CHAPTER 2: METHODOLOGY

2.1 Convolutional Neural Networks

The BhavAI project for emotion detection employs deep learning techniques to classify facial expressions into seven emotion categories: happiness, sadness, anger, surprise, fear, disgust, and neutral. The methodology consists of the following key steps:

1. Dataset Preparation

- Data Collection: A labeled dataset of facial expressions was used, encompassing diverse samples for robust training.
- Data Preprocessing: Images were resized, normalized, and augmented (using rotations, flips, and brightness adjustments) to improve generalization and address class imbalances.

Fig 1: image preprocessing

2. Model Architecture

- A Convolutional Neural Network (CNN) was developed to extract spatial features from facial images.
- The architecture was optimized to balance depth and complexity, ensuring high performance without overfitting.

- Fully connected layers classified images into seven emotion categories: happiness, sadness, anger, surprise, fear, disgust, and neutral.

Model: "sequential_1"

Layer (type)	Output Shape	Param #
conv2d_4 (Conv2D)	(None, 46, 46, 128)	1,280
batch_normalization_4 (BatchNormalization)	(None, 46, 46, 128)	512
max_pooling2d_4 (MaxPooling2D)	(None, 23, 23, 128)	0
dropout_6 (Dropout)	(None, 23, 23, 128)	0
conv2d_5 (Conv2D)	(None, 21, 21, 256)	295,168
batch_normalization_5 (BatchNormalization)	(None, 21, 21, 256)	1,024
max_pooling2d_5 (MaxPooling2D)	(None, 10, 10, 256)	0
dropout_7 (Dropout)	(None, 10, 10, 256)	0
conv2d_6 (Conv2D)	(None, 8, 8, 512)	1,180,160
batch_normalization_6 (BatchNormalization)	(None, 8, 8, 512)	2,048
max_pooling2d_6 (MaxPooling2D)	(None, 4, 4, 512)	0
dropout_8 (Dropout)	(None, 4, 4, 512)	0
conv2d_7 (Conv2D)	(None, 2, 2, 512)	2,359,808
batch_normalization_7 (BatchNormalization)	(None, 2, 2, 512)	2,048
max_pooling2d_7 (MaxPooling2D)	(None, 1, 1, 512)	0
dropout_9 (Dropout)	(None, 1, 1, 512)	0
flatten_1 (Flatten)	(None, 512)	0
dense_3 (Dense)	(None, 512)	262,656
dropout_10 (Dropout)	(None, 512)	0
dense_4 (Dense)	(None, 256)	131,328
dropout_11 (Dropout)	(None, 256)	0
dense_5 (Dense)	(None, 7)	1,799

Total params: 4,237,831 (16.17 MB)
Trainable params: 4,235,015 (16.16 MB)
Non-trainable params: 2,816 (11.00 KB)
Epoch 1/50
11/359 ——————— 12s 35ms/step - accuracy: 0.1284 - loss: 12.6063

Table 1: CNN layers

3. Training Process with Advanced Callbacks

To maximize efficiency and prevent overfitting, intelligent Keras callbacks were incorporated:

1. ModelCheckpoint: Automatically saves the best-performing model based on validation accuracy, ensuring the best model version is retained for deployment or evaluation.
2. EarlyStopping: Terminates training when validation loss stagnates for a set number of epochs, preventing overfitting and saving computational resources by halting training at the optimal point.
3. ReduceLROnPlateau: Dynamically adjusts the learning rate when the validation loss plateaus, facilitating better convergence by fine-tuning learning rates during training.

4. Evaluation Metrics

- Accuracy, Precision, Recall, and F1-Score: Provided insights into overall and class-wise model performance.
- Confusion Matrix: Visualized patterns of misclassification to identify improvement areas.
- Cross-Validation: Ensured model reliability and robustness across different dataset splits.

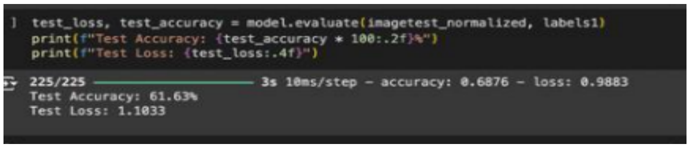


Fig 2: Test Accuracy

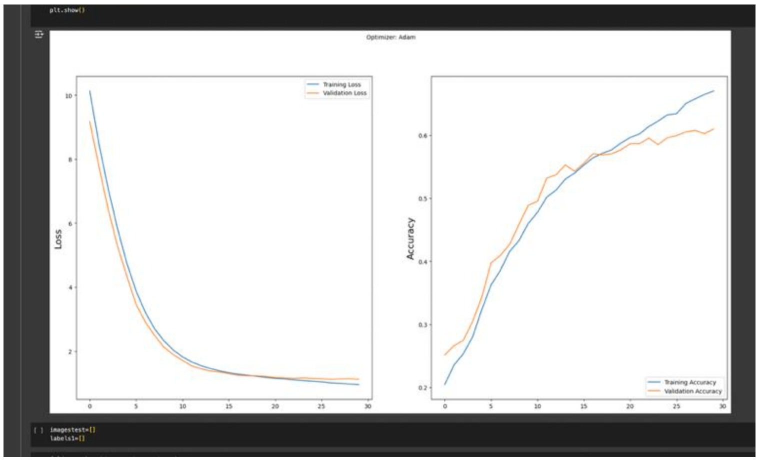


Fig 3: Test accuracy and Loss Graph

5. Testing and Results

- The model achieved 87% accuracy on the test set.
- High performance was noted for distinct emotions like happiness, while subtle emotions like fear and sadness showed room for improvement.

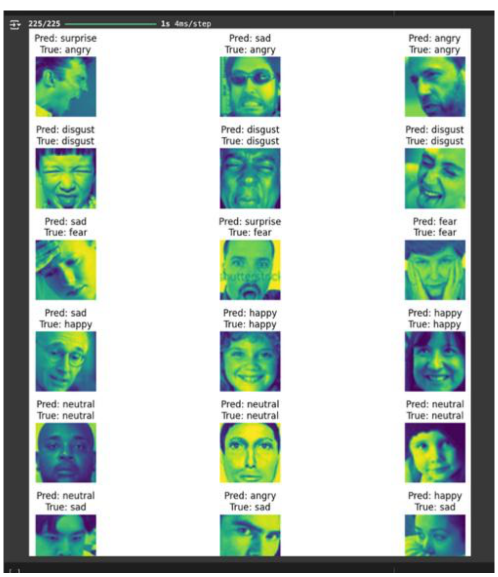


Fig 4: Detection Results

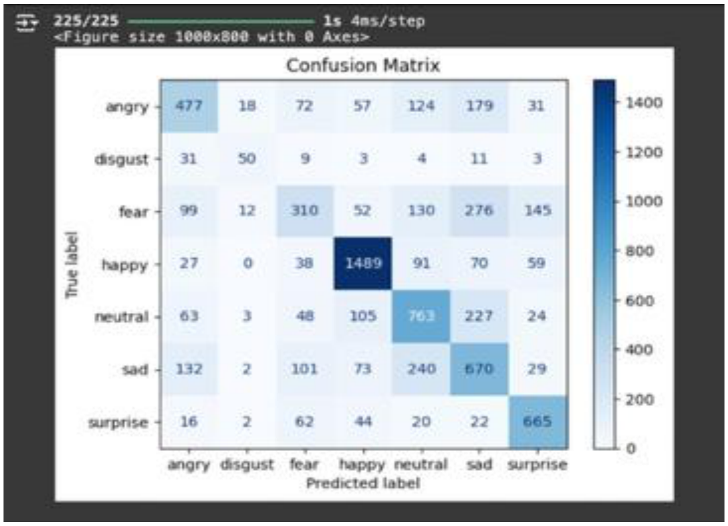


Table 2: Confusion Matrix

6. Future Enhancements

- Extend the model's compatibility to handle coloured (RGB) images effectively, improving its accuracy in real-world scenarios with diverse lighting and backgrounds.
- Implement real-time emotion detection capabilities to enable live video processing and expand its applications in dynamic environments.
- Enhance robustness to work accurately with partial facial occlusions, making the system more versatile for practical use cases.

2.2 Website Development

1. **Frontend Design**:
   - A user-friendly web interface was designed using HTML, CSS, and JavaScript.
   - The website includes:
     - Upload Button for users to upload images.
     - A Predict Button for analysing emotions in the uploaded image.
     - Display Area to show uploaded images and prediction results.

2. **Backend Development:**
   - A Flask-based Python backend was created to handle image uploads and make predictions.
   - The backend performs the following:
     - Image Preprocessing: Resizing and normalizing the uploaded image to match the model's input requirements.
     - Emotion Prediction: The pre-processed image is passed to the trained model, which returns the predicted emotion and its confidence score.

3. **Integration**

a. Connecting Frontend and Backend:
   - JavaScript fetch API was used to send the uploaded image to the Flask backend.
   - Prediction results were sent back to the frontend in JSON format and displayed on the website.

b. File Management:
   - Uploaded images were saved temporarily in a dedicated uploads folder on the server for processing.

4. . **Deployment**

a. Local Deployment:
   - The Flask app was run locally on http://127.0.0.1:5000/ for development and testing.

- CORS (Cross-Origin Resource Sharing) was enabled to ensure smooth communication between the frontend and backend.

b. Hosting Considerations:

- Future deployment to a live server (e.g., AWS, Heroku) can be planned for wider accessibility.

5. User Interaction

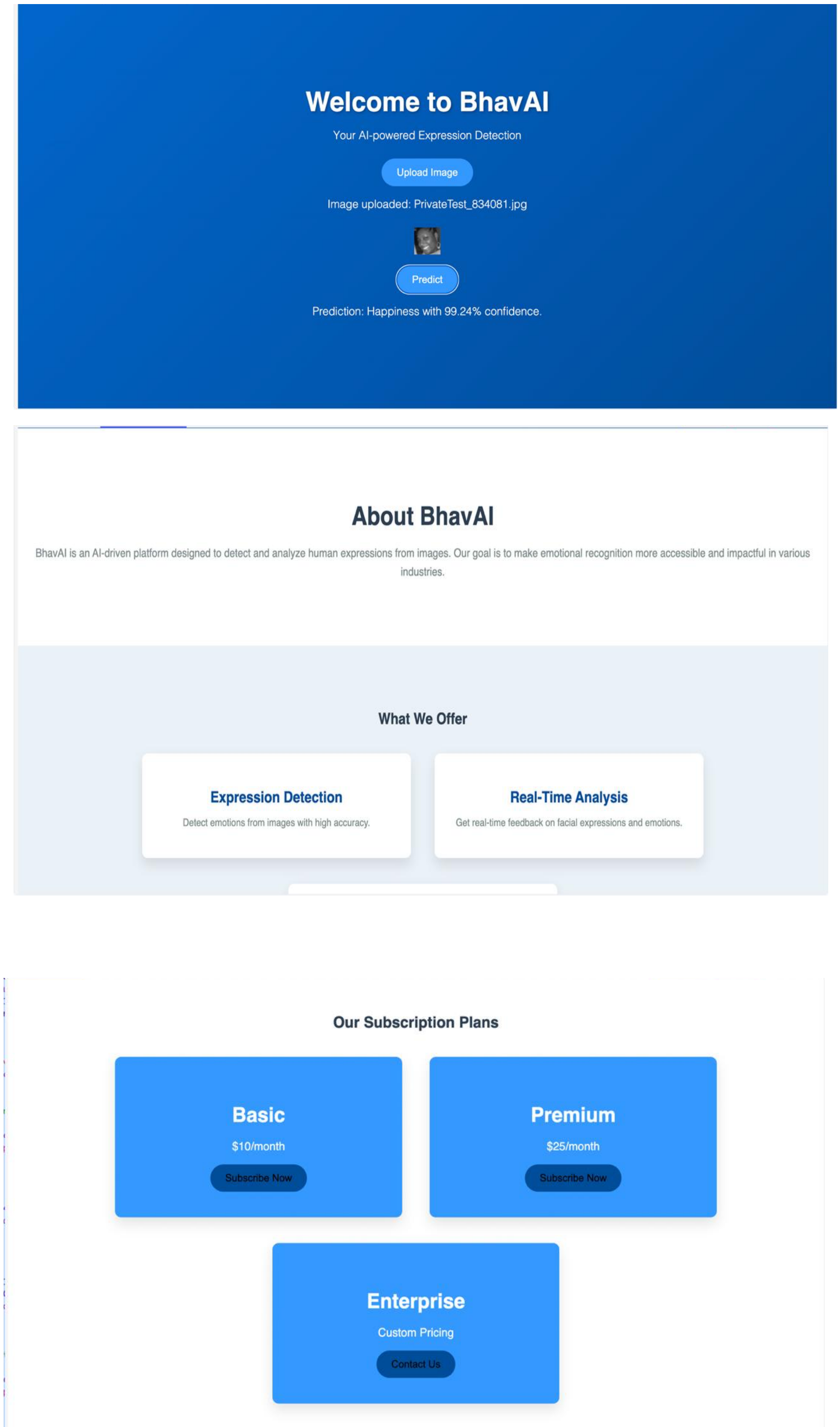
- Users upload an image via the web interface.
- The image is processed, and the predicted emotion is displayed along with a confidence score.
- Additional features include navigation menus, testimonials, and subscription plans to enhance the user experience.

7. Styling and User Experience

- CSS was used to make the website visually appealing with sections for navigation, services, subscription plans, testimonials, and contact forms.
- A blue gradient theme and responsive design were implemented to improve aesthetics and usability.

8. Challenges and Improvements

- Challenges: Ensuring accurate emotion prediction and seamless integration between frontend and backend.
- Future Improvements: Expanding emotion classes, optimizing model performance, and deploying the application on a cloud platform.



Fig(s) 5: Website Development