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Face Smile and Related Dimensions Analytics using Deep Learning

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ABSTRACT

Face Smile Detection is one of the critical domains of research in the stream of digital images in association with machine learning and predictive analysis. The key motive of face smile detection is to analyze and classify the motions of a human being on the lips and extraction of actual emotions during the scenario under investigation. The implementation of deep learning based classification and prediction approaches in association with Support Vector Machines (SVM) and Artificial Neural Networks (ANN) shall be used for the higher degree of classification with minimum error factors. This is because these approaches are metaheuristics based and associated as nature inspired approaches. A number of algorithms are devised so far still the performance of nature inspired approaches and metaheuristic approaches are quite prominent and aware with the minimum error rate. Assorted natural inspired approaches devised so far for solving the engineering problems in assorted domains but there is huge scope of research in the segment. Nature provided us a number of approaches which can be used for the resolving as well as solving the problems in different domains including engineering and social aspects. Nature Inspired Algorithms is a very active research area as problems with which we are normally familiar are getting more and more complex due to size and other aspects, but also to new problems cropping up all the time on which existing methods are not effective. Nature seems to have been there and done it, so to speak. That is why we seem to get a lot of inspiration from it these days and in the foreseeable future. The recent Nature Inspired algorithms include the Artificial Bee Colony Algorithm, the Firefly Algorithm, the Social Spider Algorithm, the Bat Algorithm, the Strawberry Algorithm, the Plant Propagation Algorithm, the Seed Based Plant Propagation Algorithm and many others. In this proposed research work, the novel and effective approaches for deep learning and classification of face smiles shall be used so that the face smile classification on multiple classes can be done with minimum error factor.

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Keywords: Deep Learning Based Face Detection, Face Smile Detection, Deep Learning, Digital Image Processing

FOREWORD

Face Detection is one the key domain of research in digital image as well as real time video processing. In face analysis, there are assorted segments which are required to be investigated in terms of getting emotions and feelings of the person. These segments include Lips, Eyes, Cheeks, Ears, Eye Brows, Nose and many others. Lips Detection is used to analyze the emotions of the person in terms of Sadness, Happiness, Frustrations and many others. Using this research work, it is proposed to work on the Lips based Smile Detection on faces to analyze the Smile Detection using metaheuristic approach which makes use of global optimization of results. In this area, the use of artificial neural networks or support vector machine can be used for classification of the Smile on Human Face. This work focus on the implementation of metaheuristic approaches based classification and pattern recognition for the Lip Smile Detection from Human Faces. The high level algorithm with the multilayered approaches for classification shall be devised and implemented using Artificial Neural Networks and Support Vector Machines with the Predictive Analysis and comparing the performance of these algorithms.

LITERATURE SURVEY

This chapter presents a detailed review of literature on face detection with the segment analysis on human faces. This chapter also presents the review of literature on the assorted approaches and algorithms devised and implemented to human faces for prediction of smiles and their classes. This chapter showcases prior literature and research related to studies exploring various disciplines, relationships, areas of concern, and other issues. To propose and defend the research work, a number of research papers are analyzed. Following are the excerpts from the different research work performed by number of academicians and researchers. The review of literature is one the imperative task while performing the research work as it is required to analyze the number of research papers, articles and manuscripts from assorted sources in the similar domain. Following are the excerpts from different research papers and related journals which address the thrust and approaches associated with the human face detection and lips based smile analysis.

Research Work and Key Dimension	Author(s)	Year
Implementation of recognition and predictive analysis of stress from the digital images fetched using algorithms for computer vision	Prithvi Krishna Gattamaneni and John Ryan	2016
Implementation of Real Time and Dynamic Facial Recognition on the Expressions with Nonverbal	Md. Sazzad Hossain and Mohammad Abu Yousuf	2017

Communication		
Evaluation of facial parameters and segments with the scoring in terms of emotions detection	Yuki Nakayama, Yuji Takano, Masaki Matsubara, Kenji Suzuki, Hiroko Terasawa	2017
The work on the estimation of gender with the integration of smile-dynamics	Antitza Dantcheva, Francois Bremond	2017
Implementation of PSO algorithm for face smile recognition and classification	Zhijie Li, Xiaodong Duan, Cunrui Wang, Jian Yun, Bo Lu	2017
Evaluation of real time dynamic video and extraction of emotional aspects and perspectives for classification	Xiaoming Chen and Wushan Cheng	2016
Pragmatic and implementation based analysis of Viola Jones Algorithm for the Detection of Smile in the Group Snaps	Saravanan Chandran	2016
Recognition and Face Detection Using Infrared Images and Visible Light	Mohammad Ali Banaee1 , Ali Akbar Khazaei	2016

Spontaneous smile detection with Application of landmark points Supported by visual indications	Karolina Nurzynska and Bogdan Smolka, Yannawar Pravin	2016
Virtual U: Defeating Face Liveness Detection by Building Virtual Models	Yi Xu, True Price, Jan-Michael Frahm, Fabian Monrose	2016
Automatic Detection of Facial Expressions from Video Streams	Manza Ganesh R	2015
Virtual Makeup Application Using Image Processing Methods	Gozde Yolcu Oztel, Serap Kazan	2015
Facial expression recognition based on Edge detection	Xiaoming Chen and Wushan Cheng	2015
Enhancing Facial Action Recognition Using Multikernel-Review	Bombale G.R, Prof. Rokade P. P.	2015
Verbal and Nonverbal Clues for Real-life Deception Detection	Ver´onica P´erez-Rosas, Mohamed Abouelenien, Rada Mihalcea,	2015

	Yao Xiao, CJ Linton, Mihai Burzo	
The empirical work on the Face Expression Analysis and Recognition with the effectual approach	Jharna Majumdar, Ramya Avabhrith	2014
Real time analytics and Expression of Face Modules for the Classification	Jaya Prakash S M, Santhosh Kumar K L, Jharna Majumdar	2014
Effectual implementation for movement analysis and face recognition for the evaluation of expressions	Mar Saneiro, Olga C. Santos, Sergio Salmeron-Majadas, and Jesus G. Boticario	2014
Face Detection and Classification using metaheuristic approach	Rekha N, Dr.M.Z.Kurian	2014
The detection psychological manifestations of non-verbal communication by Interrogator	Zuzana Metenková, Jozef Metenko	2013

METHODS

For implementation and predictive analysis, the metaheuristic approaches shall be used so that the global optimal results can be achieved with minimum errors.

This proposed work is proposed to give the effective results in terms of very less error rate and high efficiency in getting the probability factor of malware still this work can be further enhanced using other optimization approaches. In this work, the new metaheuristic approach SFO for optimization shall be done.

There exist another approach hyper-heuristic that can be integrated for deep learning of malware and predictive analysis. The key demarcation line between metaheuristics and hyper-heuristics is that nearly all the implementations in metaheuristics makes search in the search space in the span of solutions of problem. The hyper-heuristics takes the cases and search space within the range and domain of heuristics.

RESEARCH OBJECTIVES

1. Identification of Problem and Research Gaps
2. Deep Literature Review on Face Smile Detection and Classification Approaches
3. Devising a New Multilayered Algorithm
    - SVM or ANN depending upon the performance
    - We are proposing to integrate the wine formation process in the proposed task.
    - Initial Comparison between the proposed approach and classical Population Based Approach
4. Excerpts of the Research Papers on Population Based Approaches

5. Identification of Simulation Tool and Technologies
    - MATLAB / OpenCV

Support Vector Machine

Support Vector Machine (SVM) is an approach for the supervised learning, training and classification of the models based on the paradigm of machine learning and predictive analysis. Using SVM, the training of a supervised model and further prediction can be done on higher degree of accuracy. MATLAB and Python-OpenCV both can be used for the integration of SVM and results on assorted applications including Face Detection, Smile Classification, Smile Analytics, Lips Detection and many others.

Applications of SVM includes

- Classification and analytics of digital images
- Evaluation of digital video and extraction of images with the classification and regression
- Character recognition
- Image segmentation and analytics
- Text Mining and Categorization

Artificial Neural Networks

An artificial neural system is a framework in view of the operation of organic neural systems. In machine learning and subjective science, artificial neural systems (ANNs) are a group of models propelled by organic neural systems (the focal sensory systems of creatures, specifically the cerebrum) which are utilized to assess or estimated capacities that can rely on upon countless and are for the most part obscure. Artificial neural systems are regularly determined utilizing three things:

Design: It determines what variables are included in the system and their topological connections—for instance the variables required in a neural system may be the weights of the associations between the neurons, alongside exercises of the neurons.

Action rule: Most neural system models have brief time-scale elements: neighborhood rules characterize how the exercises of the neurons change because of each other. Commonly the movement principle relies on upon the weights (the parameters) in the system.

Learning rule: The learning guideline indicates the path in which the neural system's weights change with time. This learning is generally seen as occurring on a more drawn out time scale than the time size of the elements under the action standard. Generally the learning guideline will rely on upon the exercises of the neurons. It might likewise rely on upon the estimations of the objective qualities supplied by an instructor and on the present estimation of the weights.

Like other machine learning methods – frameworks that gain from information – neural systems have been utilized to comprehend a wide assortment of assignments, similar to PC vision and discourse acknowledgment, that are difficult to explain utilizing common principle based programming.

The major advantage of neural networks is that it learns through the training data, then updates its weights and gives an accurate result thus giving the high level of efficiency in real-time operations, low consumption of CPU resources during the classification phase, and its ability to generalize, which is important for detecting any previously unseen malwares."

Figure below is the classical format and diagrammatic structure of ANN. In the figure there are number of components which work together for the generation and prediction of the datasets.

RESULTS

The implementation for Smile Based Face Recognition shall be shall be done on the benchmark datasets available for research. There are assorted datasets available from diversified research and development portals including the following.

Benchmark Datasets for Face and Smile Recognition

- http://fei.edu.br/~cet/facedatabase.html
- http://rgb-d.eurecom.fr/
- http://scikit-learn.org/stable/datasets/olivetti_faces.html
- http://web.mit.edu/emeyers/www/face_databases.html
- http://www.cad.zju.edu.cn/home/dengcai/Data/FaceData.html
- http://www.cl.cam.ac.uk/research/dtg/attarchive/facedatabase.html
- http://www.face-rec.org/databases/
- http://www2.ece.ohio-state.edu/~aleix/ARdatabase.html
- https://data.mendeley.com/datasets/yz4v8tb3tp/5
- https://facedetection.com/datasets/
- https://facedetection.com/datasets/
- https://medium.com/@kidargueta/facial-emotion-recognition-single-rule-1-0-deeplearning-c90c3c2be788
- https://www.affectiva.com/facial-expression-dataset/
- https://www.behance.net/gallery/10675283/Facial-Expression-Public-Databases
- https://www.behance.net/gallery/10675283/Facial-Expression-Public-Databases
- https://www.ecse.rpi.edu/~cvrl/database/other_Face_Databases.htm
- https://www.kairos.com/blog/60-facial-recognition-databases

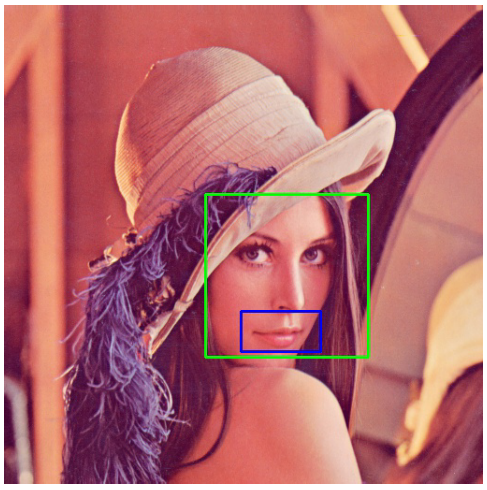

Figure 1: Extraction of Facial Segments for Analysis

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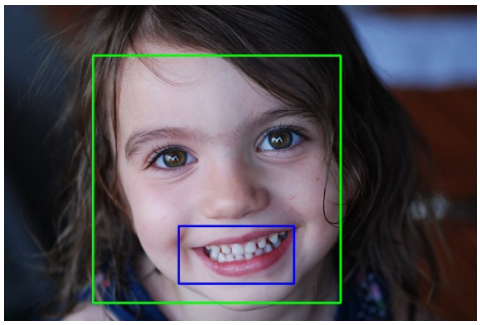

Figure 2: Recognition of Facial Points including Lips

Face Smile Detection APIs and Libraries

```
const MyThisSmileInFaceThisSmileDetector = req
uire('ThisSmile-InFace-ThisSmileDetector');
const ThisSmileDetector = new MyThisSmileInFac
eThisSmileDetector({ThisSmileScale: 1.01, ThisS
mileNeighbor: 10});
ThisSmileDetector.on('ErrorFactor', (ErrorFactor)
=> {
  console.ErrorFactor(ErrorFactor);
});
ThisSmileDetector.on('InFace', (InFaces, InImage)
=> {
  console.log(InFaces);
  InFaces.forEach((InFace) => {
    // write rectangle
    InImage.rectangle([InFace.x, InFace.y], [InFace.
width, InFace.height], MyThisSmileInFaceThisSmi
leDetector.green, 2);
  });
});
ThisSmileDetector.on('ThisSmile', (ThisSmiles, In
Face, InImage) => {
  console.log(ThisSmiles);
  ThisSmiles.forEach((ThisSmile) => {
    InImage.rectangle([ThisSmile.x + InFace.x, This
Smile.y + InFace.height/2 + InFace.y], [ThisSmile.
width, ThisSmile.height], MyThisSmileInFaceThis
SmileDetector.blue, 2);
  });
  InImage.save('./InImages/Lenna_result.jpg');
});
ThisSmileDetector.load('./InImages/Lenna.png').th
en((InImage) => {
  ThisSmileDetector.detect(InImage);
}).catch((e) => {
  console.ErrorFactor(e);
});
API
constructor
new MyThisSmileInFaceThisSmileDetector({
  InFaceScale: 1.01,
it on InFace detection default: 8
  InFaceNeighbor: 2,
tection default: 1.7
  ThisSmileScale: 1.01,
it on ThisSmile detection default: 22
  ThisSmileNeighbor: 2,
});
load
const ThisSmileDetector = new MyThisSmileInFac
eThisSmileDetector();
ThisSmileDetector.load('/foo/bar.jpg').then((InIma
ge) => {
  // InImage is Matrix instance on opencv
}).catch((e) => {
});
detect
const ThisSmileDetector = new MyThisSmileInFac
eThisSmileDetector();
```

```
ThisSmileDetector.on('InFace', (InFaces, InImage)
=> {
});
ThisSmileDetector.on('ThisSmile', (ThisSmiles, In
Face, InImage) => {
});
ThisSmileDetector.load('/foo/bar.jpg').then((InIma
ge) => {
  ThisSmileDetector.detect(InImage);
})
```

Human InFace ThisSmile Detection using OpenCV

```
import OpenCVLib
import numpy as np
import sys

InFacePath =
"/usr/local/Cellar/opencv/2.4.7.1/share/OpenCV/ha
arcascades/haarcascade_frontalInFace_default.xml"
ThisSmilePath =
"/usr/local/Cellar/opencv/2.4.7.1/share/OpenCV/ha
arcascades/haarcascade_ThisSmile.xml"
InFaceCascade =
OpenCVLib.CascadeClassifier(InFacePath)
ThisSmileCascade =
OpenCVLib.CascadeClassifier(ThisSmilePath)

cap = OpenCVLib.VideoCapture(0)
cap.set(3,640)
cap.set(4,480)

sF = 1.05

while True:

    ret, frame = cap.read() # Capture frame-by-frame
    img = frame

    gray = OpenCVLib.cvtColor(frame,
OpenCVLib.COLOR_BGR2GRAY)

    InFaces = InFaceCascade.detectMultiScale(
        gray,
        scaleFactor= sF,
        minNeighbors=8,
        minSize=(55, 55),

flags=OpenCVLib.cv.CV_HAAR_SCALE_INIM
AGE
    )
    for (x, y, w, h) in InFaces:
        OpenCVLib.rectangle(frame, (x, y), (x+w,
y+h), (0, 0, 255), 2)
        roi_gray = gray[y:y+h, x:x+w]
        roi_color = frame[y:y+h, x:x+w]

        ThisSmile =
ThisSmileCascade.detectMultiScale(
            roi_gray,
            scaleFactor= 1.7,
            minNeighbors=22,
            minSize=(25, 25),

flags=OpenCVLib.cv.CV_HAAR_SCALE_INIM
AGE
            )
        for (x, y, w, h) in ThisSmile:
            print "Found", len(ThisSmile),
"ThisSmiles!"
            OpenCVLib.rectangle(roi_color, (x, y),
(x+w, y+h), (255, 0, 0), 1)
            #print "!!!!!!!!!!!!!!!!!!"
```

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```
    OpenCVLib.imshow('ThisSmile Detector',
frame)
    c = OpenCVLib.cv.WaitKey(7) % 0x100
    if c == 27:
        break
cap.release()
OpenCVLib.destroyAllWindows()
%matplotlib inline
from pylab import *
from sklearn import datasets
InFaces = datasets.fetch_olivetti_InFaces()
InFaces.keys()
 ['InImages', 'data', 'target', 'DESCR']
One can plot a selection of InImages from the
dataset.
for i in range(10):
    InFace = InFaces.InImages[i]
    subplot(1, 10, i + 1)
    imshow(InFace.reshape((64, 64)), cmap='gray')
    axis('off')
```

```
from IPython.html.widgets import interact,
ButtonWidget
from IPython.display import display, clear_output
class DeepTrainer:
    def __init__(self):
        self.results = {}
        self.imgs = InFaces.InImages
        self.index = 0

    def increment_InFace(self):
        if self.index + 1 >= len(self.imgs):
            return self.index
        else:
            while str(self.index) in self.results:
                print self.index
                self.index += 1
            return self.index

    def record_result(self, ThisSmile=True):
        self.results[str(self.index)] = ThisSmile

DeepTrainer = DeepTrainer()
button_ThisSmile =
ButtonWidget(description='ThisSmile')
button_no_ThisSmile =
ButtonWidget(description='sad InFace')

def display_InFace(InFace):
    clear_output()
    imshow(InFace, cmap='gray')
    axis('off')

def update_ThisSmile(b):
    DeepTrainer.record_result(ThisSmile=True)
    DeepTrainer.increment_InFace()

display_InFace(DeepTrainer.imgs[DeepTrainer.ind
ex])

def update_no_ThisSmile(b):
    DeepTrainer.record_result(ThisSmile=False)
    DeepTrainer.increment_InFace()

display_InFace(DeepTrainer.imgs[DeepTrainer.ind
ex])

button_no_ThisSmile.on_click(update_no_ThisSmi
le)
```

```
button_ThisSmile.on_click(update_ThisSmile)

display(button_ThisSmile)
display(button_no_ThisSmile)
display_InFace(DeepTrainer.imgs[DeepTrainer.index])
```

Loading training dataset

```
import json
results = json.load(open('results.xml'))
DeepTrainer.results = results
```

Saving training dataset

```
#with open('results.xml', 'w') as f:
#    json.dump(DeepTrainer.results, f)
```

Visualizing the training set data

Now that our input data is ready, we can plot a little statistic from our dataset: how many people are PhaseSmiling in the pictures and how many are not?

```
yes, no = (sum([DeepTrainer.results[x] == True for x in DeepTrainer.results]),
           sum([DeepTrainer.results[x] == False for x in DeepTrainer.results]))
bar([0, 1], [no, yes])
ylim(0, max(yes, no))
xticks([0.4, 1.4], ['no ThisSmile', 'ThisSmile']);

PhaseSmiling_indices = [int(i) for i in results if results[i] == True]

fig = plt.figure(figsize=(12, 12))
fig.subplots_adjust(left=0, right=1, bottom=0, top=1, hspace=0.05, wspace=0.05)
for i in range(len(PhaseSmiling_indices)):
    # plot the InImages in a matrix of 20x20
    p = fig.add_subplot(20, 20, i + 1)

p.imshow(InFaces.InImages[PhaseSmiling_indices[i]], cmap=plt.cm.bone)

    # label the InImage with the target value
    p.text(0, 14, "PhaseSmiling")
    p.text(0, 60, str(i))
    p.axis('off')
```

Figure 3: View of the Face Dataset

```
random_InImage_button = ButtonWidget(description="New InImage!")
def display_InFace_and_prediction(b):
    index = randint(0, 400)
    InFace = InFaces.InImages[index]
    display_InFace(InFace)
    print("this person is PhaseSmiling: {0}".format(svc_1.predict(InFaces.data[index, :])==1))

random_InImage_button.on_click(display_InFace_and_prediction)
display(random_InImage_button)
display_InFace_and_prediction(0)
this person is PhaseSmiling: [ True]
```

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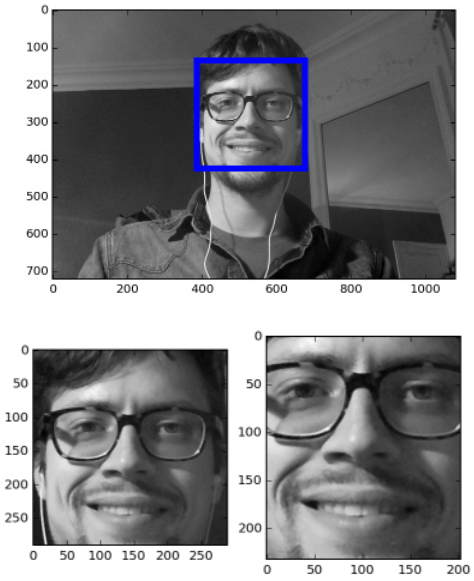

Figure 4: Evaluation of Assorted Facial Points

The benchmark and normalized dataset of faces shall be fetched from the research repositories of faces and digital images having emotions. The proposed work shall be implemented using MATLAB / Python based OpenCV implementation so that the effectual results can be fetched out with the higher degree of accuracy with the minimum false rate.

The comparative analytics shall be done on multiple parameters including

1. Confusion Matrix
2. False and True Rates of Predictions
3. Cost Factor
4. Execution Time
5. Complexity
6. Overall Performance

CONCLUSION

This proposed work is proposed to give the effective results in terms of very less error rate and high efficiency in getting the probability factor of malware still this work can be further enhanced using other optimization approaches. In this work, the new metaheuristic approach for classification and optimization of error factor shall be integrated. There exist another approach hyper-heuristic that can be integrated for deep learning of malware and predictive analysis. The key demarcation line between metaheuristics and hyper-heuristics is that nearly all the implementations in metaheuristics makes search in the search space in the span of solutions of problem. The hyper-heuristics takes the cases and search space within the range and domain of heuristics.

The prominent soft computing approaches which can be used for further optimization include

- Ant Colony Optimization
- Bat Algorithm
- Bayesian Network
- Bees Algorithm
- Cuckoo Search
- Evolutionary Approaches
- Firefly Algorithm
- Flower Pollination Algorithm
- Fuzzy Logic
- Nature Inspired Algorithms
- Particle Swarm Optimization
- River Formation Dynamics
- Simulated Annealing
- Swarm Intelligence

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