Learning Sparse Analytic Filters for Piano Transcription

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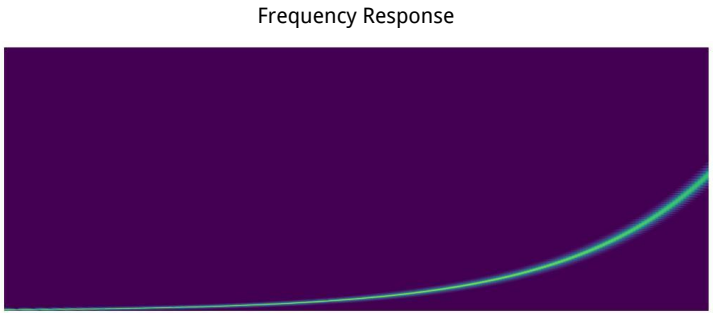
This Work

- Propose extensions to classic filterbank learning approach
- Employ module as frontend to the task of piano transcription
  - Replace Mel Spectrogram stage in simple model

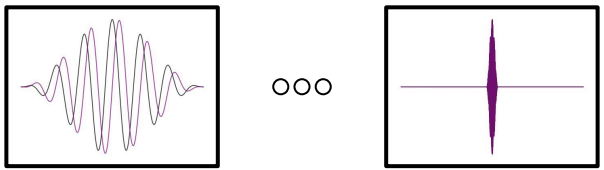
Features for MIR

- Commonly assume transforms like STFT, CQT, etc., are the best representation of audio for DNNs
  - May not be the case for all MIR tasks



Complex Filterbanks

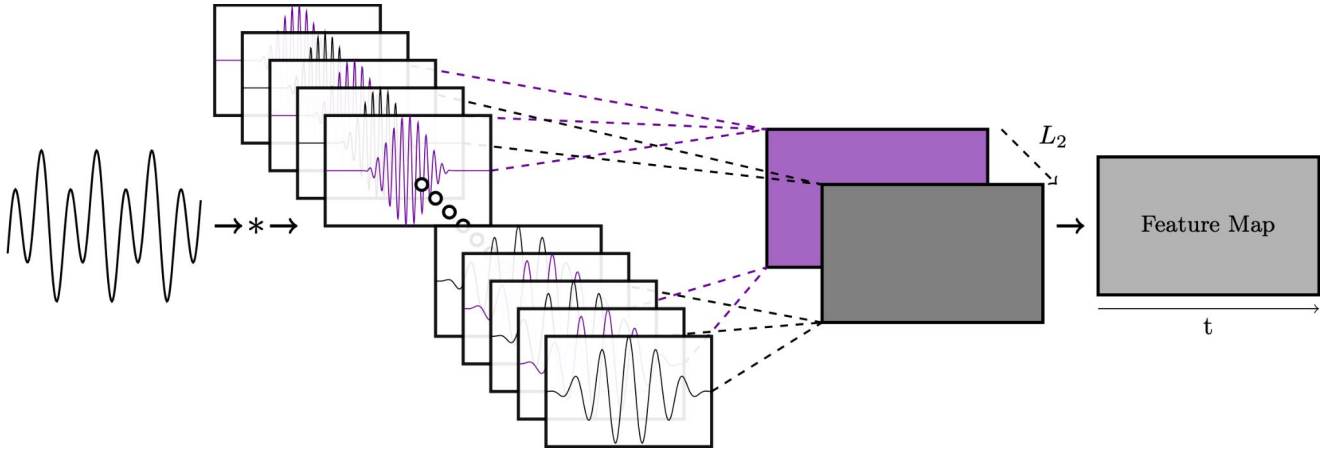
- These transforms are just complex filterbanks with fixed weights!
- Can represent these with neural networks
  - Fine-tune or learn weights from random initialization



Time Domain Weights

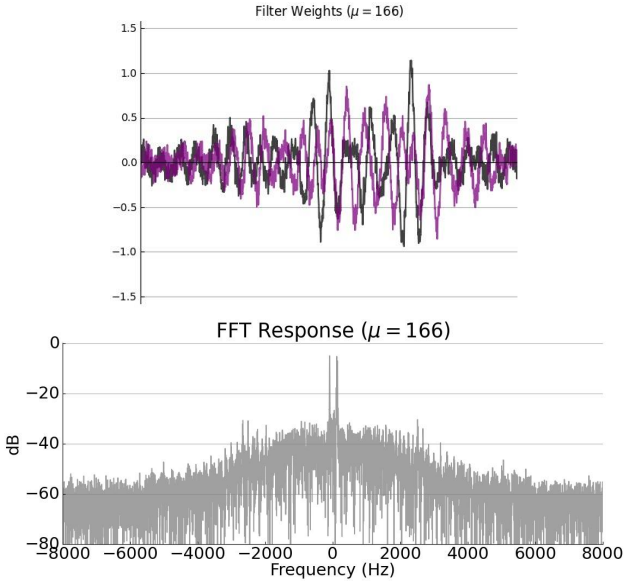
Filterbank Learning (Classic Approach)

- Learn real and imaginary parts independently (or just real)
- Combine into a single magnitude response with L_2 pooling



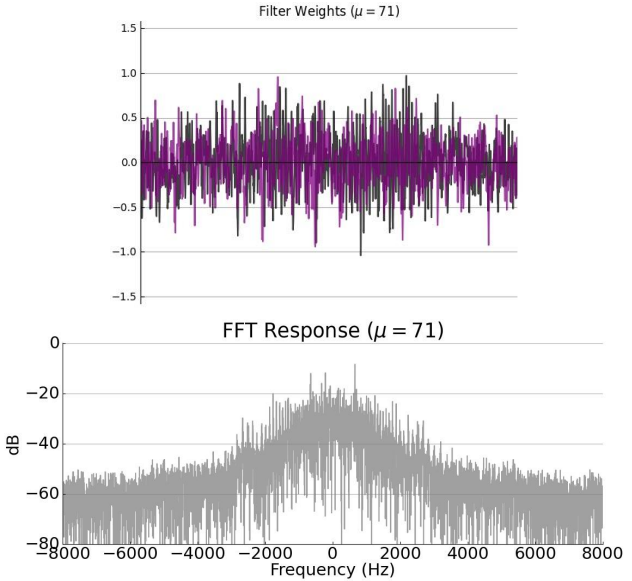
Pitfalls

- Learned filters are not analytic
  - Not shift-invariant
  - Small hop-size required
  - Energy at negative frequencies



Pitfalls

- Learned filters are often noisy
  - No localized frequency response
  - Very hard to interpret



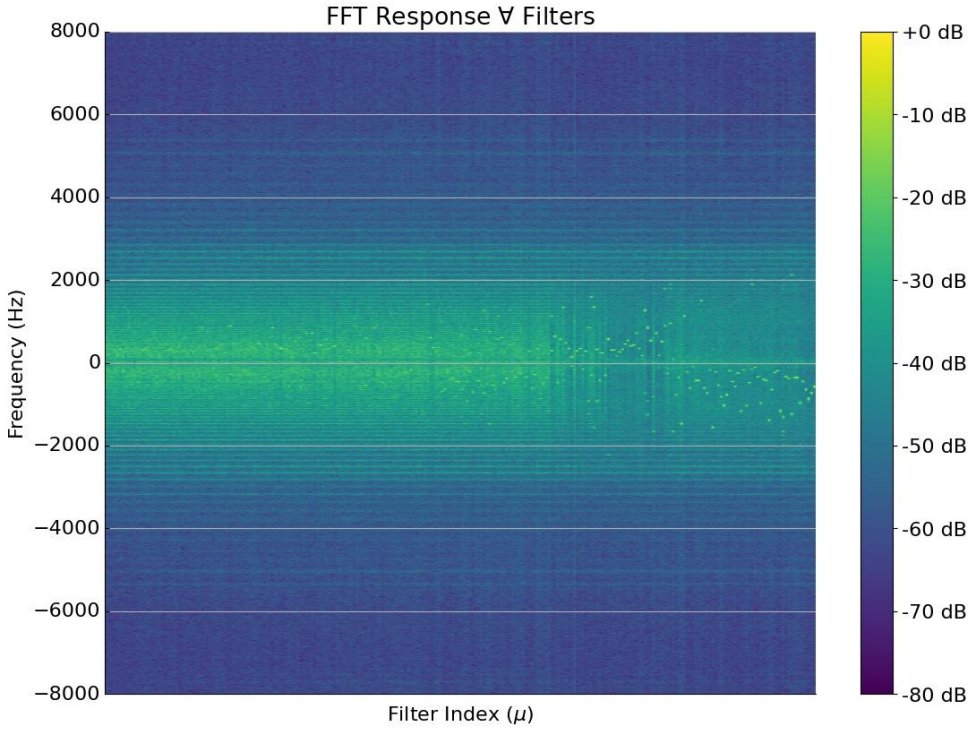
Proposed Techniques

- Only learn the real part of filter and infer imaginary part
  - Hilbert transform yields imaginary counterpart to a signal
    - Such that the resulting filter is analytic (shift invariant)
- Apply variational dropout as regularization to induce sparsity
  - Add Gaussian noise with learned variance to response

Experiments

- Frontend to Onsets & Frames piano transcription model
- Train on MAESTRO and evaluate on MAESTRO/MAPS
- Experiment with different variations/initializations
- Conduct an ablation study on proposed techniques

Classic + Random



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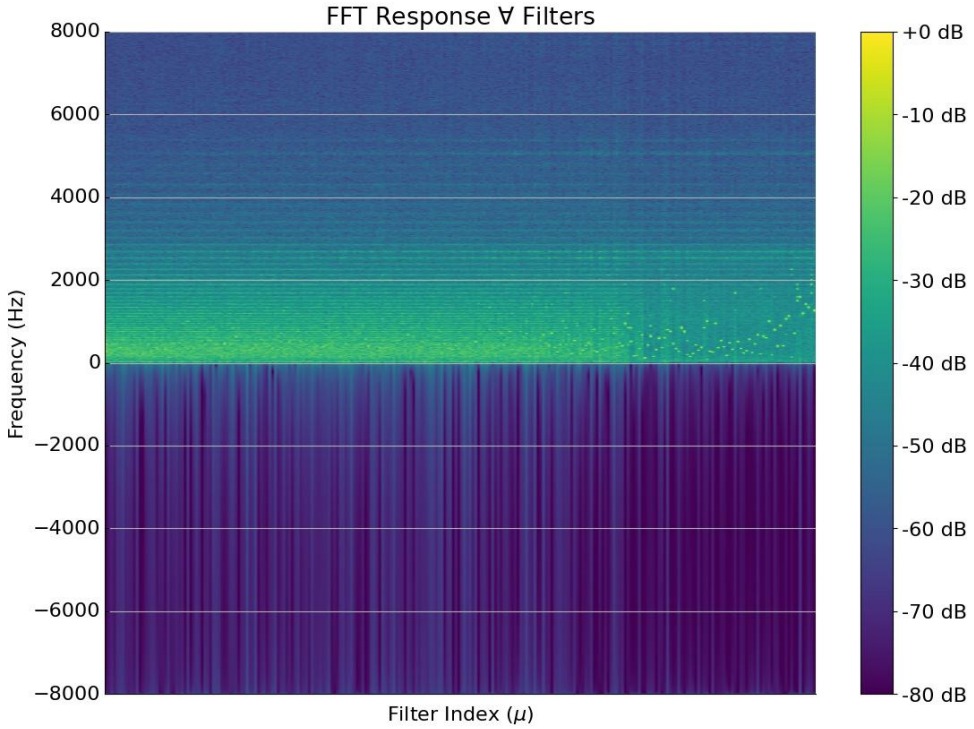
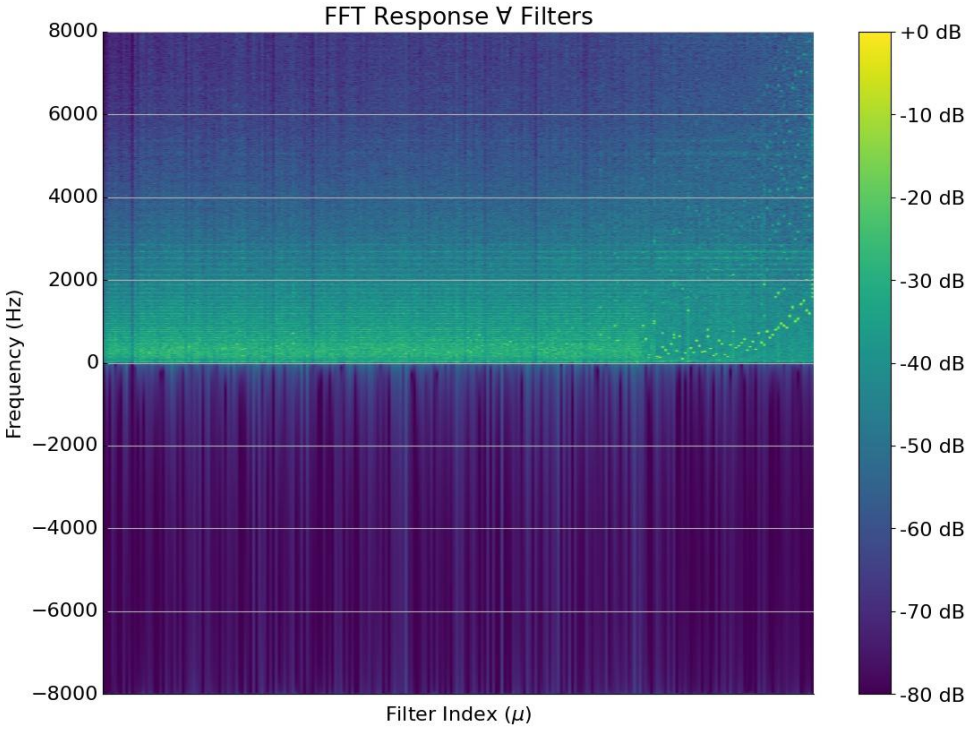
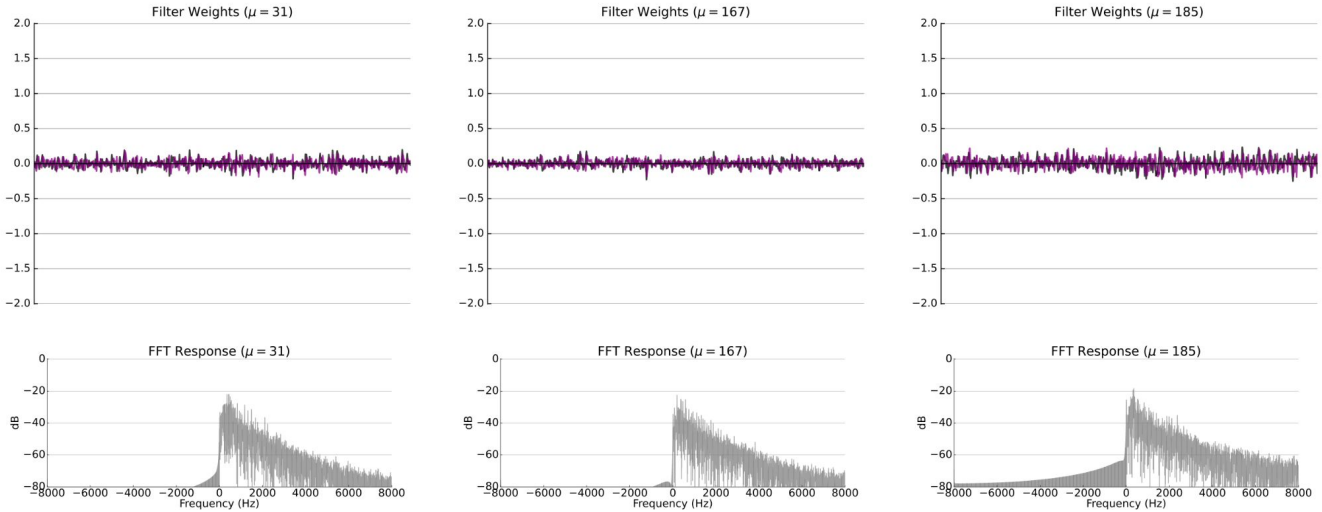
Hilbert + Random



Hilbert + Random + Variational Dropout



Hilbert + Random + Variational Dropout



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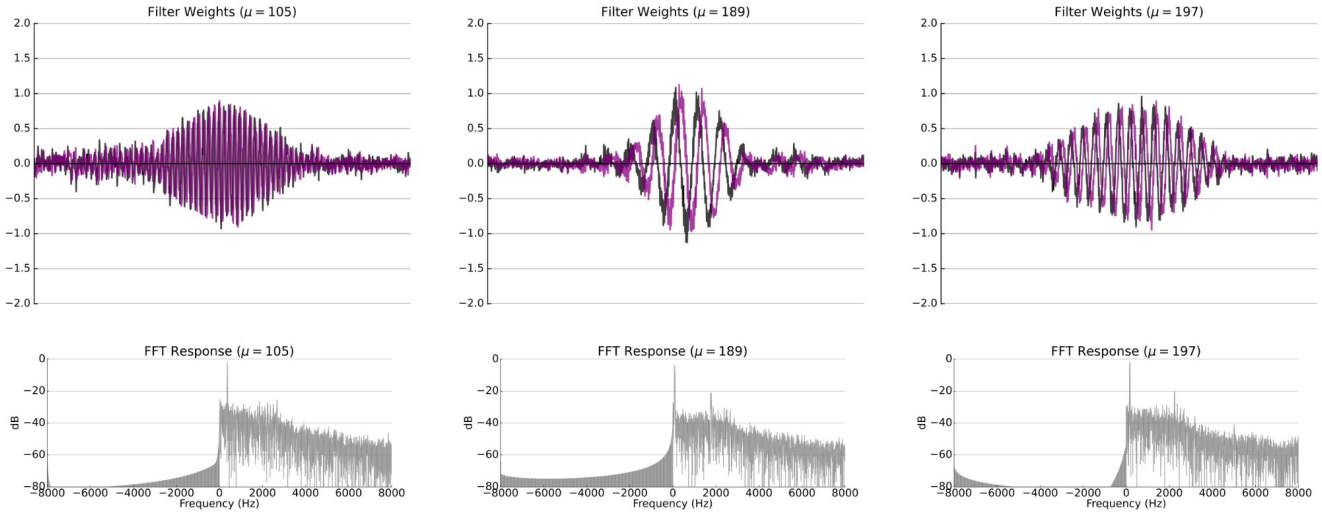
Hilbert + Random + Variational Dropout



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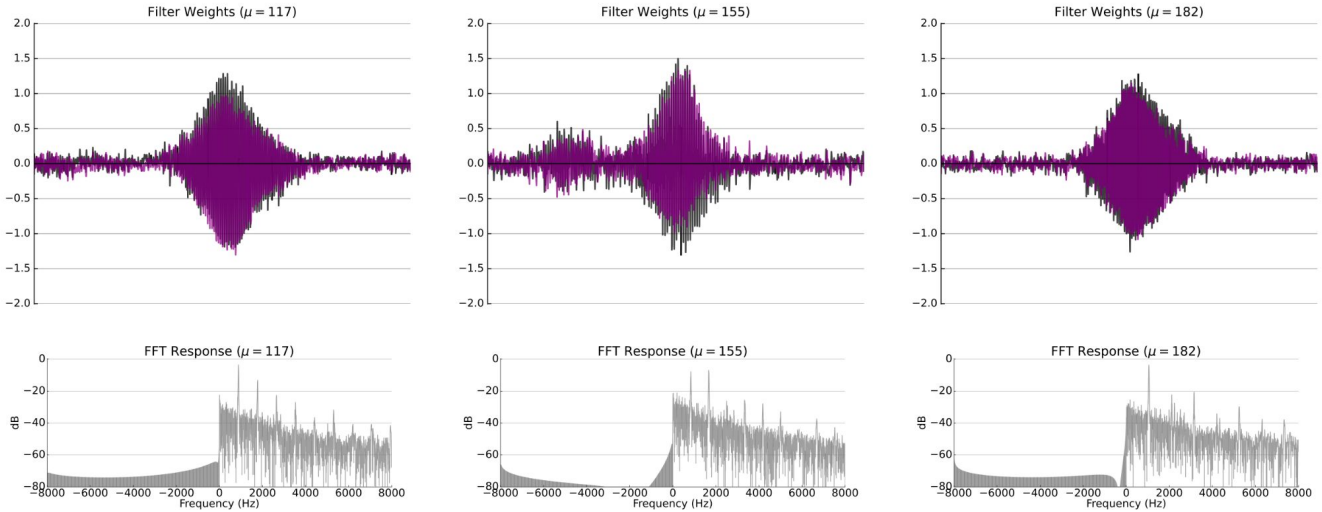
Hilbert + Random + Variational Dropout



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Discussion

- Learned filterbanks underperform standard spectral features
- Random-initialization on-par with VQT initialization
- Lots of interesting observations from filter visualization

Summary

- Investigated several variations of a complex filterbank learning module as a frontend for a simple piano transcription model
- Techniques to learn analytic filters and to enforce sparsity

All code is available at
https://github.com/cwitkowitz/sparse-analytic-filters

Many more filters can be viewed at https://arxiv.org/abs/2108.10382

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