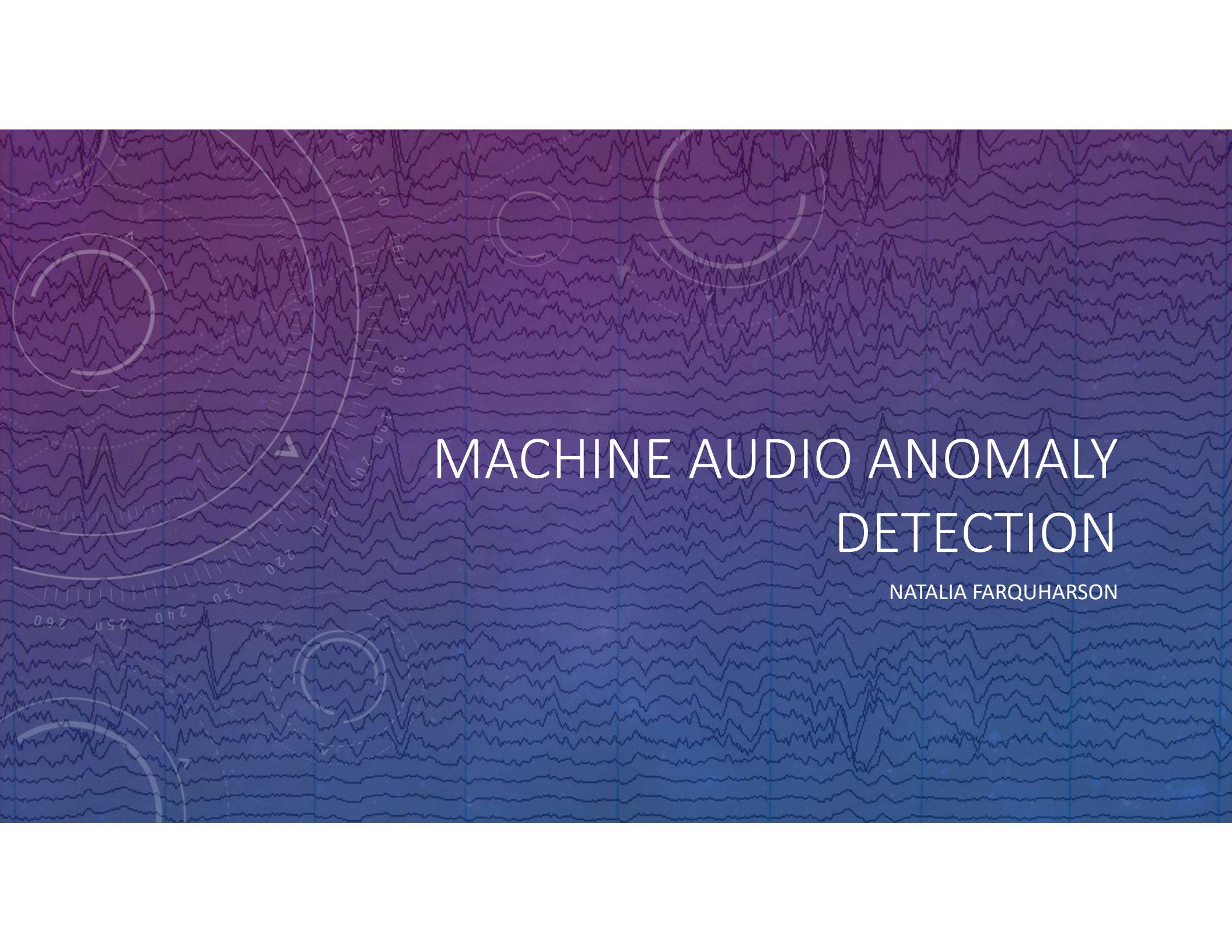


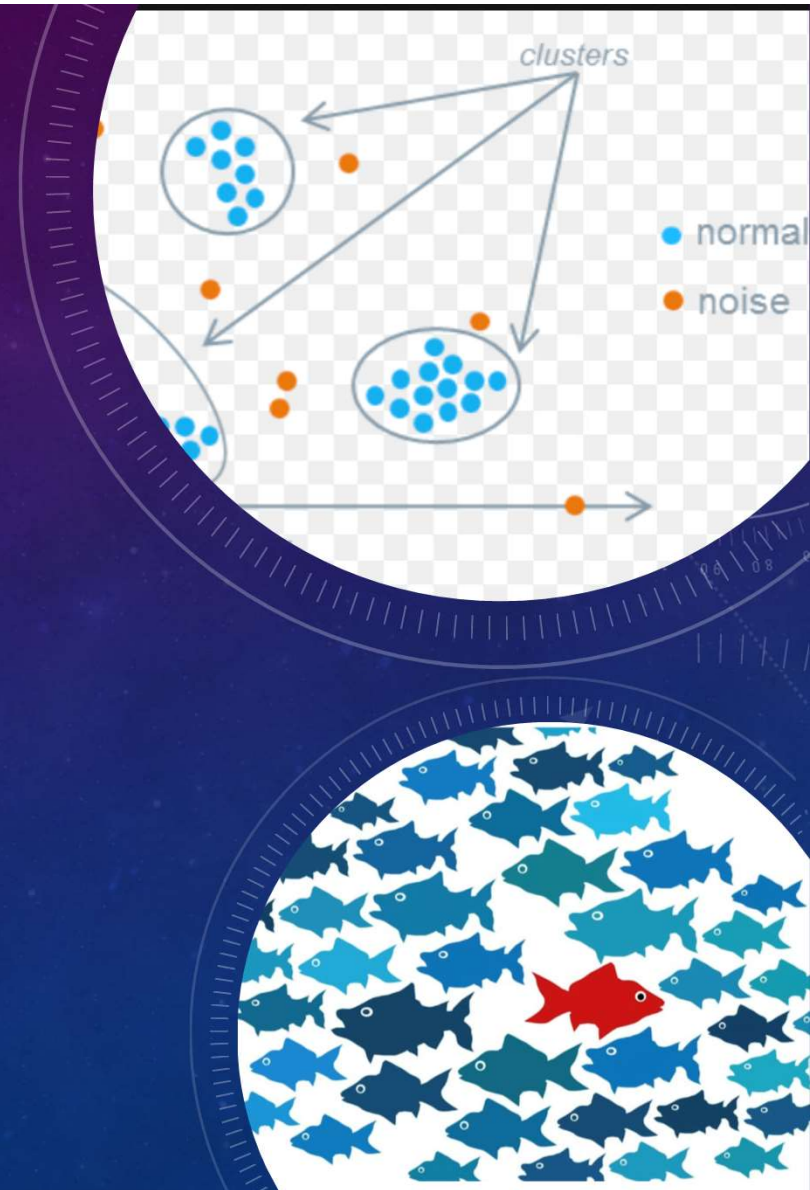
The background of the slide is a dark blue gradient. It features multiple horizontal audio waveforms in a lighter blue color. Overlaid on these are several white circular patterns, some of which are dashed and others solid, resembling orbits or signal paths. There are also some faint numerical labels like 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260 scattered across the left side, possibly indicating frequency or time markers.

MACHINE AUDIO ANOMALY DETECTION

NATALIA FARQUHARSON

INTRODUCTION AND PROBLEM

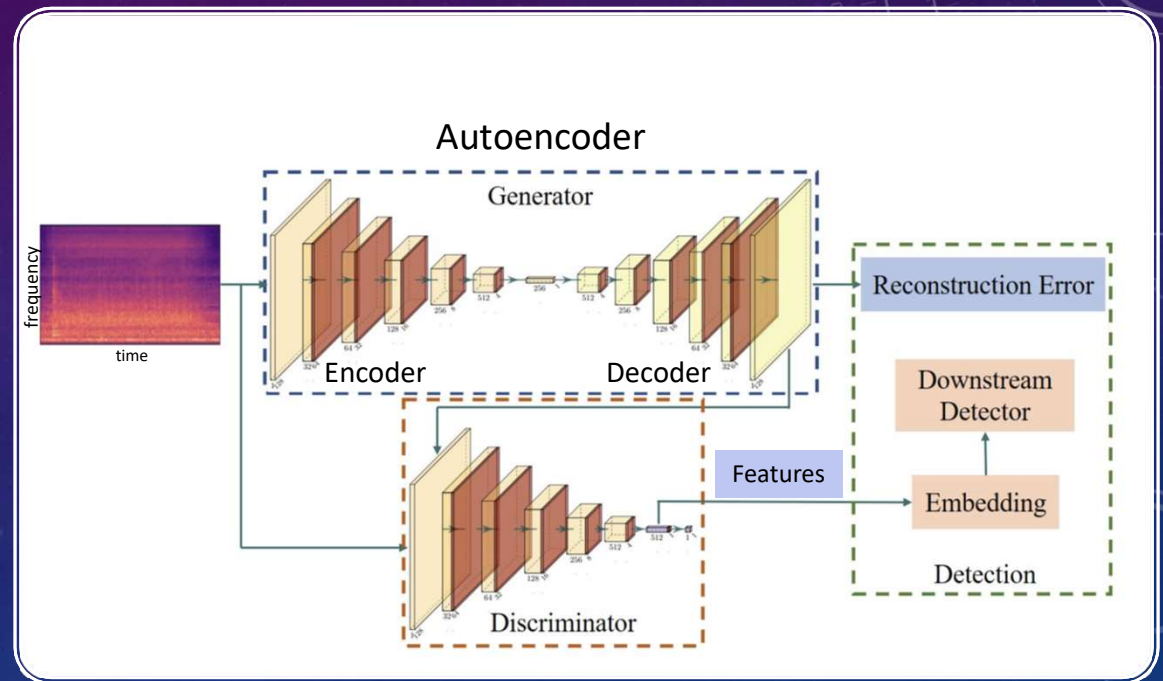
- Why anomaly detection?
- What is anomaly detection?
 - The process of identifying rare, unexpected, or abnormal patterns in data.
 - Crucial for various fields, including cybersecurity, finance, manufacturing, and healthcare.



GAN ARCHITECTURE

generative adversarial network - a class of artificial intelligence models used for generative tasks.

- **Generator** – learn how to recognize a normal signal
- **Discriminator** – learn how to make fake signals look real
- **Step 1 - Generator Phase:** Generator creates synthetic data.
- **Step 2 - Discriminator Phase:** Discriminator evaluates real and generated data.
- **Step 3 - Feedback Loop:** Generator improves based on discriminator feedback.
- Not the best method.....
- What are we measuring?
 - Feature map – from the discriminator
 - Reconstruction Error– from the generator



As shown in Figure 2, UNSUPERVISED ANOMALY DETECTION AND LOCALIZATION OF MACHINE AUDIO: A GAN-BASED APPROACH

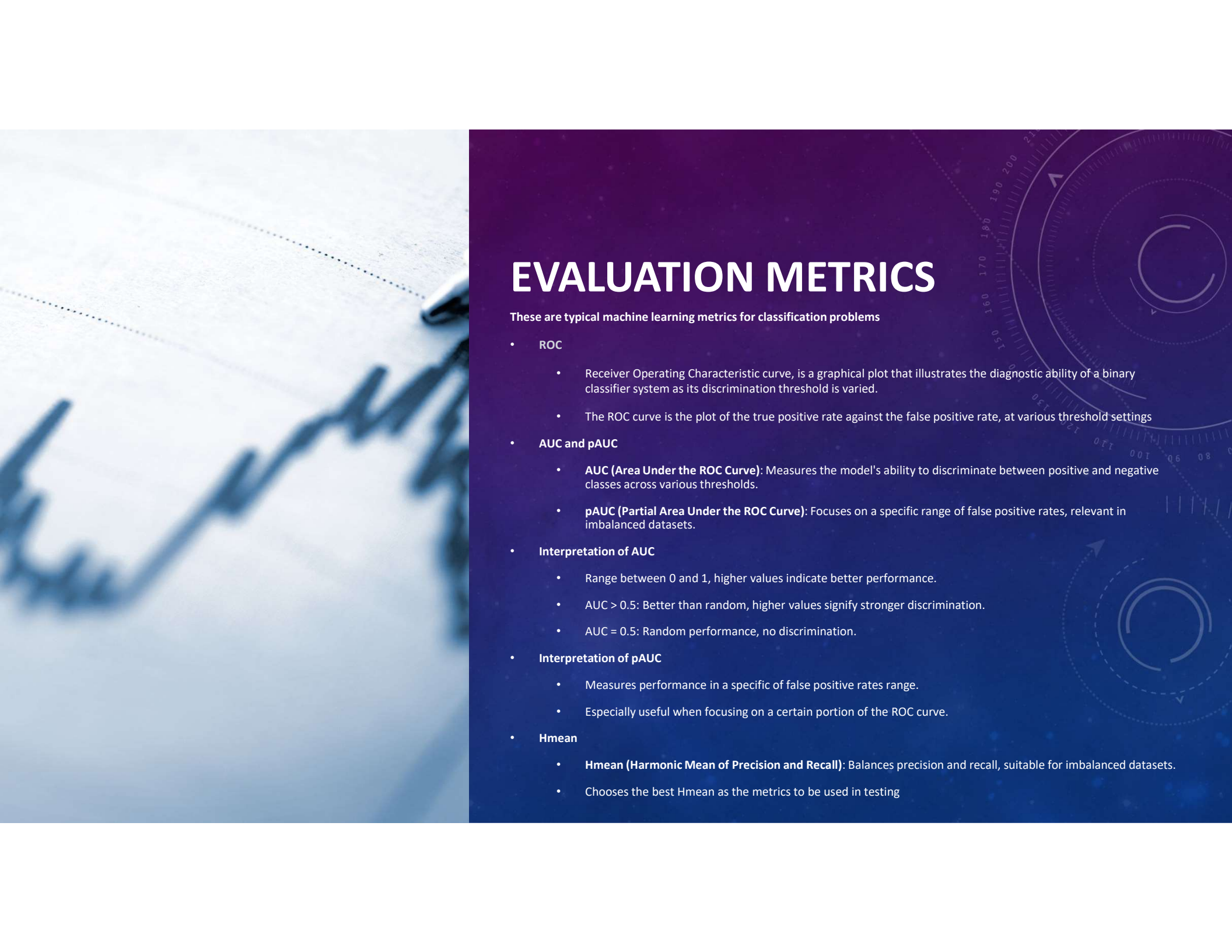
ANOMALY SCORING

Discriminator Metrics – (feature maps)

- **K-Nearest Neighbors (KNN) Overview**
 - Anomaly scoring based on the distance to K nearest neighbors.
 - Measures data point's isolation within its local neighborhood.
 - **Interpreting Anomaly Scores**
 - Low KNN Score: Data point's neighbors are similar, likely normal.
- **Mahalanobis Distance**
 - Measures distance between a data point and the center of data distribution.
 - Useful for capturing multivariate anomalies and correlations.
 - Interpreting Maha
 - Low Mahalanobis distance: Data point is close to the distribution center - normal
- **Local Outlier Factor (LOF) Concept**
 - Measures data point's isolation compared to its neighbors.
 - Identifies anomalies by considering the density of neighboring points.
 - Interpreting LOF Scores
 - $LOF > 1$: Data point is denser than its neighbors (may be in a cluster).
- **Cosine Similarity Concept**
 - Measures similarity based on the cosine of the angle between vectors.
 - Commonly used in text and content similarity analysis.
 - **Interpreting Cosine Similarity**
 - 1: Documents are identical

Generator Metrics – (reconstruction error)

- **Element-Wise Differences**
 - Comparing original data (x) and generated (reconstructed) data (G_x) using element-wise differences.
- **Squared Differences Metrics**
 - $G_x_2_sum$: Sum of squared differences between x and G_x .
 - $G_x_2_min$: Minimum squared difference between x and G_x .
 - $G_x_2_max$: Maximum squared difference between x and G_x .
- **Absolute Differences Metrics**
 - $G_x_1_sum$: Sum of absolute differences between x and G_x .
 - $G_x_1_min$: Minimum absolute difference between x and G_x .
 - $G_x_1_max$: Maximum absolute difference between x and G_x .
- **Interpretation**
 - **Squared Differences**: Measures how far the generated data is from the original data in terms of squared magnitudes.
 - **Absolute Differences**: Captures the overall dissimilarity between x and G_x .



EVALUATION METRICS

These are typical machine learning metrics for classification problems

- **ROC**
 - Receiver Operating Characteristic curve, is a graphical plot that illustrates the diagnostic ability of a binary classifier system as its discrimination threshold is varied.
 - The ROC curve is the plot of the true positive rate against the false positive rate, at various threshold settings
- **AUC and pAUC**
 - **AUC (Area Under the ROC Curve)**: Measures the model's ability to discriminate between positive and negative classes across various thresholds.
 - **pAUC (Partial Area Under the ROC Curve)**: Focuses on a specific range of false positive rates, relevant in imbalanced datasets.
- **Interpretation of AUC**
 - Range between 0 and 1, higher values indicate better performance.
 - $AUC > 0.5$: Better than random, higher values signify stronger discrimination.
 - $AUC = 0.5$: Random performance, no discrimination.
- **Interpretation of pAUC**
 - Measures performance in a specific of false positive rates range.
 - Especially useful when focusing on a certain portion of the ROC curve.
- **Hmean**
 - **Hmean (Harmonic Mean of Precision and Recall)**: Balances precision and recall, suitable for imbalanced datasets.
 - Chooses the best Hmean as the metrics to be used in testing

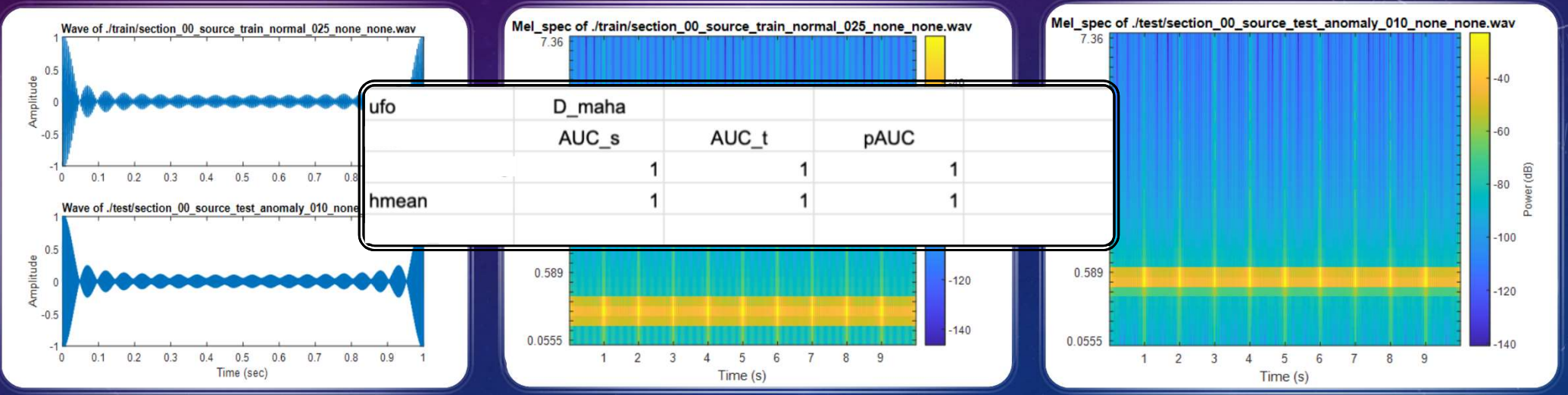
TRAINING & TESTING STRUCTURE

- Sampling rate: 16kHz
- Audio length: 10 secs
 - 160k sample point per audio file
- 100 training epochs
- FFT size: 2048
- Mel Frequency bins: 128
 - Frequency resolution
- Mel time windows: 313
 - Time resolution
- Input image size (for GAN): 128 x 128



EXPERIMENTS AND RESULTS

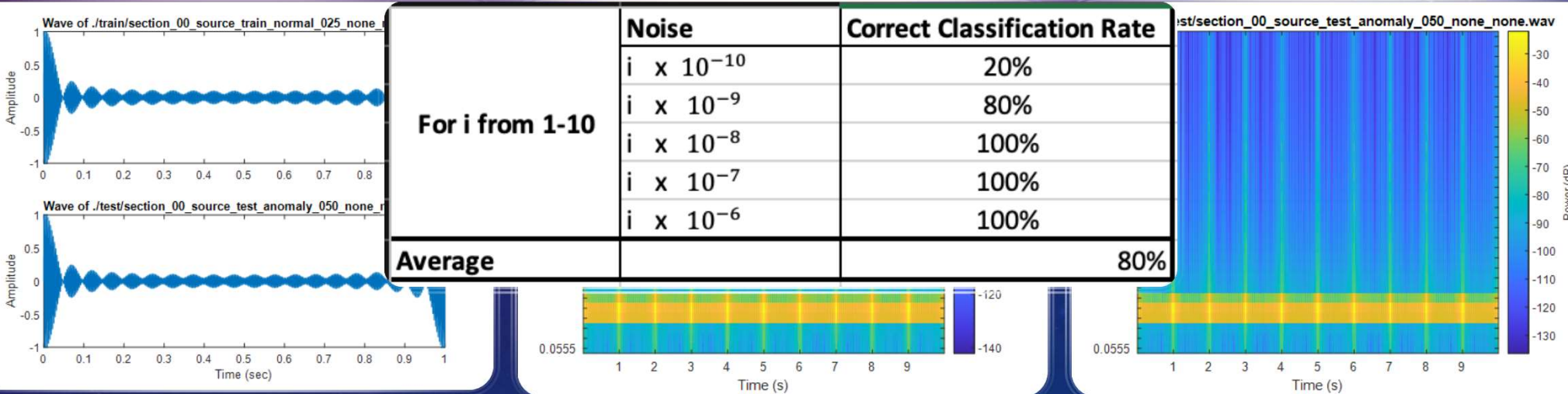
- Test Case 1: Frequency separation





EXPERIMENTS AND RESULTS

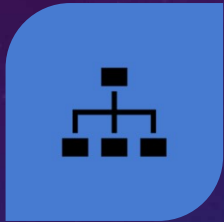
- Test Case 7: Anomaly: the same signal as normal + noise. Each anomaly sound has increasing amplitude of noise.



FUTURE WORK

- How would this be deployed?
 - Build a model that will be able to take in the resulting metrics from this process and creates a threshold that can classify individual signals as normal or anomalous.
 - Consider creating a simulation room with machinery on the ISS that takes in the signals, classifies them and we will be able to manually correct until predictions are in a reliable range.

TAKEAWAYS



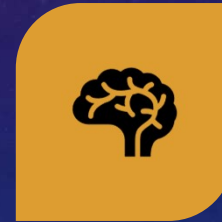
GAN STRUCTURE



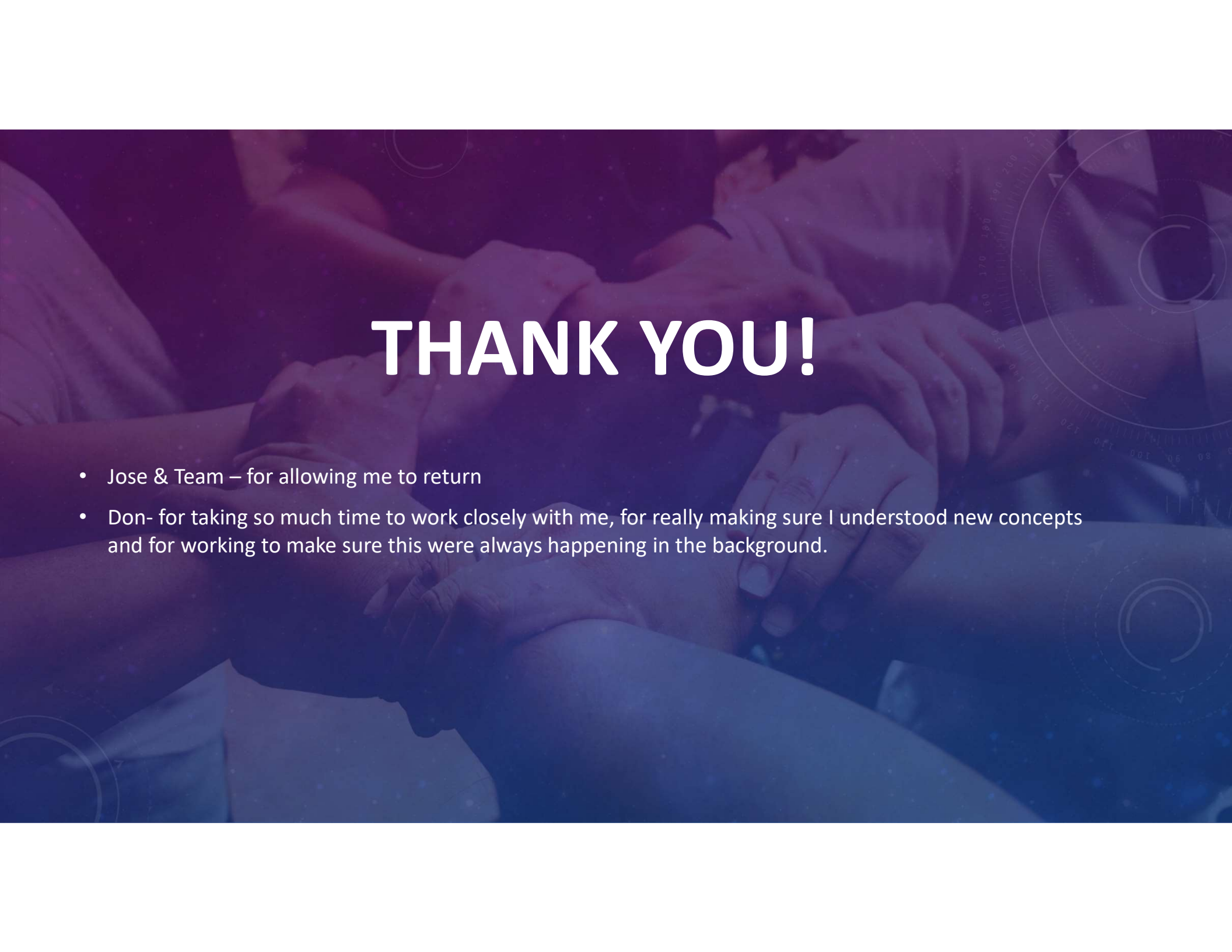
PYTHON SKILLS WHEN
IN READING THROUGH
SOURCE CODE



GPU PLATFORMS



NEURAL NETWORKS



THANK YOU!

- Jose & Team – for allowing me to return
- Don- for taking so much time to work closely with me, for really making sure I understood new concepts and for working to make sure this were always happening in the background.

REFERENCES

- [1] Unsupervised anomaly detection and localization of machine ... - arxiv.org, <https://arxiv.org/pdf/2303.17949v1.pdf> (accessed Aug. 9, 2023).
- [2] Dcase, “Unsupervised anomalous sound detection for machine condition monitoring applying domain generalization techniques,” DCASE, <https://dcase.community/challenge2022/task-unsupervised-anomalous-sound-detection-for-machine-condition-monitoring#submission> (accessed Aug. 8, 2023).