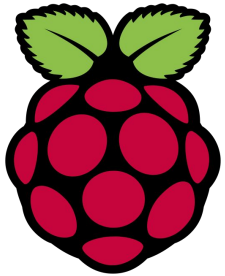
Real-Time Emotion Detection using Quad-Pi



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Agenda

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Introduction

- Present day technology demands for *Human-Machine* interaction; understanding of gestures and *emotions* by machines

- Emotions– text, vocal, verbal, *facial expressions*
- Real-time, non-uniform illumination facial detection
- Parallelizing the process for *speedup*

Literature Review

Authors	Methodology	Advantages	Limitations
Suja, P. et al.	Raspberry Pi II, CMU MultiPIE database to detect emotions	Real-time, speed and accuracy	Only facial expressions are used
Horak, K. et al.	Raspberry Pi II, Simulink in Matlab to process images	Speed, real-time, edge, corner, line detection	Increased FPS due to transfer from RPi2 to Simulink
Viji, A. et al.	Raspberry Pi II, Haar cascade classifier, PCA feature extraction, Adaboost classification	Real-time, speed and accuracy	Considers only PCA feature extraction
Viola, P. et al.	Haar feature selection, creating an internal image, Adaboost training, Cascading classifiers	Minimal computation time and high detection accuracy	Real-time conditions were ignored

Outcome of Literature Review

- Current state-of-art implementations consider *facial expressions* to be the primary source of emotion detection
- Various methods for feature extraction have been used in the past like ASM, PCA which employ *geometric-based feature detection*
- Processing on Raspberry Pi can give *speeds upto 100ms* and Viola-Jones feature detection gives about *95% accuracy*
- Current state-of-art implementations *do not consider parallelization* of the process

Issues and Challenges

- Simulation of *real-time* environment
  - Non-frontal images
  - Different illumination conditions
- Selection of *essential and accurate elements* of emotion detection
  - Text
  - Vocal (7%)
  - Verbal (38%)
  - Facial expressions (55%)
- *Image quality vs. Classification* tradeoff
- *Parallelizing* with as less computational and communication cost as possible

Motivation

- If machines can identify human emotions, it can understand human behaviour better which improves *task efficiency*
- Emotions greatly affect *decision making*, learning, attention, motivation, coping, planning, *cognition*, reasoning etc.
- Facial emotion detection from 2D images is well studied field but *lack of real-time method* to estimate features gives the necessity to develop a method for the same
- *Parallelization* of the real-time process might lead to *higher speeds* keeping accuracy at it peak

Problem Statement

- Capturing the image (real-time) using a *camera* (webcam, for experimental purposes)
- Face detection (and cropping if necessary) using *Viola-Jones detection* algorithm
- Image processing and feature extraction using *Active Shape Model* (ASM) or using *PCA* algorithm
- Classification using *Adaboost* classifier
- The recognized emotion is *displayed* on the monitor
- Finally, parallel model (master-slave) deployment using *Quad-Pi* (four RPi3)

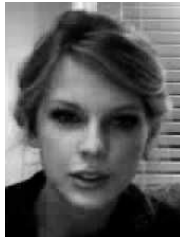
Project Objectives

- Simulate and experiment in *near real-time* environment
- Programming the *Raspberry Pi III*
- *Image Processing* (cropping and face extraction)
- *Feature extraction* from grayscale face image extracted
- Classify using *Adaptive Boosting* classifier trained with *CMU MultiPIE* database
- Finally, use *Quad-Pi* (four RPi3) to implement master-slave parallel processing model to the deployed application

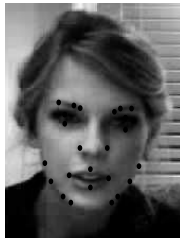
Proposed Model

Input image captured via webcam

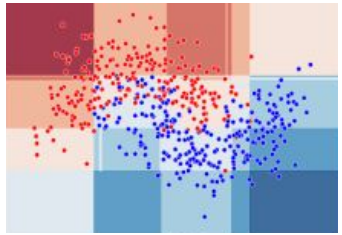
Crop the face



Cropped image is converted to grayscale and Sobel FIlter is used for smoothening



Feature extraction using ASM or PCA



Classify using Adaptive Boosting (Adaboost)

Processing on Raspberry Pi III

Display results

Methodology: Input and Output

- **Input**
  - For real-time simulations, input is taken from webcam (further development would be to use a mobile robot) to *dynamically* recognize emotions
  - Serves as input to Raspberry Pi III
- **Output**
  - For real-time simulations, input is taken from webcam (further development would be to use a mobile robot) to *dynamically* recognize emotions
  - Serves as input to Raspberry Pi III
  -

Methodology: RPi3 Processing

Pre-Processing for Facial Feature Extraction

- **Viola-Jones Face Detection**
  - *Haar-Wavelet* processing for detecting face
  - Facial image is saved for further processing and non-face part is discarded
- **Image Processing**
  - Facial image is cropped according to required size and converted to grayscale
  - *Sobel filter* is used to smoothen the image and remove noise

Methodology: RPi3 Processing

- **Feature Extraction**
  - *Active Shape Model (ASM)*, a geometric approach is used
  - *ASM automatic fiducial point location* algorithm is applied to pre-processed image
  - *Euclidean distances*(center of gravity, annotated fiducial points) are computed
  - Extract *geometric deformation difference features* between a person's neutral expression and the other basic expressions.
  - Compare with shape model to extract feature points of input facial image
- **Classification using Adaboost**

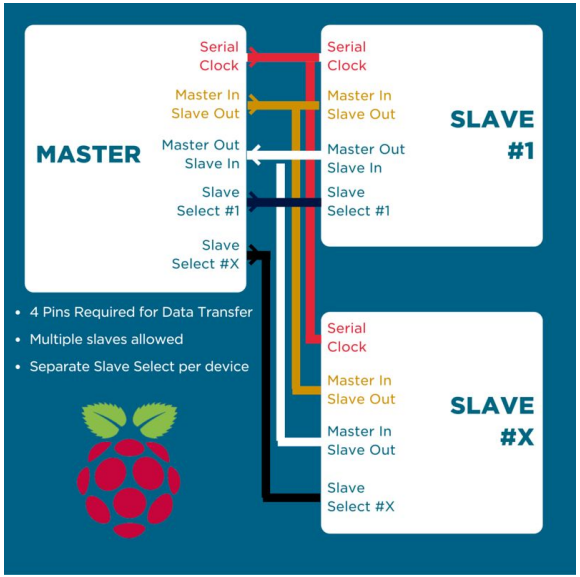
$$F_T(x) = \sum_{t=1}^{T} f_t(x)$$

F_T: strong learner after 'T' iterations

f_t: weak learner

Methodology: Quad-Pi Parallelization

- **Master-Slave model of Parallel Programming**
  - Master starts the slave computation, and the slave computation returns the result to the master
  - No significant dependencies among the slave computations
- **Quad-Pi model**
  - *Sobel filter* can be parallelized
  - In case of *multiple people* in an image, multiple emotions detection is needed where speeds and task division matter



Work Done

- Input image is captured through *webcam* (real-time)
- *Viola-Jones face detection technique* is used to detect the facial image
- Viola-Jones used *Haar wavelet concept* to develop integral image to detect face.
- Haar features consider the *different intensity* of values of adjacent rectangular region as different area of face has different value of intensity from other region (*haarcascade_frontalface_default.xml* for training)

Work Done

- After detection, facial image is saved for further processing and *non-face area is removed*
- In image preprocessing, image is cropped according to required size and converted in *gray image*
- *Crop* the image according to the requirements
- Image is used as input to *Sobel filter (Y-axis)* for smoothing to remove the noise
- The output image is the completely pre-processed image and is suitable to feed *ASM model* (trained with CMU MultiPIE database)

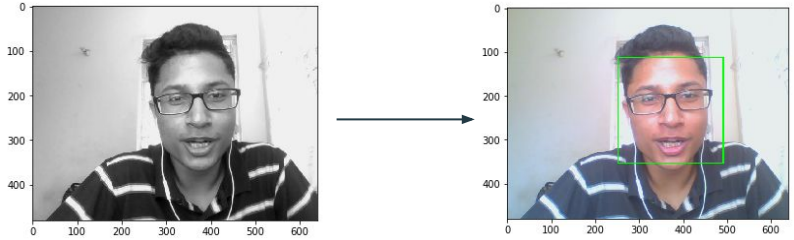
Results and Analysis

Capturing in Real-Time (different illuminations and nonuniform conditions) with low resolution

Results and Analysis

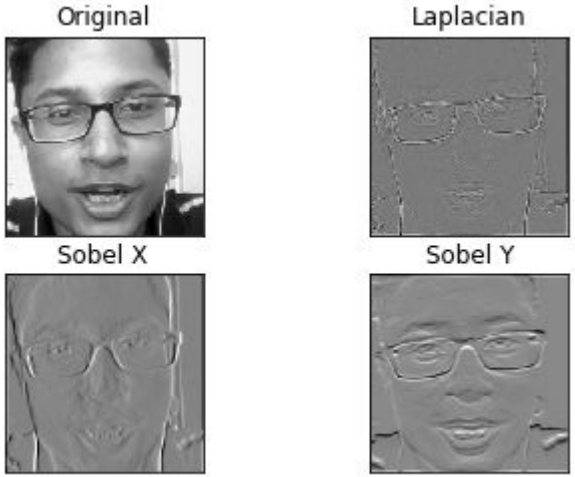
The facial image is detected by using Viola-Jones face detection technique

Single and Multiple Faces in the same frame



Results and Analysis

Different variations of **Sobel Filter**



Sobel Filter (along Y-axis) on frame with multiple faces

Timeline of Project

Milestones	February 2018	Mid-March 2018	End-March 2018	April 2018
Research and Feasibility study	✓	✓	✓	✓
RPi3 configuration, real-time input capturing and pre-processing		✓	✓	✓
Real-time emotion detection using RPi3			✓	✓
Master-Slave model using Quad-Pi (four Rpi3)				✓

Individual Contributions: (Mid-March 2018)

- Tushaar Gangarapu
  - Raspberry Pi III Configuration (Raspbian)
  - Capturing real-time input and directing it to RPi3 for pre-processing and emotion detection
- Bharath A. Kinnal
  - Use the image obtained and run Haar-Cascade classifier to obtain ‘facial’ region of the image
- Jyoti Prakash Sahoo
  - Use the facial image and run ‘Sobel Filter’ along Y-axis and remove noise

References

- Suja, P., & Tripathi, S. (2016, February). Real-time emotion recognition from facial images using Raspberry Pi II. In Signal Processing and Integrated Networks (SPIN), 2016 3rd International Conference on (pp. 666-670). IEEE.
- Horak, K., & Zalud, L. (2015). Image Processing on Raspberry Pi in Matlab. Advances in intelligent systems and computing, 4.
- Viji, A., & Pavithra, A. (2017). Real Time Face Recognition using Raspberry Pi II. IJIRSET, Vol. 6, Special Issue 3.
- Viola, P., & Jones, M. J. (2004). Robust real-time face detection. International journal of computer vision, 57(2), 137-154.
- Suk, M., & Prabhakaran, B. (2014). Real-time mobile facial expression recognition system-a case study. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops (pp. 132-137).