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Stress Detection using Deep Learning and IoT

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***Abstract*: Stress is a part of life which is an unpleasant emotional state that people experience in situations like working for long hours in front of a computer. Stress can be positive, but it can affect your health if it's chronic. Thus, it is very much necessary to inform the person about his/her unhealthy lifestyle and even alarm him/her before any acute condition occurs. To detect the stress beforehand, a Deep Learning (DL) method is used where real-time images are captured, which detects the emotional status of a person by analyzing the facial expression and Internet of Things (IoT) is used to inform the patients about his/her stress condition.**

***Keywords*: Stress, Deep Learning, IoT, Convolutional Neural Networks (CNN), Heartbeat rate.**

1. Introduction

Stress is one of the main factors due to which many lives are affected. Stress is an emotional state that people have whenever they are trying to fulfill their needs or demands. Recent studies have proven that stress can also affect the aspects of your life, including your thinking ability and physical health. To reduce the risk of being stressed and affected by its adverse effects, it is very much necessary to detect such emotions and take certain actions to relax them.

In this work, the stress is detected based on the analysis of facial expression and the stress level using the pulse sensor. We make use of a technique that allows us to train a model and analyze differences in predicting the features. Our system uses a deep learning algorithm to achieve the expected results in the areas such as computer vision. A camera is used to capture the frontal view of the person while he/she is working in front of the computer. We detect an individual emotion in a picture frame and the decision on the stress level is captured. The captured image is then analyzed according to the variation in the position of the eyebrow from its mean position.

Here, Convolutional Neural Network (CNN), a deep learning algorithm is used for automatic classification of images. This supervised classification technique analyzes and trains the classifier on the labeled images and extracting features from them. By using the learned information of the training, the newly provided image will be classified based on the features observed in the image. Our system uses the FER dataset as a benchmark for classification of grayscale images. The grayscale images in the data set used for training require more computational power for classification of images. The technique, after training the model will learn the weights and the accuracy of the classifier is improved.

The prototype developed here detects whether a person is in stress based on the variations in his/her heart rate. To find out heart rate, Pulse Sensor is used. It is an open-source microcontroller board that establishes a connection with a Wi-Fi module and supports a micro python which is a minimal version of python. It detects the pulse rate of the body which is counted as beats per unit time. Stress cannot be quantified and hence through mapping of stress and heartbeat, we can identify a lot of things.

2. Literature survey

Human stress has been an intermittent topic in research papers due to its increased relevance in modern society. [1] uses Theano, a python framework where stress is detected by the position of the eyebrow from its mean position. CNN's can be used for image classification using images from handwritten MNIST dataset [2]. Face recognition is an interesting technique which extracts meaningful features from an image. OpenCV library's Haar cascade classifier performs face detection with high efficiency [3]. Many studies have been conducted to identify the precise facial characteristics that are associated to depression. A depressed/stressed face has the same characteristics of a sad face which can be classified by SVM classifier [8]. [9] gives a brief introduction about convolutional neural networks developing brilliantly image recognition models. [10] A deep learning CNN based on Keras and tensor flow where four different structures of CNN on CPU system are compared with each other.

Heart rate variability refers to the beat alterations in the heart rate. Based on heart rate we can predict whether a person is in stressed or not. An IoT device named Remote Stress Detector can be used to identify the stress level of any person using his/her heart-rate [4]. Stress can also be detected by measuring body temperature and skin conductance using sensors, and which analyzes the stress level [7]. With the help of different wearable sensors signals like ECG and breathing rate are measured [6].

[5] This paper presents an emotion detection system for smart phones which can be used as a smart keyboard. The smart keyboard detects a person's emotional state using ML techniques.

3. Dataset

For our work, we have used FER2013 dataset. The FER2013

dataset originally consists of 35,887 grayscale 48x48 sized face images with 7 different emotions. This dataset was used in Kaggle competition. During the competition, 28,709 images and 3,589 images were shared as training and public tests respectively and the remaining 3,589 images were kept as a private test. We have altered this dataset based on our requirements. For our use we have classified into two parts stressed images and not stressed images. The images such as happy, surprise and neutral belong to the not stressed part and the other images such as angry, sad, fear belongs to the stressed part.

4. Proposed approach

The proposed approach consists of two main sections:

- Deep Learning (CNN)
- IoT

A. *Deep Learning (CNN)*

Deep Learning models are inspired by the human brain, and particularly its ability to extract structures patterns from the raw data. Deep learning models operate on a large number of successive transformations from the raw data, to discover different representations of such data.

The operated transformations are combinations of linear and nonlinear operations. These transformations are used to represent the data at different levels of abstraction. The popular image processing structure of Deep Learning Models is CNN [10] which is constructed by three main processing layers: Convolutional Layer, Pooling Layer, and Fully Connected Layer. The adopted architecture is shown in Figure 1.

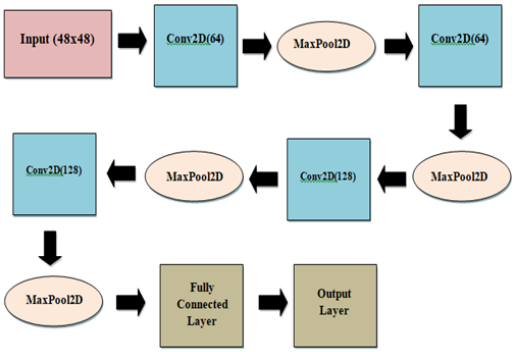


Fig. 1. Architecture of CNN

The ConvNet which is proposed mainly consists of four Convolutional Layer with four max pooling layer included in between the Convolutional Layers, followed by a fully connected layer and lastly a softmax output layer indicating the two classes.

- *Convolutional Layer:* Convolutional Layer plays an important role in how CNN operates. The use of learnable kernals are mainly concentrated in this layer. When the input data enters a convolutional layer, the layer convolves each filter throughout the spatial dimensionality of the input which produces a 2D activation map. The scalar product for every value in the Kernal is calculated, as we glide through the input data.
- *Pooling Layer:* Pooling layer mainly intends to reduce the dimensionality of the representation by reducing the number of parameters and also complexity of computation.
- *Fully Connected Layer:* This layer is used to connect every single neuron from one layer to every single neuron in the next layer. This layer takes the output information from the convolutional networks. The last fully connected layer contains a softmax function which classifies the image into different classes using the features generated.

B. *IoT*

- *Components used:* The components used in this project are described in the following.
- *Arduino Mega:* It is a microcontroller board which is based on ATmega 2560 micro-controller. It consists of 54 I/O digital pins along with 16 Analog pins. Out of 54 I/O pins, 15 are PWM (Pulse Width Modulation) pins. This board contains a USB cable port which is used to connect and transfer code from the computer to the board.

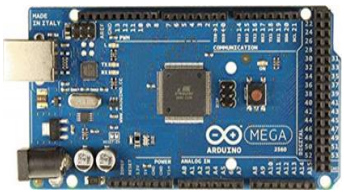


Fig. 2. Arduino mega board

Pulse Sensor: This module is used to detect the pulse rate of the body which can be used to find out the heart rate of a person. It can be used in our daily lives to calculate stress and anxiety. The pulse Sensor has a threshold value which needs to be calibrated. To count the heart rate, one needs to count the number of pulses in a minute. This is done by calculating the inter beat interval.

Fig. 3. Pulse sensor

Wi-Fi Module: A Wi-Fi module is a self-contained SOC which contains TCP/IP protocol stack which helps to give any micro-controller access to any Wi-Fi network.

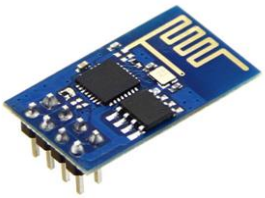


Fig. 4. Wi-Fi module

5. Implementation

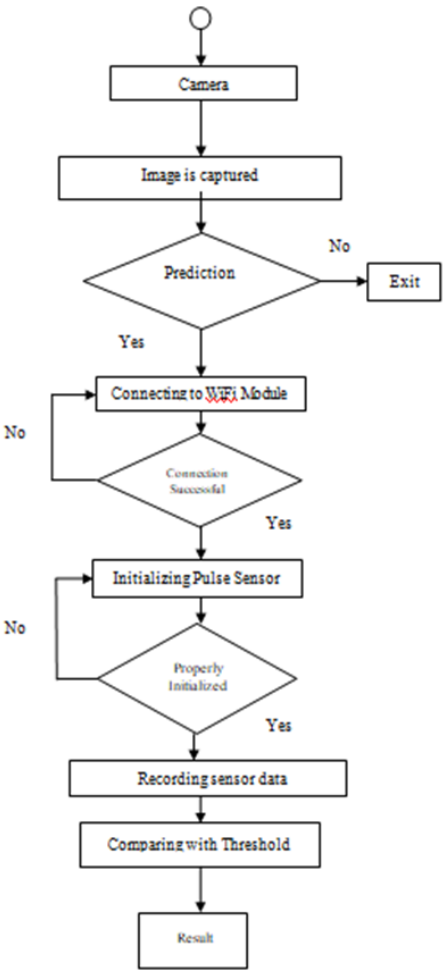


Fig. 5. Dataflow diagram

The dataflow diagram is shown in figure 5. The image of the person is captured by the camera. The camera processes the image sequence using the CNN model. It predicts the stress using the image captured. If the prediction is true, it is then connected to the Wi-Fi module that can give any micro-controller access to our Wi-Fi network. If the connection to the Wi-Fi is successful, it initializes the pulse module. If the initialization does not go through, it retries to connect with the pulse sensor which records a reading when you place the tip of a finger on it or attaching the sensor with your wrist. Once the initialization is done correctly, the collected data is recorded. The data is then sent to the server. If the value is greater than the threshold value then it displays that the person is stressed on the webpage.

6. Results

The final model of CNN is used to predict the Stress of the person from the image captured. If the prediction of the image is Stress, then using the pulse sensor the pulse data is recorded and the result is displayed whether the person is stressed or not.

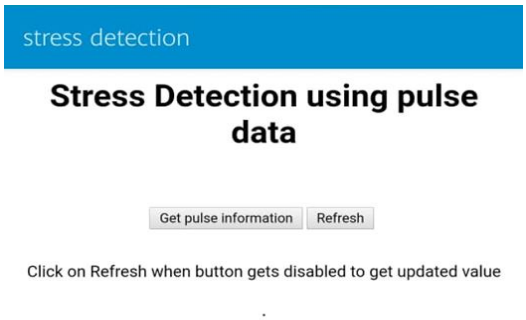
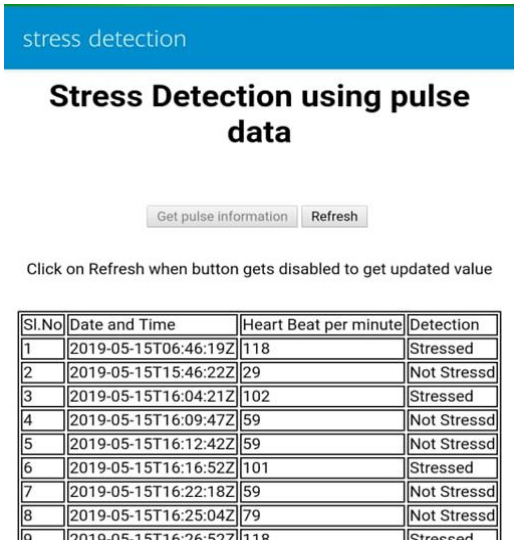


Fig. 6. Webpage before getting pulse data



Sl.No	Date and Time	Heart Beat per minute	Detection
1	2019-05-15T06:46:19Z	118	Stressed
2	2019-05-15T15:46:22Z	29	Not Stressd
3	2019-05-15T16:04:21Z	102	Stressed
4	2019-05-15T16:09:47Z	59	Not Stressd
5	2019-05-15T16:12:42Z	59	Not Stressd
6	2019-05-15T16:16:52Z	101	Stressed
7	2019-05-15T16:22:18Z	59	Not Stressd
8	2019-05-15T16:25:04Z	79	Not Stressd
9	2019-05-15T16:26:52Z	118	Stressed

Fig. 7. Output of the final result

7. Conclusion and future work

Detection of stress in Human is very important because excessive stress can lead to depression. This paper provides an insight into the applications of Stress/Anxiety prediction and serves as a stepping stone for any new research work in this field. An effort was made to detect the stress using methods from Deep Learning and the Internet of Things. In the future, this project can be extended by using more databases for training which contains image taken from all the directions and also adding more layers to the CNN network. This method can also be used to continuously monitor the patients undergoing depression and assure their safety.

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