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How Do Room Acoustics Impact Machine Learning Accuracy in Voice Disorder Detection

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INTRODUCTION & AIM

In acoustic voice assessment, recordings are typically collected from diverse acoustic environments with varying levels of noise and reverberation (Bottalico et al., 2020). Room acoustics are known to affect the quality of recordings (Rollins et al., 2019), but their impact on advanced tools like machine learning (ML) remains not well understood. This work reveals the influence of room acoustics (reverberation) on ML accuracy in detecting voice disorders.

METHOD

Voice recordings (sustained vowel /a:/, 3 seconds) were analyzed from 135 subjects with voice disorders and 49 normal individuals. These recordings were collected in a sound booth with minimal background noise and reverberation. Using a MATLAB script and Praat software, twenty acoustic measurements were extracted representing different temporal- and spectral-based features of the acoustic voice signal. These features were used to form a training subset and build six ML binary classifiers (normal vs. disorder voice): Support Vector Machine (SVM), Random Forest (RF), Gradient Boosting (GB), k-Nearest Neighbors (k-NN), AdaBoost (AB), and Extra Trees (ET).

The classifiers were then tested using features from a testing subset. To further test model robustness against poor room acoustics, the testing subset recordings were corrupted by adding on two reverberation levels—short (0.48 s) and long (1.82 s) reverb time (T20)—creating two extra challenging test sets. Audacity software was used to simulate these two adverse room acoustic conditions. The classifiers were evaluated for accuracy, F-score, and Area Under the Curve (AUC) of Receiver Operating Characteristic (ROC) curves to compare the impact before and after adding reverberation effects on ML performance.

RESULTS & DISCUSSION

Results show how the classifiers' performance was influenced by room acoustics (reverberation). Figure 1 illustrates the adverse impact of reverberation on almost all the classifiers, showing worse performance with higher reverberation. Under low reverb, SVM and k-NN were less vulnerable than the other classifiers while RF performance was highly impacted.

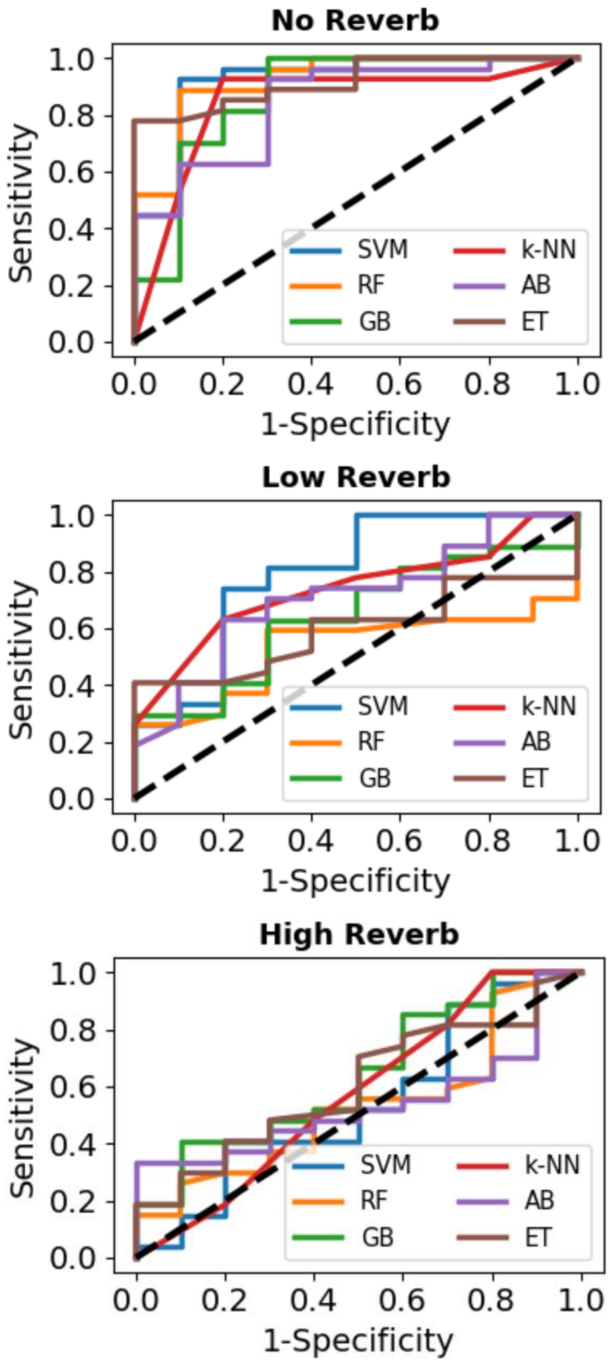

Figure 1: ROC for all classifiers on the test set, without and with 2 levels of reverb.

In Figure 2, by visually examining each classifier AUC, F-score, and accuracy, almost all models show a drop in the testing metrics when adding reverb. Overall, RF was the most vulnerable in poor room acoustics. SVM and K-NN were the most robust: accuracy and F-score were unchanged but AUC declined. This study showed an adverse impact on ML in unideal room acoustics: suggesting training ML by challenging recordings/dataset for a robust application.

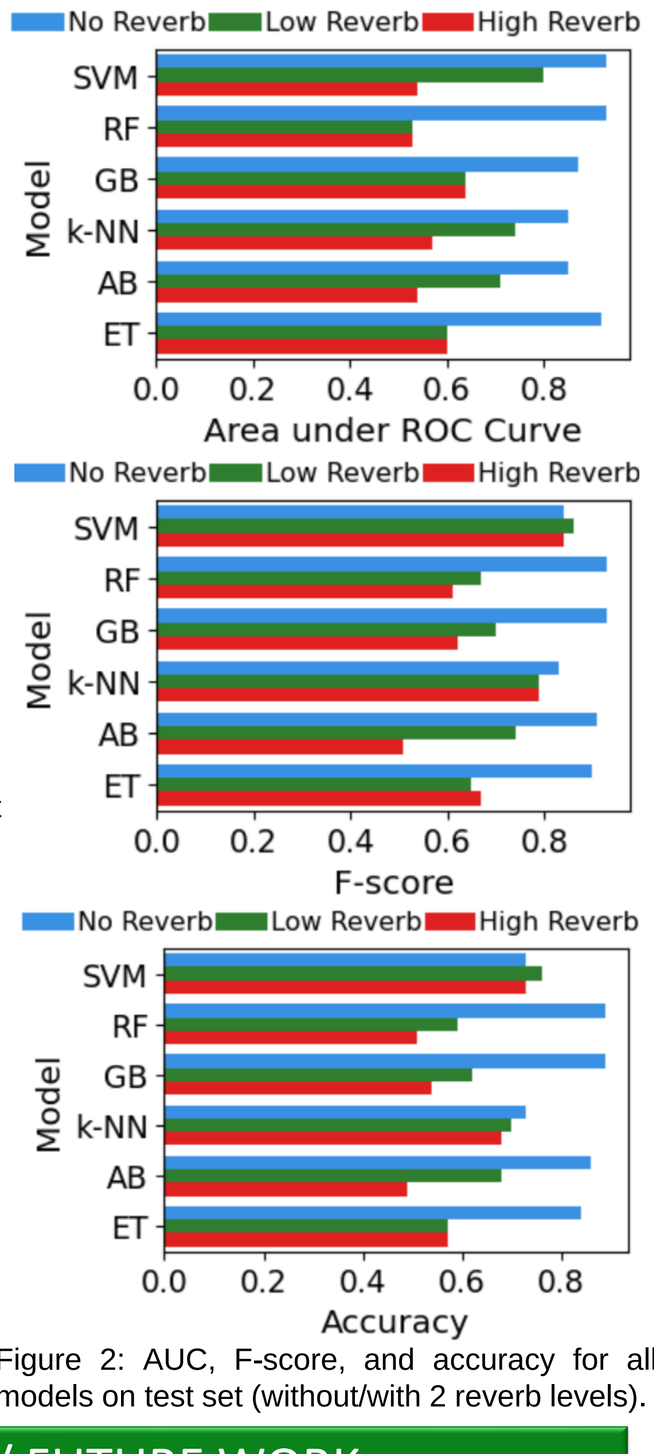

Figure 2: AUC, F-score, and accuracy for all models on test set (without/with 2 reverb levels).

CONCLUSION / FUTURE WORK

Recording in poor room acoustics can affect ML application performance—commonly trained on recordings with ideal room acoustics. Training ML on recordings with challenging environmental conditions is essential for robust performance; a research area that should be further investigated in future.

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