Implementation of Gabor filters and its applications for emotion detection

Report of IVP Project

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ABSTRACT

The human face plays an important role in the field of automatic recognition of emotion and interaction between human and computers.

Feature Extraction from the human face is an important step in emotion recognition . Various techniques have been used to extract features such as eyes, nose, lips and more from the human face in the recent times. Here Gabor Filter with changing parameters is being used to extract not only features but also the various forms these features can take when displaying emotions - Tilted eyebrows when expressing anger or sadness.

To detect the emotions, facial attributes are extracted using dimensionality reduction and convoluting the images with a variety of Gabor filters. Finally to determine facial expressions separately, the processed feature vector is channeled through the already learned pattern classifiers.

CANDIDATE'S' DECLARATION

We hereby declare that the work presented in this project report entitled "**Implement Gabor filters and its applications for emotion detection**", submitted as report of IVP Project (Sem VI) at Indian Institute of Information Technology, Allahabad, is an authenticated record of our original work carried out from January 2017 to March 2016 under the guidance of **Prof. Anupam Agrawal**. Due acknowledgements have been made in the text to all other material used. The project was done in full compliance with the require
ments and constraints of the prescribed curriculum.

Place: Allahabad
Date: 20.03.2017

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CERTIFICATE

This is to certify that the above statement made by candidates is correct to the best of my knowledge.

Date: 20.03.2017
Place: Allahabad

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1.) Introduction

One of the fundamental challenges in the recent times is that of an computer being able to recognize the emotion a human face has currently. This has necessitated the need of accurate and efficient automatic emotion recognition systems.

Based on the facial attributes the facial emotion can be classified into one of the six fundamental expression :

- Sadness
- Disgust
- Anger
- Happiness
- Fear
- Surprise.

We can also add "No emotion" to the above list to express the same state of the face.

Initially face extraction is performed in order to reduce the dimensionality of the training data. Then, we apply the Gabor Filter onto these reduced images in order to extract features which constitute the emotions. Finally the KNN Algorithm is utilized in order to classify the test image into an emotion.

2). Problem definition and objectives:

The main objective of this project is to classify the human faces based on their facial expressions which basically convey emotions. To do so we used Gabor Filter to extract features and supervised machine learning algorithm to classify.

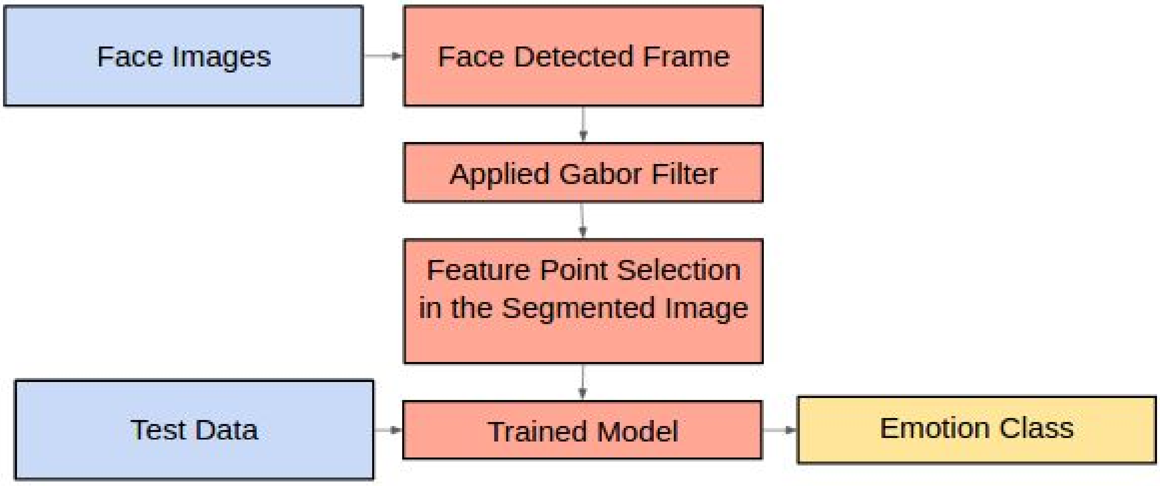
We have considered seven classes with each class representing an emotion. Initially we have taken 5 fold crossover which is a classification technique that involves us splitting the dataset into 5 regions where each region is taken as the test data, other regions being training data, and this is repeated for every region. Gabor filter is applied to each of the training folds and we generate 80 features which in total occupy 213*768 bytes of memory . Then using KNN we classified the test data into one of the seven classes.

3. Literature Survey

Year	Author	Problem Formulation	Solution	Features Extraction	Classification	Performance Rate (%)
2001	Andrew J Calder et al.	Can PCA code facial expression in a form that can support their recognition?	Yes and 4 set PCA data showed good categorization rate.	PCA	LDA	86
2003	Ira Cohen et al.	To develop a system that interact with the user	First time use Hidden Markov Model (HMM) classifier (combine temporal info.)	Tracking feature point	HMM	85
2005	Spiros V. Loannou et al.	To develop robust system and facial action person variation	NeuroFuzzy N/W System has learning/Adaptation and Inference rules for knowledge refinement	Neurofuzzy Network	Rules based	78
2007	Jun Wang et al.	Robust System	Topographic context describes the distribution of topographic label in a region of interest of a face (split face into no. of expressive region)	Topographic Context (TC)	LDA	82.61
2008	Praseeda Lekshmi et al.	Shape+ location and whole image work.	Combine geometric and Eigen face at classification step	PCA	Weight Vector	88
2008	Shishir Bashyal et al.	Improve performance of recognition phase.	Proposed that learning vector quantization (LVQ) performs better in recognition of fear expressions than multilayer perceptron (MLP)	Gabor Wavelet	LVQ	90.22
2009	Caifeng Shan et al.	To build a system that works against illumination , changes and take less time as the other existing system	Use Linear Binary Pattern (LBP) that tolerant illumination and taken less time in computation.	LBP	SVM	89
2011	Luiz S. OLiveira et al.	To solve some of PCA's Computational problems (which effect recognition problem)	Modify the PCA by working on the whole image.	2DPCA	K-NN	91
2011	Dahmane M. et al.	System to implement the general expression model (even when a person poses at different time)	The baseline method was used. HOG is used to extract the appearance feature by gradient magnitudes for a set of orientations	Histogram of Oriented Gradient	SVM	70
2012	Wenfei Gu. et al.	Person- independent expression recognition	Gabor filters have the useful property of robustness against slight rotated object, distortion and variation in illumination.	Gabor Filter	Classifier synthesis	91

4.) Proposed Approach

The methodology of the whole application is subdivided into 3 broad and independent modules as described below:-



4.1 Feature Extraction

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right)\exp\left(i\left(2\pi\frac{x'}{\lambda}+\psi\right)\right)$$

Gabor Filter was used to extract feature map for every image by varying the parameters such as lambda , theta , sigma , gamma psi and so for every given image 80 Responses were collected which in aggregation acted as a single feature map. These 80 responses were collected by varying theta across 16 values and lambda (wavelength) across 5 values.

The intuition behind the same is explained below:-

- **Theta** is the most important attribute passed to the gabor filter constructing function. Whenever we express our emotions our eyebrows, eyes and lips tilt at certain angles, where higher tilt angles usually denotes a more intense emotion. Each of the theta passed to the function captures a certain intensity of the emotion and hence we have taken 16 possible values of theta in order to obtain a good balance of depth and contrast in images.
- **Lambda** basically tells us the wavelength of the sinusoidal wave which is convolved with

the gaussian function to ultimately create the gabor filter. Higher the value of lambda, less will be the effect of the sinusoid on the gaussian and hence the gabor filter will be smoother and the response with the image will also have less contrast. Lower values of lambda will capture even subtle changes in the image, such as brow furrows and shadows.

- **Gamma** controls the ellipticity of the gaussian. When gamma = 1, the gaussian envelope is circular.
- **Psi** controls the phase offset of the sinusoidal wave.

4.2 Dimensionality Reduction

Since for every image 80 Responses were collected and every image was of the size 256 * 256 , the feature map was of huge size. Therefore dimensionality reduction was done by extracting only the face out of the images. This effectively sped up the process by approximately 4 times and also reduced the space complexity by about half.

4.3 Finding Emotion by Classifying the Images

Once the dimensionality reduced feature maps are obtained , these are used to train the model for all the emotions present in the images and map a label for every given face image. We have used KNN classifier from weka to do the same.

5.) Hardware and Software requirements:

- 1 GB RAM
- Python
- OpenCV
- Weka
- MatplotLib
- SciPy
- Scikit-Learn
- Numpy

6. Activity Time Chart

	Before Mid-Sem		After Mid-Sem	
	Phase-I 1 Mar - 8 Mar	Phase-II 9 Mar - 16 Mar	Phase-III 17 Mar - 24 Mar	Phase-IV 25 Mar - 31 Mar
LITERATURE SURVEY	Done			
PROBLEM IDENTIFICATION	Done			
IDENTIFY AN APPROACH		Done		
FACE DETECTION		Done		
IMAGE FILTERING			Done	
FEATURE POINTS SELECTION			Done	
CREATING FEATURED DATA				Done
CLASSIFICATION				Done

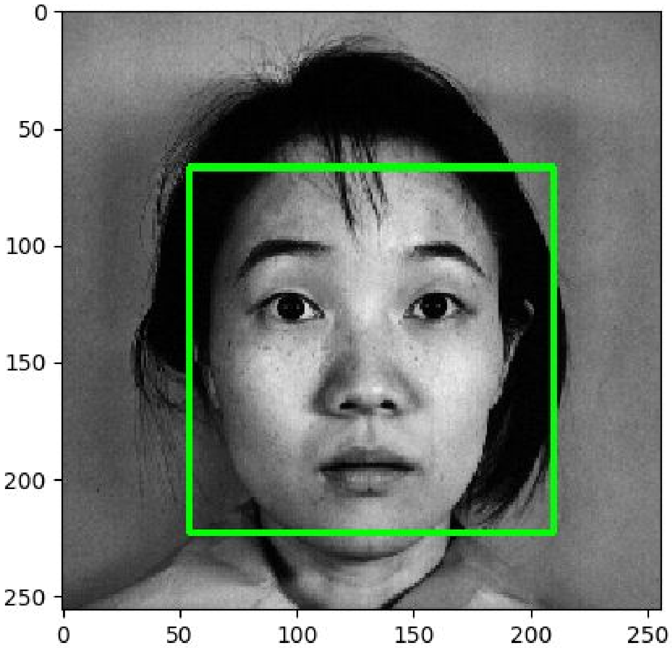
7.Experiment Setup and Results

Experimental Setup:

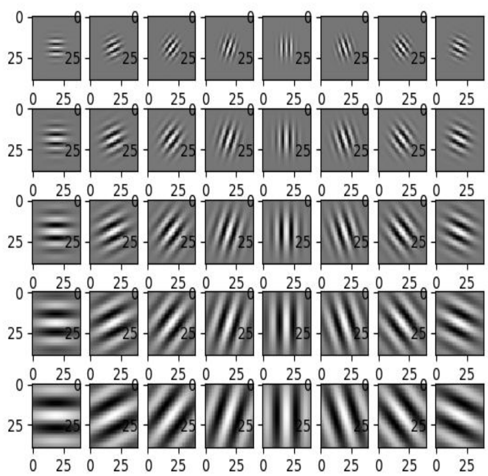
- We used **OpenCV** for performing basic image processing tasks such as extraction of face from given image, cropping the image.
- We used **Matplotlib** for analysing the image , viewing coordinates and indexes on the images.
- **SciPy** is an open source Python library used for scientific computing and technical computing. SciPy contains modules for optimization, linear algebra, integration, interpolation, special functions, FFT, signal and image processing, ODE solvers and other tasks common in science and engineering.
- **NumPy** is a library for the Python programming language, adding support for large, multidimensional arrays and matrices, along with a large collection of high-level mathematical functions to operate on these arrays.
- **Scikit-learn** is a free software machine learning library for the Python programming language. It features various classification, regression and clustering algorithms including support vector machines, random forests, gradient boosting, *k*-means and DBSCAN, and is designed to interoperate with the Python numerical and scientific libraries NumPy and SciPy.
- Weka contains a collection of visualization tools and algorithms for data analysis and predictive modeling, together with graphical user interfaces for easy access to these functions.

Results:

- This is the result of extracting the face from the image. This reduced our running time by a factor of 4 and our space complexity by an approximate factor of 2.



- These are few of the gabor kernels we have used to capture the facial features. The variations in theta can be easily seen from the below picture. The lower row also contains higher wavelength values. As one increases the wavelength the response becomes weaker and smoother.



- This is the results window as displayed by WEKA GUI. Important things to note from here is the number of correctly - 83.56% and incorrectly classified instances - 16.44%, which give us the accuracy of our project. The confusion matrix tells us the number of 'hits' and 'misses' for each test image.

```
Instances:     213
Attributes:    769
Test mode:     5-fold cross-validation

=== Classifier model (full training set) ===

IB1 instance-based classifier
using 1 nearest neighbour(s) for classification

=== Summary ===

Correctly Classified Instances         178               83.5681 %
Incorrectly Classified Instances        35               16.4319 %
Total Number of Instances              213

=== Detailed Accuracy By Class ===

                 TP Rate   FP Rate   Precision   Recall   F-Measure   Class
                 0.833     0.016     0.893       0.833    0.862          SU
                 0.967     0.049     0.763       0.967    0.853          NE
                 0.677     0.033     0.778       0.677    0.724          HA
                 0.900     0.022     0.871       0.900    0.885          AN
                 0.719     0.017     0.885       0.719    0.793          FE
                 0.871     0.044     0.771       0.871    0.818          SA
                 0.897     0.011     0.929       0.897    0.912          DI

=== Confusion Matrix ===

  a  b  c  d  e  f  g   <-- classified as
 25  1  1  0  1  2  0 |  a = SU
  0 29  1  0  0  0  0 |  b = NE
  0  5 21  1  0  4  0 |  c = HA
  1  1  0 27  0  0  1 |  d = AN
  2  1  3  0 23  2  1 |  e = FE
  0  1  1  0  2 27  0 |  f = SA
  0  0  0  3  0  0 26 |  g = DI
```

8.Performance Comparison

K-Nearest Neighbors

Correctly Classified Instances	178	83.5681 %
Incorrectly Classified Instances	35	16.4319 %

RandomForest

Correctly Classified Instances	150	70.4225 %
Incorrectly Classified Instances	63	29.5775 %

Support Vector Machine

Correctly Classified Instances	159	74.6479 %
Incorrectly Classified Instances	54	25.3521 %

9.Conclusion

Till today all of the existing vision system for facial muscle action detection deal only with the frontal-view face images and cannot handle the temporal dynamics of facial actions. However, with this shortcoming we have shown based on experimental confirmation that the proposed framework for automatic emotion detection can be well appertained to real time facial expression and emotion characterization task. Also for some human beings, they don't show their emotion and mental states by facial expressions, for this kind of situation our proposed model significantly fails to recognize the emotion and provides false positive result.

10). References

[1] Debishree Dagar, Abir Hudait,H. K. Tripathy,M. N. Das *"Automatic Emotion Detection Model from Facial Expression*" in International Conference on Advanced Communication Control and Computing Technologies 2016.

[2 Shruti Karkra , Jagandeep Kaur "*Compound Facial Expression Recognition through Gabor Filter and RBF Network "* in International Journal of Computer Science and Mobile Computing 2016.