

# Emotion Recognition From Facial Expressions: A Preliminary Report

Tanja Jaschkowitz\* Leah Kawka\* Mahdi Mohammadi\* Jiawen Wang\*

{Tanja.Jaschkowitz, Leah.Kawka, Mahdi.Mohammadi, Jiawen.Wang}@campus.lmu.de

## 1. Introduction

*Facial emotion recognition* (FER) [4, 5] is a topic of significant frontier and ongoing debate, not only in our daily life, but also in the fields of artificial intelligence and computer vision. In this short proposal, we aim to leverage several *deep neural networks* (DNNs), which contain convolution layers and residual/attention blocks, to detect and interpret six basic universally recognized and expressed human facial emotions (i.e., happiness, surprise, sadness, anger, disgust, and fear). To make our model more transparent, we explain this emotion classification task with *class activation mapping* (CAM) and *gradient-weighted class activation mapping* (Grad-CAM).

The structure of this report is arranged as follows. In Section 2, we address the datasets we collected and the model architecture we implemented. The preliminary evaluation results of our models are given in Section 3. Section 4 describes the optimization strategies we have already used and plan to investigate in the coming weeks. Finally, an overview of our time schedule for the entire final project is given in Figure 2. Our code and supplementary material are available at <https://github.com/werywjw/SEP-CVDL>.

## 2. Approach

### 2.1. Dataset Acquisition and Processing

To initiate the project, we acquired the databases such as FER+ [1]<sup>1</sup>, RAF-DB [6, 7], CK+ [9], TFEID [2, 8], as well as the video database DISFA [10], from public institutions and GitHub repositories<sup>2</sup>. Based on these databases, we created a dataset by augmentation to increase variety, full details of augmentation (see Section 4.1 for details). In terms of illustrating the content of used pictures, we exclusively analyze human faces representing 6 emotions. That is, we generalized a folder structure annotating the labels 1 (surprise), 2 (fear), 3 (disgust), 4 (happiness), 5 (sadness), and 6 (anger). Besides the original format of images and videos, we set standards for extracting frames from the

videos, resize training pictures to 64x64 pixels, and save them as the JPG format.

The images are converted to greyscale with three channels, as our original *convolutional neural network* (CNN) is designed to work with three-channel inputs with random rotation and crop. Emotions were assigned tags to each individual picture in a CSV file to facilitate further processing in the model. We create a custom dataset, which is a collection of data relating to all training images we collected, using PyTorch<sup>3</sup>, as it includes plenty existing functions to load various custom datasets in domain libraries such as TorchVision, TorchText, TorchAudio, and TorchRec.

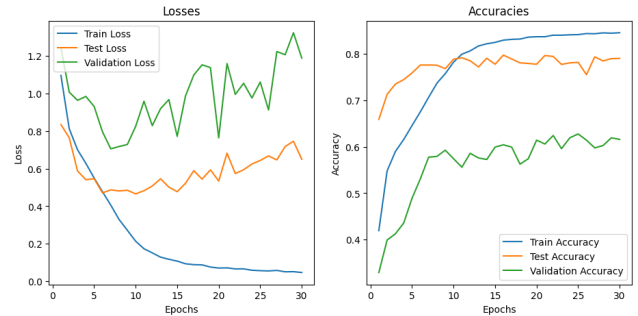


Figure 1. Empirical results in terms of the loss and accuracy on different training epochs for our current best model

### 2.2. Model Architecture

We implement an emotion classification model from scratch with four convolution layers at the very beginning. Following each convolutional layer, batch normalization is used, as this stabilizes learning by normalizing the input to each layer. Afterward, three linear layers are applied to extract features to the final output. We also add a dropout layer to prevent overfitting. The activation function after each layer is *Rectified Linear Unit* (ReLU), since it introduces the non-linearity into the model, allowing it to learn more complex patterns. The test results in Figure 1 are aggregated from

<sup>1</sup><https://github.com/microsoft/FERPlus>

<sup>2</sup><https://github.com/spenceryee/CS229>

<sup>3</sup><https://pytorch.org>

Hyperparameter	Configuration
Learning rate	{0.1, 0.01, 0.001, 0.0001}
Batch size	{8, 16, 32, 64}
Dropout rate	{0.5}
Epoch	{10, 20, 30, 40}
Early stopping	{True, False}
Patience	{5}

Table 1. Explored hyperparameter space for our models

Models	Accuracy (Train)	Accuracy (Test)	Accuracy (Vali)
CNN (Baseline)	66.3	75.2	52.6
CNN (SE+Aug)	74.3	79.9	59.6
CNN (SE-Aug)	84.6	79.5	<b>62.8</b>
CNN (SE+Res)	71.5	78.9	56.4
ResNet18 [3]	76.8	79.8	60.3
CNN (Ours-Aug)	<b>84.9</b>	<b>80.0</b>	62.6

Table 2. Accuracy (%) for different models in our experiments (Aug stands for data augmentation, SE for squeeze and excitation, and Res for residual connections; +/- represent)

the database RAF-DB<sup>4</sup>. In order to find the best hyperparameter configuration (see Table 1 for details) of the model, we utilize the parameter grid from sklearn<sup>5</sup>.

### 3. Preliminary Results

For evaluation, we use the metric accuracy. As seen in Table 2, we report all the training, testing, and validation accuracy in % to improve the performance of our models. The loss function employed for all models is cross-entropy, which is typically for multi-class classification. The best results of the performance of the model with respect to loss and accuracy are depicted in Figure 1.

### 4. Optimization Strategies

Techniques like dropout, renormalization, and data augmentation are employed to enhance model performance during training. Additionally, we increase the depth of the network by adding some convolutional layers to learn more complex features. To help the training of deeper networks more efficiently, we add the residual connections, as they allow gradients to flow through the network more easily, improving the training for deep architectures. Moreover, we add squeeze and excitation (SE) blocks to apply channel-wise attention. In the coming weeks, we will focus on the following tasks Section 4.1 and Section 4.2. Further re-

search is orientated on papers engaging similar investigations [7, 12, 13].

#### 4.1. Data Augmentation

In machine learning and artificial intelligence, augmentation stands as a transformative technique, empowering algorithms to learn from and adapt to a wider range of data. By introducing subtle modifications to existing data points, augmentation effectively expands the dataset, enabling models to generalize better and achieve enhanced performance. As models encounter slightly altered versions of familiar data, they are forced to make more nuanced and robust predictions. With this process, we aim to prevent overfitting, a common pitfall in machine learning. Additionally, we guide the training process to enhance the recognition and handling of real-world variations. During the project, we pursue various approaches. We are implementing different combinations of functions from the `pytorch.transforms` library and testing already established filters that have been developed, in other research contexts. We create various replications of existing photos by randomly altering different properties such as size, brightness, color channels, or perspectives.

#### 4.2. CAM

Generally speaking, Class Activation Mapping is a visualization technique designed to highlight the regions of an image or video that contribute the most to the prediction of a specific class by a neural network, typically the final convolutional layer of a CNN before the fully connected layers. Technically, CAM generates a heatmap that highlights the important regions of the image in terms of the decision of the model. Besides proposing a method to visualize the discriminative regions of a classification-trained CNN, we adapte this approach from Zhou et al. [14] to localize objects without providing the model with any bounding box annotations. The model can thus learn the classification task with class labels and is then able to localize the object of a specific class in an image.

The final convolutional layer produces feature maps, and the GAP layer computes the average value of each feature map. The weights connecting the feature maps to the output class are obtained. The weighted combination of feature maps, representing the importance of each spatial location, is used to generate the CAM heatmap. CAM helps interpret CNN decisions by providing visual cues about the regions that influenced the classification. It aids in understanding the model’s behavior and can be useful for model debugging and improvement. The global average pooling (GAP) layer is used to obtain a spatial average of the feature maps.

<sup>4</sup><https://www.kaggle.com/datasets/shuvoalok/raf-db-dataset>

<sup>5</sup>[https://scikit-learn.org/stable/modules/generated/sklearn.model\\_selection.ParameterGrid.html](https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.ParameterGrid.html)

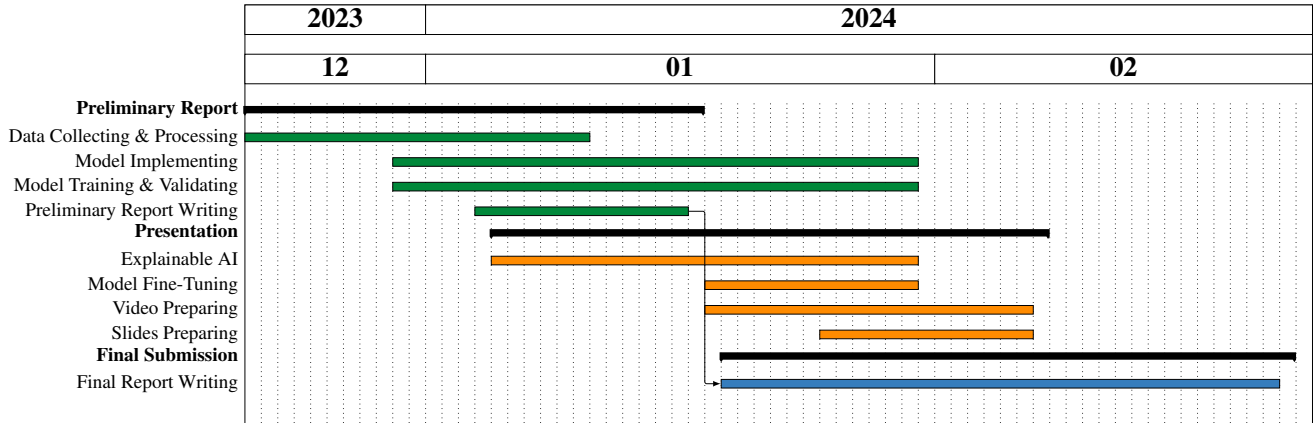


Figure 2. Overview of the schedule for the final project

### 4.3. Grad-CAM

Despite CAM can provide valuable insights into the decision-making process of deep learning models, especially CNNs, CAM must be implemented in the last layer of a CNN. We thus follow up Gradient-weighted CAM [11], introduced as a technique that is easier to implement with different architectures. This task will be implemented by using the libraries of Pytorch and OpenCV<sup>6</sup>.

### 4.4. Table of Classification scores

To further analyze the separate scores of the each class of the model, we wrote a script that takes a folder path as input and iterates through the images inside a subfolder. The output is a CSV file representing the corresponding classification scores.

### Author Contributions

Equal contributions are listed by alphabetical order of surnames. Every author did the literature research and contributed to the writing of the paper.

- **Tanja Jaschkowitz** implemented the model architecture, training and testing infrastructure, and CSV file aggregations.
- **Leah Kawka** collected the training data, prepared data processing, implemented augmentation, and ran the results. She also takes part in the explainable AI and Grad-CAM.
- **Mahdi Mohammadi** implemented the augmentation, did the research searching, conclusion reasearching, data pre-processing, and CAM-Images inquiry.
- **Jiawen Wang** implemented the model architecture, training and testing infrastructure, and optimization strategies. In the specific writing part, she also draw the figures and tables and improved this report from other team members.

<sup>6</sup> <https://opencv.org>

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