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RFexpress! RF Emotion Recognition in the Wild

ABSTRACT:

1) RFexpress!: The first-ever RF-based DFAR emotion recognition system to exploit body movement, gesture and pose.
2) Identification of critical SNR levels for DFAR-based on recognition of relevant emotion-indicating gestures (case study with 5 subjects)
3) Exploitation of RFexpress! concepts for the first-ever RF-DFAR-based driver assistant system to detect risky driving behaviour (in-car case study with 8 subjects using a driving-simulation)
4) Exploitation of RFexpress! concepts for human motion based emotion recognition (non-scripted case study with 5 subjects)

Ongoing Work:

We are extending our emotion classes (angry, happy, tired, sleepy, sad) and refining our signal processing and machine learning modules to achieve high accuracy for our car driving scenario. We intend to analyze the impact of multiple persons in car and emotion detection for each paasenger. We plan to perform a larger human study and in moving car to testify the practical applicability of our system.

ARCHITECTURE AND SNR STUDY:

The RFexpress has modular architecture. We determine the accuracy of DFAR systems in real environments.

We first measure the radio characteristics of real environments where the SNR is the primary parameter. Then, we model these SNR values, and perform case studies with 5 subjects to identify critical SNR values for DFAR.

Analysis:

Higher SNR fosters better accuracy but also depends on the complexity of the activity. SNR values of about 30dB and higher can be considered for robust activity recognition of different activities. 20dB and below is not feasible for DFAR.

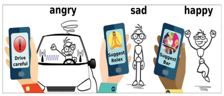

Fig 1. RFexpress! detects emotions from RF signals.

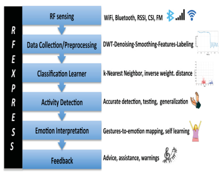

Fig 2. RFexpress modular architecture.

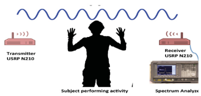

Fig 3. RFexpress basic experiment setup

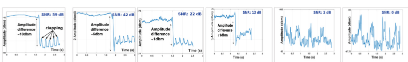

Fig 4. The impact of SNR on gesture recognition. Each graph shows the gesture recognition at different SNR value. The gestures are hands down vs. clapping.

ANGRY DRIVING BEHAVIOUR DETECTION:

We exploit RFexpress! concepts for the distinction between different emotional states in two realistic cases: (1) Detection of risky, agitated driving behaviour and (2) detection of angry argument in an indoor setting.

1) Experiment: We performed a driving experiment with 8 subjects. For normal driving, the subjects drive through the simulator video while performing normal driving. For the angry driving case, we created a cover story for emotion elicitation. The subjects act and respond accordingly.

2) Data Collection: We used mean and variance features with non overlapping windows and a k-NN classifier with k=6 neighbours. We trained the models for individual data as well as aggregated data from all subjects.

3) Results and discussion: An overall accuracy of 98% for individual model and 82.9% for the inter-subject combined data model is achieved. If the angry state is being spotted for a very long interval, then the driver needs to be alarmed and provided with safety guidance.

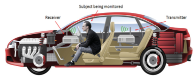

Fig 5. RFexpress expeiment setup in car scenario.

Fig 6. Images captured during the driving car experiment. Neutral vs. angry driving for 2 subjects.

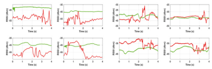

Fig 7. Denoised Graphs of driving experiment for neutral case (green) and angry case (red).

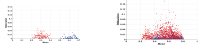

Fig 8. Scatterplots representing neutral case in blue dots and angry case in red dots.

ANGRY CONVERSATION DETECTION:

In this scenario, a subject carries out a conversation, with another subject either on the phone or in person in an office environment.

1) Experiment: 5 subjects. The space is a large meeting room of about 12x18 sqft. The distance between the transmitter and receiver is 8m, SNR is 42dB and all the equipment, configuration, emotion induction, data collection, pre-processing and feature calculation are the same as for the driving experiment For each subject, the first neutral vs. angry data is first captured by keeping 2m distance between receiver and subject and then at 5m.

2) Results and Discussion: As the SNR value is high enough in office, even at 5m distance, the body gestures prove to be promising indicators of anger. The overall accuracy has, however, decreased as compared to individual results for driving experiments. Inter-subject classification for all subjects reduces the accuracy down to 64%.

Fig 9. Images captured during the conversation experiment. Neutral vs. angry conversation for 2 subjects.

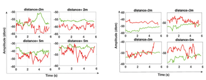

Fig 10. Denoised Graphs of conversation experiment for neutral case (green) and angry case (red).

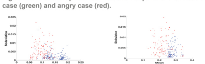

Fig 11. Scatterplots representing neutral case in blue dots and angry case in red dots.

CONCLUSIONS:

We have presented RFexpress!, Device-free motion and gesture-based emotion sensing system. The system has been exploited in a vehicular scenario and an indoor scenario, to detect risky vs. neutral behaviour.

We observed that a car has well suited conditions for DFAR-based emotion recognition as could achieve an accuracy of 98%. In the office scenario, we considered the distinction of angry versus neutral conversation with increasing distance between subject and receiver. In this experiment we could achieve an accuracy of up to 82.9% for individually trained models and 64% for inter-subject models.

In addition, we studied the accuracy of DFAR, in real environments as compared to controlled environments The results show that accuracy above 80% can be achieved at SNR higher than 30dB. At SNR 20db and below, the accuracy of gesture recognition drops significantly.