Separation of an audio signal into harmonic/percussive components

Project work guidance session

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SGN-14006 Audio and Speech Processing

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Outline

1. Organisational matters
2. Objectives
3. Implementation
4. Evaluation and discussion
5. Report
6. Submission and guidance
7. References
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Organisational matters

- Mandatory, pass/fail.
- Groups of one–two.\(^1\)
- Code + part of test data + report.
- Deadline: **28.10.2014**.
- Submission & questions by email. sgn14006@cs.tut.fi

\(^1\) Email the lecturer if need a pair
Organisational matters

Start now.

- DL is far away, but you do not want to get stuck helpless in the end.

- Implementation is straightforward. Takes a couple of hours.

- Once it is working, there is still a lot of work: optimisation, justification of the performance, reporting.

- The earlier you start, the more help you may expect from the support line.
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Objectives

- **Implement** a drum separation algorithm [1].

- **Evaluate** its performance with some test data **subjectively** (perceptual quality of separation) and **objectively** (SNR).

- **Discuss** e.g.:
  - Dependency of separation quality on **parameters**.
  - **Applicability** of the algorithm in terms of acoustic **material**.
  - Sensibility of the **quality measures**.

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Implementation
Separation algorithm

- Implement as a function:

```matlab
[drumsSep, harmSep] = drumSeparator(mixture, fs, alpha...);
```

- No constants hardcoded!
  - If some constants are needed (fftlength, e.g.), declare and define them in one place.
  - Default separation parameter values, in case the corresponding parameters are omitted in the function (optional), can be specified in the beginning of the separation function:

```matlab
if ~exist('alpha','var')
    alpha = 0.3;
end
```
Implementation

Separation algorithm

- The algorithm (Eq. 24–30 in the paper) does separation based on the **power spectrogram** $W_{h,i}$, calculated from the complex spectrogram $F_{h,i}$.

- In the end, we **need to reconstruct the complex spectra** $(H_{h,i})^{1/(2\gamma)} e^{j\angle F_{h,i}}$ and $(P_{h,i})^{1/(2\gamma)} e^{j\angle F_{h,i}}$ and then the **time-domain signals** $h(t)$ and $p(t)$ (Eq. 29, 30).

- **Bugs** can be hiding there.

- **Advice**: at first, do not do separation, try to implement just this. Doing STFT and reconstructing the time-domain signal back. I.e., steps 1–3, 8 (Eq. 24, 25, 29, 30).

- If you get a signal that resembles the original well enough, only then proceed to steps 4–7.
Implementation

Separation algorithm

- Doing STFT: the spectrogram command:
  
  ```
  spectrogramFREQs = linspace(1,fs,fftlength);
  windowValues = sqrt(hann(winLength_samples));
  F_hi = spectrogram(inputSignal, windowValues, windowOverlap_samples, spectrogramFREQs, fs);
  ```

- In the end, we use the modified power spectrum for amplitude, and get the **phase** information **from the original spectrum**. Frame-wise.
  
  ```
  for frameID = 1:noFrames
      currentP_hi = P_hi_result(:,frameID);
      amplSpectrumP = (currentP_hi).^(1/(2*gamma));
      phaseSpectrum = angle(F_hi(:,frameID));
      fullSpectrumP = amplSpectrumP.*exp(j*phaseSpectrum);
  ..
  ```
Implementation

Separation algorithm

- Now reconstruct the time-domain signal:

```matlab
% ...
    timeDomainFrameP = ifft (fullSpectrumP, ifftlength, 'symmetric');
    drumsSep (startSample:endSample) = drumsSep (startSample:endSample) + windowValues.*
        timeDomainFrameP;
end
```

- Think what value to set for `ifftlength`.

- In the same loop the separated harmonics are reconstructed identically.
Implementation

Separation algorithm

- The omitted intermediate steps, where the actual analysis is performed, are straightforward. Just as in the paper.

- You may want to plot the values of $H_{h,i}^{(k)}$ and $P_{h,i}^{(k)}$ along the iterations to make sure that you are getting similar patterns on the spectrograms to the ones in the paper.

```matlab
imagesc(20*log10(H_hi{k+1}));
```
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Implementation

Script-wrapper for evaluation

- Specifies parameters
- Specifies acoustic data\(^1\)
- Reads audio tracks (remember \(F_s\))

\[
[vocalsOrig,fs] = \text{wavread}(\text{vocalsAudioPath});
\]

- Mixes them

\[
mixture = vocalsOrig + drumsOrig + guitarOrig;
\]

- Runs the algorithm

\[
[drumsSep,harmSep] = \text{drumSeparator}(mixture,fs,\text{params});
\]

Implementation

Script-wrapper for evaluation

- Evaluates the separated drums signal vs. original drums
  - **subjectively**
    
    ```
    sound(drumsSep,fs);
    ```
  - **objectively**: SNR
    
    \[
    \text{SNR} = 10 \log_{10} \frac{\sum_t s(t)^2}{\sum_t n(t)^2} \tag{1}
    \]

    ```
    Psignal = sum(drumsOrig.^2);
    Pnoise = sum((drumsOrig-drumsSep).^2);
    snr = 10*log10(Psignal./Pnoise);
    ```
Evaluation and discussion

- For the initial parameters, you may set the ones suggested in the paper.

- You evaluate the algorithm
  - subjectively by listening to the separated signals,
  - objectively by measuring SNR.

- Then you might try out other parameter values until you get a more satisfactory separation quality (no need for extensive four-dimensional sweeps!)
Evaluation and discussion

- Find **good parameter values** for **various acoustic material**.

- Try to **justify** (e.g., different for different audio – why?)

- What sort of **material** works best, what is inapplicable?

- Do **peaks in SNR values correspond to peaks in your subjective assessment**? Why?

- What are the **pros and cons** with each method? Can you **think of some** fast, cheap and reliable separation quality **criterion**?
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Report

- 4-5 pages, depending on illustrations.
- \LaTeX{} is not a must, but it never hurts.
- Proper language.
Proper **structure**. Roughly (not necessary exactly):

- Abstract
- Introduction
- Methodology
- Evaluation and Discussion
- Conclusions
- References
- Appendix
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6 Submission and guidance

SGN-14006 Project work guidance session – A. Diment 7.10.2014
Abstract

- Very briefly: **why** and **what** was done in simple words.
- **Good results!**
- How the results will/might **help** the humanity...
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Introduction

- **Problem**, how it has been addressed *before*, how it is solved *here*.

- **Motivation** for this solution (shortly from the paper – summary with a reference).

- How your work is *organised*: first this, then that, finally conclusions are drawn along with future research suggestions. . .
Report
Methodology

- **Implementation** details.
- What you did in the key points.
- What **tools** you used (frame-blocking, STFT etc.), values of some fixed **parameters**.
- You may draw a **block-diagram** of the whole system or just the crucial blocks.
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Evaluation and Discussion

- What **material** you used.
- What **measures** of evaluation were employed,
- **Results, tables, figures.**
- **Answers** to the questions you needed to answer.
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Conclusions

- **What** we did. What a wonderful **result** we got.
- **What new we introduced** to the scientific community:
  - we found optimal parameters for separating jazz music,
  - we came up with a novel criterion of measuring separation quality,
  - or our implementation is superfast, compared to original etc.
- Actually, **novelty is not expected** here, but if you have it, mention is bravely.
- End with how you suggest to continue the work. What exciting **future directions** were revealed to you while working on the problem.
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References and appendix

- **References**: at least the original article, maybe other sources.

- **Appendix**: Workload allocation. Mention very briefly, who did what in your group.
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Submission and guidance

- Submit well-commented code + chunk of test data + report to sgn14006@cs.tut.fi
- Questions: same email (so that both assistants see it).
- Try to start doing the thing now and ask questions now.
- Another support session may be also organised next week, if there is a need. Let us know.
- Exam: no idea, ask the lecturer.
References