Project Title: PIG Detection Using Machine Leaning Using SVM and NN Classification Methods

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Problem Statement

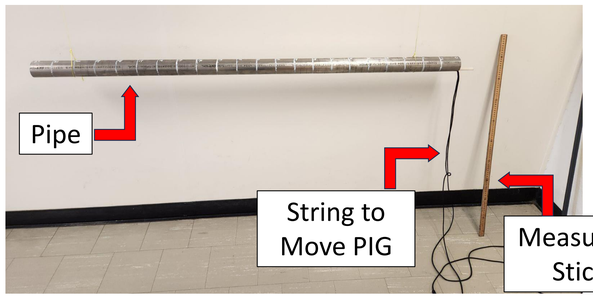
- Pipeline Inspection Gauges (PIGs) are widely used for pipeline cleaning and inspection.
- Under various circumstances, the PIG can get stuck in pipelines, leading to larger issues.
- Percussion Based Machine Learning can offer a nondestructive method to detect a stuck PIG.

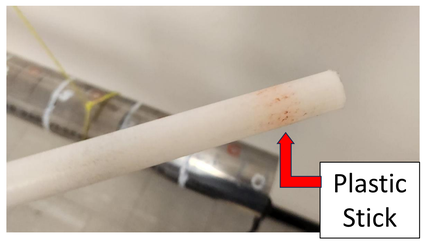
Brief Literature Review

- Wuhan University of Science created a CNN model to detect the volume of water in a pipe using MFCC features.
  - Achieved >90% accuracy for detecting various percentages of fluid volume.
  - Used Decision Tree, SVM, and CNN models.

Experimental Setup and Collection of Data

- The experiment consisted of a pipe, measuring stick, plastic striking rod, and a rubber pig on a string.
  - An iPhone was used to record audio files of the pipe being struck.
  - The pipe is divided into 22 3” sections.

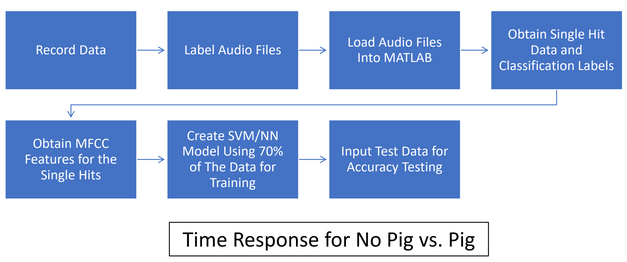




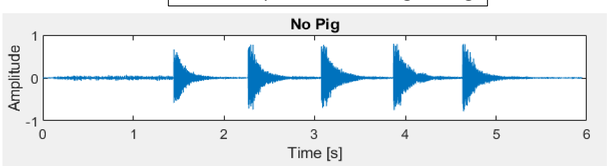
- For data collection, the PIG will be moved from section 3-20 and the following steps will be repeated.
  - The location of the PIG will be struck 20 times.
  - The empty sections will be struck 5 times.
- Once the data was collected it was named using the following conventions.
  - A hit on the PIG used “PIG#”, where “#” is the section, the PIG is located.
  - An empty section used for example, “7L-4”, where 7 is how many sections away the hit happened, “L” signifies that the hit happened to the left of the PIG, and 4 represents the section the PIG is in.

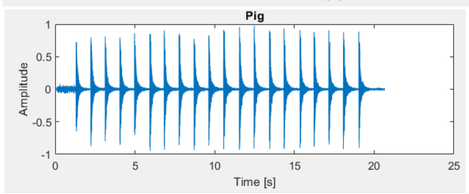
PIG6 7L-4
PIG5 7L-3
PIG4 6R-20
PIG3 6R-19

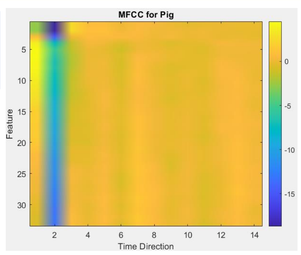
Method(s)

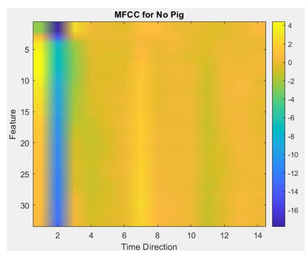


Time Response for No Pig vs. Pig







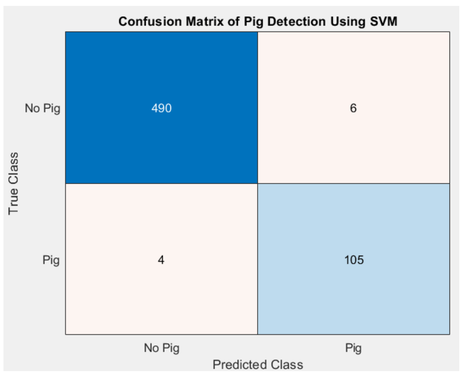


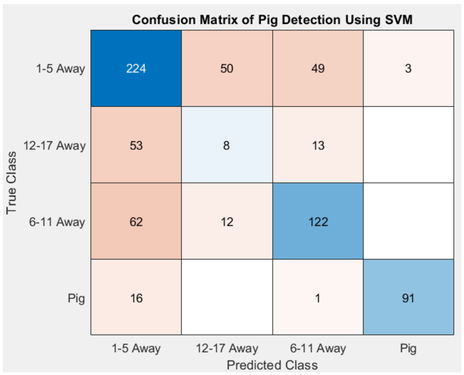
MFCC Features for No Pig vs. Pig

- The Two Classification Methods are as Follows:
- Support Vector Machine (70% Training)
  - Gaussian Kernal Function
- Neural Network (60% Training)
  - Variable Learning Rate Gradient Descent
  - Sigmoid Hidden Activation Layer
  - SoftMax Output Layer

Results, Analysis and Discussion

SVM Classification



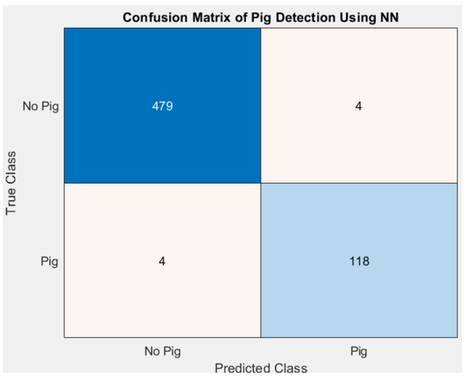


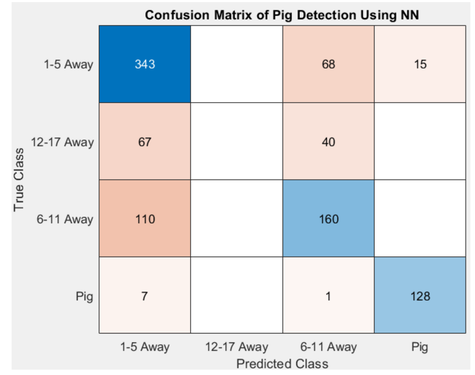
SVM Classification	
Number of Labels	Accuracy [%]
2	98.35
4	63.21
6	57.81

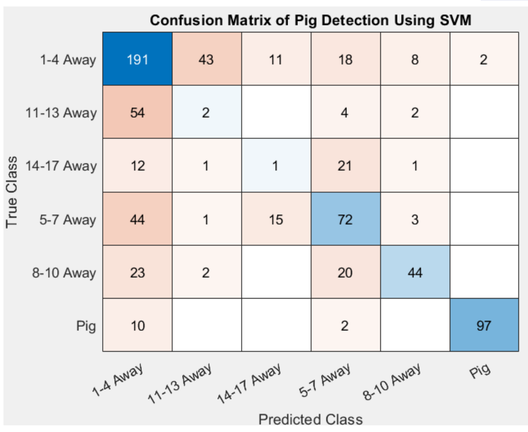
NN Classification	
Number of Labels	Accuracy [%]
2	98.68
4	67.20
6	55.59

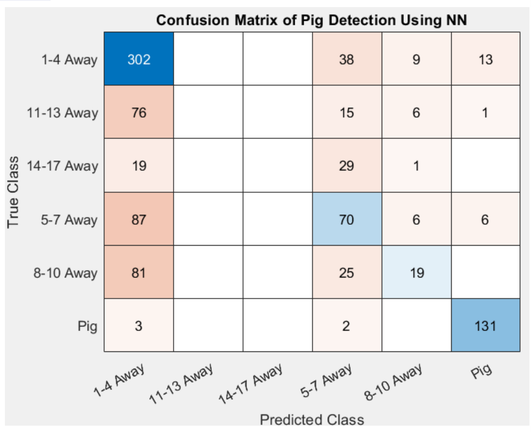
NN Classification	
Number of Labels	Number of Neurons
2	88
4	51
6	36

NN Classification









Conclusion

- For 2 and 4 Label Classification, Neural Network had higher accuracy than Support Vector Machine.
- For 6 Label Classification, Support Vector Machine had higher accuracy than Neural Network.
- The number of Neurons decreased for NN as the labels increased.
- The models struggled to predict hits that occurred 12 to 17 sections away from the PIG.

Future Work

- Record a larger sample size and experiment with different signal processes for finding features.

Acknowledgements

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References (brief)

1. Yang, Dan, Mengzhou Xiong, Tao Wang, and Guangtao Lu. “Percussion-Based Pipeline Ponding Detection Using a Convolutional Neural Network.” *Applied Sciences* 12, no. 4 (February 18, 2022): 2127. https://doi.org/10.3390/app12042127.
2. UH MECE Machine Learning Lecture