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Summary

- The final draft paper was rewritten with feedback from Mia.
- Literature review changed the structure of a paragraph.
- The words of the paper were refined to fit the English format.

What TN completed this week

- Literature was written problems and solutions for each other's research.
    - UAV detection using audio data

        UAV detection research has become active due to the potential malicious threats of these UAVs. To solve these threats of UAVs, research has also been conducted to detect UAVs using computer vision, RADAR, and audio data [2], [3]. Research using audio data shows promising results.

        One research "A Feature Engineering Focused System for Acoustic UAV Detection" by Y. Wang, F. E. Fagian, K. E. Ho and E. T. Matson used multiple feature extraction methods (mfcc, mel, contrast, chroma, and tonnetz) to try and find the best feature extraction method to use when extracting UAV characteristics from audio data. SVM, Gaussian Naive Bayes (GNN), K-Nearest Neighbor (KNN), and Neural Network were used to find the best feature extraction. 300 audio data was collected from a DJI Phantom 4 and an Evo 2 Pro, and 600 more dataset will be collected from an outdoor environment. The mfcc shows over 99% accuracy compared to other models (SVM: 99.6%, GNB: 99.5%, KNN: 99.0%, NN: 99.7%). A combination of machine learning and feature extraction shows an accuracy over 100% [1].

        Audio data is a cost-effective way to distinguish UAVs despite having noise limitations. "Audio Based Drone Detection and Identification using Deep Learning" by E. Kubera, A. Wieczorkowska, A Kuranc, T. Słowik focused on the malicious activities of drones and conducted a study to identify UAVs using audio data. According to the paper, the use of SVM is effective for drone detection, but requires optimization of hand-created functions. To remediate this, deep learning was used as a way to have feature extraction and optimization. Experiments were conducted using three deep learning models: CNN, Recurrent Neural Network (RNN), and Convolutional Recurrent Neural Network (CRNN). RNN shows the shortest time required (389.02 seconds) that is required to

process this data, but it also showed the lowest accuracy (57.16%) among the three models. CRNN has both RNN and CNN features. It has a time of 605.67 seconds and an accuracy above 90%. CNN has the longest time to train (807.10 second), however it shows an accuracy above 90%. CNN has better accuracy than CRNN by 0.72% [2] [4] [5].

- Velocity prediction

  There have been some trial researchers to predict the speed of the objects by using audio data not only to detect.

  One research has been conducted to predict the car's speed and the gear's position using the audio data of the engine using Gradient Boosting (GB). The author confirmed the relationship between audio and the car's speed. The author uses 3 microphones to get the dataset in controlled condition. Two microphones attached on the inside and outside the windshield to induce wind noise. The other microphone is placed next to the engine. After normalizing the dataset, the dataset went under feature extraction using MFCC, zero crossing rate, and spectral centroid. The audio contains features of speed and gear state, and this audio went under feature extraction where the result will be used as input to GB. GB's accuracy increases when the speed interval is large and time frame is minimal. When only using GB accuracy is under 75%. The author uses correlation matrix to optimize GB. As a result, GB shows over 90% accuracy in gear position and speed prediction [6].

  "Discovering Speed Changes of Vehicles from Audio Data" by E. Kubera, A. Wieczorkowska, A Kuranc, T. Słowik used machine learning to find out the changes in the velocity of passing vehicles. The dataset was created by installing a microphone about five feet from the road and obtaining audio data from vehicles passing by the road. Acquired audio data were parameterized through different methods based on audio features and spectrogram data before putting the audio data through machine learning.There are five types of machine learning used: random forest, SVM with linear kernel (SVML), SVM with quadratic kernel (SVMQ), SVM with RBF kernel(SVMR), and multi-layer perceptron (MLP). The result shows random forest, SVML, SVMQ, SVMR, and MLP accuracy results as 90.5%, 85.4%, 87.1%, 90.9%, and 88.6% respectively. Models that have the highest accuracy were put into a classifier ensemble that consists of the best performing classifiers. The ensemble resulted in an accuracy of 94.7%[7].

Things to do by next week

- Thinking about what kind of Pythorch version is used and installed.
- Machine Learning study will begin [8].
- Training code for Machine Learning will be finished.

Problems or challenges:

- What kind of Pytorch version will be installed?

References

[1] Y. Wang, F. E. Fagian, K. E. Ho and E. T. Matson, "A Feature Engineering Focused System for Acoustic UAV Detection," *2021 Fifth IEEE Int. Conf. on Robot. Comput. (IRC)*, 2021, pp. 125-130, doi: 10.1109/IRC52146.2021.00031.

[2] S. Al-Emadi, A. Al-Ali, A. Mohammad and A. Al-Ali, "Audio Based Drone Detection and Identification using Deep Learning," *2019 15th Int. Wireless Commun. & Mobile Comput Conf. (IWCMC)*, 2019, pp. 459-464, doi: 10.1109/IWCMC.2019.8766732.

[3] S.Jamil, Fawad, M.Rahman, A.Ullah, S.Badnava, M.Forsat, S.S.Mirjavadi, "Malicious UAV Detection Using Integrated Audio and Visual Features for Public Safety Applications", *Sensors (Basel) vol. 20,14 3923.* , 2020, doi: 10.3390/s20143923.

[4] S. Seo, S. Yeo, H. Han, Y. Ko, K. E. Ho and E. T. Matson, "Single Node Detection on Direction of Approach," *2020 IEEE Int. Instrum. and Meas. Technol. Conf. (I2MTC)*, 2020, pp. 1-6, doi: 10.1109/I2MTC43012.2020.9129016.

[5] S. Li et al., "Convolutional Neural Networks for Analyzing Unmanned Aerial Vehicles Sound," *2018 18th Int. Conf. on Control, Automat. and Syst. (ICCAS)*, 2018, pp. 862-866.

[6] H. V. Koops and F. Franchetti, "An ensemble technique for estimating vehicle speed and gear position from acoustic data," *2015 IEEE Int. Conf. on Digit. Signal Process. (DSP)*, 2015, pp. 422-426, doi: 10.1109/ICDSP.2015.7251906.

[7] E. Kubera, A. Wieczorkowska, A Kuranc, T. Słowik "Discovering Speed Changes of Vehicles from Audio Data." *Sensors (Basel, Switzerland) vol. 19,14 3067.* , 2019, doi:10.3390/s19143067

[8] holehouse, "Stanford Machine Learning", holehouse.org. http://www.holehouse.org/mlclass/ (accessed June. 02, 2022)