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Fostering positive team behaviors in human-machine teams through emotion processing: Adapting to the operator's state

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14. ABSTRACT
FOSTERING POSITIVE TEAM BEHAVIORS IN HUMAN-MACHINE TEAMS THROUGH EMOTION PROCESSING was a collaborative project between RMIT and AFRL/RH. The focus was on identifying features in human voice data and facial images to inform algorithms that can detect and predict emotions, for the purpose of increasing human trust in human-machine teaming applications. This project developed a low-cost, real-time emotion recognition system and a deep neural network model to predict trust at low and high levels. The contributions of this research include 3 conference papers, 1 journal paper, a new research databased created at AFRL/RH, and a new research project agreement between RMIT and Australia's DSTG.

15. SUBJECT TERMS
Multimodal, Human-Machine Team, Speech Perception

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TITLE: FOSTERING POSITIVE TEAM BEHAVIORS IN HUMAN-MACHINE TEAMS THROUGH EMOTION PROCESSING

(FA2386-17-1-0095)

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Final Performance Report 2017-2019

Background: Machines' inability to understand non-linguistic information in people's voices and facial images reduces human trust in machines.

Objective(s):

- Design algorithms capable of detecting and predicting emotions from audio-visual data.
- Design algorithms predicting trust from audio-visual and EEG data.

Impact to AF: Objective measures and models of inter-personal trust-related behavior that can be applied to increase trust in machine autonomy.

Summary of Project Activities in 2017-2018:

1. Developed a novel low-cost, real-time, speech emotion recognition system; published in [1],[3],[4]. The software simultaneously recognises 7 emotional categories as speech is produced. It is suitable for applications on cellular phones and online speech communication platforms. A demo can be viewed on: (https://www.youtube.com/watch?v=fuMpF3cUqDU&t=6s).

2. Introducing a new concept of a multi-stage classification system with intermediate learning (MSIL); published in [2]. The software applies two stages of classification. The first stage used a deep neural network (DNN) model trained on physical data. The second stage uses a shallow NN trained on the probability vectors generated during the first-stage learning to refine the first-stage classification outcomes.

Summary of Project Activities in 2018-2019:

1. Completed analysis of amplitude-frequency characteristics of emotional speech; published in [3], [4]. This study used an indirect approach to determine the differences between the amplitude-frequency characteristics of different emotions to support the development of future, more efficient, SER methods. The outcomes lead to a new Research Agreement between RMIT and Defence Science Technology Group, Australia signed in February 2019.

3. Applying the MSIL concept to different practical classification problems. The MSIL was shown to provide a significant improvement of classification results in crowd-density estimation from images, classification of fine art paintings and prediction of public trust in politicians from audio-visual data and tweeter messages. These experiments were conducted within 3 PhD projects that stemmed from this grant.

4. Commencing and progressing through team-trust data collection. Dr Panganiban has been collecting audio-visual and EEG data from teams conducting problem-solving exercises. The data is currently being delivered from AFRL to RMIT periodically as it is collected.

5. Conducting preliminary trust experiments based on the AFRL data. After receiving team-trust data from 24 teams, preliminary experiments were conducted. The aim was to determine if the self-reported trust in the team partner can be objectively predicted from changes in acoustic speech parameters of the team members. The experiments conducted to date are very promising showing that we can predict two trust levels (low and high) with accuracy reaching up to % (KNN classifier) and 82% (shallow NN).

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Future Research Directions:

Research team-trust prediction using different targets (e.g. pre- and post-task reports) and data modalities (speech, facial images and EEG).

Summary of Project Outcomes 2017-2019: The project research outcomes to do date led to

- 4 peer reviewed research publications,
- 3 new PhD projects,
- A new research data base created at the AFRL, and
- A new Research Project Agreement between RMIT and DSTG, Australia signed in February 2019

Project Publications (with acknowledgements of funding from AOARD and DSTG, Australia)

[1]. MN Stolar, M Lech, RS Bolia and M Skinner, "Real Time Speech Emotion Recognition Using RGB Image Classification and Transfer Learning", Proceedings of the 11th International Conference on Signal Processing and Communication Systems, ICSPCS'2017, 13-15 December, Surfers Paradise, Australia, pp. 1-8.
DOI: 10.1109/ICSPCS.2017.8270472
https://ieeexplore.ieee.org/abstract/document/8270*472*

[2]. MN Stolar, M Lech, RS Bolia and M Skinner, "Towards Autonomous Machine Reasoning: Multi-Stage Classification System with Intermediate Learning", Proceedings of the 11th International Conference on Signal Processing and Communication Systems, ICSPCS'2017, 13-15 December, Surfers Paradise, Australia, pp. 1-6.
DOI: 10.1109/ICSPCS.2017.8270486
https://ieeexplore.ieee.org/abstract/document/8270486

[3]. M. Lech, M. Stolar, R. Bolia, and M. Skinner, "Amplitude-Frequency Analysis of Emotional Speech Using Transfer Learning and Classification of Spectrogram Images", Advances in Science Technology and Engineering Systems Journal (ASTESJ), Special Issue on Multidisciplinary Sciences and Engineering, Volume 3, Issue 4, Page No 363-371, 2018.
ASTESJ ISSN: 2415-6698
https://www.astesj.com/publications/ASTESJ_030437.pdf

[4] M. Stolar, M. Lech, R. Bolia, M. Skinner, "Acoustic Characteristics of Emotional Speech Using Spectrogram Image Classification", The 12th International Conference on Signal Processing and Communication Systems, ICSPCS'2018, 17-19 December 2018, Cairns, Australia, pp.1-6.
DOI: 10.1109/ICSPCS.2018.8631752
https://ieeexplore.ieee.org/abstract/document/8631752