# LEVEL OF PAIN DETECTION FROM IMAGES


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# Certificate

We hereby acknowledge the work included in this report titled: **LEVEL OF PAIN DETECTION FROM IMAGES**, as a validation to the necessary guidelines for the partial completion of the degree of BS in Computer Science.

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# Declaration

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# Dedication

I devote this project to our beloved parents who helped us and guided us through every walk of life. They supported us throughout the years to help us grow and study in such a prestigious institution. We are also very thankful to our teachers who have guided us, acquired us with knowledge and appreciated our efforts throughout our entire degree. Our educational journey towards this phase wouldn't have been possible without our beloved teacher's presence. Finally, we would especially thank our supervisor, Dr. NAVEED IJAZ, without whom this project would have not been possible. His encouragement and guidance leaded us on achieving such an immense milestone with not much difficulty.

# Acknowledgements

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# Abstract

The purpose of this document is to present a detailed description of our project **LEVEL OF PAIN DETECTION FROM IMAGES**. We are basically creating a desktop application where the user will be able to capture real time images of patient face to detect the presence of pain. Most of our users would be doctors. Our app will provide a level of pain according to facial expression after processing the images. Our system has been trained using dataset to detect the level of pain accurately. Our main purpose is that some people cannot convey their feelings and emotion to doctors while suffering from acute pain because of their critical condition. To give doctors a proper knowledge of their patients suffering so that they can provide proper treatment to patients according to their pain level.

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# Chapter 1 Introduction

## 1.1. Overall Description

Pain is a natural phenomenon that indicates if the person is suffering from illness or has some kind of sickness. A person while enduring pain interprets their feelings and emotion. Due to severe medical conditions sometimes patients are not in the condition to tell information about their health and pain level. In this condition, doctors are unable to provide proper care. So what if there is any way that we can detect the pain level of the patient it can help.

### 1.1.1. Objectives

The objectives of this application is that people cannot convey their feelings and emotion to doctors while suffering from acute pain because of their critical condition. To give doctors a proper knowledge of their patients' suffering so that they can provide proper treatment to patients according to their pain level.

### 1.1.2. Problem Description

There are many medical conditions in which patients have to visit their doctors on a daily/weekly basis. Sometimes it is very difficult for patients due to their severe condition they might be in Intensive-care Unit(ICU). It is also difficult for people who cannot speak to tell about their sufferings to doctor. Doctors also require some way to get understanding about infants pain and illness.

### 1.1.3. Methodology

Our software will select images from system. This software help us in a pain detection system by selecting images which detect the presence of pain if any. This software recognize different levels of pain through facial expressions. We are going to use the dataset available for this project. Then we normalize our data for best results. By spliting the data into training and testing we can check the accuracy level of the system.

### 1.1.4. Product Scope

The system we are going to build can be used in every hospital and clinic. This software help us in a pain detection system by selecting images which detect the presence of pain and intensity of pain.

### 1.1.5. User Classes and Characteristics

For our Desktop Application we are creating single class, USER DATABASE OPERATIONS for users.

### 1.1.6. Operating Environment

Our operating environment would be

Desktop Computers

Laptops

### 1.1.7. Assumptions and Dependencies

When we talk about detecting the level of pain from facial images, many questions come to the discussion. The main question is that our software is capable and well trained that it will provide the best outcome. There are many studies considering the possibility regarding facial expression and how we can assure that the person providing the picture is showing his/her natural expression. Our system is mainly dependent on database. We require data base to train our system so that outcome of our system would become affective.

## 1.2. External Interface Requirements

### 1.2.1. User Interfaces

As we have mentioned our project will work on desktop computers. Installation of our system is very easy. User Interface of our system is very user friendly and can easily use by users. User can operate and understand our system with no difficulty.

### 1.2.2. Hardware Interfaces

Our system would be compatible to run on any Desktop Computer/ Laptops and our system does not require any internet connection as well.

### 1.2.3. Software Interfaces

Our system does not require any connection with other software. Our system would already be trained on a dataset. It would only take images as an input and process then according to training data.

For desktop Application development we are using python.

### 1.2.4. Communications Interfaces

There is no requirement associated with any communication functions required by our system.

## 1.3. System Features

### 1.3.1. Images as Input

1.3.1.1 Description and Priority

Our system will allow user to select images or already taken as an `input.

Priority of this feature is High because of those pictures our system would tell us the level of pain.

Rated High to 9

1.3.1.2 Stimulus/Response Sequences

On our system home page user will be given an option to select images. As response our system will comply according to user.

1.3.1.3 Functional Requirements

Our system will give option to user to select image to carry out the process of detecting pain level.

REQ-1: Select images

REQ-2: Process Images

### 1.3.2. Pain Level Detection

1.3.2.1 Description and Priority

Once images are selected then our system will process those images using training data and show the detected result to user screen.

High priority due to training dataset.

Rated High to 9.

1.3.2.2 Stimulus/Response Sequences

After selecting images, system would process them. As response system would use training dataset to show the results.

1.3.2.3 Functional Requirements

After selecting there would be an option to PROCESS those images to give us the expected result.

REQ-1: Select images

REQ-2: Process Images

## 1.4. Nonfunctional Requirements

### 1.4.1. Performance Requirements

- Minimum specs would be required to run our Application on Desktop Computers i.e., Intel core i3 or newer, Microsoft Windows 7/8/10 x32/64 bit, 4GB RAM, 250/500GB HDD.
- The response time of our Desktop Application will be Affective.

### 1.4.2. Safety/ Security Requirements

Our main security concern is patients' privacy. To overcome that issue, we will provide our application to licensed doctors and hospital w/ user agreement.

### 1.4.3. Software Quality Attributes

**Availability:** Our Desktop Application will be widely available to any Hospital/ Clinics around Pakistan, to use with compatible Computer

**Flexibility:** User can use our Application in Hospitals and clinic easily.

**Maintainability:** To ensure that no bug would harm our system we will maintain our Application regularly and update to Add new features to Application.

**Reliability:** Our Desktop Application is safe and reliable to use for users of all ages and gender.

**Usability:** It is easy to use, interface of the App is very simple, user friendly and understandable.

# Chapter 2 Literature Review

## 2.1. Introduction

Pain is a natural phenomenon that indicates if the person is suffering from illness or has some kind of sickness. A person while enduring pain interprets their feelings and emotion. Due to severe medical conditions sometimes patients are not in the condition to tell information about their health and pain level. In this condition, doctors are unable to provide proper care. So what if there is any way that we can detect the pain level of the patient it can help.

Our main purpose is that some people cannot convey their feelings and emotion to doctors while suffering from acute pain because of their critical condition. To give doctors a proper knowledge of their patients' suffering so that they can provide proper treatment to patients according to their pain level.

## 2.2. Related Works

There is plenty of research is being done in this field. Following studies are mentioned below to show us the comparison and analysis between their work and ours.

- Pain Level Detection From Facial Image Captured by Smartphone
- The Painful Face – Pain Expression Recognition Using Active Appearance Models

### 2.2.1. Pain Level Detection From Facial Image Captured by Smartphone

They have used facial images captured by smart phone to detect pain level accurately. In this pain detection process, existing algorithms and infrastructure are used for cancer patients to make cost low and user-friendly. The pain management solution is the first mobile-based study as far as we found today.

#### 2.2.1.1. Terminology

Facial images captured by smart phone to detect pain level accurately, symptom of cancer patient, pain level detection, remote monitoring, quality of life, cancer patient’s pain level.

### 2.2.2. The Painful Face – Pain Expression Recognition Using Active Appearance Models

In this paper we explore an approach for automatically recognizing acute pain without the need for human observers. Specifically, our study was restricted to automatically detecting pain in adult patients with rotator cuff injuries

#### 2.2.2.1. Terminology

Frame-level ground truth was calculated from presence/absence and intensity of facial actions previously associated with pain, active appearance models, support vector machines, pain, facial expression, automatic facial image analysis, FACS

### 2.2.3. Categorization of Existing Techniques/Works/Research

As we have seen both studies are using images or video as their dataset to train their system. To detect the level of pain both studies are pretty accurate when it comes to results. We also need dataset to train our system for the patient to get the accurate results. As in first study they are using Mobile to capture images and detect the level of pain. In second study they are using PCs. We are going to provide a desktop application for the hospitals. Our software will capture real-time images from the web cam. This software will help us in a pain detection system by capturing real-time images which detect the presence of pain if any. First study is for cancer patient only. Second study is for patients suffering from shoulder pain. Our system is covering patients might be in Intensive-care Unit(ICU) and for people who cannot speak to tell about their sufferings to doctor. Doctors also require some way to get understanding about infants pain and illness.

### 2.2.4. Limitations/Gaps within Existing Techniques/Works

There are few limitations that I might bring to attention.

- Their systems are limited to certain illness like cancer and shoulder pain.
- They are not using real-time images.

## 2.3. Proposed Improvements in Existing Works

They can use real-time image system for patients so doctor can see patients pain level on spot and advise them how to end their suffering and prescribed them medicine. They should also

increase the scope of their system by not limiting to certain illness or decease like cancer and shoulder pain.

## 2.4. Summary

The aim of this document is to provide the detail analysis and comparative study between our system and existing systems related to detecting level of pain. Features and specifications are discussed for the sake of comparison. The focusing and unique feature of our system is also described which makes it unique from other application mentioned in the document.

# Chapter 3

### 3.1. Introduction:

In our system we will use the image processing to develop the deep learning application. We will use neural network models of Convolutional Neural Network (CNN) for extracting image features. Once user select image from our desktop application then Neural Network will process those images using labeled dataset and then extract features from Input images. Then those features would help us in predicting intensity of pain.

#### 3.1.1. Purpose:

The purpose of our system is to predict Level of Pain from images. Our system will prosses real-time images or uploaded images through machine learning algorithm that will help in predicting us the level of pain.

#### 3.1.2. System Overview:

Our system will take selected images as an input and use machine learning algorithms to extract features from labeled data to predict Level of Pain using neural network models

#### 3.1.3. Design Map:

We will build our system by the following design structure.

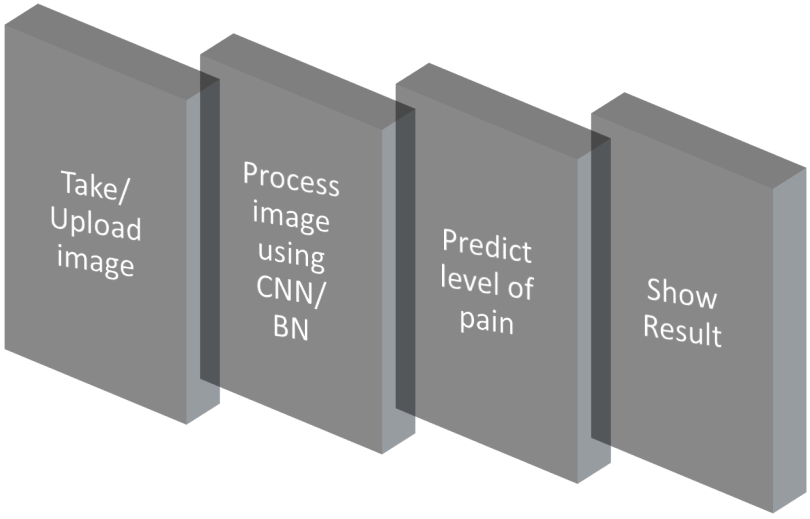


*Figure 1 Design Map*

### 3.2. Design Consideration:

Level of pain detection from images is only possible by using machine learning algorithms and deep learning algorithms to extract features from testing images and predict pain using trained dataset. It will help doctors in the hospital or clinic who cannot understand patient suffering due to their severe illness or they might be unconscious. So, this software helps them predicting the pain of patient.

#### 3.2.1. Assumption:

As we have mentioned above our machine learning algorithm will extract features from real-time capture image or uploaded image (TEST IMAGE) and predict pain. So, we are assuming that our neural network will be able to work and extract features better on unconscious patient as it will work on conscious patients.

#### 3.2.2. Design Methodology:

In our system, we will be use neural network techniques for features extraction and for pain prediction. We have a large dataset of almost 48,398 images. The system will be developed should be divide into two parts and using many algorithms of deep learning and machine learning.

#### 3.2.3. Risk and Violate Areas:

The support vector machine (SVM) Algorithm should be used for generating the risk map. The Support Vector Machine is the supervised Machine Learning Technique. It is the most used validation technique. The datasets should be original and real. The images of datasets must be clear, make sure the images shouldn’t be blurry and no watermarks should present on it.

### 3.3. ARCHITECTURAL DIAGRAM:

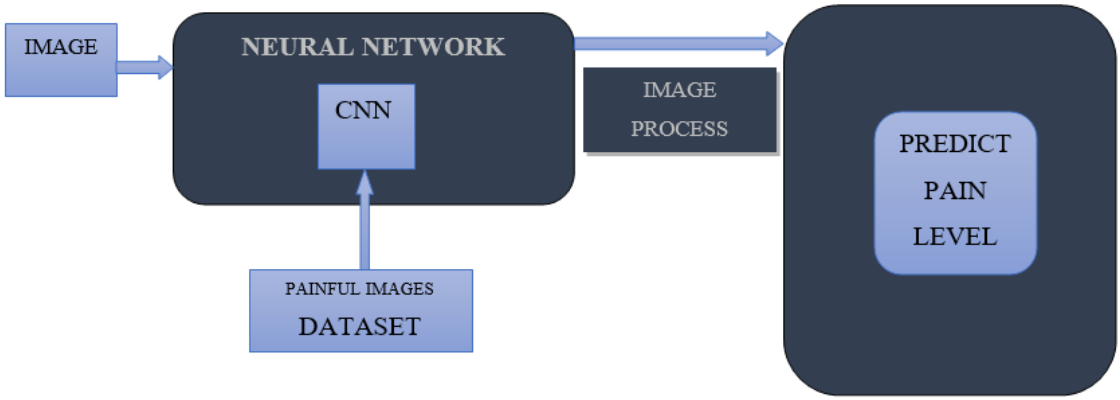


*Figure 2 Architectural Diagram*

### 3.4. Use Case Diagram:

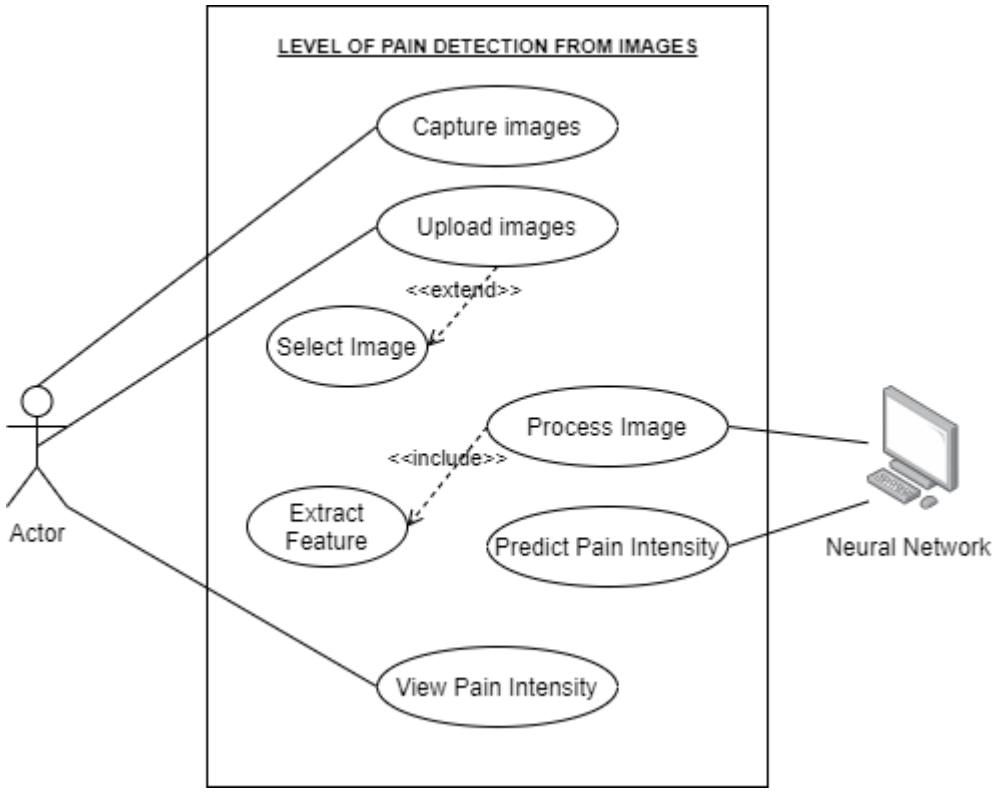


*Figure 3 Use Case*

### 3.5. Activity Diagram

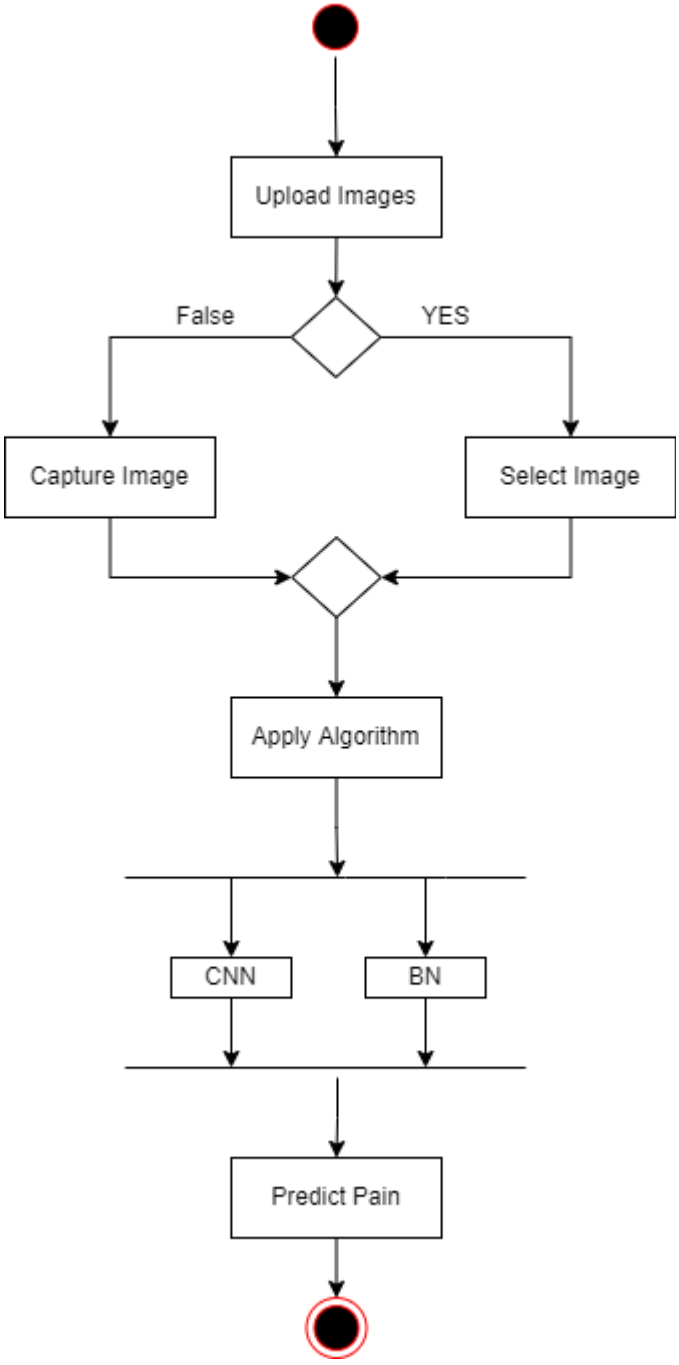


*Figure 4 Activity Diagram*

# Chapter 4 Implementation

## 4.1. Discussion

For the implementation of our project, we must train our machine learning model. the main requirement for our project to train machine learning model was achieving a dataset and extracting features of that dataset.

**Dataset**

Getting a dataset wasn't the easy task for us. It took us roughly about a month to get our hand on one. Once we get the dataset our next task was to understand that dataset, to understand the attributes of that dataset and to see how the dataset was labelled. Our dataset contain more than 48000 thousand images. To understand and label that amount of data is not easy. It took us some time to understand the dataset and its attribute.

First, we are going to evaluate our dataset to the desire need of our machine learning model and then we extract its features. Once we extract feature then we identify the Action Units (AU) that will help us in calculating pain using Prkachin and Solomon Pain Intensity (PSPI).

## 4.2. Development Methodologies

### Feature extraction

For the feature extraction Keras VGG_face tool is used in Visual Studio which is going to extract 66 features of face and 43 AU. Using AUs we will find the PSPI values. After getting PSPI values then we train our machine learning classifier. We have used the following classifier for our project.

### CNN

The keras convolutional neural network is used to extract the most relevant pixels from a matrix. Through a mathematical operation known as convolution, the network can learn complex features at each layer.

### 4.3. Implementation Tools and Technologies

- Visual studio
- Python
- Microsoft excel
- Keras

### 4.4. Summary

For implementation generic design flow of our application

- Containing Dataset
- Evaluating Dataset
- Extracting Features
- Training Machine learning algorithm
- Testing

# Chapter 5 Testing

## 5.1. Test Results

**For 10 classes:**

Table 1 Test Result For 10 classes

| | | | | |
|---|---|---|---|---|
| **accuracy** | | | **0.31** | **460** |
| **Macro avg** | **0.28** | **0.28** | **0.27** | **460** |
| **Weighted avg** | **0.38** | **0.31** | **0.33** | **460** |

**For Binary classes:**

Table 2 Test Result For 10 classes

| | | | | |
|---|---|---|---|---|
| **accuracy** | | | **0.73** | **886** |
| **Macro avg** | **0.73** | **0.76** | **0.73** | **886** |
| **Weighted avg** | **0.79** | **0.73** | **0.74** | **886** |

# Chapter 6 Data Analysis and Results

## 6.1. Data Analysis

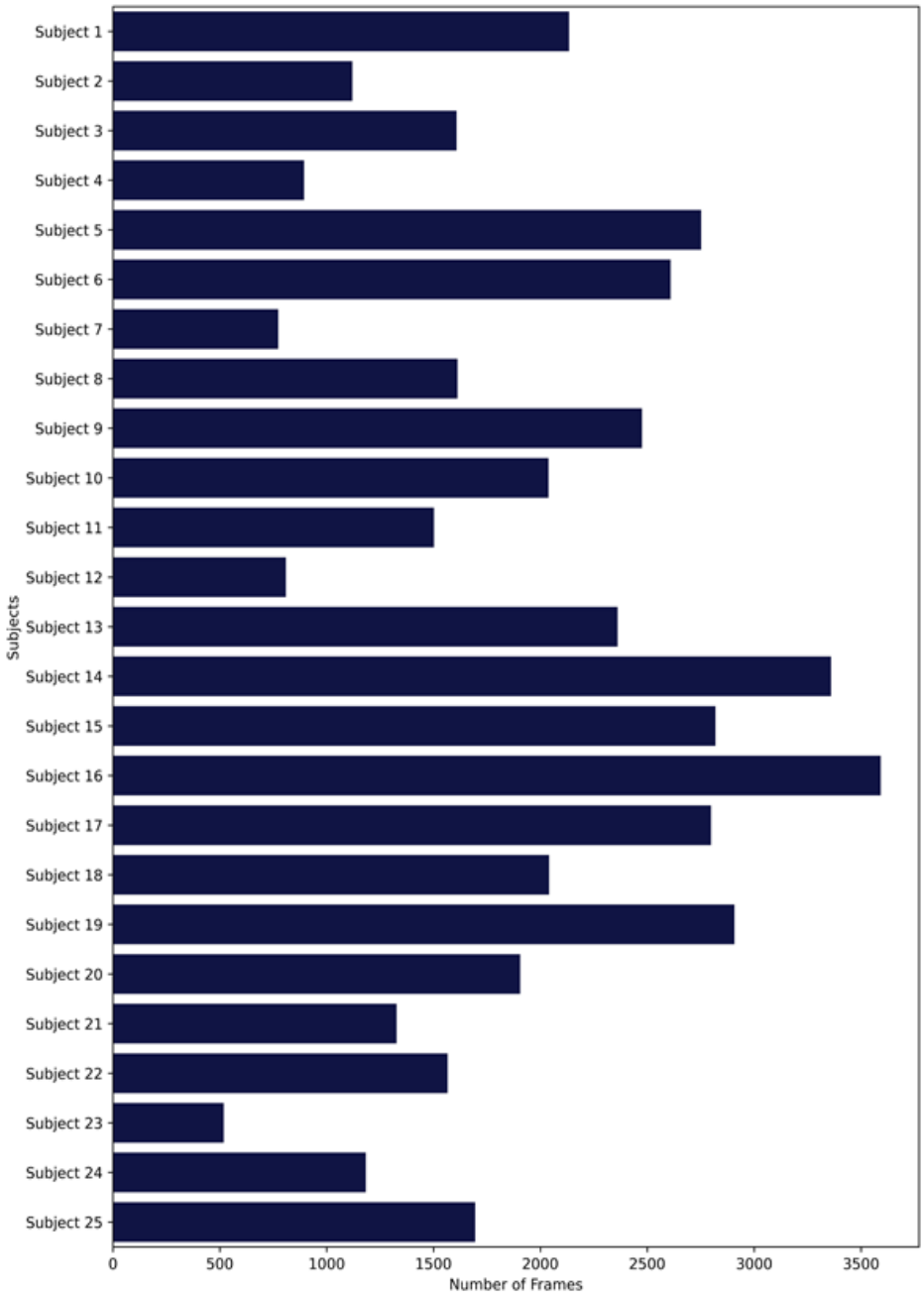


*Figure 5 No. of Frames Per Subject*

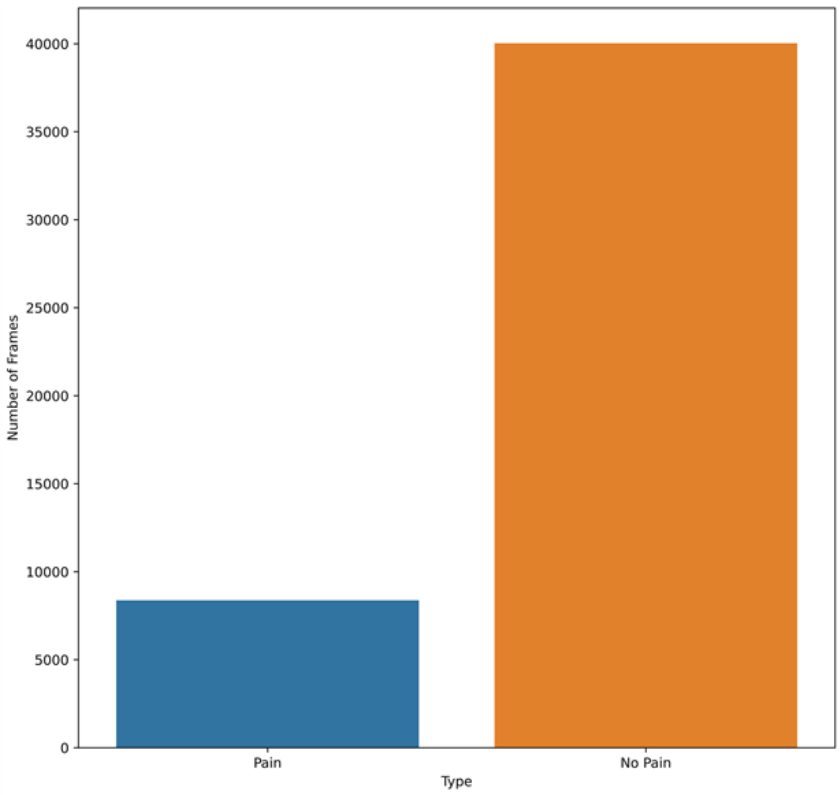


*Figure 6 Comparison btw Pain images and No Pain images*

## 6.2. Data Preprocessing

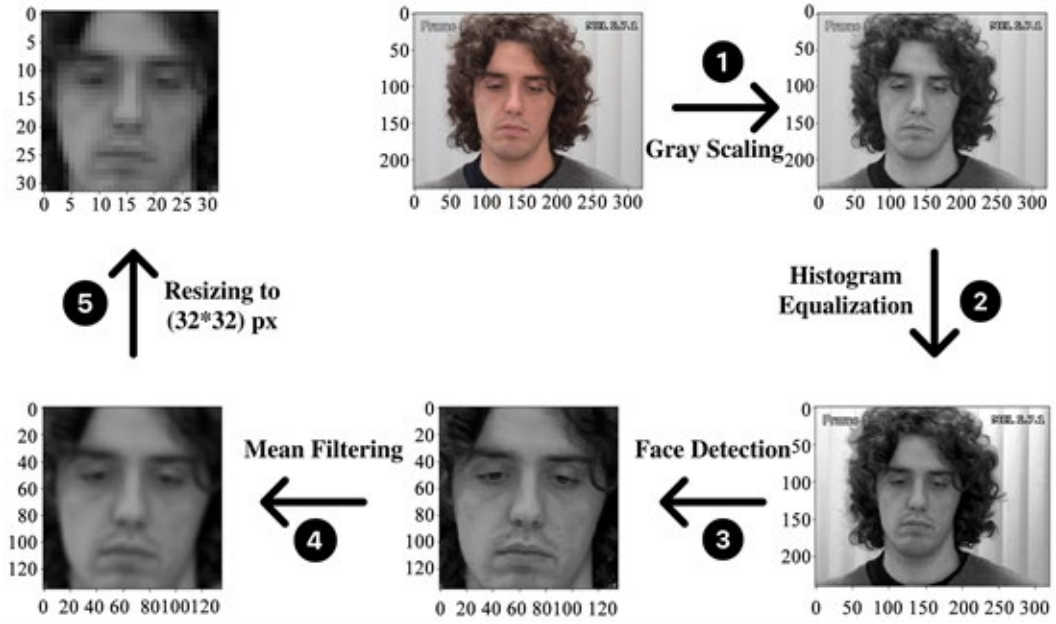


*Figure 7 Image processing*

## 6.3. Metrics for Result Comparison

### 6.3.1. Test Case 1 – Confusion Matrix for 10 classes

Table 3 Confusion Matrix for 10 classes

| Prediction \ TEST-LABELS | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 30 | 3 | 2 | 10 | 4 | 0 | 0 | 1 | 0 | 0 |
| 1 | 13 | 15 | 3 | 11 | 4 | 0 | 2 | 2 | 0 | 0 |
| 2 | 15 | 14 | 4 | 10 | 6 | 0 | 0 | 0 | 0 | 1 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 2 | 0 | 9 | 11 | 27 | 0 | 0 | 1 | 0 | 0 |
| 5 | 1 | 1 | 0 | 0 | 1 | 2 | 1 | 40 | 6 | 0 |
| 6 | 0 | 0 | 0 | 2 | 1 | 7 | 10 | 7 | 20 | 5 |
| 7 | 0 | 0 | 1 | 0 | 0 | 6 | 7 | 20 | 11 | 7 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 11 | 35 | 0 |
| 9 | 0 | 0 | 0 | 1 | 1 | 9 | 1 | 35 | 5 | 0 |

### 6.3.2. Test Case 2 – Confusion Matrix for Binary classes

Table 4 Confusion Matrix for Binary classes

| Prediction \ Test-Label | 0 | 1 |
|---|---|---|
| 0 | 250 | 187 |
| 1 | 40 | 401 |

## 6.4. Statistical Evaluation

### 6.4.1. Test Case 1

#### 6.4.1.1. Classification report for 10 classes:

Table 5 Classification Report For 10 Classes

| | precision | recall | f1-score | support |
|---|---|---|---|---|
| 0 | 0.60 | 0.49 | 0.54 | 61 |
| 1 | 0.30 | 0.45 | 0.36 | 33 |
| 2 | 0.08 | 0.21 | 0.12 | 19 |
| 3 | 0.00 | 0.00 | 0.00 | 45 |
| 4 | 0.54 | 0.61 | 0.57 | 44 |
| 5 | 0.04 | 0.08 | 0.05 | 24 |
| 6 | 0.19 | 0.37 | 0.25 | 27 |
| 7 | 0.38 | 0.17 | 0.24 | 117 |
| 8 | 0.67 | 0.45 | 0.54 | 77 |
| 9 | 0.00 | 0.00 | 0.00 | 13 |

### 6.4.2. Test Case 2

#### 6.4.2.1. Classification report for Binary classes:

Table 6 Classification report for Binary classes

| | precision | recall | f1-score | support |
|---|---|---|---|---|
| **0** | **0.57** | **0.84** | **0.68** | **298** |
| **1** | **0.89** | **0.68** | **0.77** | **588** |

## 6.5. Accuracy Comparison Btw VGG-16 & CNNs

### 6.5.1. Testing Accuracy For 10 Classes

Table 7 Testing Accuracy For 10 Classes

| **VGG-16** | **CNN For 10** |
|---|---|
| **12.61% Accuracy** | **31% Accuracy** |

### 6.5.2. Testing Accuracy For Binary Classes

Table 8 *Testing Accuracy For Binary Classes*

| **VGG-16** | **CNN For 10** |
|---|---|
| **73% Accuracy** | **55% Accuracy** |

# Chapter 7 Conclusions and Future Work

## 7.1. Contributions

For the automatic pain detection challenge, we have used a CNN model VGG-16 in this study. By using the UNBC McMaster Shoulder Pain Expression Archive database, it was developed and taught to recognize signs of pain in patients' facial expressions. Based on patients' facial expressions, our suggested model can quickly inform medical staffs of their illnesses. The model's accuracy for 10 classes is 31 percent and for the binary classes the accuracy boost up to 73 percent.

## 7.2. Future Work

There is always a room for improvement as we had very small variation in our dataset, to improve the accuracy of our project we should consider the dataset that should have more variations in it. For more improvement we should use customize algorithms.