On Improving Glitch Classification Performance for Gravitational Wave Detection using Generative Adversarial Networks

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CHALLENGES

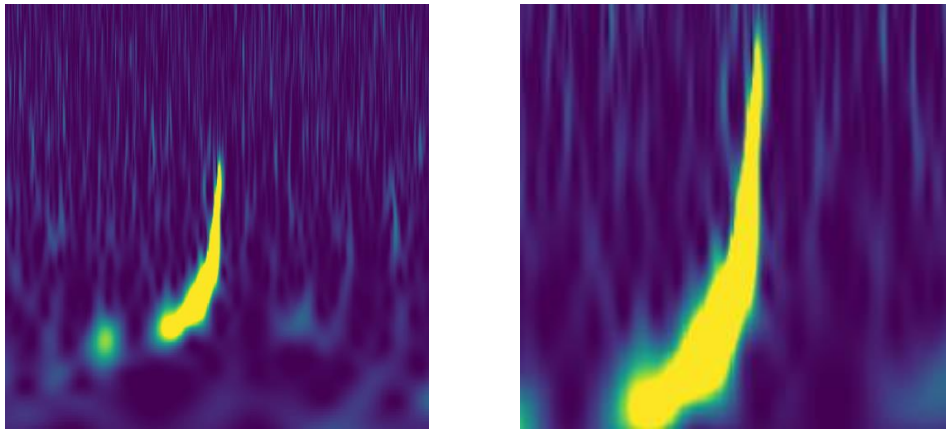
- Traditional data augmentation methods on images such as center cropping, random cropping, flipping and rotations cannot be used for spectrogram classification.

- There are different numbers of spectrograms for different glitch classes in the Gravity Spy dataset leading to the imbalanced data problem.

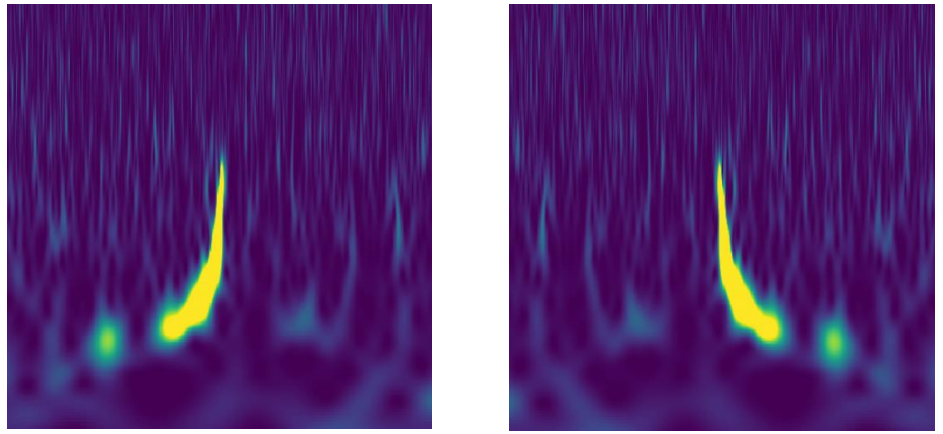
- Traditionally Generative Adversarial Networks (GANs) are used to generate low-resolution images with resolutions like 128 x 128.

CHALLENGES

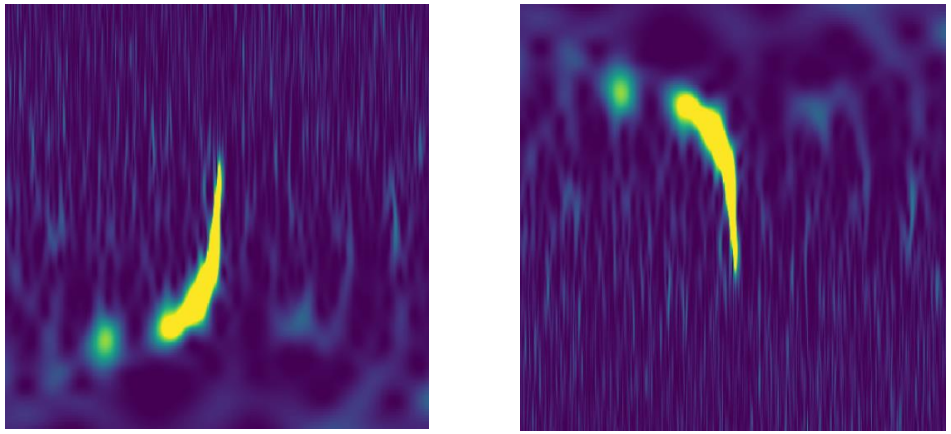
Traditional Data Augmentation Methods



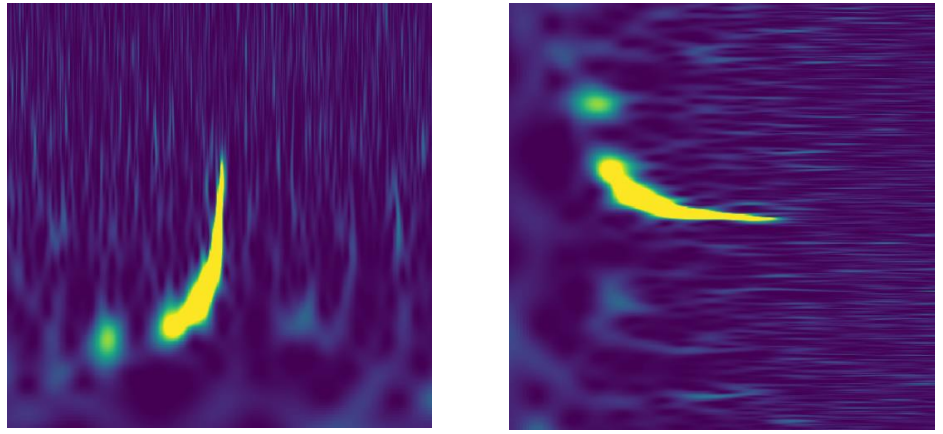
Center Cropping



Flip Spectrogram Horizontally



Flip Spectrogram Vertically



Rotation

CHALLENGES

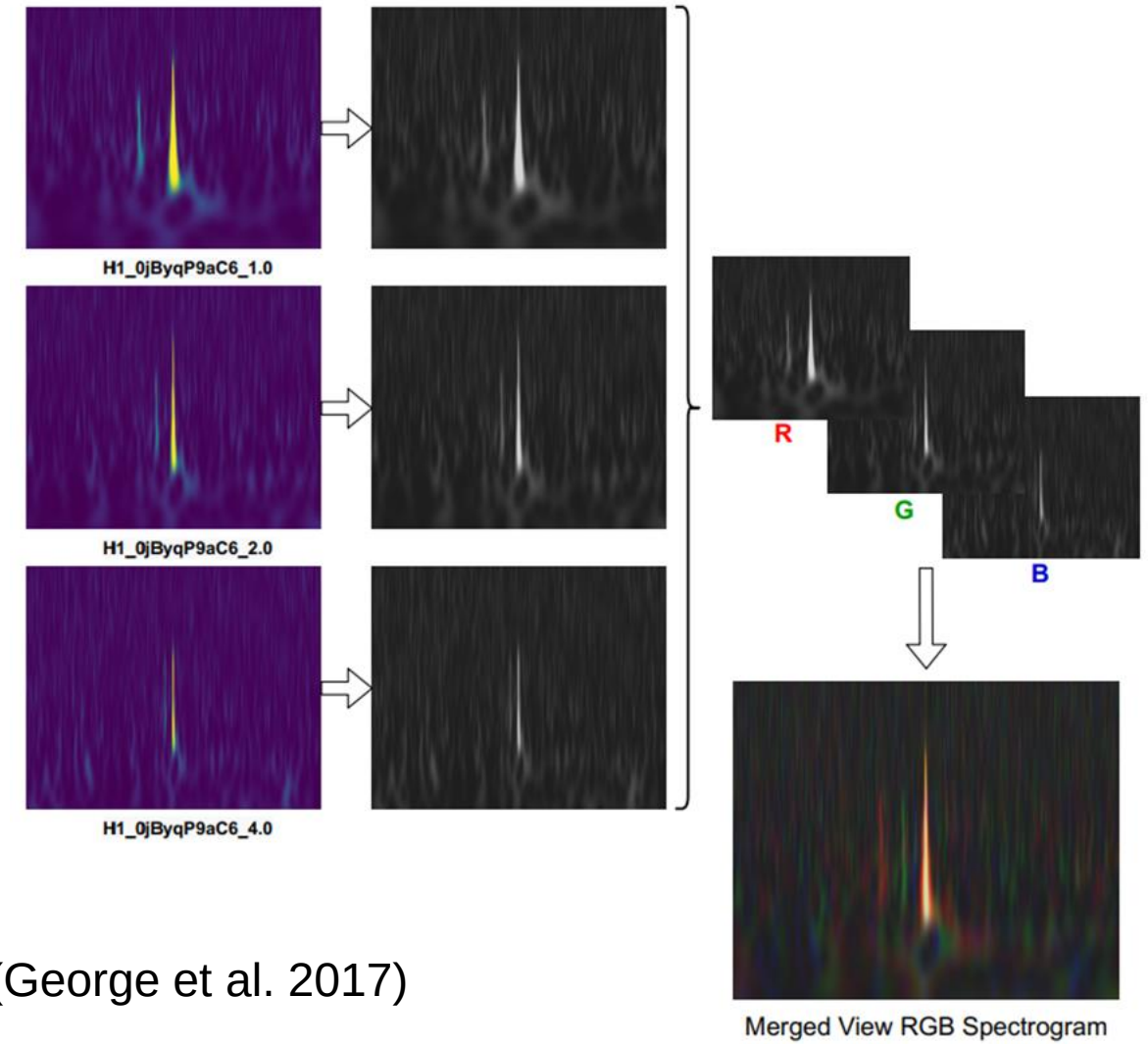
Imbalanced Data Problem

Class	Number	Class	Number
1080Lines	1312	No_glitch	724
1400ripples	928	Paired_doves	**108**
Air_compressor	232	Power_line	1812
Blip	**7476**	Repeating_blips	1140
Chirp	264	Scattered_light	1836
Extremely_loud	1816	Scratchy	1416
Helix	1116	Tomte	464
Koi_fish	3320	Violin_mode	1888
Light_modulation	2292	Wandering_line	176
Low_frequency_burst	2628	Whistle	1220
Low_frequency_lines	1812	None_of_the_above	352

OUR CONTRIBUTIONS

- We have achieved the top-1 accuracy of **99.21**% for glitch classification on the Gravity Spy dataset.
- We also obtain the top-3 accuracy of **100%** on the Gravity Spy dataset.
- With the trained classifier, the spectrograms of the unidentified sources can further be analyzed and classified with our method.
- High-resolution spectrograms for each glitch class are generated to tackle the imbalanced data problem.

DATA PREPROCESSING



This method is introduced by George et al. (George et al. 2017)

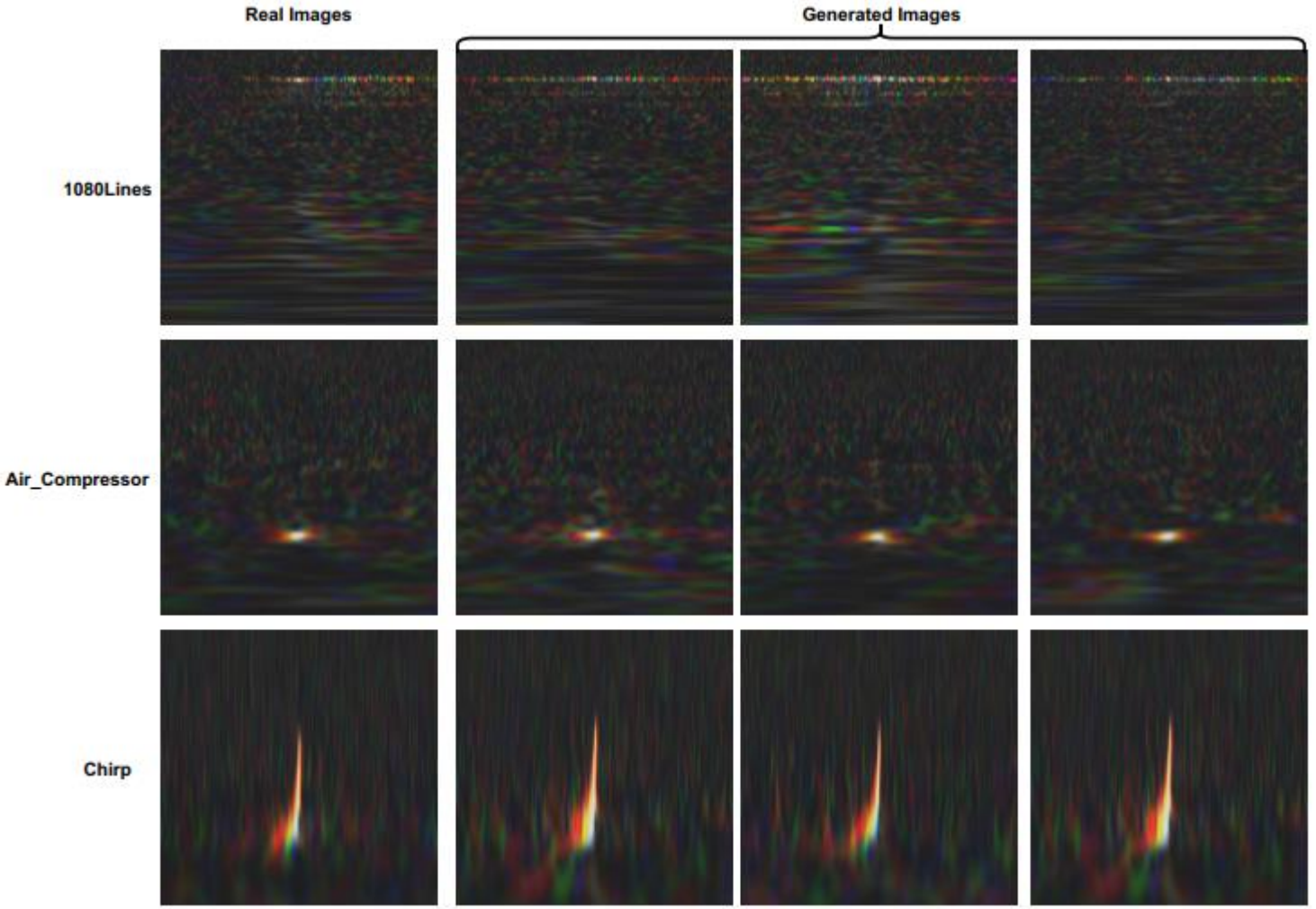
THE PROPOSED METHOD

- Our approach avoids overfitting for deep learning with a dataset large enough for generalization using data augmentation.

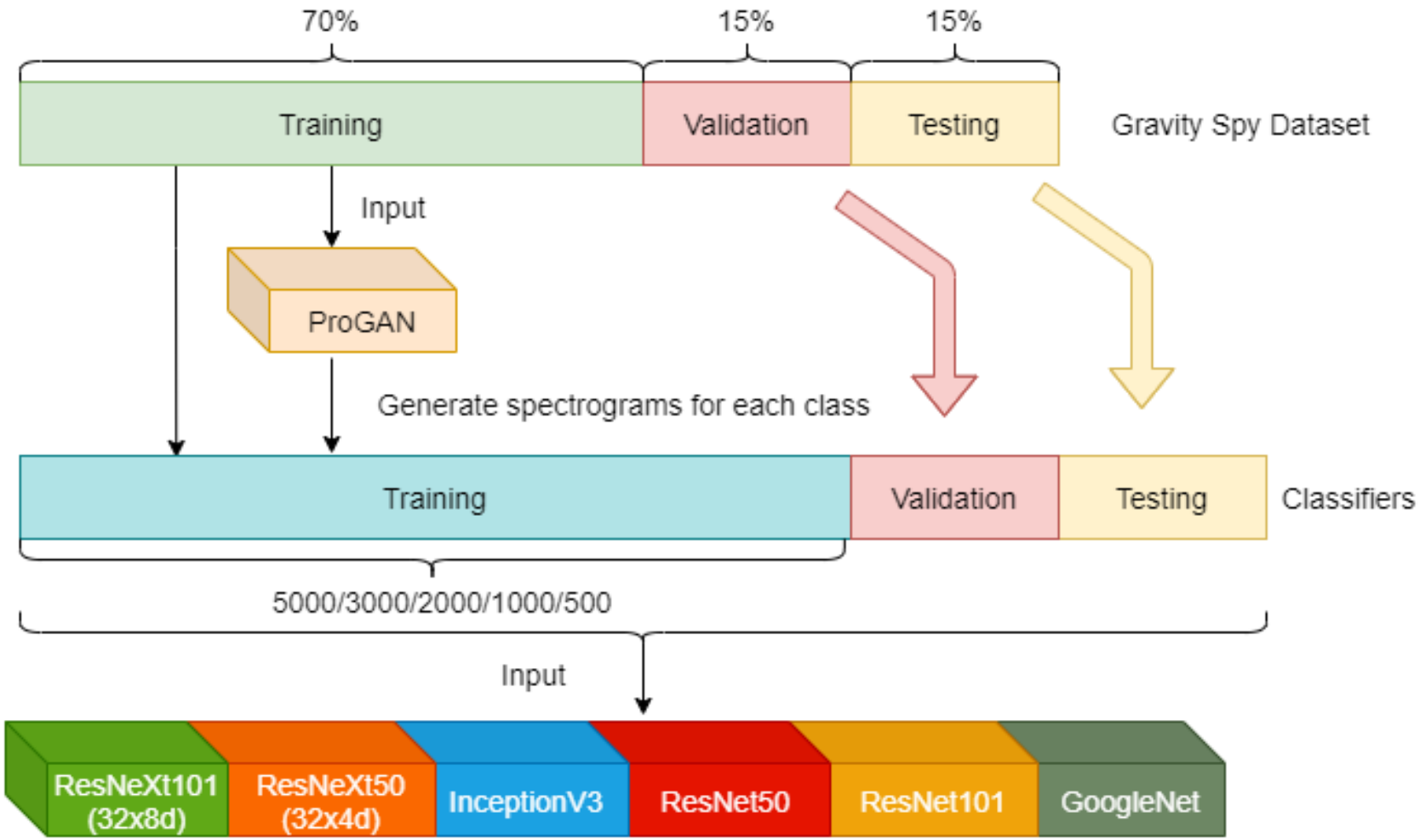
- A number of different data augmentation methods have been considered and experimented.

- We found that **ProGAN** which is recently proposed to generate high-resolution images works well for our problem with glitches from gravitational wave detection.

GENERATED SPECTROGRAMS



IMPLEMENTATION METHODS



EXPERIMENTAL RESULTS

Table 5. Top-1 accuracy of glitch classification on the Version 1.0 test set.

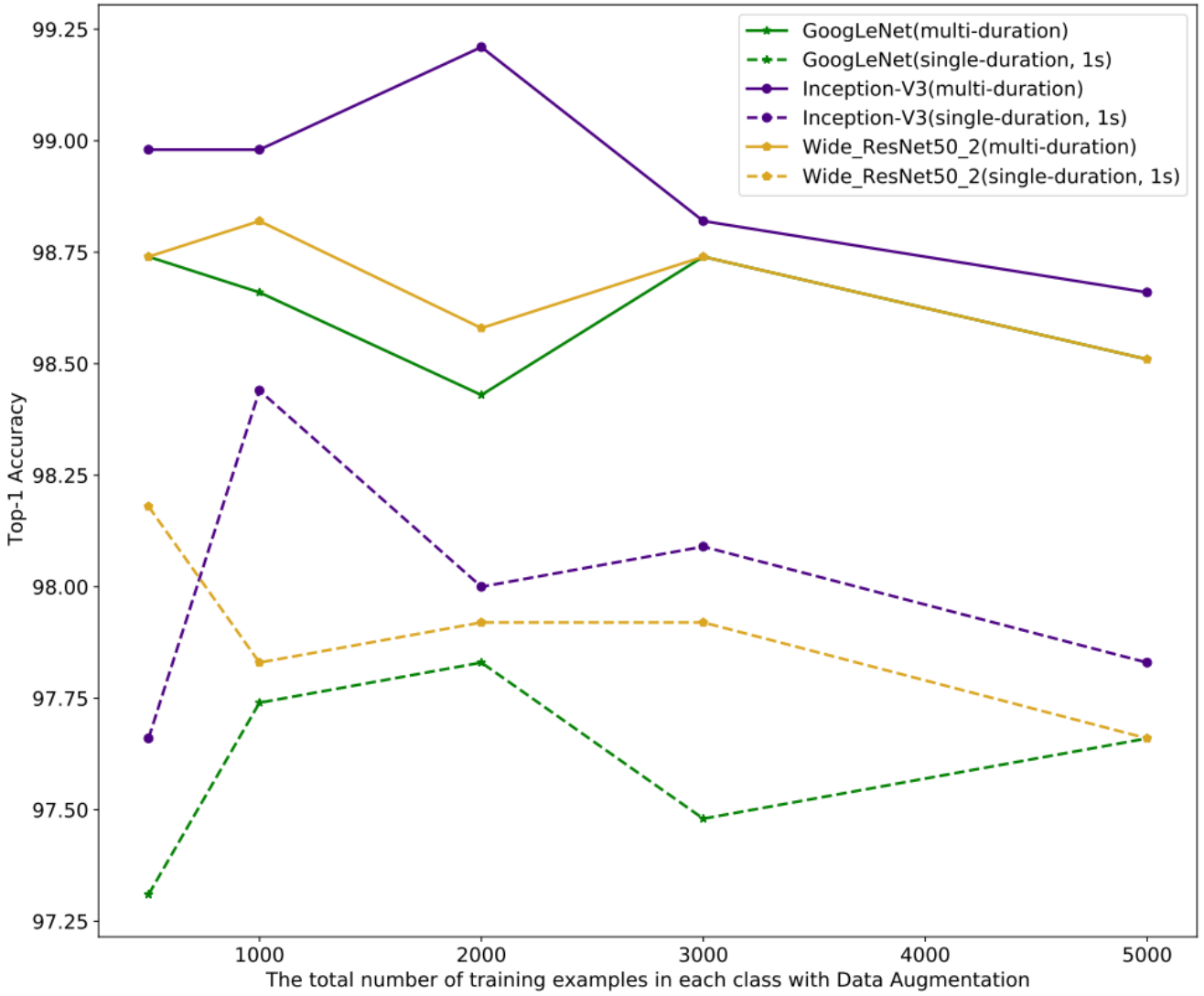
	ResNet50 (224×224)	ResNet101 (224×224)	GoogLeNet (224×224)	Inception-V3 (299×299)
Gravity Spy dataset (v1.0)	98.19%	98.58%	99.06%	98.35%
Gravity Spy dataset (pre-trained)	98.90%	98.66%	98.90%	98.89%
N_{aug} = 500	98.74%	98.82%	98.74%	98.98%
N_{aug} = 1000	98.51%	98.43%	98.66%	98.98%
N_{aug} = 2000	98.58%	98.19%	98.43%	**99.21%**
N_{aug} = 3000	98.43%	98.35%	98.74%	98.82%
N_{aug} = 5000	98.35%	98.43%	98.51%	98.66%

EXPERIMENTAL RESULTS

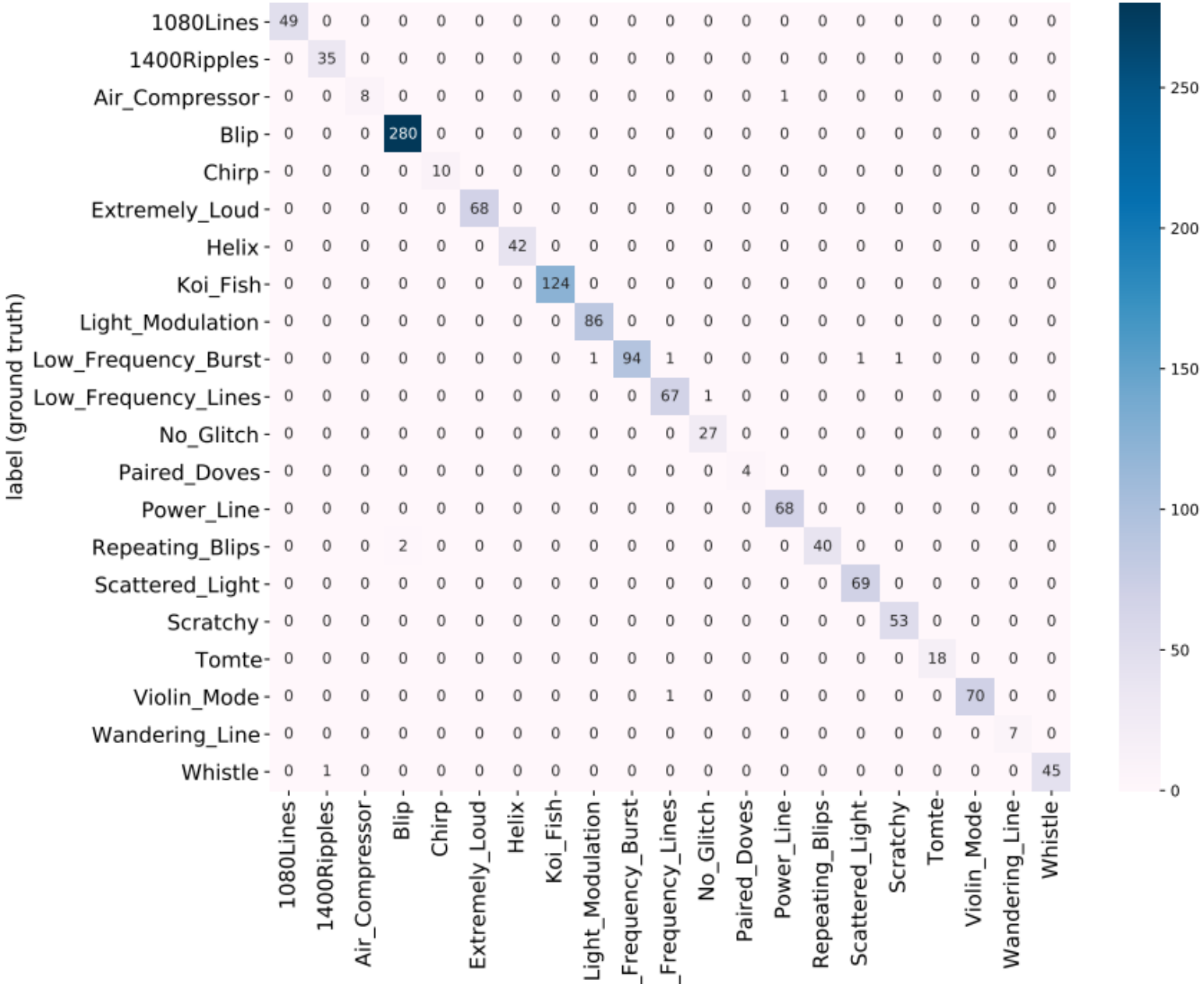
Table 6. Top-k accuracy of each network architecture in our experiments (Top). Previous results with only transfer learning of each network architecture in (George et al. 2018) (Bottom).

	Top-1	Top-2	Top-3	Top-4	Top-5
ResNet50 (500)	98.74%	99.61%	99.84%	99.92%	**100%**
ResNet101 (500)	98.82%	**99.84%**	99.84%	99.84%	99.92%
GoogLeNet (3000)	98.74%	**99.84%**	**100%**	**100%**	**100%**
Inception-V3 (2000)	**99.21%**	**99.84%**	**100%**	**100%**	**100%**
VGG16 (1000)	98.82%	99.92%	**100%**	**100%**	**100%**
VGG19 (1000)	98.35%	**99.84%**	**100%**	**100%**	**100%**
Wide_ResNet50_2 (1000)	98.82%	**99.84%**	99.92%	**100%**	**100%**
ResNext50_32x4d (1000)	98.58%	99.69%	99.92%	**100%**	**100%**
ResNext101_32x8d (500)	98.66%	99.61%	99.84%	**100%**	**100%**
Inception-V3	98.84%	99.71%	99.88%	99.94%	**100%**
ResNet50	98.84%	99.71%	99.83%	99.94%	**100%**
VGG16	98.15%	99.36%	99.71%	99.83%	99.88%
VGG19	98.21%	99.31%	99.60%	99.71%	99.71%

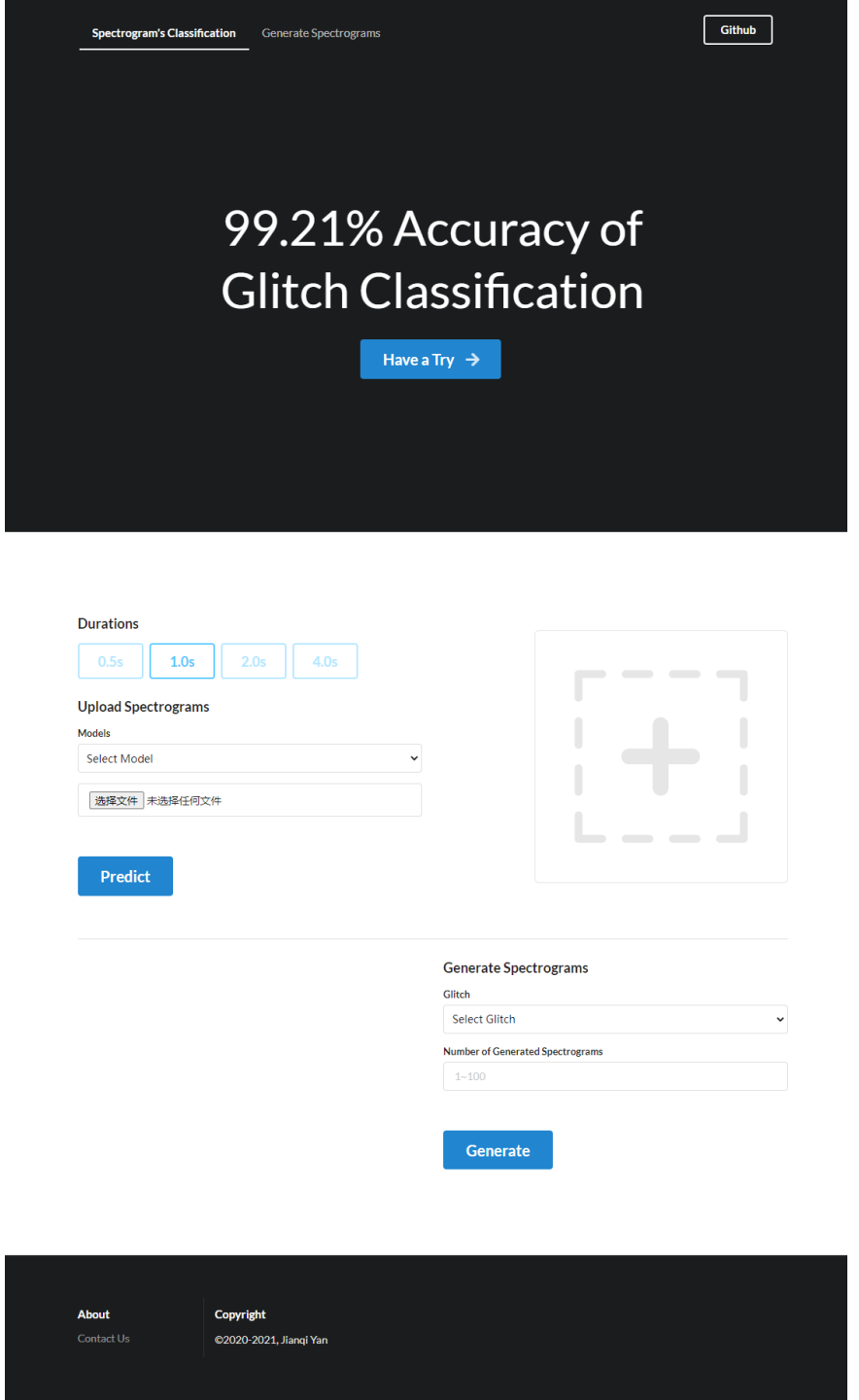
EXPERIMENTAL RESULTS



We achieved perfect recall and precision on 9 classes on the Gravity Spy dataset.



FUTURE WORK


Spectrogram's Classification
Generate Spectrograms
Github
99.21% Accuracy of
Glitch Classification
Have a Try
Durations
0.5s
1.0s
2.0s
4.0s
Upload Spectrograms
Models
Select Model
选择文件
未选择任何文件
Predict
Generate Spectrograms
Glitch
Select Glitch
Number of Generated Spectrograms
1~100
Generate
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THANK YOU VERY MUCH