Transformer-Based Beat Tracking with Low-Resolution Encoder and High-Resolution Decoder

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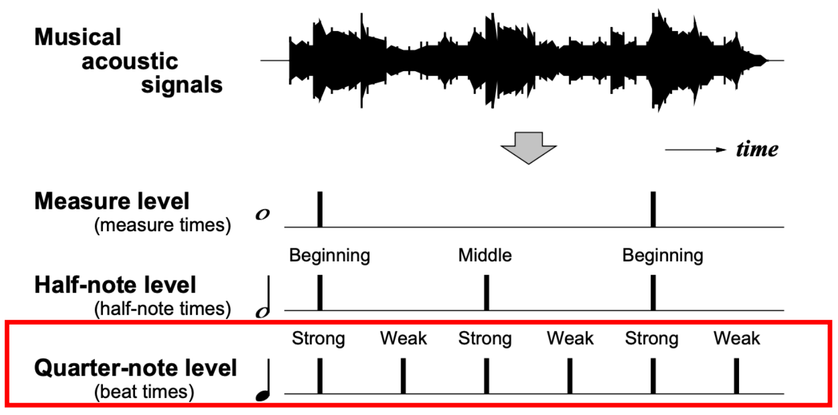
1. Introduction

We address the beat tracking task which is to predict beat times corresponding to the input audio.



[Goto&Muraoka1997]

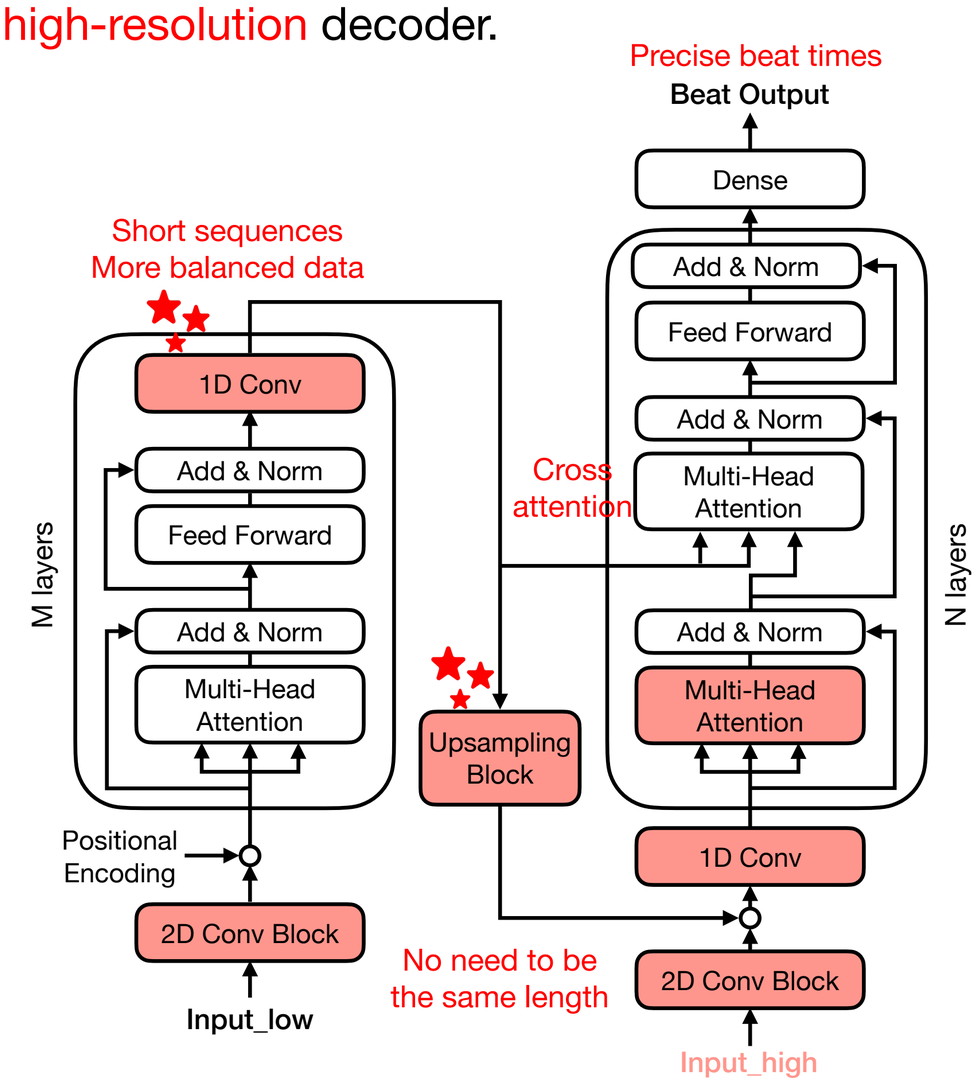
Motivation

- To produce good results, the model needs to consider both local timing and global consistency.
- This brings a contradiction on choosing the temporal resolution.

Low resolution	short sequences, more balanced data, no precise beat times
High resolution	long sequences, imbalanced data, precise beat times

2. Proposed model

A novel beat tracking model based on the Transformer with low-resolution encoder and high-resolution decoder.



Main modifications

1D Conv & Upsampling Block

In comparison to previous models,

our model uses both the encoder and decoder.

- Multi-scale features
- A more reasonable resolution for sequence modelling

3. Experiment

Data augmentation

- Tempo-wise
- Triple data using HPSS

Training

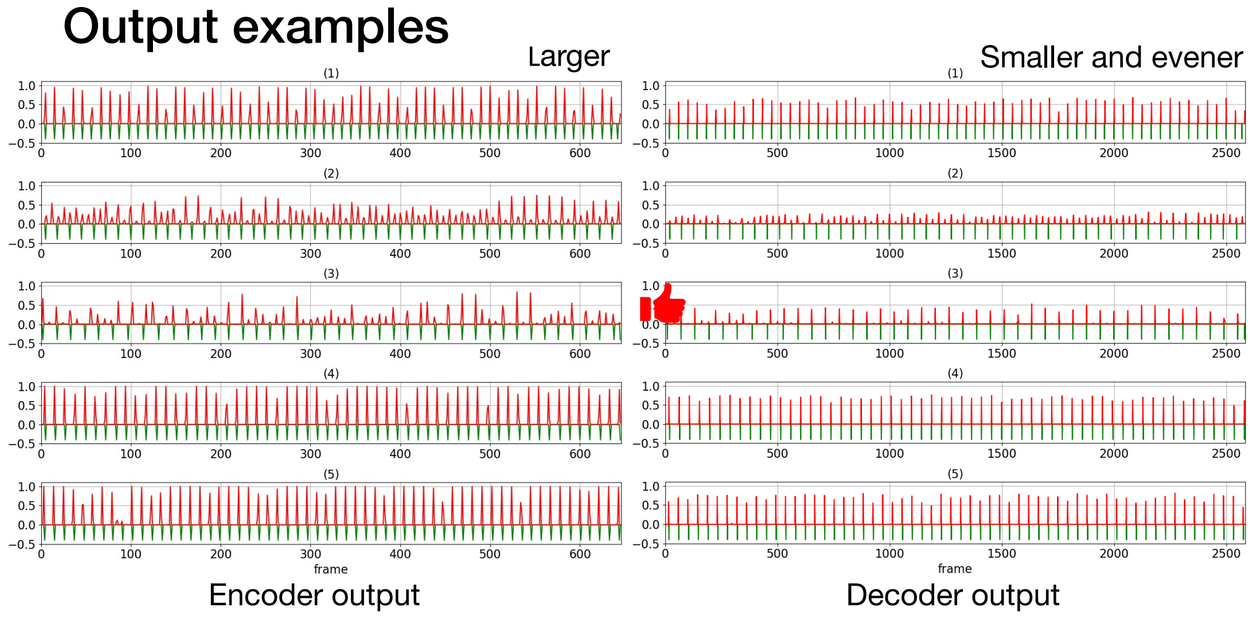
- Train the model with the pre-trained encoder

Results

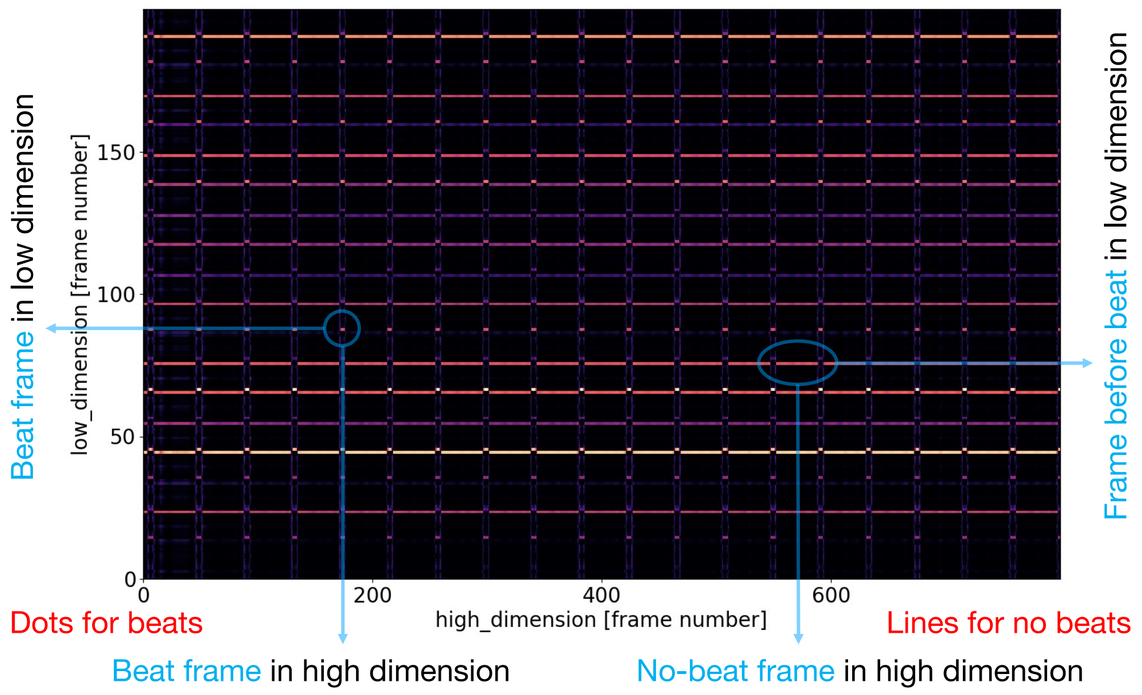
- Impressive results on the encoder by thresholding only.
- The decoder improves results of the Ballroom and GTZAN datasets.
- Post-processing (DBN) improves results especially for continuity-based ones.

Method	F-measure	CMLt	AMLt
Dataset: Ballroom			
Encoder (Th)	90.7	80.1	85.7
Encoder	93	87.4	96.1
Decoder (Proposed)	95	91.1	96.4
Beat trans [9]	96.8	95.4	96.6
TF trans [8]	96.2	93.9	96.7
TCN [7]	96.2	94.7	96.1
Dataset: Hainsworth			
Encoder (Th)	84.4	66.7	81.8
Encoder	88.2	81	93.4
Decoder (Proposed)	87	76.2	93.6
Beat trans [9]	90.2	84.2	91.8
TF trans [8]	87.7	86.2	91.5
TCN [7]	90.4	85.1	93.7
Dataset: SMC			
Encoder (Th)	53.9	32.9	45.6
Encoder	55	45.8	64.1
Decoder (Proposed)	55.4	45.1	65.6
Beat trans [9]	59.6	45.6	63.5
TF trans [8]	60.5	51.4	66.3
TCN [7]	55.2	46.5	64.3
Dataset: GTZAN			
Encoder (Th)	87.1	72.8	85.5
Encoder	87.8	78.5	93.7
Decoder (Proposed)	88.4	80.8	94
Beat trans [9]	88.5	80	92.2
TF trans [8]	88.7	81.2	92
TCN [7]	88.5	81.3	93.1

Output examples



Cross Attention Visualisation



4. Conclusions

- We present a novel Transformer-based model for beat tracking with the encoder and decoder of different resolutions.
- It provides a new framework for handling multi-scale features and learns features jointly by the cross attention in the decoder.
- It enables us to sample the features with more reasonable time resolutions, which helps to model the sequences more efficiently.
- We believe that the above advantages are beyond beat tracking and can be useful for other tasks too.