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DeepFake Detection with Voronoi Regions

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Outline

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   A. Problem Definition
   B. Related Work
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   B. Preprocessing
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   D. Dataset Construction
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III. Results and Evaluation
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I. Introduction

- What is a DeepFake?

Figure 1: Synthesizing Obama: Learning Lip Sync From Audio[3].

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[3] S. Suwajanakorn, S. M. Seitz, and I. Kemelmacher-Shlizerman, “Synthesizing obama: Learning lip sync from audio,” ACM Trans. Graph., vol. 36, July 2017

DeepFakes are created with taking input a video of a specific individual (**'target'**) and outputting another video with the target's faces replaced with those of another individual (**'source'**).

Figure 2: Video: Synthesizing Obama: Learning Lip Sync[3].

[3] S. Suwajanakorn, S. M. Seitz, and I. Kemelmacher-Shlizerman, "Synthesizing obama: Learning lip sync from audio," ACM Trans. Graph., vol. 36, July 2017

Figure 3: CELEB - DF Dataset DeepFake

[5] Y. Li, X. Yang, P. Sun, H. Qi, and S. Lyu, “Celeb-df: A new dataset for deepfake forensics,” 09 2019.

- What is Voronoi Features?

In mathematical terms, we are given a finite set of points in the plane and, for each point, the corresponding **Voronoi cell** consists of all the **locations** closer to it **than** to any of the other points [1].

Voronoi diagrams used in:

- Biological structures
- Aviation, (nearest airport in case of diversions).
- Mining,
- Epidemiology [1].

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[1] P. Lynch, "How Voronoi diagrams help us understand our world", The Irish Times, 2020. [Online]. Available: https://www.irishtimes.com/news/science/how-voronoi-diagrams-help-us-understand-our-world-1.2947681. [Accessed: 13- May- 2020].

I.A Problem Definition

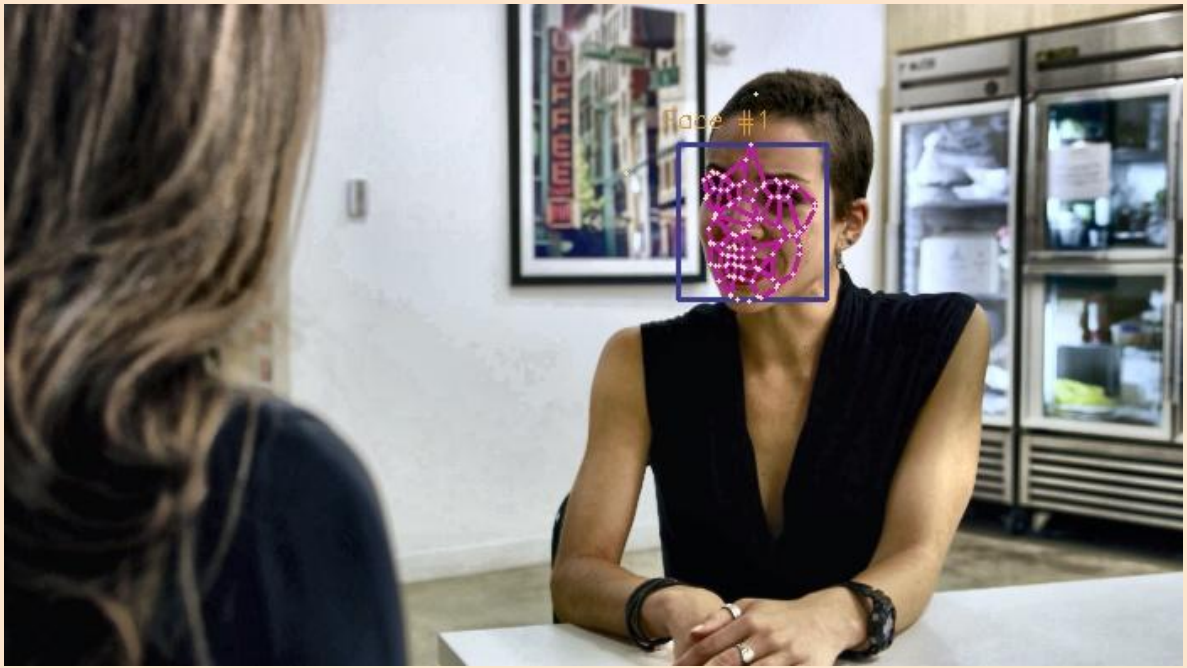


Figure 4: Voronoi Region detection done by current model

Voronoi regions are already used in:

Face recognition, face segmentation, 3D face reconstruction from 2D images

How to detect DeepFakes with Voronoi regions?

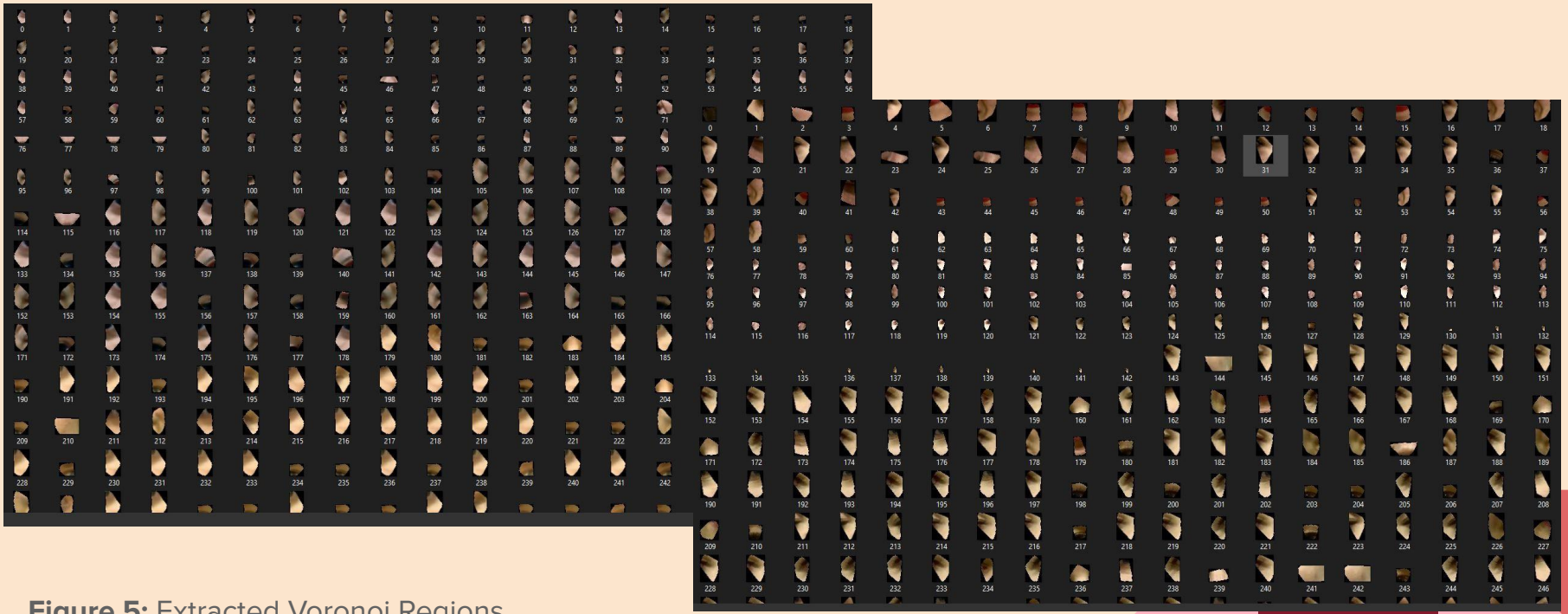


Figure 5: Extracted Voronoi Regions

I.B Related Work

- Face Action Units [8]
- Eye blinking, [9]
- Biological signals [10],
- facial features optical distortions [11][12];
- there are also neural network methods which proposes CNN based models [13],
  - CNN and RNN based models [14],
  - two-stream neural networks [15],
  - autoencoders [16],
  - Long-Short Memory model [17].

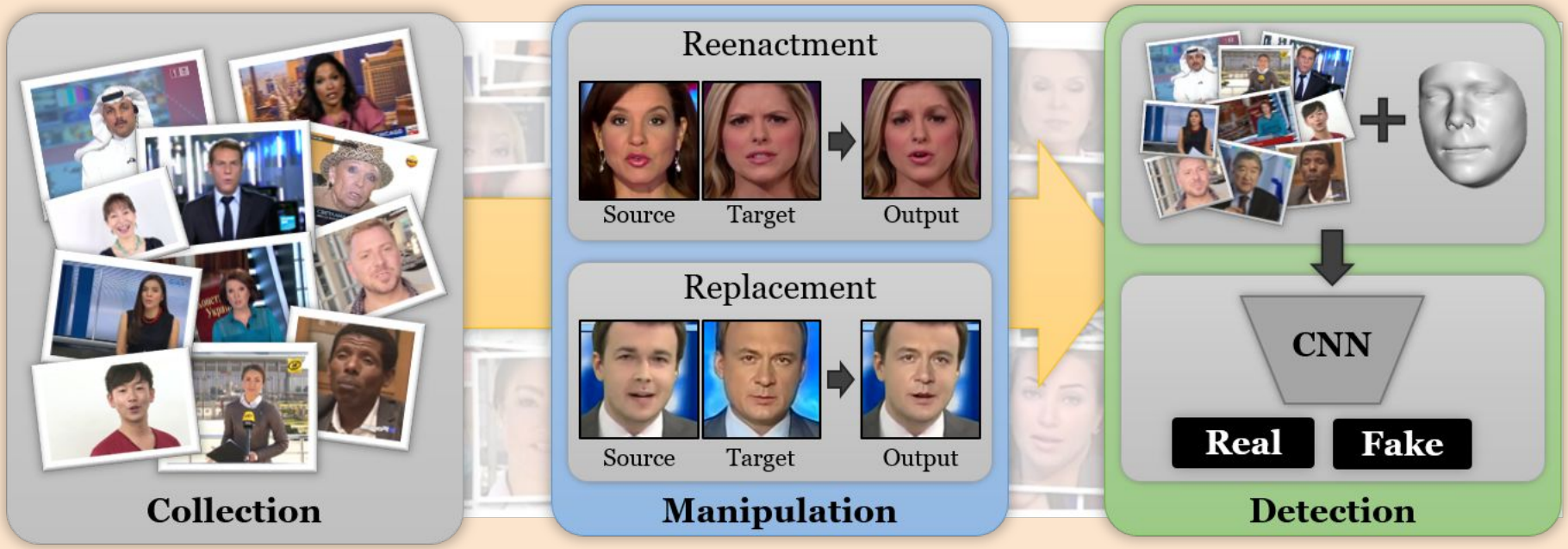


Figure 6: Summary of related work [2]

[2] A. Rossler, D. Cozzolino, L. Verdoliva, C. Riess, J. Thies, and M. Nießner, "Faceforensics++: Learning to detect manipulated facial images," 01 2019

II. Model

II.A Dataset

Face Forensics++ is used.[2] Including four methods,

- Deepfakes,
- Face2Face,
- FaceSwap, and
- NeuralTextures

Face Forensic (first version) 977 images from YouTube (without consent). New version (Face Forensics++) : Google also contributed to the dataset. 28 paid actors in 16 different scenes and over 3000 manipulated videos

[2] A. Rossler, D. Cozzolino, L. Verdoliva, C. Riess, J. Thies, and M. Nießner, “Faceforensics++: Learning to detect manipulated facial images,” 01 2019

-Only a *small* subset of the *dataset* is used.

-Main concern for using Voronoi Regions → train the system with **less data**, gain **robustness** with looking to the Voronoi Regions in different frames.

-Videos are **long**, 100~250 **Voronoi Regions** Images can be extracted from only 1 video. (Voronoi regions with small area is filtered as they do not give much clue)

-Currently using:

- Original Sequences: 30 Actor and 30 Youtube Original videos
- Manipulated Sequences: 60 DeepFakeDetection videos

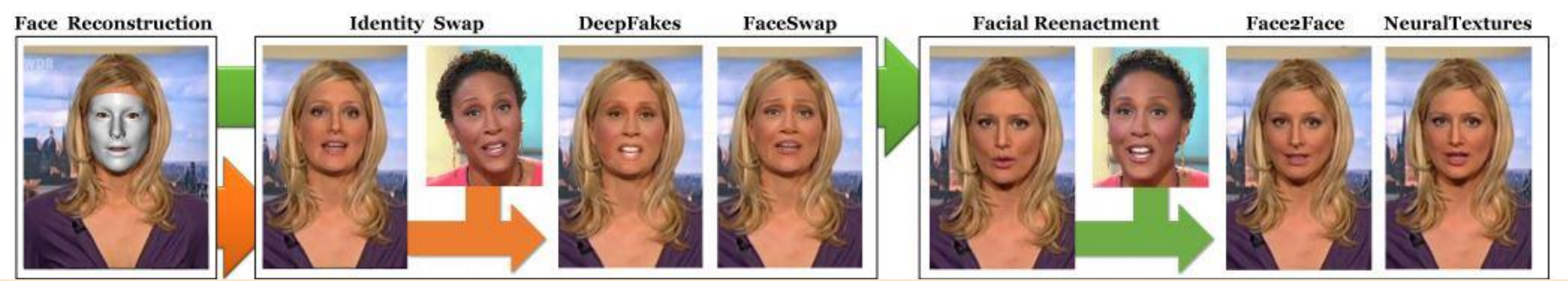


Figure 7: FaceForensics++ example of DeepFake Methods [2]

II.B Preprocessing

Two main preprocessing steps applied:

- To detect face regions : Illumination Normalization.
- To extract voronoi regions from face regions: Gamma Normalization.

Figure 8: Lightning ill affected image (Left) vs preprocessed image (Right)

- To extract voronoi regions from face regions: Gamma Normalization.

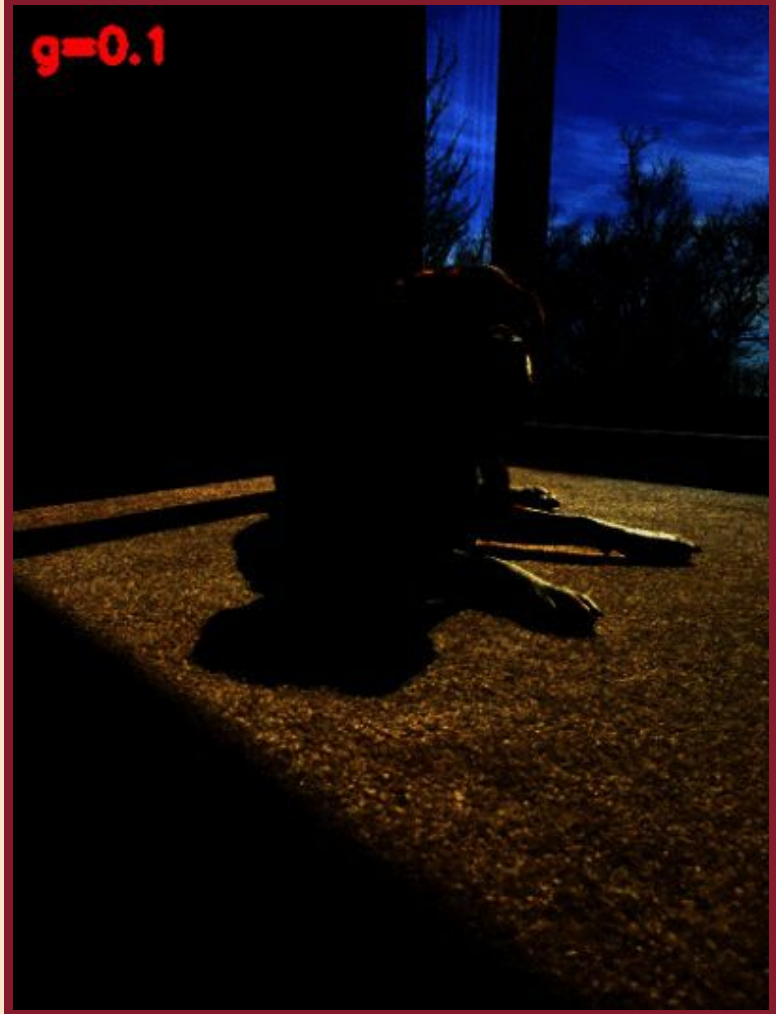


Figure 9: OpenCV Gamma Correction [4]

[4] A. Rosebrock, "OpenCV Gamma Correction - PyImageSearch", PyImageSearch, 2020. [Online]. Available: https://www.pyimagesearch.com/2015/10/05/opencv-gamma-correction/. [Accessed: 13- May- 2020].

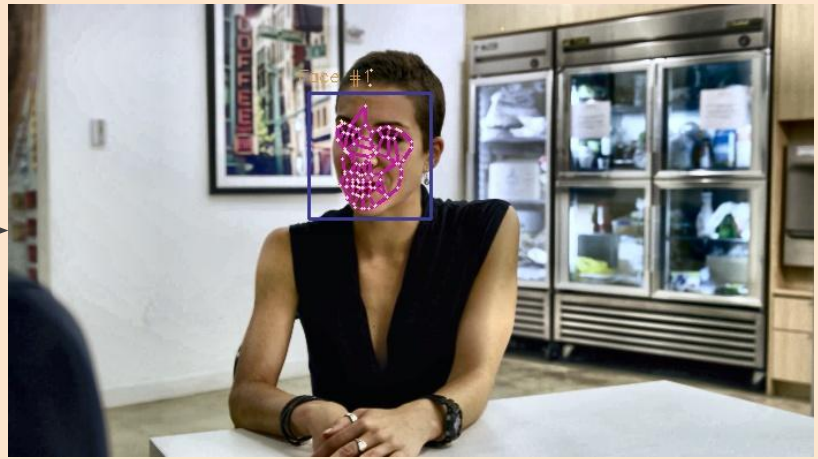
II.C Voronoi Features

1. Apply Illumination Normalization
2. Use a pre-trained model to detect the face **region**. (dlib [6])
3. Apply Gamma Normalization
4. Use a pre-trained model to detect the facial **landmarks**. (dlib [6])
5. Generate Voronoi Mapping with facial landmarks.

[6]D. King, "Classes — dlib documentation", *Dlib.net*, 2013. [Online]. Available: http://dlib.net/python/index.html. [Accessed: 30- Mar- 2020]

Figure 9: Voronoi regions without and with post processing are illustrated.

- scipy.spacial's Voronoi to generate Voronoi [7]
- Voronoi regions might have points outside the bounding box.
- Post Processing required.



[7]"scipy.spatial.Voronoi — SciPy v0.18.1 Reference Guide", *Docs.scipy.org*, 2016. [Online]. Available: https://docs.scipy.org/doc/scipy-0.18.1/reference/generated/scipy.spatial.Voronoi.html. [Accessed: 30- Mar- 2020].

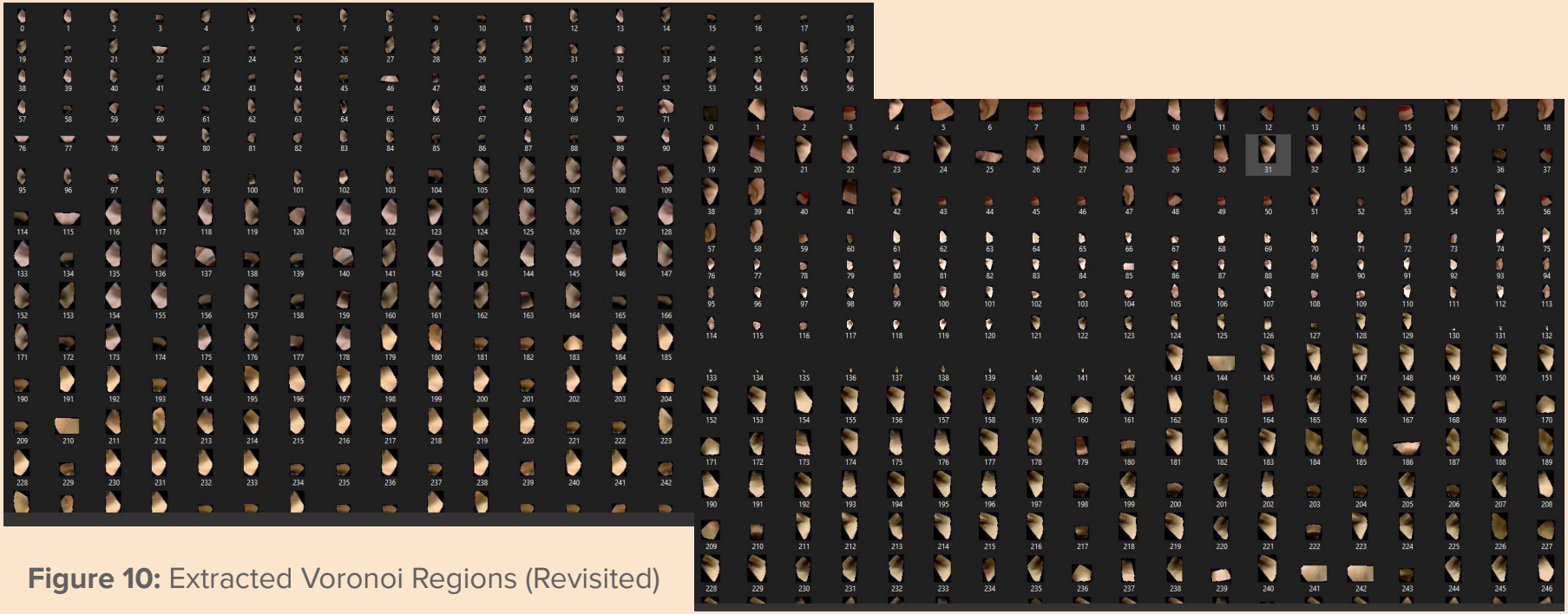
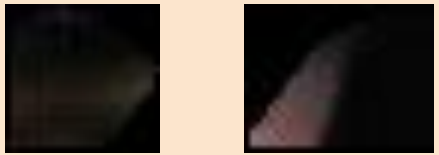


Figure 10: Extracted Voronoi Regions (Revisited)



➜ **Eliminate these**

II.D Dataset Creation

Extracting features every time → Slow

Saved **voronoi regions** as features to create new dataset.

- Train: ~1600 Manipulated, ~2400 Original
- Validation: ~800 Manipulated, ~900 Original
- Test: ~300 Manipulated, ~400 Original

II.E Detection Model

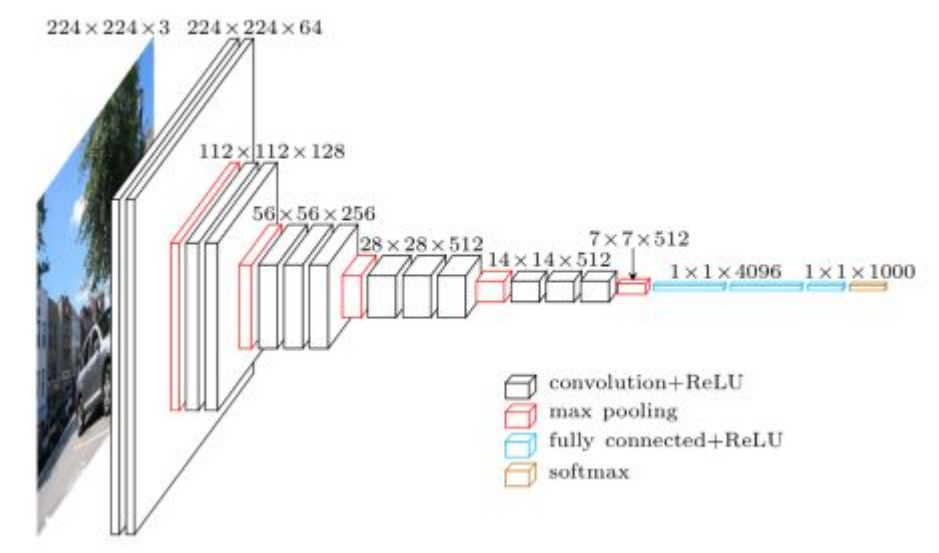


Figure 11: VGG16 Model [19]

Drawbacks:

- **Slow** to train → However, we have features, small images (100 x 100).
- The network architecture **weights** themselves are quite large (concerning disk/bandwidth). Still not a problem, we already have features.

[19]R. Thakur, "Step by step VGG16 implementation in Keras for beginners", towardsdatascience, 2020. [Online]. Available: https://towardsdatascience.com/step-by-step-vgg16-implementation-in-keras-for-beginners-a833c686ae6c. [Accessed: 13- May- 2020].

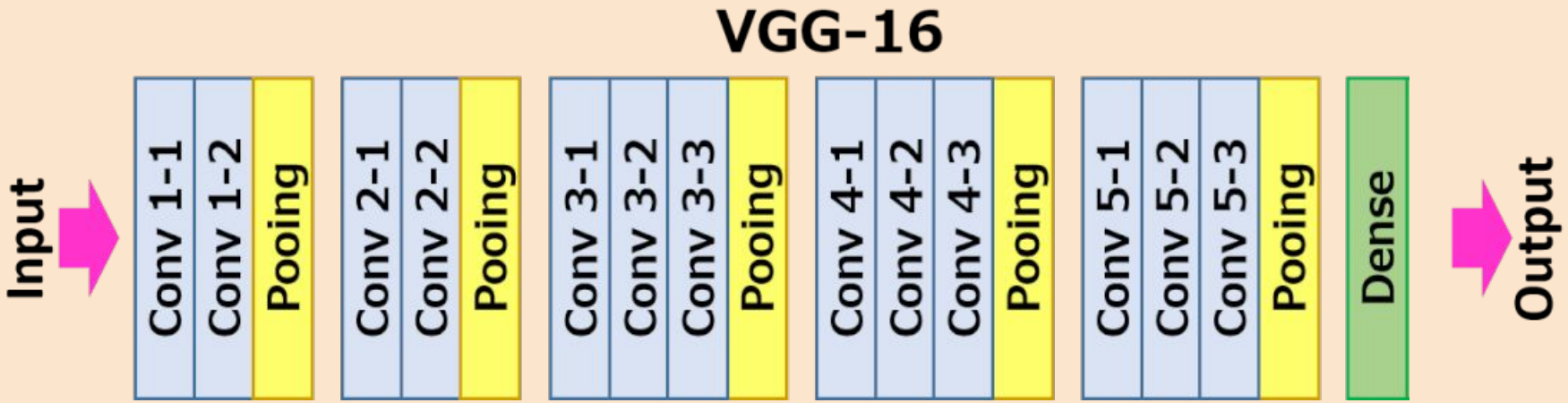


Figure 11: VGG16 Model Architecture

Advantages:

- Working good with images, especially binary classification.
- Convolutions followed by pooling layers help generalize the data

[19]R. Thakur, "Step by step VGG16 implementation in Keras for beginners", towardsdatascience, 2020. [Online]. Available: https://towardsdatascience.com/step-by-step-vgg16-implementation-in-keras-for-beginners-a833c686ae6c. [Accessed: 13- May- 2020].

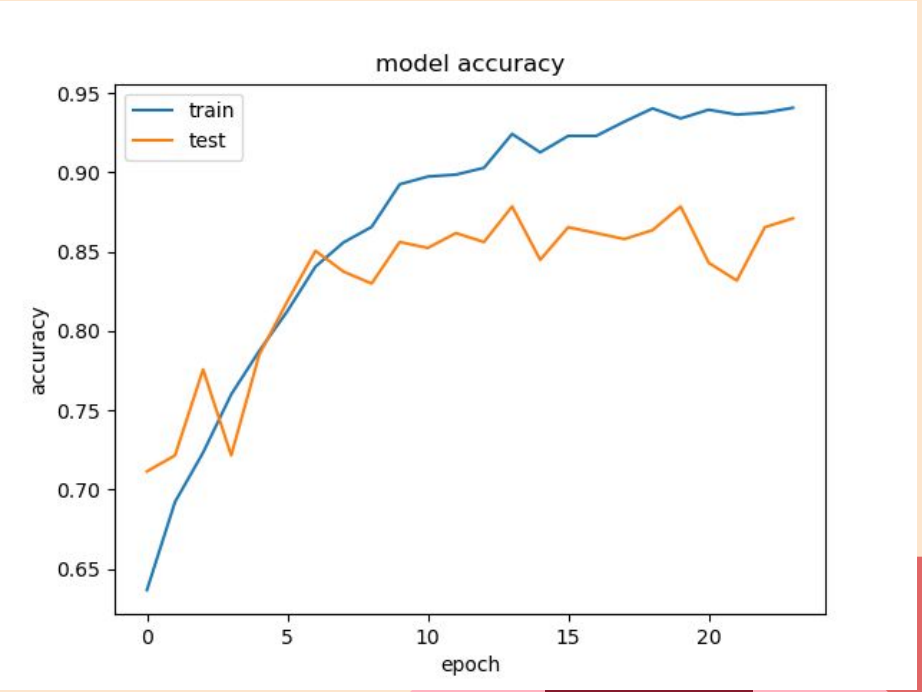
Hyper Parameters

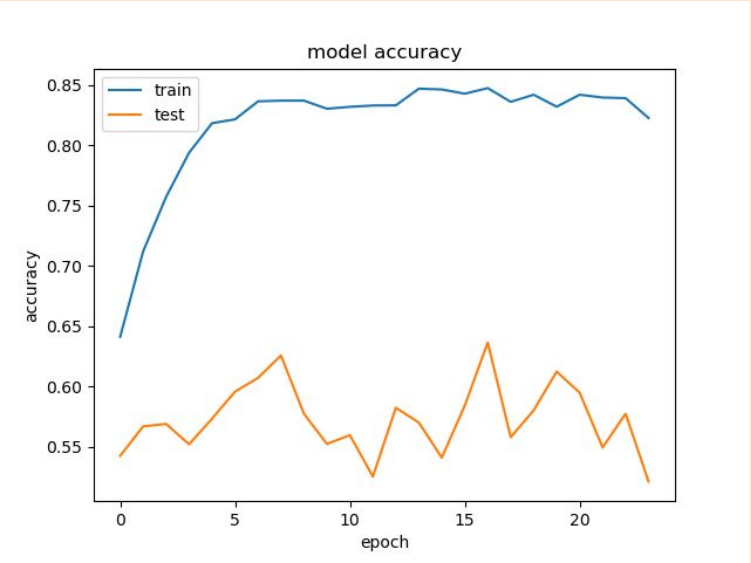
- Using RELU activation in the CONV - 2D layers.
- Sigmoid activation in Dense layers. (Also tested with Softmax)
- RMSProp as optimizer
- Binary Cross Entropy as loss function.
- Input shape = (80 x 100 x 3)
- 24 Epoch
- Batch size is 16

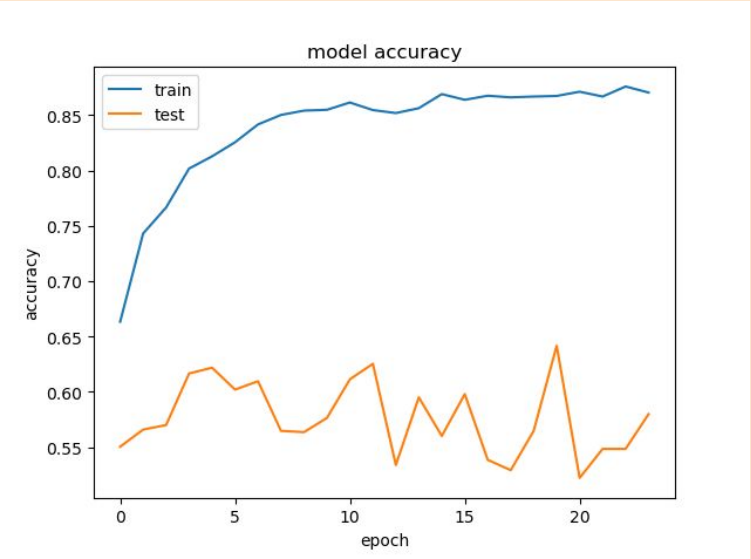
III. Results and Evaluation

First trial:

- Worked with only 6 original images and 6 manipulated images.
  - (Because feature extraction takes time)
- Divided train, val and test **after** feature generation.
- **loss: 0.1780 - accuracy: 0.9377 - val_loss: 0.0980 - val_accuracy: 0.8654**
- Learned too fast.
- Overfit after 8th epoch.







Second Trial:

- Trained with 30 manipulated, 30 original.
- Not working.
- Problem with Model? Problem with Features?
  - To be answered in the final report.

Evaluation

- Looking only a region of Face might not be *enough* to detect DeepFakes.
- Looking every voronoi region on a face to train?
  - Requires more data,
  - More time for feature extraction.
- Looking only the length of the edges of Voronoi?
  - Not meaningful.
- The quality of the video?
  - Quality of the videos used height= 1200,width=1600.
  - Quality of Voronoi Regions height= 80 ,width=100
- Future work:
  - Use only one person’s manipulated and original data.

Conclusion