

# Anxiety Analyzer: A Deep Learning Approach for Classification of Stress

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**Abstract** - In today's digital era and the pandemic situation like Covid 19, most of the things are conducted in online mode like lectures, businesses, conferences, etc. So the interaction and communication amongst the peoples is lagging behind. Due to this, the chances of mental health diseases like depression, anxiety, loneliness are increasing. In existing solutions, they are diagnosed by means of abstract methods such as quiz, questionnaire or discussion with the patient. But there is inaccuracy and uncertainty in diagnosing mental health diseases with the help of traditional abstract methods. Nearly 9 out of 10 Indians are stressed. The 2018 Cigna 360 Well-Being Surveys — Future Assured, conducted by Cigna TTK Health Insurance, shows that Indians are more stressed than people in other developed countries like the United States, and other developed and emerging countries. Moneycontrol reports that 95% of Indian millennials aged 18-34 are stressed, surpassing the global average of 86%. Shockingly, 1 out of 8 Indians struggle immensely with managing stress. Some Indian respondents also revealed that 17% of Indians are hesitant to seek help from medical professionals when it comes to discussing their problems or stress issues. Also, the consultation cost is one of the major barriers to seeking medical professionals. Due to stress many times patients suffer from severe headaches so our solution was going around this fact. There are many types of headaches from which humans suffer. They are migraine, hypertension, stress etc. The proposed solution to this problem mentioned in this paper is to detect the mental health diseases with accuracy by means of generating a body heat map of the patient with the help of a thermal camera and applying techniques of image processing and deep learning image classification models to measure the magnitude of the detected disease. And finally the model will predict whether the person is in stress or not.

**Keywords:** Thermal imaging, facial analysis, deep learning, image processing and classification, CNN.

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## 1. Introduction

Anxiety Analyzer is the system which addresses the solution for the people who are suffering from mental diseases. To recognize whether the person or patient is in stress or not, is not possible or the results are not that accurate when it is observed by the ordinary people or the trained experts. One of the suggested solutions for doctors or the medical section is that they should treat such patients in a very friendly manner. Work and finances are the key reasons people attribute their stress to.

In order to address these issues, we utilized thermal imaging technology. Through the use of thermal imaging, we are able to measure physiological features such as blood flow, pulse rate, blood vessel distribution, and breathing rate in a non-invasive manner. The thermal camera captures the surface skin temperature, which can fluctuate based on specific emotional and physiological states in the body. This means that facial thermal analysis has the potential to offer accurate indicators of deception, as controlling emotions can be challenging [6][7]. There are 2 types of stress:

1. Instantaneous stress- In this type increase in periorbital blood flow occurs [8].

2. Sustained stress- In this type elevated blood flow in the forehead occurs.

The rapid and sustained nature of stress can both be detected through thermal imaging since instantaneous stress results in an increase in the blood flow around the eyes while sustained stress results in a rise in blood flow to the forehead. Finding relevant patterns in the input features can be done using statistical or deep learning techniques in order to classify responses as stressed or unstressed. Proposed system will generate a body thermal facial image with the help of a thermal camera. Deep learning neural networks will be trained with collected data sets to model stress levels by applying image processing techniques (to extract the precise stress locations from human faces) and image processing approaches (to extract the exact location of the stress). The GUI with Django framework is developed by putting this model in back- background to make the system more productive and market based. To make the system more convenient and simpler, the results are retrieved on the front end after uploading the test image.

### **1.1 Overview and Problem Statement**

Based on the results of the 2018 Mental Health Foundation study, YouGov conducted an online survey with a sample size of 4,619 respondents which is the largest known stress study in the UK. Feeling overwhelmed or incapable due to stress the causes of stress are diverse; 36% of all adults who reported stress in the previous year stated their own state of health or that of a friend or relative as a factor; among adults it was as much as 44% over 55 years old. Debt was cited as a stressor by 22% of those who said they felt stressed in the previous year. The feeling of having to reply to messages immediately was a stressor for 13% of those reporting high levels of stress. 49% of 18-to-24-year-olds felt stressed, more than any other age group. 23% of men and 36% women felt stressed because they didn't like how they looked or how they looked. Housing concerns are a major source of stress for young people

(32% of 18 to 24-year-old said they were a source of stress in the last year) Older people have less stress (22% for people between 45 and 54 years old, and only 7% for people 55 and older). Younger people feel more stressed because they have to do well. 60% of people aged 18-24 said this. 41% of those 25 to 34 years and 41% of those 25 to 34 years.

There are many behavioural and psychological effects of stress. 46% said they overeat or eat unhealthily because of stress. 29% said they had started or increased their alcohol consumption, while 16% reported that they had started or increased their tobacco consumption. 51% of adults who felt stressed said they felt sad, and 61% said they felt scared. Of those who said they felt stressed at some point in their lives, 16% hurt themselves and 32% thought about killing themselves. 37% of adults who felt stressed said they felt lonely. People who suffer from psychological stress don't feel comfortable talking to others about their problems. They're a little nervous when they talk about their problems [14].

Due to stress, patients suffer from different types of headache like migraine, hypertension, stress. The fig.1 explains the types of headache. This concept gave us a spark for a solution to cash in on. When a person suffers from a headache the blood flow from that head part increases and such blood flow can be detected with the help of a thermal camera. A group of engineers from Aalto University studied 700 people from Finland, Sweden, and Taiwan to learn how their bodies feel when they feel certain emotions. Fig. 2 shows the results that it is evident that happiness and depression are, as expected, the most divergent emotional states. Love is known to increase body activation, whereas depression is known to decrease it. They are sadness, neutrality and depression. The emotions most strongly associated with the approach, such as love, anger, joy and pride, activate the arms while activating the chest area and experiencing most of the emotions except for the neutral and depressed state.

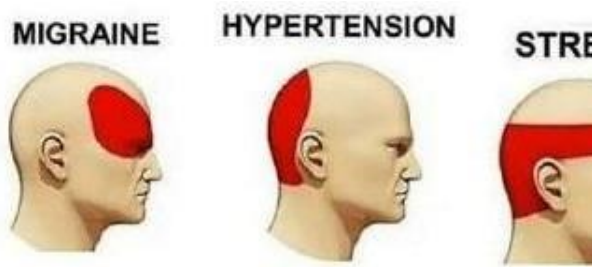


Figure 1: Types of headaches in human

And we come up with solutions which can diagnose mental health diseases like stress, anxiety etc. by using thermal imaging techniques and deep learning image classification models. With this Anxiety Analyzer we can predict whether the person is under stress or not by comparing the percentages of stress and unstressed.

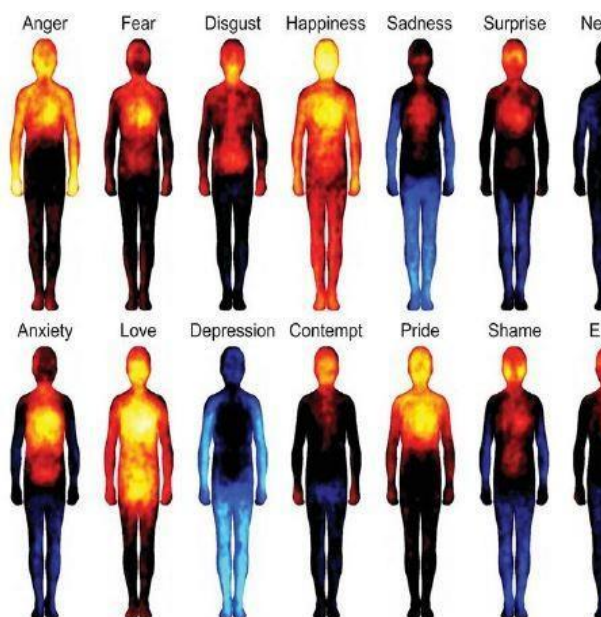


Figure 2: Emotion states in human

## 1.2 Motivation and Significance of the problem

The survey also found that 95% of Indian millennials aged 18-34 are stressed, compared to the global average of 86%. To make things worse, one in eight Indians is very stressed, but almost 75% of them don't feel comfortable talking to a doctor about their stress. The cost of counselling has been cited as one of the main barriers to finding skilled workers. So to make patients more comfortable while sharing his or

her feelings with a doctor or any consulting facility we designed the system which is more contact less such that patients are not aware that someone is going to diagnose him or her. The system is more contact less simple to handle for any professional.

The main motivation behind this solution is to make the system more reliable as it is based on scientific principles. To make the model increasingly accurate as it gets processed by the Neural Networks. To compute the severity of the disease with the help of image processing. The single biggest goal with our model is that we want to see each and every healthcare unit in India ranging from small clinics to Multi-Specialty Hospitals to take into consideration their patient's mental health and check if they're a victim just like how every 35+ year old is checked for one's blood pressure level with Sphygmomanometer whether or not one's got a problem with it; for though mental health diseases are a disease by themselves, they are the root cause for many other diseases too. And that is also the business impact that we are aiming to create with our model. The entire paper is divided into four sections; the second section provides information regarding literature review. Third section gives information regarding the proposed solution for the above stated problem. Fourth section defines the experimental setup and performance analysis. And the last section defines the conclusion.

## 2. Related Work

Veronica Engert, et. al [1][18] examined the use of infrared thermal imaging technology in human stress research. The aim of this study was to test the use of infrared thermal imaging technology in human stress research. In both tests, most thermal prints were found to be sensitive to change. Heat impressions correlated with stress-induced mood swings. The excitement, anxiety, and recovery phases of both tests. This is about studying groups of people who have a hard time using standard tools to collect data and studying how their bodies change over time. Stress markers are better at showing how their bodies change over time.

Nandita Sharma, et. al [2] modelled stress with thermal facial patterns: a spatio-temporal approach. Stress is a big problem in our world today. We need to find ways to understand stress without making it too obvious. The job involved using heat to see where people's faces are stressed. The work uses facial areas recorded on video in thermal (TS) and visible (VS) spectra and introduces our ANU StressDB database. This article explains how we got videos of people watching movies who were stressed and unstressed for the ANU StressDB. In addition, it shows how to use binary patterns in three planes (LBPTOP) in VS and TS videos to detect stress. It proposes a new method to capture dynamic thermal patterns in histograms (HOTP) so that TS can use the associated thermal and spatio-temporal properties. Support vector machine classifiers have been developed to detect stress. The results show that facial patterns from VS and TS videos gave better stress detection rates than patterns from VS or TS videos alone.

The Finnish research team has created heat maps that show where and how emotions are experienced in the human body [3]. The aim of the study was to find out whether there is a consistent association between what we feel and the physical perception of that feeling across different demographics and geographic regions.

Stress has an increasing impact on human health [4] [13] [16], so stress assessments are actively carried out using various methods. Recent research has contributed to the advancement of the use of physiological contact sensors, such as the EEG and the galvanic skin reaction, to detect changes in human stress levels. Nonetheless, these methodologies are primarily theoretical and are rarely associated with stress evaluation in practical scenarios.

Studies on remote sensing of stress are increasing all the time [5] [11] [17]. For example, the researchers examined the horror's thermal signature and reported that the need for immediate blood in the periorbital region is increasing. The characteristic warmth pattern with metabolic activity, skin tissue and local vascular system changes significantly with emotional stimuli. In addition to the analysis of

the facial print, the measurement of physiological vital parameters by the image sensor has moved into the focus of research.

The study on "Automatic Stress Detection Evaluating Models of Facial Action Units" focuses on detecting emotional stress through facial expressions using Facial Action Units (AUs). The authors developed a model that analyzes facial features like geometric shapes and appearance-based histograms to differentiate between neutral and stress states. Using Support Vector Regression (SVR), the model was trained on two annotated facial datasets (UNBC and BOSPHORUS) and tested on a stress dataset (SRD'15). Results show that specific facial AUs, such as increased intensity in AU17 (Chin raiser) and AU25 (Lips part), correlate with stress states, leading to more expressive facial features under stress. The model achieved high accuracy and can differentiate between stress-induced and neutral expressions effectively [10].

In this paper "Stress Detection and Monitoring Based on Low-Cost Mobile Thermography", authors have described a method for the monitoring of stress using inexpensive smartphone-based thermal imaging cameras. This paper examines associations between changes in facial temperatures, particularly over the forehead, nose, and eyes, and stress levels. Experiment respondents' responses were recorded when they viewed a movie, which was designed to be rather stressful; above normal temperature elevations were established as markers for higher stress levels. This technology is a great low-cost, non-invasive alternative to the high-priced systems like EEG or ECG. It enables monitoring of stress at home. The scope further extends and makes it even more practical as an integral part of health monitoring solutions to be included into daily life [14].

The paper on "Implementation of Thermal Camera for Human Stress Detection: A Review" explained the use of thermal imaging technology in the detection of stress in humans [15]. Stress is cited as being a significant problem that may affect performance and health and is likely to lead to severe conditions such as hypertension and heart disease if it goes

unchecked. Thermographic cameras, for instance, are non-touch and non-intrusive monitors that can measure the subtlety of changes in the skin temperature, especially in the facial area, which is where physiological responses to stress, such as alterations in blood flow, occur. Generally, the system architecture of stress detection would consist of image acquisition, pre-processing, ROI tracking, feature extraction, and classification. Capturing temperature variance and having popular brands with FLIR and Seek Thermal among others is common. Pre-processing thermal images involves resizing, conversion to grayscale, and histogram equalization for example CLAHE to enhance quality. The correct detection of stress calls for the need to track ROI mostly in regions like forehead, nose, and eyes. Such algorithms are used in different forms to enhance performance in detecting stress. Adequate detection of stress at more accurate levels can be achieved through combining thermal imaging with machine learning and statistical analysis.

### 3. Proposed Methodology

To detect stress of a patient or person, we are going to use Thermal Image. Thermal image provides all the features which are required to detect the stress [9]. The person having mental stress can be diagnosed by any medical professionals with the help of the proposed system. The captured thermal image is pre-processed by applying image processing techniques. Features are extracted from thermal images. Machine Learning models will be trained with the help of machine learning libraries. Data-set contains two parts: stressed frames and non-stressed frames. The model with convolutional neural network is trained with the help of collected data-set [19]. TensorFlow is the open source library used to train the model. Once the model is trained, it is capable of distinguishing the stressed image and non-stressed image. To make the system user-friendly, a web application is created for users. Machine learning model is deployed using the Django framework. Integration of proposed machine learning model and web application is

done by using Flask Framework. The required test image is uploaded on the application and the result will be shown on the same application. The trained CNN model is run in background when the test image is uploaded.

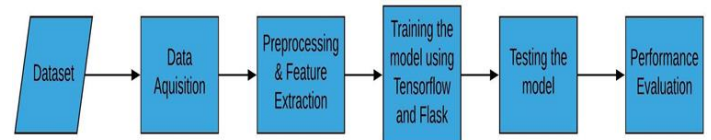


Figure 3: System flow

Convolutional Neural Network is used as an image Classification algorithm. The sigmoid is used as an activation function. Here the binary Classification is used. We can also be upgraded into a Multi-way Classification Model. The number utilized in one iteration is 16. That is the batch size used is 16. The 6 layers are used in CNN algorithm. Data sets of 100s of such Labelled Body Heat Maps can be collected and fed into the Image Classifying model empowered by Convolutional Neural Networks for training. The trained model will thus be able to map the given unlabelled body heat map to its corresponding mental health condition with the help of the concept of Deep Learning. The magnitude of the thus identified condition can be computed by means of Image Processing with the help of the colour scale.

#### 3.1 Problem Statement

Stress detection with accuracy by means of generating a body heat map of the patient with the help of a thermal camera and applying techniques of image processing and Deep Learning image classification models to measure the magnitude of the detected disease.

#### 3.2 Proposed System

**Data Acquisition:** To get information, we will use a special camera called Seek Compact Thermal Imager for Android. It can take pictures of people's faces at different temperatures, from -20 degrees C to 1000 degrees C. We will use an Android phone with the camera to take pictures. You can get the information using these methods:

1. Monitoring people and interviewing them.
2. To tell a subject about another person.
3. Interview different topics

When you interview different people, their skin can be different temperatures. These variations can change the thermal maps and affect how well stress detection works. During this time, each subject will sit on a chair and do nothing or say anything. Using a deep learning model to experiment with the data from the above step. A data set of 100 Labelled Body Heat Maps can be used to train a Convolutional Neural Network Image Classifying Model.

**Train the Model:** The CNN is used to train the model with stress and non- stress data. 6 convolutional layered models are used to train the model. The trained model will thus be able to map the given unlabelled body heat map to its corresponding mental health condition with the help of the concept of Deep Learning. The magnitude of the thus identified condition can be computed by means of Image Processing with the help of the colour scale. Training data set consists of 2361 stressed images and 620 non-stressed images [19].

**Test the Model:** To calculate the accuracy of the model the model is tested with different images. 2361 images of stressed and non-stressed are used for testing.

**Make Web Application:** The web application is used to make the system simpler. The image is uploaded on application and in background the trained model will run and result will be fetched on the same window of an application.

### 3.3 System Analysis and Design

The proposed system is designed to get more accuracy the system is designed with following technologies.

**Convolution Neural Network:** It is used to recognize and classify images. It is used in many areas, such as object detection, recognition of faces, etc. CNN image classifications take an

input image, process it and classify it into certain categories (E.g., Dog, Cat, Tiger, and Lion) Computers see an image as a group of pixels and how big it is depending on how clear it is. Depending on how clear the picture is, it will have dimensions of h, w, and d. A 6 x 6 x 3 array of RGB values and a 4 x 4 x 1 array of gray-scale values. To train and test deep learning CNN models, they use layers of filters called Kernels, Pooling, and fully connected layers called FC. They then use a function called Softmax to classify an object using probabilistic values between 0 and 1. The below figure shows how CNN works to classify objects in an image by their values.

Choose parameters, apply filters with strides, and padding if needed. Do a process called convolution on the picture and use ReLU activation on the matrix. Add more layers of convolution until you are satisfied. Use an activation function to output the class and classify images.

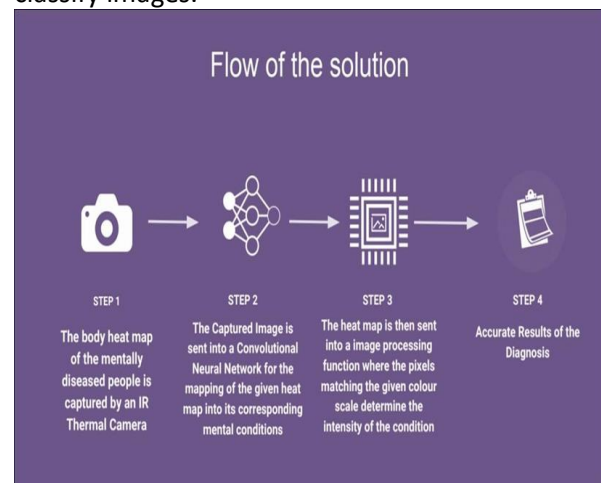


Figure 4: Proposed Solution

**Image Processing:** It is the use of mathematical operations to improve the quality of a digitized image. Image processing can produce a set of characteristics or parameters related to an image. Digital image processing is when computers use algorithms to make pictures. Digital image processing is a better way to process digital signals than using analog signals. It lets more algorithms work on the data and can prevent noise and distortion when processing. Digital image processing can be done in many different ways because images have two dimensions. This has happened

because of computers, math, and many different uses in the environment, agriculture, military, industry, and medicine. Here are the steps of image processing.

Importing an image from a camera.

1. Using the image to analyze it.
2. You can change an image or make a report by looking at it.

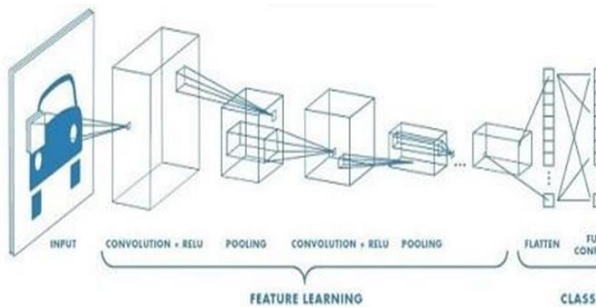


Figure 5: CNN Architecture [20]

#### 4. Experimental Setup

We will use a camera called Seek Compact Thermal Imager for Android to take pictures of people's faces at different temperatures, from -20 degrees C to 1000 degrees C. We will use an Android phone with the camera to take pictures. The data set can be obtained by clicking on the thermal image of the person who is being watched. For this the person must be clear in front of the thermal camera for taking thermal images in different angles.

##### 4.1 Steps involved:

Following are the steps to create classifier-

1. Importing Libraries and Splitting the Data into two parts training set and testing set. Training set has 2385 heat maps.
2. Creation of Convolutional Neural Network [CNN] i.e. Convolution, Pooling and flattening layers.
3. Selection of appropriate layers and filters, then compiling our network.
4. Creating a new training data with help of existing data by using Data Augmentation technique.
5. Training the model using python libraries.
6. Analyzing the model by giving it the input of test images that we have split in the previous step and calculate the efficiency.

7. Develop the web application with the Django framework to make the system more market oriented and simpler to use for any users.

8. Flask Framework is used for Integration of machine learning model and web app.

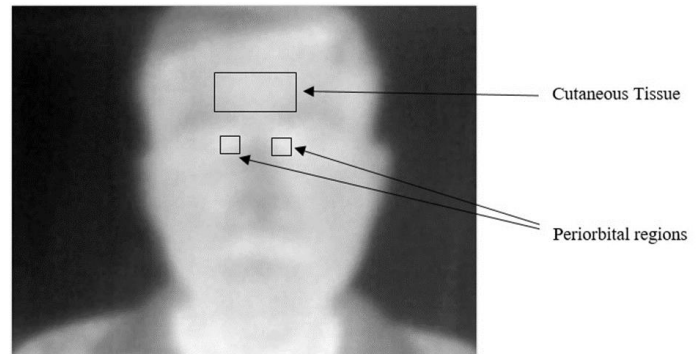


Figure 6: Stress Detection

There are two types of stress:

1. Instantaneous stress- Elevated blood flow in periorbital region.
2. Sustained stress- Elevated blood flow in forehead. The thermal imaging technique can detect both kinds of stress and classify them accordingly.

##### 4.2 Data Processing:

The implementation is done completely in the python environment. Deep learning is used to train and test the model. The software packages used are as follows-

1. Open cv2
2. numpy
3. matplotlib

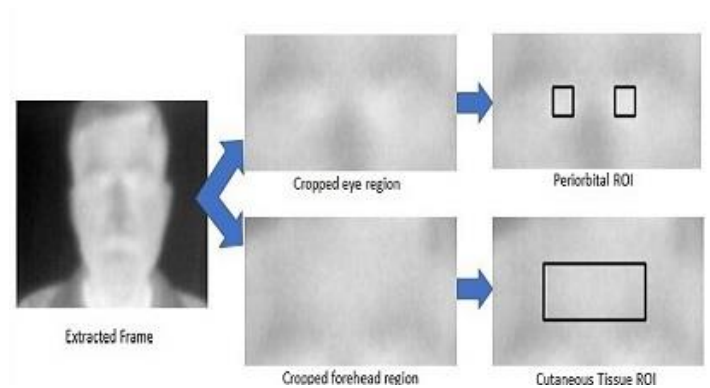


Figure 7: Data Processing

The python language being the simplest and powerful language is chosen for the project. The

Jupyter notebook provides all the required and suitable environment required for the project. The open cv2, numpy and matplotlib are used for the image processing and deep learning used to train and test the model. The data set used contains two types of images, Stressed and non-stressed faces captured with the help of a thermal camera. The data set details are as follows [19]:

- Number of thermal sequences: 20.
- Variations include: front, left, right, indoor or outdoor, glasses or hat.
- Format of images = 8-bit gray-scale JPEG
- The pictures are in JPEG format with 8 bits of grayscale. They are 320 by 240 pixels.

The accuracy obtained is: for training it is 75% and for validation it is 87.5% over 3000 iterations.

## 5. Conclusion and future scope

Overall, the process of creating a stress detection classifier using thermal images is complex and involves multiple steps. The first step is to import the necessary libraries for image processing and machine learning. Next, the dataset is split up into training and testing sets to make sure the model is accurate. The core of the methodology involves creating a convolutional neural network (CNN) that can effectively classify stress levels based on thermal images. Data augmentation techniques are then applied to increase the diversity of the dataset and improve the model's performance. Once the CNN is built and trained on the dataset, its efficiency is analyzed through various metrics such as accuracy, precision, recall, and F1 score. This evaluation helps determine the model's effectiveness in detecting stress levels accurately. Finally, a web application is developed using the Django and Flask frameworks to provide a user-friendly interface for users to upload their thermal images and receive stress level predictions. This application allows for easy access to the stress detection classifier and enhances its usability for a wider audience.

The future scope for the stress detection classifier using thermal images encompasses

several key areas of development. Firstly, ongoing refinement of the CNN architecture promises improved performance in stress level classification. This includes exploring transfer learning techniques from pre-trained models to enhance feature extraction efficiency. Additionally, integrating multi-modal data sources, such as physiological signals, alongside thermal images could provide a more holistic understanding of stress levels. Personalization of the classifier for individual users may enhance its accuracy and applicability in real-world scenarios. Implementing real-time stress monitoring capabilities would enable timely interventions and notifications. Longitudinal studies and clinical validation efforts are essential for assessing the classifier's effectiveness and ensuring its practical utility. Ethical considerations, including privacy protection and addressing potential biases, must be carefully addressed to foster user trust. Finally, optimizing the classifier for scalability and deployment on various platforms would facilitate its widespread adoption, ultimately contributing to mental health promotion and well-being enhancement initiatives.

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