Acoustic Feature Analyzer: Progress

TOC

Past Iterations of Script Package (Audio-Manip main branch)

Past iterations of script had incorrect formatting of data matrices, clunky handling of visuals, and an overall lack of formatting to take in *.wav files outright.

- Data intake was too rigid.
- Data Matrices were incorrectly formatted and led to bad training for Autoencoder.
- Visuals were unsightly/didn’t make sense.
- Data preparation scripts were useful for only the *.wav files being used on my PC.
- Duplicated names of variables across script package caused training/testing issues.

Current Iteration of Script Package (newest-version-Audio-Manip)

The new additions to the updated scripts have gone through the full process of data retrieval, preparation, training, and testing.

Visuals provided use 200 samples of audio files with 160000 points, a sampling rate (Hz) of 16000 Hz, 7 Channel Audio, and a total time length of 10 seconds.

Shown tests take on the 1 second chunks of each sound sample, providing more accurate classification and more distinct learned patterns/hidden features that the Auto Encoder learned.

Current Iteration of Script Package (newest-version-Audio-Manip)

01 **AutoEncoderSVMPairing.mlx:**

Holds the Auto encoder and paired SVM that takes on the learned features for classification.

02 **competitorsvm.mlx:**

Holds the SVM that follows: Data/Feature Preparation->SVM Train/Testing.

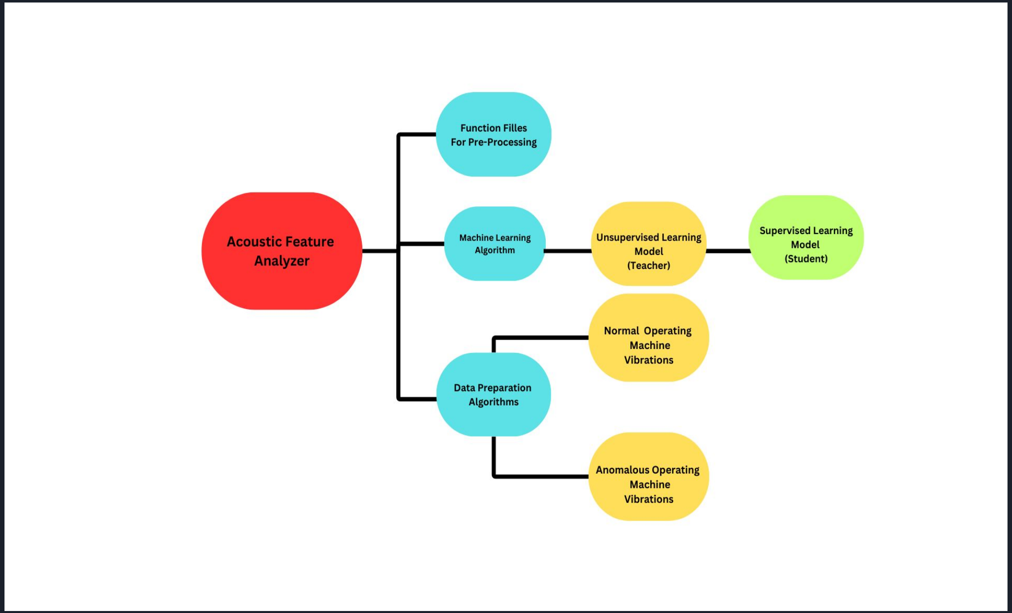
03 **trainingdataprep.mlx:**

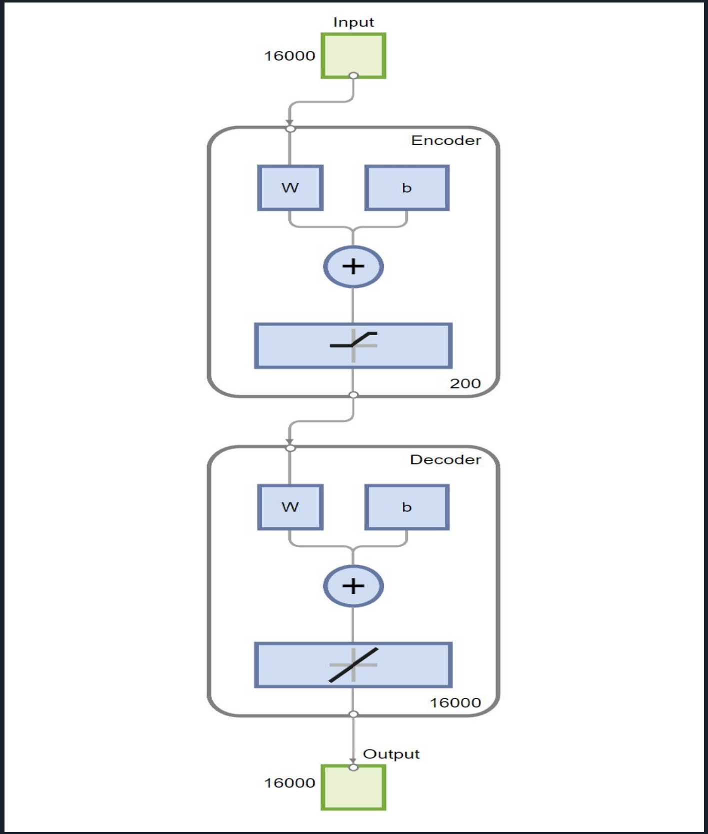
Holds the normal data preparation script for AutoEncoderSVMPairing.mlx.

04 **abnormaldataprep.mlx:**

Holds the abnormal data preparation script for AutoEncoderSVMPairing.mlx.

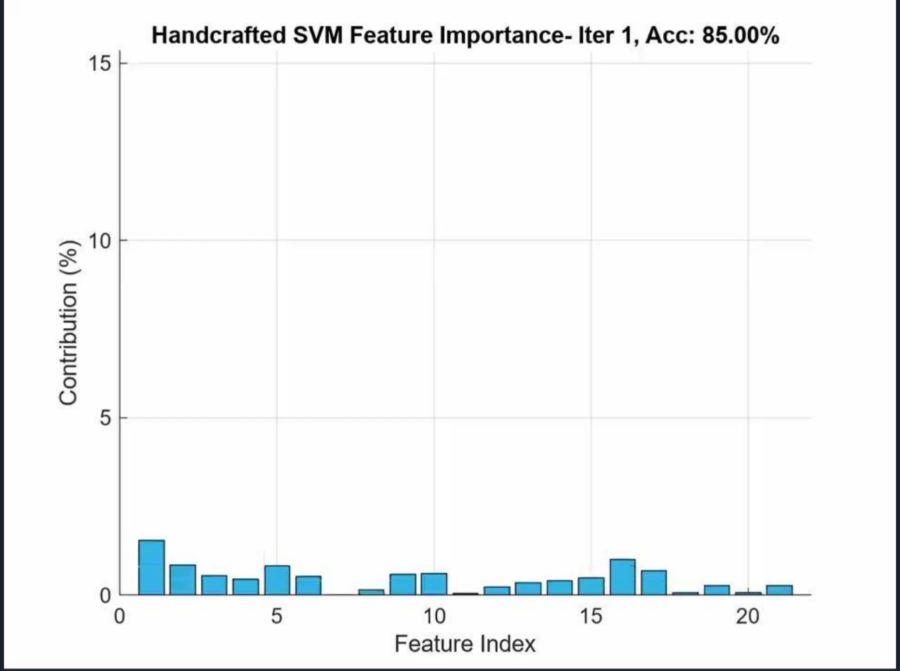
Performance: Comparisons





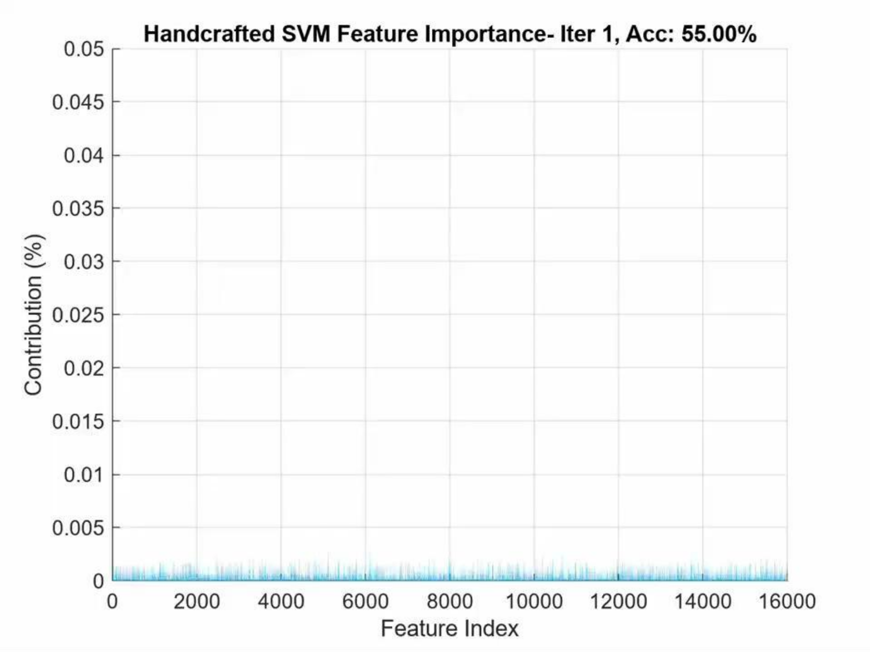
Performance: Comparisons

```
SVM Accuracy: 85.00%
Iteration Number 1.000000
      9      1
      2      8
SVM Accuracy: 80.00%
Iteration Number 2.000000
     17      3
      5     15
SVM Accuracy: 83.33%
Iteration Number 3.000000
     28      2
      8     22
SVM Accuracy: 78.75%
Iteration Number 4.000000
     33      7
     10     30
SVM Accuracy: 86.00%
Iteration Number 5.000000
     48      2
     12     38
SVM Accuracy: 77.50%
Iteration Number 6.000000
     54      6
     21     39
SVM Accuracy: 74.29%
Iteration Number 7.000000
     57     13
     23     47
SVM Accuracy: 66.25%
Iteration Number 8.000000
     54     26
     28     52
SVM Accuracy: 75.00%
Iteration Number 9.000000
     75     15
     30     60
```



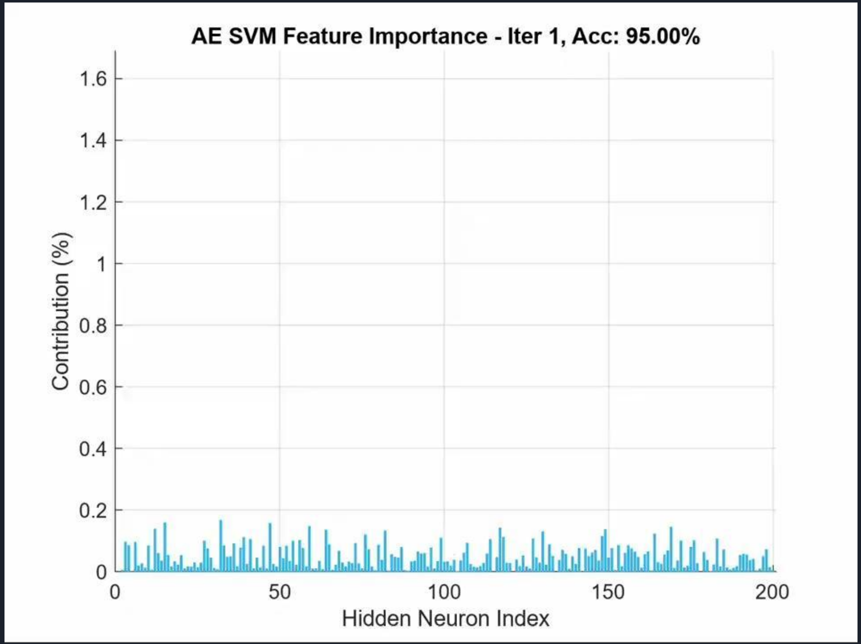
Performance: Comparisons

```
SVM Accuracy: 55.00%
Iteration Number 1.000000
     5      5
     4      6
SVM Accuracy: 37.50%
Iteration Number 2.000000
     8     12
    13      7
SVM Accuracy: 51.67%
Iteration Number 3.000000
    20     10
    19     11
SVM Accuracy: 46.25%
Iteration Number 4.000000
    19     21
    22     18
SVM Accuracy: 49.00%
Iteration Number 5.000000
    25     25
    26     24
SVM Accuracy: 51.67%
Iteration Number 6.000000
    35     25
    33     27
SVM Accuracy: 55.00%
Iteration Number 7.000000
    34     36
    27     43
SVM Accuracy: 55.00%
Iteration Number 8.000000
    38     42
    30     50
SVM Accuracy: 48.89%
Iteration Number 9.000000
    56     34
    58     32
```

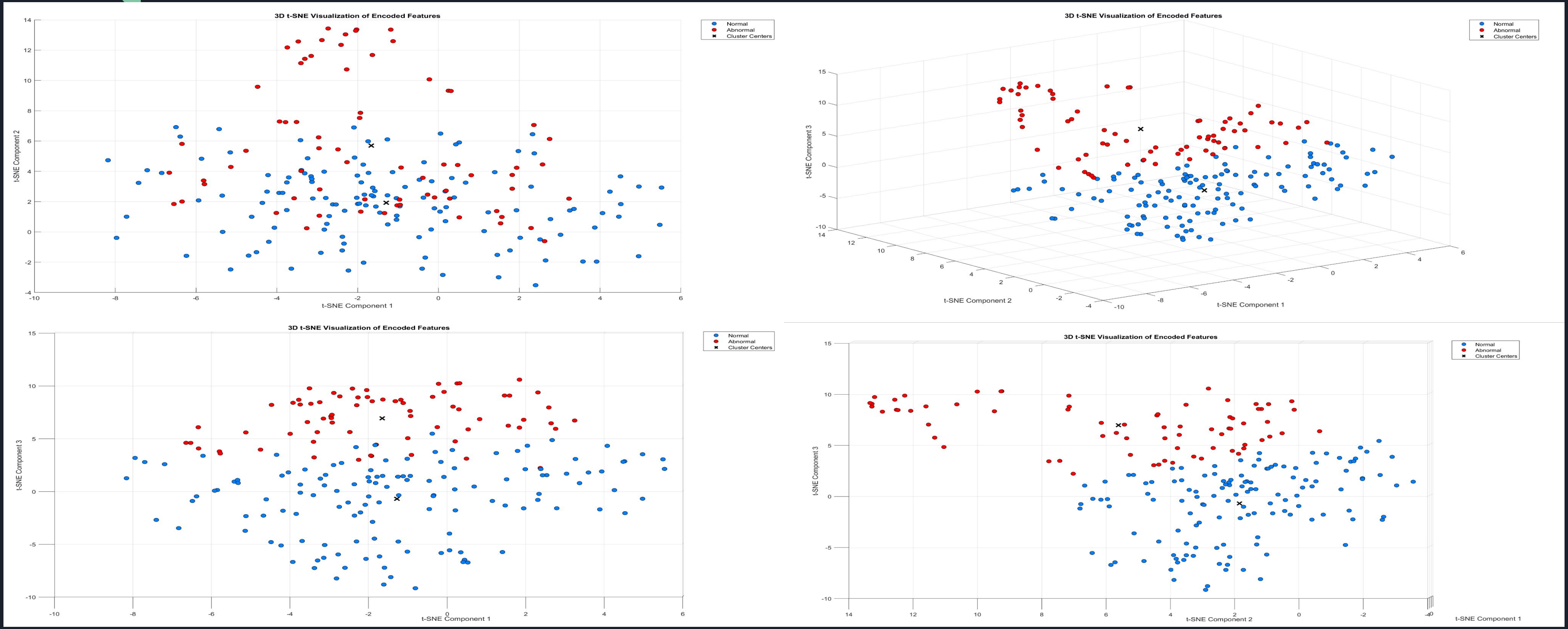


Performance: Comparisons

```
SVM Accuracy (Autoencoder Features): 95.00%
Iteration Number 1.000000
     9     1
     0    10
SVM Accuracy (Autoencoder Features): 95.00%
Iteration Number 2.000000
    18     2
     0    20
SVM Accuracy (Autoencoder Features): 93.33%
Iteration Number 3.000000
    26     4
     0    30
SVM Accuracy (Autoencoder Features): 93.75%
Iteration Number 4.000000
    37     3
     2    38
SVM Accuracy (Autoencoder Features): 96.00%
Iteration Number 5.000000
    46     4
     0    50
SVM Accuracy (Autoencoder Features): 95.00%
Iteration Number 6.000000
    57     3
     3    57
SVM Accuracy (Autoencoder Features): 94.29%
Iteration Number 7.000000
    64     6
     2    68
SVM Accuracy (Autoencoder Features): 94.38%
Iteration Number 8.000000
    75     5
     4    76
SVM Accuracy (Autoencoder Features): 81.11%
Iteration Number 9.000000
    63    27
     7    83
```



Performance: Comparisons



Moving Forward

My personal conclusion from various testing cases and analyzing hyperparameters, learned parameters, encoded/decoded spaces, the latent space of the Auto Encoder, the weights and performance of the SVM's, and playing around with different data formats, is as follows:

- Data time frame doesn't matter, what matters is that the provided time frame holds the right features in the right places (i.e., healthy data looks relatively uniform, anomalous data has distinct peaks in time frame)
- The method of passing raw data through the Auto Encoder and providing the learned features to an SVM has consistently outperformed the initial process of just Data Processing -> SVM Classification. These were the hypothesized results and the hypothesis has been confirmed true.
- If you were to prepare your own array of features from your sound samples and conduct the same tests with: Data Prep -> Auto Encoder Analysis -> SVM Data Prep -> SVM Performance between both methods is similar, with the Auto Encoder route still outperforming the initial SVM method by ~=1%.

Moving Forward

Questions and comments from me:

- **Content for slideshows that can be provided?** Amidst final lectures, we are to put together a slideshow detailing our work. If there's anything that can be used for that from your guys' end?
- **During this time I could start the framework on a Multi-head Attention.**
- **Professor is satisfied with progress so far so we are in a good time frame.**
- **Any news on when to start working with experimental data?**

Grading Rubric: Spring 2025

ABET defined Design Experience
The capstone experience, ideally demonstrated via an open-ended project-based experience, must include a formal design or drafted product with analysis, and presentation material.

ABET Required Topics	Assessment Rubric		
	0	1	5
a. use of 3D parametric computer-aided drafting and design software for a variety of mechanical drawing techniques (such as orthographic, section, auxiliary, assembly models, detailed working drawings and rendered images).	None	Manual sketches, incomplete	Drawings are complete, appropriate views to clearly explain component geometries, correct assembly
b. apply principals of 1. geometric dimensioning and tolerancing; 2. fundamentals of engineering materials, applied mechanics; 3. manufacturing methods.	None	Inappropriate use of GD&T (or no use where appropriate), material selection not justified, manufacturing method inappropriate or design not compatible with manufacturing method.	Appropriate GD&T on drawings; Selection of materials appropriate to use, environment, and disposal; manufacturing methods proposed are appropriate to production volume and cost targets (documented)
c. applications of calculus and statistics.	None	Inappropriate use of calculus and/or statistics; no use of calculus and/or statistics where needed	Appropriate use of calculus and/or statistics with clear documentation explaining purpose and application.
d. use of advanced 3D parametric modeling tools for design and analysis.	None	Inappropriate use of 3D parametric modeling or no use where 3D parametric modeling is appropriate	Appropriate use of 3D parametric modeling. Documentation indicating design evolution/optimization through use of 3D parametric modeling
e. application of physics, materials, manufacturability, environmental and economic concepts to design of machine or mechanical elements.	None	Very limited and incomplete documentation of the application of the listed concepts	The documentation includes evidence of multiple concepts, trade-offs, calculations, and selection and application of "best" options in the design execution
f. use of industry codes, specifications and standards (ASME, ANSI or others);	None	Inappropriate or incorrect standards considered and applied	Appropriate standard applied in an appropriate fashion with suitable documentation

Grading Rubric: Spring 2025

ABET defined Design Experience

The capstone experience, ideally demonstrated via an open-ended project-based experience, must include a formal design or drafted product with analysis, and presentation material.

	Assessment Rubric		
	0	**1**	**5**
g. technical communications typically used in preparation of engineering proposals, reports, and specifications.	None	Documentation is disorganized, incomplete, verbose, lacking ownership, and/or illogical	Documentation is clear, concise, logical, with significant graphical explanatory elements, and complete.

Section Specific Required Elements

Competitive analysis of a range of products available in the market. The documented analysis should reveal essential functional requirements and trade-offs required for the manufacturing, distribution, sales, use, and disposal of the products.	None	Comparison is unclear, key functional requirements not revealed, not all phases of product lifecycle evaluated	Comparison is clear, reveals the key function requirements, all phases of the product lifecycles have been considered, design requirements are established
Development and documentation of a minimum of 3 distinct concepts to fulfill the product design requirements established by the project team.	None	Only a single design considered, lacking documentation to justify selection	A minimum of 3 distinct design concepts have been evaluated that could fill a majority of the key functional requirements as well as the critical business requirements
Selection of the concept to develop using the Pugh Concept Selection Matrix	None	Pugh Concept Selection matrix has inappropriate criteria or is not providing adequate justification for design selection	Pugh Concept Selection matrix has appropriate functional and commercial criteria. Selection of concept to develop is substantiated by the matrix.
Function Model, Interface Matrix, and Design FMEA performed with revision history	None	Documents are incomplete, are done inconsistent with examples in "The Power of Deduction" text, not logical, and/or revisions are not documented	The documents are complete, consistent in format and intent as shown in "The Power of Deduction" text, logical, and revisions indicate how design has been evolving/optimized.

Grading Rubric: Spring 2025

ABET defined Design Experience

The capstone experience, ideally demonstrated via an open-ended project-based experience, must include a formal design or drafted product with analysis, and presentation material.

	Assessment Rubric		
	0	**1**	**5**
Project schedule based on Design FMEA risk assessment with weekly update	None	Project schedule not organized based on risks and/or not regularly updated	Project schedule incorporates the planning for developing all of the elements for the Design FMEA and then subsequent steps based on executing required activities and mitigating identified high risks. Schedule updated at least weekly.
Prototype plan, test and validation based on Design FMEA risk assessment	None	Plan is incomplete or unclear	The number of required prototypes, tests, and iterations are documented. Plan is updated at each iteration of the prototypes.
Final report documenting project schedule, competitive analysis, design requirements, concept selection, function model, interface matrix, Design FMEA, engineering analyses, engineering drawings, prototype and test and validation plan and results, final recommendation	None	Documentation is disorganized, incomplete, verbose, lacking ownership, and/or illogical	Documentation is clear, concise, logical, with significant graphical explanatory elements, and complete.

Q&A