# **Detecting DeepFakes by Comparing Facial Action Units**

# Abstract

- A DeepFake is a digitally altered face intended to mimic another person (Figure 7A/7B)
- This technology is advancing rapidly, with the amount of DeepFakes increasing by 84% in 2019 (Samson)
- Traditional detection methods that observe artifact and pixel inconsistencies fail to keep up

# Introduction

## The Challenge

- There has been a significant rise in the amount of DeepFakes in media
- There is an ongoing war between DeepFake software developers and DeepFake detection developers

#### The Plan

- To develop a DeepFake detection software to analyze Action Units (AUs) rather than visual artifacts (see FACS for a breakdown)
- We planned to find unique behaviors for individuals by looking for consistencies between a person's AUs

# Lip Corner Pulle Chin Raiser Profile: Billie Eilish Real

Profile: Billie Eilish Deeptake

### Lid Tightener Nose Wrinkler Upper Lip Raiser Lip Corner Puller Figure 2A/2B.

AU comparison matrix for real and fake Billie Eilish profiles

# How We Did It

- We processed videos using OpenFace 2.0 (Figure 1) to measure AUs and generate CSV data files • The main C++ program features a user-interface to process CSV file AU data into profiles for POI. Profiles contain a matrix of percentage values which represent similarities between AU behavior. Users can create, view, delete, and compare profiles (Figure 3)
- To store long-term data on various POI for comparison and detection, we created a database in the backend to update, add, delete, analyze, and organize (Figure 5A/5B)
- We used a program called Processing to visualize the profiles and their differences. The program shows the profiles as a matrix of action units based on the likelihood that two AUs were activated simultaneously (Figure 2A/2B)

# Literature Cited

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0.156 0.156 0.155 0.156 0.155 0.1 0.156 0.156 0.156 0.156 0.155 0.154

Baltrusaitis T. TadasBaltrusaitis/OpenFace. GitHub. [accessed 2021 May 7]. https://github.com/TadasBaltrusaitis/OpenFace

https://www.cs.cmu.edu/~face/facs.htm

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### **Our Solution**

- To combat this issue, our team developed a DeepFake detection software that:
- 1. Analyzes facial data derived from the motion capture software OpenFace (Baltrusaitis)
- 2. Creates profiles to represent certain individuals
- 3. Compares profiles to detect differences in facial Action Unit behavior

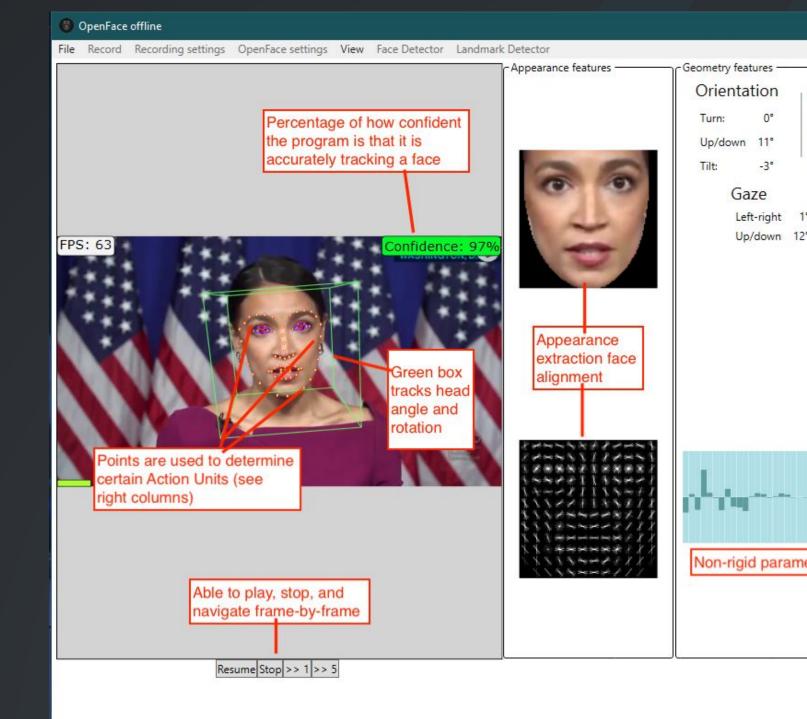


	Figure I. Example	otav	/ideo inputt	ed into Op	penhace		
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	> 📰 action_units		Daniele	Struppa	Chapman's President		
	> 📰 au_names		Billie	Eilish	American Singer		
	> 📰 av_matrices		Tom	Cruise	American Actor		
	> 🔠 df_vids		Erik	Linstead	Associate Dean		
	> mofiles		Elon	Musk	Tesla Founder		
	> 📰 real_vids		Bill	Hader	American Actor		
	> in collations 272		Tom	Holland	American Actor		

Figure 5A/5B. Database Structure and 'Profiles' Schema



- FACS Facial Action Coding System (2002 Revision is here). FACS (Facial Action Coding System). [accessed 2021 May 7].
- Samson D. 2019 Oct 9. Number Of Deepfake Videos Online Rises 84 Percent In Less Than A Year. Tech Times. [accessed 2020 May 22]. https://www.techtimes.com/articles/245628/20191009/number-of-deepfake-videos-online-rises-84-percent-in-less-than-a-year.htm.

	Action Units	Contraction of the second
se	Classification	Regression
101.0	AU01 - Inner Brow raiser	AU01 - Inner Brow raiser
6 mm	AU02 - Outer Brow raiser	
-16 mm	NOUZ - Outer brow raiser	AU02 - Outer Brow raiser
507 mm	AU04 - Brow lowerer	AU04 - Brow lowerer
	AU05 - Upper lid raiser	AU05 - Upper lid raiser
	AU06 - Cheek raiser	AU06 - Cheek raiser
	AU07 - Lid tightener	AU07 - Lid tightener
	AU09 - Nose wrinkler	AU09 - Nose wrinkler
	AU10 - Upper lip raiser	
	AU12 - Lip corner puller (	AU10 - Upper lip raiser
	AU14 - Dimpler	AU12 - Lip corner puller (
	AU15 - Lip corner depres	AU14 - Dimpler
	AU17 - Chin Raiser	AU15 - Lip corner depres
	AU20 - Lip Stretcher	AU17 - Chin Raiser
	AU23 - Lip tightener	AU20 - Lip Stretcher
	AU25 - Lips part	AU23 - Lip tightener
ers	AU26 - Jaw drop	AU25 - Lips part
	AU28 - Lip suck	AU26 - Jaw drop
	AU45 - Blink	AU45 - Blink

lease select an option . View Existing Profile Upload File 3. Create New Profil Compare Profile

lease select an opti Select a profile . Main Menu

lease enter name of an existing profile or "quit" to quit: Billie Eilish

#### otal amount of videos: 3 otal amount of frames: 36792

Avera	Average Matrix for profile:																	
	AU01	AU02	AU04	AU05	AU06	AU07	AU09	AU10	AU12	AU14	AU15	AU17	AU20	AU23	AU25	AU26	AU28	AU45
AU01	0.00	0.58	0.38	0.35	0.28	0.25	0.21	0.20	0.19	0.18	0.18	0.18	0.17	0.16	0.17	0.19	0.18	0.18
AU02	0.00	0.00	0.18	0.18	0.18	0.18	0.17	0.17	0.16	0.17	0.16	0.17	0.16	0.16	0.16	0.17	0.17	0.17
AU04	0.00	0.00	0.00	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15
AU05	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
AU06	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
AU07	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.16
AU09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.15
AU10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
AU12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15
AU14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.16	0.16	0.16	0.16	0.16	0.15	0.16
AU15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.16	0.16	0.16	0.16	0.15	0.15
AU17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.15	0.15	0.15
AU20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.15	0.15
AU23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.15
AU25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15
AU26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15
AU28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
	0 00																	

#### Figure 3. Terminal output of detection program displaying Billie Eilish profile

aring Billie Eilish to Billie Eilish Fake 3

Figure 4A/4B. Terminal output of detection program displaying comparisons between Billie Eilish and her DeepFake, and Billie Eilish and AOC respectively



Figure 7A/7B. Original vs. DeepFake of Jan from the television show The Office, and Billie Eilish

# Acknowledgements

• We would like to thank Dr. Farid & Shruti Agarwal, Dr. Erik Linstead, and our previous GCI professors Carter Berry, Shana Welles and Brenna Gormally for their guidance during our project.

## Results

• The first hypothesis was that one could generate a profile for a POI by comparing each of their AUs to one another and generating float values to represent behavior similarities between them (Figure 3). A second profile is generated for the potential DeepFake video, and both profiles are compared This hypothesis was tested using videos of Billie Eilish, consisting of over 36,000 frames of real footage and 2,700 frames of DeepFake footage. The results are two AU comparison matrices (Figure 2A/2B) and a simple difference comparison determining the two profiles to be 96.33% similar (Figure 4A)



Figure 6. BIllie Eilish OpenFace analysis

## Conclusions

 Due to the skewed results and the data set being too small to reach a decisive answer, the efficacy of this method is currently inconclusive.

• After comparing two POI profiles of AOC and Billie Eilish, we can determine that AU behavior amongst all people is generally consistent, resulting in a 90%+ similarity (Figure 4B)

 Moving forward, the team plans to create a control profile generated from 4700 hours of footage of thousands of different faces to determine unique characteristics of POI profiles. This will help pinpoint key differences between profiles and prevent general similarities of human facial behavior from obscuring results