2312, doi.org/10.1016/j.neucom.2021.01.016
- **A. Abbas** and S.K. Chalup, "From Face Recognition to Facial Pareidolia: Analysing Hidden Neuron Activations in CNNs for Cross-Depiction Recognition", accepted in International Joint Conference on Neural Networks (IJCNN), Budapest, Hungary on July 14-19, 2019. Publisher: IEEE, DOI: 10.1109/IJCNN.2019.8852013
- **A. Abbas** and S.K. Chalup, "The Impact of Image Resolution on Facial Expression Analysis with CNNs", accepted in International Joint Conference on Neural Networks (IJCNN), Budapest, Hungary on July 14-19, 2019.Publisher: IEEE, DOI: 10.1109/IJCNN.2019.8852264
- **A. Abbas**, S.K. Chalup, "Group Emotion Recognition in the Wild by Combining Deep Neural Networks for Facial Expression Classification and Scene Context Analysis", ICMI'17, Proceedings of the 19th ACM International Conference on Multimodal Interaction, Glasgow, Scotland (2017). Publisher: ACM, DOI: 10.1145/3136755.3143010

by:

- Contributing to each study's conception and design
- Developing analysis plans

- Developing research material and collecting data
- Performing both quantitative and qualitative analyses
- Writing code and execution of programs
- Interpreting data
- Leading the writing of the manuscripts

Signed: Stephan Chalup

Date: 02-11-2020

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Dedicated to my Parents

Muhammad Ramzan and Kaneez Fatima

For their endless love, support and encouragement

Abstract

With recent advancements in affective computing, computers have become better at describing human emotional responses using facial expression and scene-context analysis. However, the topic of face pareidolia, which is the imagination of non-existent faces in random patterns, its computational modelling and application in product design is recently gaining increased attention in the research community. This thesis aims to answer an interdisciplinary research question, "Can we simulate the face pareidolia ability of humans and predict associated emotional responses using deep learning?" This interdisciplinary thesis question was based on research literature published in the disciplines of Cognitive Science and Psychology. Findings from these research disciplines suggest that abstract and minimal face-like patterns can subconsciously activate face-selective regions in the brain producing face pareidolia. Moreover, face pareidolia, along with various other contextual variables present in the visual scene, can trigger an emotional response in our neurobiological systems without conscious awareness. The first part of this thesis investigates a group emotion recognition task by using an ensemble of convolutional neural networks. The findings from this part are consistent with the literature in cognitive science and psychology that an individual's face and associated facial expressions are always perceived and evaluated within a surrounding context. The second part of this thesis presents two research studies addressing the poor generalisation capacity of convolutional neural networks, as poor generalisation capacity limits the direct application of deep learning techniques to simulate face pareidolia. In the first study, the impact of image resolution on the generalisation capacity of convolutional neural networks trained for facial emotion recognition was analysed. The second study was inspired by face perception in the brain and improves the generalisation capacity of a convolutional neural network, trained for face recognition, to simulate the facial pareidolia capability of the human visual system. The third part of this thesis consolidates previous findings and presents a novel deep learning-based cross-domain weakly supervised three-step progressive domain adaptation framework. The proposed framework can simulate face pareidolia and predict associated emotional responses in two-dimensional valence and arousal space for various product designs. The proposed framework was evaluated on a new image dataset. Both quantitative and qualitative experimental results show that our approach can outperform other state-of-the-art methods.