Towards a musical beat emphasis function

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0 abstract

We present a new method for generating input features for musical audio beat tracking systems. To emphasise periodic structure we derive a weighted linear combination of sub-band onset detection functions driven by a measure of sub-band beat strength.

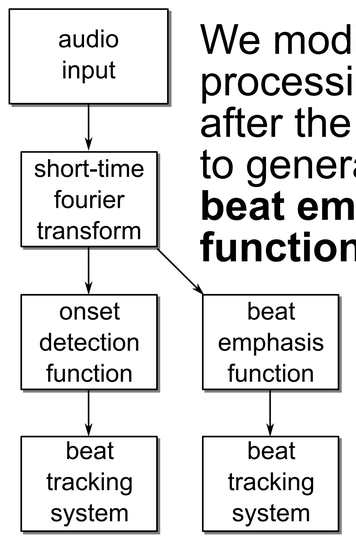
Results demonstrate improved performance over existing state of the art models, in particular for musical excerpts with a steady tempo.

1 introduction

A common input to audio beat tracking systems is the **onset detection function** [2]. A mid-level representation of the input audio signal with peaks at likely note onset locations.

Onset detection functions can be generated by measuring changes in (e.g.) spectral content in audio signals over short time scales (~10ms).

With the aim of extracting **beat locations** from music signals we explore the generation of an input feature which emphasises inherent periodicity in sub-band onset detection functions.



We modify the processing chain after the STFT to generate a **beat emphasis function**.

2 approach

We base our approach on the **complex spectral difference** onset detection function [2].

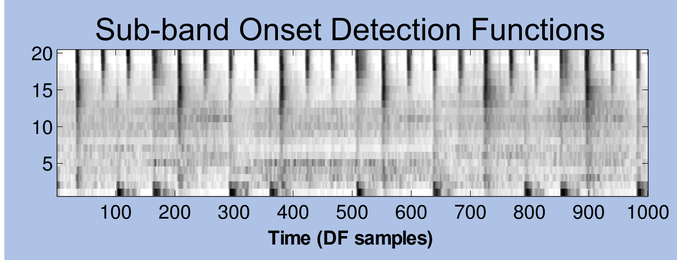
We use a Gammatone filterbank [5] to create a set of sub-band onset detection functions.

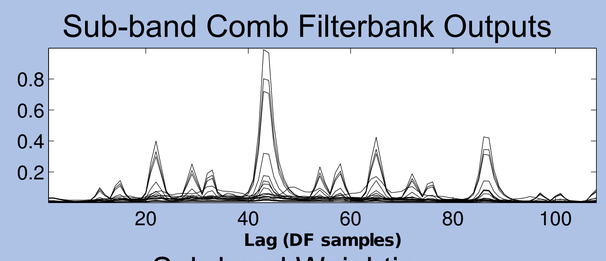
Within each sub-band we employ the periodicity detection stage from [3] by passing sub-band autocorrelation functions through a shift-invariant comb filterbank.

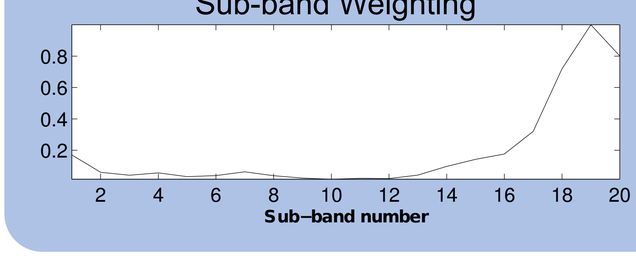
The height of the main peak of each filterbank output signal is taken as an indicator of periodicity strength and used as weighting for each band.

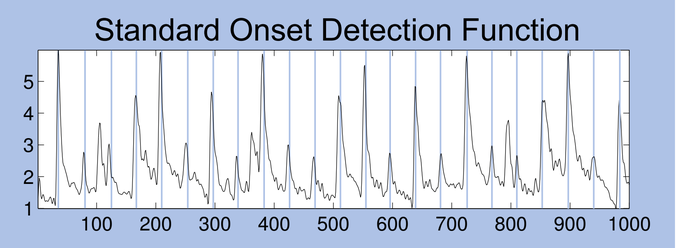
The resulting **beat emphasis function** is the linear combination of weighted sub-band detection functions.

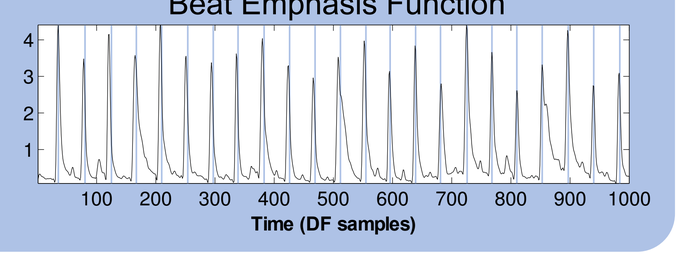
example 3











4 evaluation

We employ two methods for evaluation on an annotated database of 222 excerpts [4]:

1. **beat contrast:**
   the ratio of energy in the input feature at beats compared to non-beat locations.
2. **beat tracking accuracy:**
   using continuity-based evaluation, we find the longest continuously correct segment at the correct tempo (**CMLc**) and the total number of correct beats allowing for tapping at double or half the annotated tempo (**AMLt**).

5 results

Input Feature	Annotated Beats	Random Beats
BEF	1.501	1.002
ODF	1.398	1.003

Beat contrast: results indicate that there is more energy in the (BEF) beat emphasis function than in the standard (ODF) onset detection function at annotated beat locations.

Beat Tracker	CML_c (%)	AML_t (%)
BEF_{10}	59.7	82.5
BEF_{20}	58.7	83.2
BEF_{40}	57.8	82.0
ODF	56.1	81.0
KEA	55.7	80.0
DP	54.8	78.9

Beat tracking accuracy: results indicate that over a range of numbers of sub-bands, the BEF is able to outperform existing state of the art beat tracking systems: KEA [4] & DP [3].

Implementations of the ODF and DP beat tracking algorithms are available as plugins for Sonic Visualiser [1].

6 conclusions

Examining beat tracking performance across musical genres revealed that the BEF was most effective for musical excerpts with a steady tempo (Rock, Dance, Folk) and less effective for music characterised by variable tempo (Classical, Choral).

In future work we intend to explore methods for creating a **dynamic** weighting of sub-band onset detection functions able to contend with changes in tempo.

We also plan to investigate the fusion of other types of onset detection functions beyond the complex spectral difference approach [2].

7 references

[1] C. Cannam et al, "The Sonic Visualiser: A visualisation platform for semantic descriptors from musical signals," in Proc ISMIR 2006.

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[3] M. E. P. Davies and M. D. Plumbley, "Context-dependent beat tracking of musical audio," IEEE Transactions on Audio, Speech and Language Processing, 2007.

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[5] M. Slaney, "Auditory toolbox: A matlab toolbox for auditory modeling work," Interval Research Corporation, Tech. Rep., 1998.

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