

Facial Expression Recognition Using Xception And DenseNet Architecture

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Facial Expression Recognition Using Xception And DenseNet Architecture

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¹**Abstract**— Researchers pay much attention to facial expressions recognition due to the rapid development of Artificial Intelligence. Facial expression recognition is used to help human-computer interaction. In addition, facial expression recognition is also used in psychological recognition, Human-computer interaction, assisted driving, and security station in everyday life. But most of the research focused on the machine learning approach rather than deep learning and the emotion classifications are also smaller. This facial expression recognition can be implemented using a deep learning approach. The architecture that is often used and considered to be the best in image classification is Convolutional Neural Network. Therefore, this study builds a Convolutional Neural Network Model with Xception and DenseNet architecture. The accuracy of the two models is compared, with Xception received an accuracy of 70% and DenseNet got 79%.

Keywords—Convolutional Neural Network; Facial Expression; Basic Emotion; Deep Learning

I. INTRODUCTION

Understanding people's expressions or feelings is very important in social interaction [1]. This ability is needed to see and anticipate the reactions shown by others. In addition, a lot of information is obtained when observing the person's facial expressions or feelings without knowing other additional information [2]. Usually, the determination of these expressions is a subjective process and accumulated from human experience, but this is different from computers where the computer needs prior knowledge and input to recognize expressions [3].

Not a few researchers who research emotion recognition, one of which Nguyen argues that facial expression recognition is a topic that has been widely studied, both in terms of theory and application in various fields such as biology, psychology, medicine, neuroscience, or computer science [4]. In addition, the

recognition of facial expressions has been paid much attention by researchers due to the rapid development of Artificial Intelligence. where facial expression recognition is the one-way computers interact with humans. The following are examples of the use of facial expression recognition in everyday life such as psychological recognition, Human-Computer Interaction, Assisted Driving, and station security [5].

²¹In general, humans use different signs to show expressions, such as facial expressions, hand gestures, and voice. However, the cues that show their most expression are facial expressions, in which facial expressions represent 55% of human emotions while other cues only show 7% of human emotions [6]. Therefore, it can be said that facial expression has a big influence in showing various human expressions.

Facial expression recognition has been widely studied [7]. The previous expression study used the SVM and facial landmark methods with an accuracy of 70.65% [4]. In addition, other studies use machine learning methods with random forest classification and the accuracy obtained is only up to 72% [8]. However, this research only detects 3 expressions and the accuracy obtained is still quite low, while for its use, facial expression recognition requires a fairly high accuracy [5].

Based on this research, the application of facial expression recognition that uses has not implemented a deep learning model and only classifies 3 types of emotions. Therefore, this research is focused on the application of facial expressions using a deep learning model, as well as adding the classification of the detected emotions. The classification of emotions that is often used in expression research is the basic emotion consisting of happiness, sadness, fear, disgust, surprise, anger, and neutral [7].

⁵This study uses the CNN (Convolutional Neural Network) architecture because CNN is often used and also gets higher

accuracy for image detection [9]. The design of this model will also use DenseNet and Xception architectures. DenseNet is a popular architecture because of its accuracy results that exceed other standard models in object recognition or image processing. In addition, DenseNet wants to be compared with the Xception architecture because the best accuracy results are obtained using the imageNet dataset compared to other architectures for image detection [10].

Based on what was discussed earlier, this study aims to create a basic emotion classification model using deep learning with architecture, DenseNet, and Xception. Then, the accuracy of DenseNet and Xception will be compared to determine the most superior model for this research.

II. LITERATURE REVIEW

The article entitled "An Efficient Real-Time Emotion Recognition Using Camera and Facial Landmarks" was written by Binh T. Nguyen, Minh H. Trinh, Tan V. Phan, Hien D. Nguyen [4] uses machine learning models for expression recognition in the face with his method using the Support Vector Machine. In addition, the model created achieves an accuracy of 70.65% with 3 expression classifications.

The second article is entitled "Facial Expression Recognition Using Facial Landmarks and Random Forest Classifier" and was written by M. I. N. P. Munasinghe [8]. This study focuses on making machine learning models for facial expression recognition using the random forest algorithm. The model that was made obtained an accuracy of 72% with the number of classified expressions being 3.

The third article entitled "Deep Facial Expression Recognition: A Survey" was written by Shan Li and Weihong Deng [11]. This study discusses the dataset used to train the expression recognition model. One of the datasets discussed is RAF-DB.

The fourth article is entitled "Identifying Student Mood Based on Facial Expressions by Using Discrete Wavelet Transform and Fuzzy K-Nearest Neighbor" [12]. This study focuses on making programs to identify student moods based on facial expressions using the Fuzzy K-Nearest Neighbor algorithm and only classifying 3 types of emotions, namely angry, happy, and sad.

Based on previous research, many studies examine the creation of expression recognition using machine learning models. In addition, only 3 types of expressions are classified. Meanwhile, in this study, the model to be developed uses a deep learning approach and classifies 7 types of expressions. The dataset used is also the dataset in the previous study, namely RAF-DB.

III. METHODOLOGY

Cross-Industry Standard Process for Data Mining or CRISP-DM is a method that compiles Data Mining projects in interrelated phases, turning the process into an iterative and interactive form [13]. In this research, CRISP-DM will be used as the methodology when making the model for Xception and

DenseNet. The following are the steps carried out in this research:

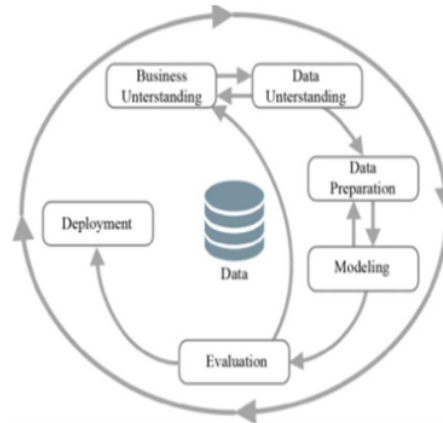


Fig. 1. CRISP-DM Methodology

A. Business Understanding

This stage describes the background and objectives of the research activity, namely the recognition of emotions based on facial expressions using the Convolutional Neural Network where the resulting model is following the objectives of the study.

B. Data Understanding

At this stage, the dataset used will be clarified regarding the content and types of images to be used. At this stage, several things need to be done such as collecting initial data, describing the data, exploring the data, and verifying the quality of the data [14].

C. Data Preparation

This stage prepares the data that will be used by the model. This stage also requires clear analysis and sufficient knowledge to determine the preparation required for the study. This study also did not perform data cleansing because the data were obtained from previously prepared studies [11].

Load Data is a step taken to read data from another format or form to the form needed when training the model. The dataset used has data in the form of a text file, therefore this text data is converted into a data frame form.

Class Weight is one way to deal with the class imbalance that occurs in the dataset, where the class imbalance is a problem that arises if the number of each classification is not balanced. The RAF-DB dataset is a dataset that has class imbalance problems because the number of each type of emotion is very different.

Data Augmentation is a technique for manipulating data without losing the essence or meaning of the data. The following data augmentation techniques were used in this study [15]:

- Flip - The image is rotated horizontally or vertically.
- Rotation - The image is rotated based on the specified number of degrees.
- Zoom - Image is enlarged or reduced.
- Shift - Image shifts by axis horizontally or vertically.
- Shear - The image is tilted and stretched according to the axis.

D. Modeling

At this stage, a model for facial expression recognition will be made using the CNN architecture with 2 architectures, namely DenseNet and Xception. DenseNet is a popular architecture because of its accuracy results that exceed other standard models in object recognition processing or image processing [16]. Xception is used because the best accuracy results are obtained using the imageNet dataset compared to other architectures for image detection [10].

This research uses the Deep Learning method using CNN architecture. The main reason for using CNN is the weight sharing feature where the number of parameters being trained is reduced and can reduce overfitting in the model [15]. In addition, for the implementation of the model on a large scale, CNN is easier to use than other neural networks. [15]. The following architectures that will be used in this research are Xception and Densenet.

At this stage, the monitoring configuration is carried out before training the model. This configuration is done to prevent errors or overfitting of the model. The following parameters are used for monitoring:

- **Learning Rate** – Learning rate is one of the parameters used to calculate the weight of the correction value during the training process. The learning rate value has a range from 0 to 1. The greater the learning rate value, the less accuracy in the model and vice versa if the learning rate value is smaller [17]. For this research, we will use the step decay formula the learning rate scheduler. This step Decay lowers the learning rate by a factor of every few epochs.
- **Early Stopping** - Early Stopping is a technique used to stop model training to prevent model overfitting [17]. This Early Stopping is called using the callbacks function in the keras library.
- **Model Checkpoint** - Model Checkpoint is a strategy used to store the model based on the specified parameters. In this study, the checkpoint model is used to store the model with the best validation accuracy, so that the stored model can load the model weights and continue with the same model to improve accuracy [17]. This Checkpoint model is also called by using the callbacks function in the keras library.

- **Callback** -Callbacks are parameters provided by the TensorFlow and Keras libraries to monitor performance on certain parameters in running the training model. These callbacks are executed depending on the parameters specified for execution [17]

At this stage, the model whose architecture has been built can be trained with the RAF-DB dataset. The model is trained as much as the specified epoch. If the model stops in the middle of the training process, the model can be run again from the beginning and use the checkpoint model to load the final model weight with the highest accuracy.

At this stage, the model that has been built can be trained with the RAF-DB dataset. The model is trained as much as the specified epoch. If the model stops in the middle of the training process, the model can be run again from the beginning and use the model checkpoint to load the final model weights with the highest accuracy.

E. Evaluation

This stage interprets the results of the modeling carried out. Evaluation is carried out on the model to determine whether this model meets the needs or not. The evaluation of the model will be based on accuracy and confusion matrix.

F. Deployment

At the deployment stage, the model created will be demoed with the OpenCV Library and detect faces using the camera on a laptop. Emotions that appear on the face will be detected and the detection results will also appear on the video in real-time.

IV. RESULTS & DISCUSSION

A. Data Understanding

This study uses the RAF-DB (Real-World Affective Faces Database) dataset which consists of various emotional images in free conditions [18]. This dataset consists of basic emotions and combined emotions but this study only discusses basic emotions. This basic emotion consists of 7 types of emotion classification, namely Anger, Surprise, Fear, Disgust, Neutral, Happiness, and Sadness. The number of images on basic emotions is 15,367 consisting of 12,271 training data and 3,096 testing data. Here's the distribution for each of the basic emotion classifications:

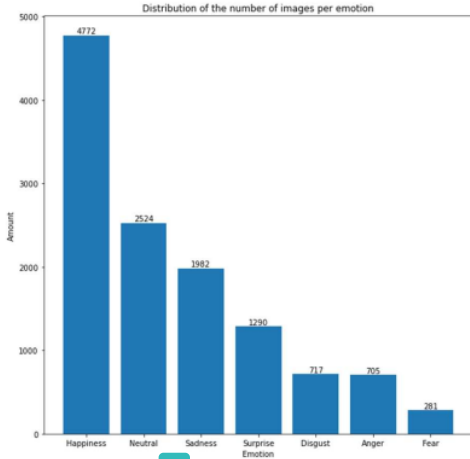


Fig. 2. Class Distribution of RAF-DB Dataset

In Fig. 2, it can be seen that the image with the Happiness classification has a fairly large number, namely 4,772 while the image with the Fear classification has a total of 281. From this number, it can be concluded that each emotion has a considerable difference in number.

B. Data Preparation

Before creating a deep learning model, the dataset used needs to be prepared first. The first stage is to create a data frame for training and testing data because this dataset does not have a CSV file but a txt file. Creating a data frame is used for reading in tabular form and moving image data to be more structured. The reading process begins with the creation of a label_loader function which reads the data in the txt file and converts it into a dictionary.

After entering the data into a dictionary form, the data is converted into a data frame form with the pandas library. The data frame consists of 3 columns, namely the image name (imageName), emotion labels using numbers (emoLabel) and the last is emotion labels using words (emoString). The manufacturing process begins with creating a data frame with 2 columns, namely imageName and emoLabel, and then looping to fill in the emoString data.

From the results of the data frame, image data is moved to their respective emotion classification folders based on the demo string column because previously the image data had a folder structure of image data only divided into train and test but there were no subfolders based on their emotional classification while using TensorFlow needed a certain folder structure. This process uses shutil copy to copy the data in the previous folder to the destination folder with their respective emotion subfolders.

After moving the data to the original folder, it's time to create class weights. Making this class weight is used to overcome imbalanced datasets in RAF-DB because, at the data preparation stage, the number of datasets on the Happiness

emotion is far compared to other emotion classifications. The class weight process begins with calculating the total for each type of emotion, after calculating the weight for each emotion.

After calculating the weight of each emotion classification, the weight is combined in a dictionary form so that it can be entered into the model during training.

Next, the data augmentation stage is carried out to multiply the different conditions on the data and improve performance on the model. This augmentation is applied to the images randomly and does not change the amount in the training data. Data augmentation is performed using the ImageDataGenerator function from the TensorFlow library.

This Data Augmentation process produces datasets with various conditions, from changing positions, zoomed images, and other conditions but this augmented data does not change in number. Although there are many augmentation techniques used, the image only follows one condition randomly, so the data is not duplicated. This augmentation is implemented on 271 training data and testing data that have been prepared. The flow from directory function is used to read the image dataset in the specified directory. The target size is 100x100 because the created model accepts 100x100 input and the class model is made categorical because the dataset has a multiclass classification. The output of this process is data with a generator data type and contains a collection of tensor image data that has been implemented with augmentation.

Then the data is modified again with AUTOTUNE to optimize CPU/GPU usage on Google Colab. The dataset also uses prefetch to allow the process of pre-processing and execution of the model to run in parallel.

C. Modeling

This stage begins with the creation of a CNN model that can classify basic emotions based on facial expressions. CNN model created using Xception and DenseNet architecture to find the model with the best accuracy.

The process of making a CNN model with the Xception architecture is made using the TensorFlow library. This stage begins with the creation of an Xception model for the classification of facial expressions. This model is structured with an input layer to accept image input and an output layer to provide predictive results for expression classification. The following layers are used in the Xception architecture in table I.

TABLE I. XCEPTION MODEL LAYER

10.	Layer
1	Input Layer
2	Convolutional 2D
3	Batch Normalization
4	Activation
5	Separable Convolutional 2D
6	Max Pooling 2D
7	Global Average Pooling 2D

Modeling CNN with DenseNet architecture is made using Tensorflow Library. DenseNet is an architecture focused on making deep learning models even deeper by shortening the connections at each layer. The following layers are used in the DenseNet architectural model in table II.

TABLE II. DENSENET MODEL LAYER

No.	Layer
1.	Bn_rl_conv
2.	Dense block
3.	Transition layer
4.	Convolutional 2d
5.	Max Pooling 2D
6.	Global Average Pooling 2D

Before compiling the model, it is necessary to create a step decay function to match the existing learning rate to the running epoch. This is done so that the model can learn more complex patterns, the smaller the learning rate, the more complex the model.

After the step_decay function is created, a callback model is created with the EarlyStopping, ModelCheckpoint, and learning rate functions. EarlyStopping functions to stop the training model if there is no improvement in the specified parameters, and in this study, the validation loss parameter is used.

If validation loss does not develop for 15 epochs then the model training will stop. ModelCheckpoint also functions to create a model for each epoch, because each training epoch takes longer, then each epoch model is saved so that the training model can be continued from the previously-stored model.

The compiled model will then be trained using data from the results of the data preparation stage by using the callback function and the class weight that has been set.

D. Evaluation

At this stage, an evaluation of the Xception and DenseNet models was made for the classification of basic emotions. The evaluated model has been processed with augmentation data during training. The following are the accuracy results obtained in table III.

TABLE III. MODEL ACCURACY RESULT

Model	Accuracy
Xception	0,70
DenseNet	0,79

The Xception model has an accuracy of 70% while the DenseNet model has an accuracy of 79%. From the results obtained, the DenseNet model has better accuracy than the Xception. The Xception model also has a different architecture from the DenseNet model. Xception has a separate convolutional layer that distinguishes it from other models, this

separate convolutional layer serves to change the image once and channel it to the next channel without having to change the image several times. Whereas DenseNet focuses on dense network blocks. This solid block takes all the features in the previous input to help with the vanishing gradient training process. Then based on the results of the confusion matrix table IV. the Xception model and the DenseNet model have a slight difference where Xception gets 34% and DenseNet gets 32%. However, each model has advantages for different emotions, where the DenseNet model gets a correct prediction of 65% for Happiness and the Xception model gets 39% for Neutral so it is difficult to compare when using the average of all correct predictions as a comparison. In addition, even though the class weight has been used, there is still a bias towards the data that has the highest number of classifications.

TABLE IV. CONFUSION MATRIX RESULT

DenseNet							
	Surprise	Fear	Disgust	Happiness	Sadness	Anger	Neutral
Surprise	120	5	41	142	42	9	55
Fear	4	21	14	30	12	2	12
Disgust	15	4	107	71	21	4	28
Happiness	35	0	17	498	69	6	139
Sadness	45	7	47	199	185	13	98
Anger	15	5	17	67	27	34	25
Neutral	61	6	80	287	95	12	220
Correct Prediction	0,13	0,22	0,43	0,65	0,31	0,18	0,29
Average	0,32						
Xception							
	Surprise	Fear	Disgust	Happiness	Sadness	Anger	Neutral
Surprise	147	11	21	121	61	23	67
Fear	13	24	2	29	12	1	16
Disgust	25	4	72	61	24	7	34
Happiness	25	1	45	426	76	9	151
Sadness	50	10	23	189	183	26	104
Anger	18	1	7	54	29	69	44
Neutral	71	20	46	241	111	48	264
Correct Prediction	0,20	0,34	0,33	0,38	0,37	0,38	0,39
Average	0,34						

Although the accuracy results for Xception and DenseNet are not the best, but still better than some previous studies. The accuracies of basic classification models were 66.82% using shape features, 72.71% using LBP, 74.35% for HOG, 77.28% for Gabor, 68.90% for AlexNet, and 70.53% for VGG-16 [19]. The low accuracy may occur because of the imbalanced data. The happiness samples are too dominant. It is required to apply some solution for imbalanced data [20]. The sample size is also needed to be enlarged by combining with other sources. Emotion recognition can be improved by solving imbalanced data problems [21].

E. Deployment

At this stage, the implementation of the basic emotion classification model is carried out using video capture in the

OpenCV Library. Models created are loaded with the TensorFlow library. After that, video detection is made in real-time using video capture in the OpenCV Library. The loaded model is used to predict the image captured by the video webcam and the prediction results are displayed on the video in Fig 3.



Fig. 3. Emotion Detection Example

V. CONCLUSION

Based on the research problem, this study succeeded in implementing the basic facial expression classification model, namely anger, surprise, sadness, neutral, disgust, fear, and happiness using a deep learning approach with DenseNet and Xception architecture. Due to the previous research, the model used a machine learning approach and only classified 3 types of emotions. Based on the research results obtained, the Xception model gets an accuracy of 70% while DenseNet gets an accuracy of 79%. This difference in results is due to the use of different layer types in the model and the number of layers used by the DenseNet model is more than Xception.

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REFERENCES

[1] R. Kosti, J. M. Alvarez, A. Recasens, and A. Lapedriza, "Emotion Recognition in Context," in 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Honolulu, HI, Jul. 2017, pp. 1960–1968. doi: 10.1109/CVPR.2017.212.

[2] A. Hassouneh, A. M. Mutawa, and M. Murugappan, "Development of a Real-Time Emotion Recognition System Using Facial Expressions and EEG based on machine learning and deep neural network methods," *Inform. Med. Unlocked*, vol. 20, p. 100372, 2020, doi: 10.1016/j.imu.2020.100372.

[3] X. Sun, P. Xia, and F. Ren, "Multi-attention based Deep Neural Network with hybrid features for Dynamic Sequential Facial Expression Recognition," *Neurocomputing*, p. S0925231220317756, Nov. 2020, doi: 10.1016/j.neucom.2019.11.127.

[4] B. T. Nguyen, M. H. Trinh, T. V. Phan, and H. D. Nguyen, "An efficient real-time emotion detection using camera and facial landmarks," in 2017 Seventh International Conference on Information Science and Technology (ICIST), Da Nang, Vietnam, Apr. 2017, pp. 251–255. doi: 10.1109/ICIST.2017.7926765.

[5] B. Li and D. Lima, "Facial expression recognition via ResNet-50," *Int. J. Cogn. Comput. Eng.*, vol. 2, pp. 57–64, Jun. 2021, doi: 10.1016/j.ijcce.2021.02.002.

[6] N. Samadiani, G. Huang, B. Cai, W. Luo, C. H. Chi, Y. Xiang, and J. He, "A Review on Automatic Facial Expression Recognition Systems Assisted by Multimodal Sensor Data," *Sensors*, vol. 19, no. 8, p. 1863, Apr. 2019, doi: 10.3390/s19081863.

[7] W. B. Putra and F. Arifin, "Real-Time Emotion Recognition System to Monitor Student's Mood in a Classroom," *J. Phys. Conf. Ser.*, vol. 1413, p. 012021, Nov. 2019, doi: 10.1088/1742-6596/1413/1/012021.

[8] M. I. N. P. Munasinghe, "Facial Expression Recognition Using Facial Landmarks and Random Forest Classifier," in 2018 IEEE/ACIS 17th International Conference on Computer and Information Science (ICIS), Singapore, Jun. 2018, pp. 423–427. doi: 10.1109/ICIS.2018.8466510.

[9] Y. Chen, J. Wang, S. Chen, Z. Shi, and J. Cai, "Facial Motion Prior Networks for Facial Expression Recognition," *ArXiv190208788 Cs*, Dec. 2019, Accessed: Apr. 01, 2021. [Online]. Available: <http://arxiv.org/abs/1902.08788>

[10] M. Rahimzadeh and A. Attar, "A modified deep convolutional neural network for detecting COVID-19 and pneumonia from chest X-ray images based on the concatenation of Xception and ResNet50V2," *Inform. Med. Unlocked*, vol. 19, p. 100360, 2020, doi: 10.1016/j.imu.2020.100360.

[11] S. Li and W. Deng, "Deep Facial Expression Recognition: A Survey," *IEEE Trans. Affect. Comput.*, pp. 1–1, 2020, doi: 10.1109/TAFCC.2020.2981446.

[12] N. I. R. Amalia and J. Y. Sari, "Mengidentifikasi Mood Mahasiswa Berdasarkan Ekspresi Wajah dengan Menggunakan Discrete Wavelet Transform dan Fuzzy K-Nearest Neighbor," p. 5, 2019.

[13] H. J. G. Palacios, R. A. J. Toledo, G. A. H. Pantoja, and Á. A. M. Navarro, "A comparative between CRISP-DM and SEMMA through the construction of a MODIS repository for studies of land use and cover change," *Adv. Sci. Technol. Eng. Syst. J.*, vol. 2, no. 3, pp. 598–604, Jun. 2017, doi: 10.25046/aj020376.

[14] T. Mauritsius, "Bank Marketing Data Mining using CRISP-DM Approach," *Int. J. Adv. Trends Comput. Sci. Eng.*, vol. 8, no. 5, pp. 2322–2329, Oct. 2019, doi: 10.30534/ijatcse/2019/71852019.

[15] L. Alzubaidi, "Review of deep learning: concepts, CNN architectures, challenges, applications, future directions," p. 74, 2021.

[16] Z. Alom, T. M. Taha, C. Yakopcic, S. Westberg, P. Sidike, and M. S. Nasrin, "The History Began from AlexNet: A Comprehensive Survey on Deep Learning Approaches," p. 39, 2017.

[17] A. Gulli and S. Pal, *Deep learning with Keras: implement neural networks with Keras on Theano and TensorFlow*. Birmingham Mumbai: Packt, 2017.

[18] S. Li, W. Deng, and J. Du, "Reliable Crowdsourcing and Deep Locality-Preserving Learning for Expression Recognition in the Wild," in 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Honolulu, HI, Jul. 2017, pp. 2584–2593. doi: 10.1109/CVPR.2017.277.

[19] S. Li and W. Deng, "Reliable crowdsourcing and deep locality-preserving learning for unconstrained facial expression recognition," *IEEE Trans. Image Process.*, vol. 28, no. 1, pp. 356–370, 2019, doi:10.1109/TIP.2018.2868382.

[20] A. Chatziagapi, G. Paraskevopoulos, D. Sgouropoulos, G. Pantazopoulos, M. Nikandrou, T. Giannakopoulos, A. Katsamanis, A. Potamianos, and S. Narayanan, "Data Augmentation Using GANs for Speech Emotion Recognition," *Interspeech*, pp. 171–175, 2019.

[21] D. Deng, Z. Chen, and B. E. Shi, "Multitask emotion recognition with incomplete labels", in 2020 15th IEEE International Conference on Automatic Face and Gesture Recognition (FG 2020), pp. 592–599, 2020.

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