

# Non-intrusive Car Driver's Emotion Recognition Using Thermal Camera

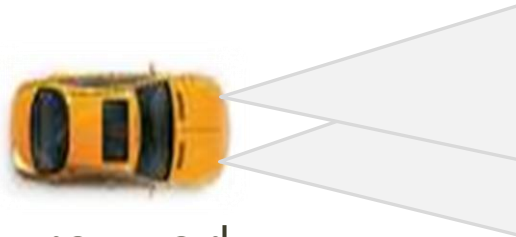


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# Outline

- Motivation
- Background
- Limitations
- State of the art
  - Different approaches
  - Issues
- Proposed approach
  - Face Detection
    - Difference between thermal camera and visual ray camera (VRC) outputs
    - Disadvantages
  - Feature Extraction
  - Classification
- Results
- Conclusion and future work



# Motivation

- According to **WHO**
  - Approx. 1.3 million people die each year due to road accidents
  - 20-50 million sustain non-fatal injuries each year due to road accidents
- 1%-3% of GDP loss

Road injuries in 2010 by mode of transport

3,722	8%
4,835	11%
4,963	11%
3,179	7%
26,770	58%
706	2%
754	2%
280	1%
649	1%



Road fatalities in 2010 by mode of transport

18%	98
6%	32
3%	18
12%	68
53%	292
1%	8
2%	10
1%	7
3%	19

Source: Federal Ministry for Transport, Innovation and Technology, Austria



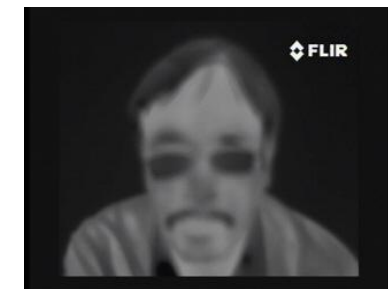
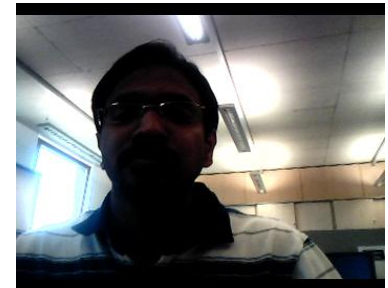
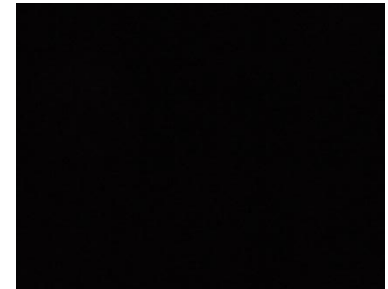
# Background

- Several papers are available for human emotions detection
  - Using VRC alone [4] [5]
    - Automatic Analysis of Facial Expressions: the State of the Art
      - M. Pantic, and L.J.M. Rothkrantz
    - Automatic Facial Expression Analysis: A Survey
      - B. Fasel, and J. Luetlin
  - Using audio alone [3] [6]
    - A Comparison of Classifiers for Detecting Emotion from Speech
      - Shafran, I. and M. Mohri
    - Emotion recognition using novel speech signal features
      - T.S. Tabatabaei, S. Krishnan, and A. Guergachi
  - Fusion of VRC and audio [7]
    - Analysis of Emotion Recognition Using Facial Expressions, Speech and Multimodal Information
      - C. Busso et al
  - Fusion of VRC, thermal camera and audio sensor [1]
    - Effect of sensor fusion for recognition of emotional states using voice, face image and thermal image of face
      - Y. Yoshitomi, S. Kim, T. Kawano, T. Kitazoe
  - Using thermal camera alone [8]
    - Automated classification and recognition of facial expressions using infrared thermal imaging
      - Khan, Masood Mehmod, Ward, Robert D, Ingleby, Michael



# Limitations

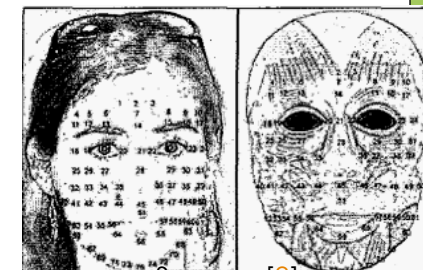
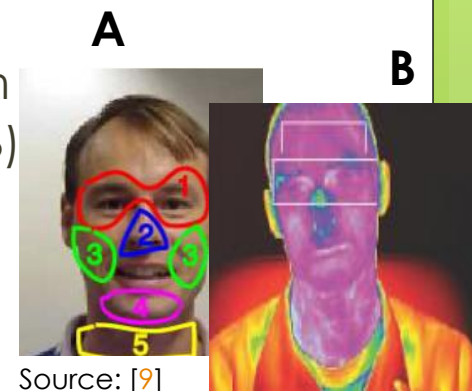
- Short comes of using Visible Ray Camera(VRC) [1]
  - Poor/no visibility of the images at improper/varying illumination conditions(image a)
  - Prone to shade, reflection, and local darkness influence the accuracy
  - Inability to clearly distinguish the fatigue and smiling faces(image b)
- Short comes of using Active-Infrared Camera [2]
  - Lack of standardisation
  - Temperature increase on human arm and forehead is  $1.5 \pm 0.5^{\circ}\text{C}$  (p, 9)
  - Probability of human cell death increases when the cell temperatures are sustained above  $41^{\circ}\text{C}$
- Short comes of using Audio Sensors [3] [6]
  - Only accuracy of range 37.7% to 81.3% has been achieved
  - Requires separate database for each language





# State of the art

- Approaches for face emotion detection (thermal camera)
  - Monitoring of face regions temperature
    - Work done on facial muscle due to transition from one emotional state to another (Figure A and B)
    - Work done leads to temperature variations
  - Using facial thermal feature points (FTFPs) (Figure C)
- Why a new project using only thermal camera?
  - The inability of the current system to use an integrated approach
    - Lack of integrated face detection technique
    - Lack of integrated post processing
    - Lack of optimization of project for car environment



C



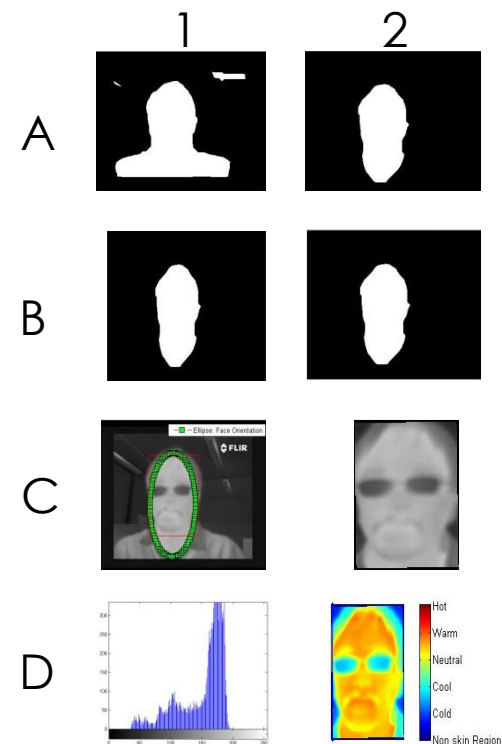
# Proposed approach

- Face detection
  - Colour based
  - Region growing based
  - Morphological based
  - Fusion of the above
- Feature extraction
  - TIVS
  - HOG
- Classification
  - Modified Hausdorff distance



# Output for Thermal Images

- Image (A,1) --- Output of colour based technique.
- Image (A,2) --- Output of morphological operations based technique
- Image (B,1) --- Output of region growing
- Image (B,2) --- Output of AND (above three images)
- Final face region in red bounding box and its orientation in green ellipse
- The cropped detected face from the original input image
- Histogram of the cropped image
- Representation of several temperature regions with pseudo colours
- Command window displayed output:
  - Maximum value detected before region growing: 195
  - Maximum value detected before region growing: 1
  - Person is leaning towards his "left"

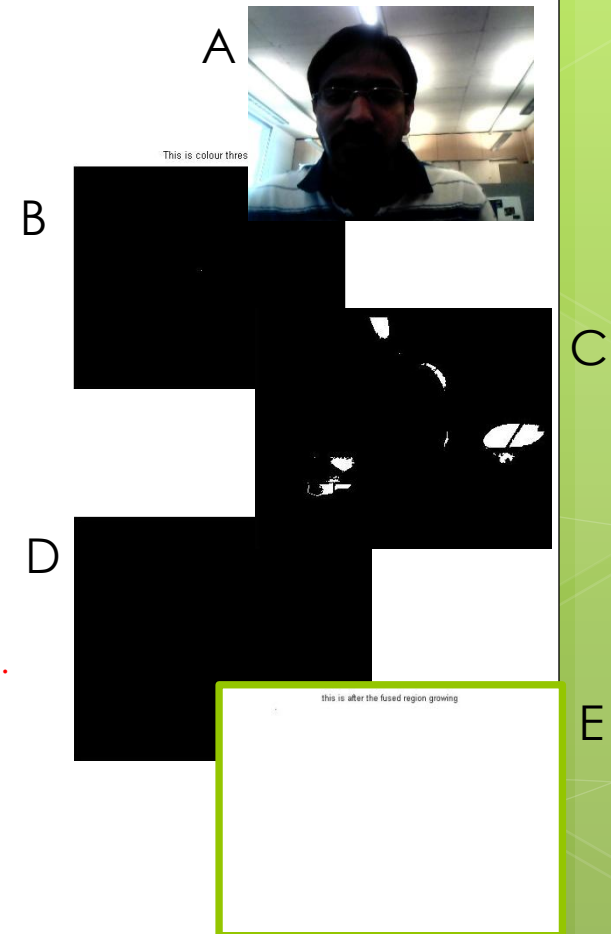






# Output for VRC Images

- Image A --- Input colour image
- Image B --- Output of colour based detection technique
- Image C --- Output of region growing technique
- Image D --- Output of AND (above three images)
- Image E --- Output of fused image region growing
  - Maximum value detected before region growing: 255
  - Maximum value detected before region growing: 0
  - ??? Too many outputs requested. Most likely cause is missing [] around left hand side that has a comma separated list expansion.
  - Error in ==> faceorient at 199
  - ee = Rp.Orientation;





# Results

## Performance of face detection algorithms

Algorithm	Performance (%)	
	<i>True Positives</i>	<i>False Positives</i>
Color based detection	55	45
Region growing based detection	80	20
Morphological operation based detection	70	30
Fusion of resulting images	70	30

## Performance of classifier

Emotion	Angry	Disgust	Fear	Happy	Sad	Surprise
<b>Angry</b>	<b>66.67</b>	18.49	12.18	0.83	0.4	1.43
<b>Disgust</b>	2.94	<b>69.81</b>	6.07	0.85	19.50	0.83
<b>Fear</b>	13.66	29.90	<b>48.37</b>	0.71	1.91	5.75
<b>Happy</b>	3.01	1.13	1.20	<b>82.36</b>	0.71	11.59
<b>Sad</b>	1.30	20.84	2.13	0.64	<b>70.18</b>	4.91
<b>Surprise</b>	1.65	6.51	3.18	22.60	2.65	<b>63.41</b>



# Conclusion and future work

- Proposed approach
  - Lack of integrated face detection technique
  - Lack of integrated post processing
  - Lack of optimization of project for car environment
  - Classifies more number of emotions compared to state of the art
- Improving the performance of the classifier
  - Increasing the number of samples of the database
  - Reducing the dimensionality of the mean image
- Fusion of sensors
  - Audio
  - VRC
  - Thermal camera



# References

1. Y. Yoshitomi, S. Kim, T. Kawano, T. Kitazoe, Effect of sensor fusion for recognition of emotional states using voice, face image and thermal image of face, in: Proceedings of ROMAN, 2000, pp. 178-183
2. Bozkurt A, Onaral B: Safety assessment of near infrared light emitting diodes for diffuse optical measurements. *BioMedical Engineering OnLine* 2004, 3:9.
3. Shafran, I. and M. Mohri: 2005, 'A Comparison of Classifiers for Detecting Emotion from Speech'. Proceedings of the International Conference on Acoustics, Speech, and Signal Processing, Philadelphia, PA: IEEE, pp. 341-344.
4. M. Pantic, and L.J.M. Rothkrantz, "Automatic Analysis of Facial Expressions: the State of the Art," *IEEE Trans. Pattern Analysis and Machine Intelligence*, Vol. 22, No. 12, pp. 1424-1445, Dec. 2000.
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6. T.S. Tabatabaei, S. Krishnan, and A. Guergachi. Emotion recognition using novel speech signal features. In *International Symposium on Circuits and Systems*, pages 345–348, 2007.
7. C. Busso et al., "Analysis of Emotion Recognition Using Facial Expressions, Speech and Multimodal Information," *Proc. Sixth ACM Int'l Conf. Multimodal Interfaces (ICMI '04)*, pp. 205-211, 2004.
8. Khan, Masood Mehmod, Ward, Robert D, Ingleby, Michael, "Automated classification and recognition of facial expressions using infrared thermal imaging," 2004 IEEE Conference on Cybernetics and Intelligent Systems, 2004, p 202-206.
9. I. Pavlidis, J. Levine, P. Baukol, Thermal imaging for anxiety detection, in: *IEEE Workshop on Computer Vision Beyond the Visible Spectrum: Methods and Applications*, 2000, pp. 104–109.
10. Liangbin Zhang, Lifeng Xi, Hybrid Image Compression Using Fractal-Wavelet Prediction, in: *Proceedings of the 5th WSEAS Int. Conference on Information Security and Privacy*, November 20-22, 2006.

# Questions