Musical Instrument Identification with Supervised Learning

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Aim

The classification of musical instruments using supervised learning is studied. A combined feature set including psychoacoustically relevant spectral features is used. A fairly small dataset consisting of 496 sound examples from 4 instruments - violin, clarinet, saxophone and bassoon is used. Perfect classification accuracy is achieved on the test set with multi-class logistic regression and SVM with RBF kernel.

Dataset

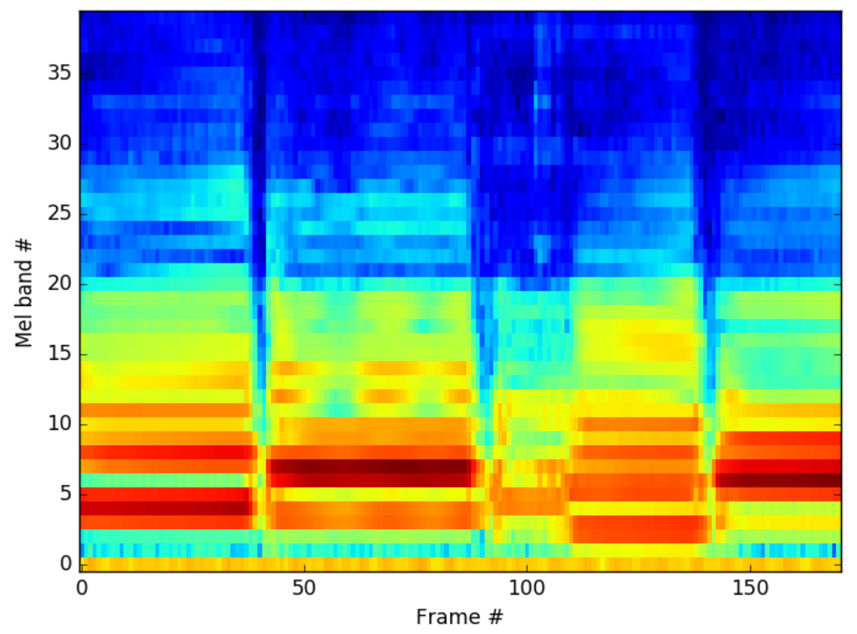
- **Bach 10**[1] dataset – audio recordings of the ensemble of ten pieces of four-part J.S. Bach chorales, and their MIDI scores.
- Soprano, Alto, Tenor and Bass of each piece are performed by violin, clarinet, saxophone and bassoon.
- 2s excerpts of each instrument – total **496** sound files, **164** labelled sounds for each instrument.

Results

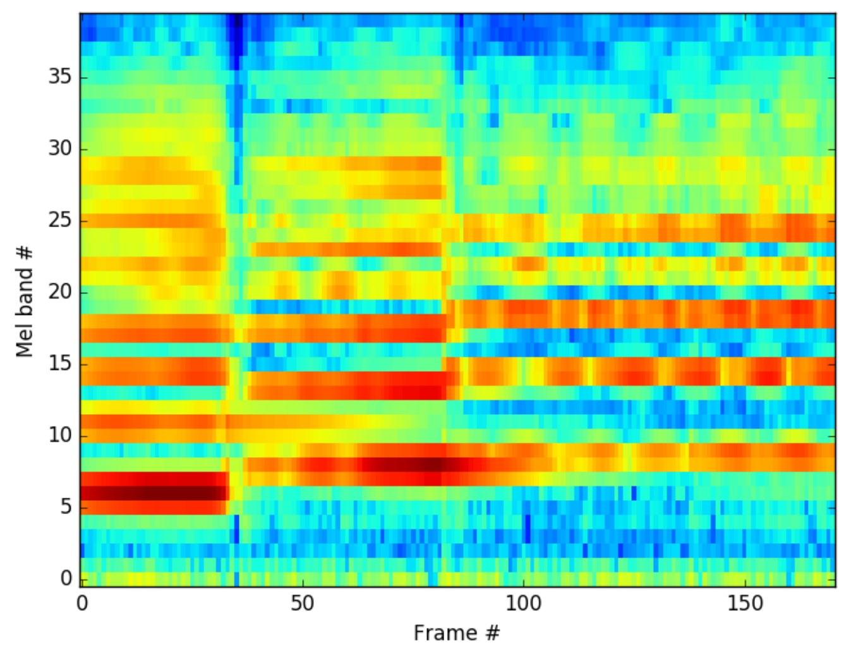
- Dataset randomly split into training (75%) and test set (25%)
- 41 sound files in the test set and 123 sound files in the training set for each instrument.
- 3-Fold Cross-validation done with a log-spaced grid search to select regularization parameters for both logistic regression and SVM, and γ, the kernel parameter for SVM.
- 100% classification accuracy is achieved on the test set with both logistic regression and SVM

Features

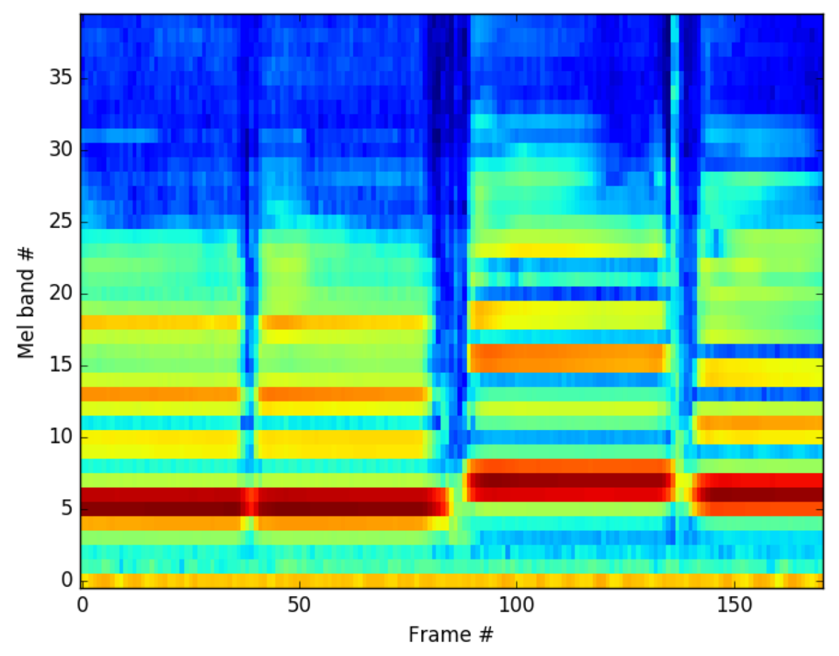
- Each file is broken into frames of size 1024 samples, with overlap of 512 samples.
- 15 MFCCs[2] computed per frame.
- 15 Warped LPCs[3] computed per frame.
- Median values across all frames selected as features.



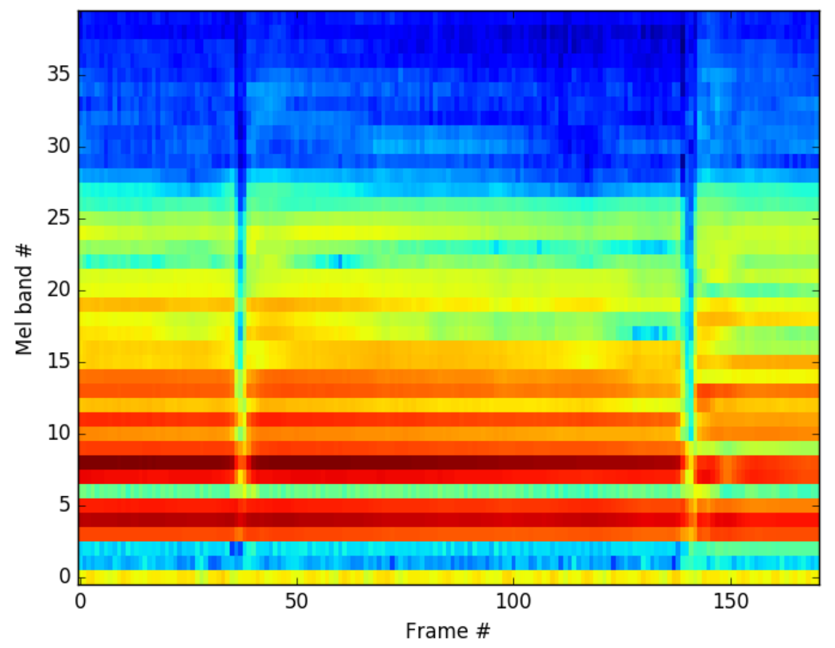
Bassoon



Violin



Clarinet



Saxophone

Methods

Multi-class Logistic Regression

- Softmax probability distribution

$$P(y=k|x;\theta)=\frac{\exp\left(\theta_k^T x\right)}{1+\sum_{j=1}^{K-1}\exp\left(\theta_j^T x\right)}$$

- Maximum log likelihood with L1 regularization.

SVM with RBF kernel

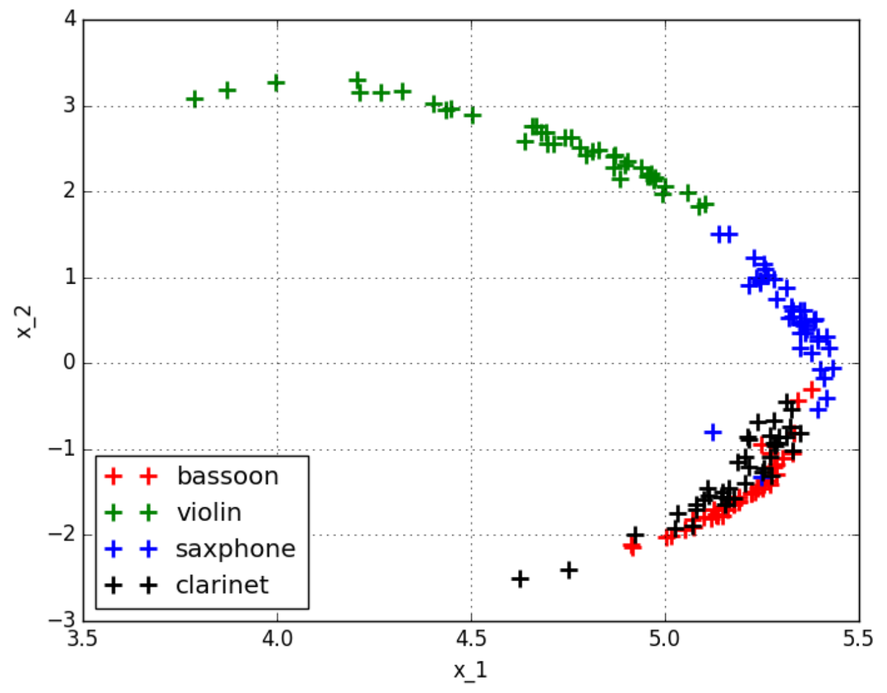
- Non-linear SVM with infinite dimensional feature map, given by the RBF kernel

$$K(x^i,x^j)=\exp\left(-\gamma\|x^i-x^j\|^2\right)$$

- Kernel determines similarity between two feature vectors.

Discussion

No misclassifications between same family of instruments (eg:single-reed, woodwind) . Instruments purely harmonic, Not percussive. Method should be extended to include many more instruments.



References

[1] Z. Duan, B. Pardo, and C. Zhang, “Multiple fundamental frequency estimation by modeling spectral peaks and non-peak regions,” IEEE Transactions on Audio, Speech, and Language Processing, 2010.

[2] A. Eronen, “Comparison of features for musical instrument recognition,” in Proceedings of the 2001 IEEE Workshop on the Applications of Signal Processing to Audio and Acoustics. IEEE, 2001,

[3] A. Harma, M. Karjalainen, L. Savioja, V. V¨alim¨aki, U. K. Laine, and J. Huopaniemi, “Frequency-warped signal processing for audio applications,” Journal of the audio engineering society, vol. 48, no. 11, pp. 1011–1031, 2000.