

# Chord-Conditioned Melody Harmonization with Controllable Harmonicity

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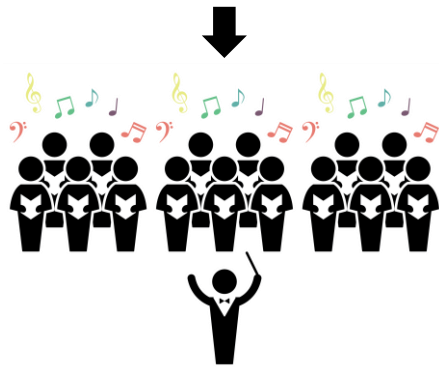
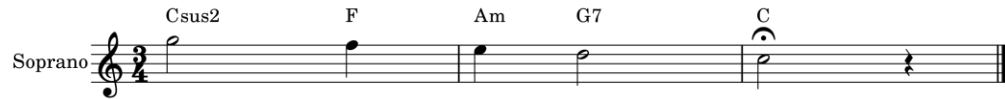
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# Melody Harmonization

Input  
Melody and Chord



Melody Harmonization System

A musical score for a four-part chorale in 3/4 time. The top staff is the 'Soprano' part, identical to the input. Below it are three staves for 'Alto', 'Tenor', and 'Bass'. The chord sequence (Csus2, F, Am, G7, C) is written above the Soprano staff. The Alto, Tenor, and Bass parts provide harmonic accompaniment for the melody.

Output Chorale

## Input

Soprano sequence  $S_{1:t} = \{S_1, S_2, \dots, S_t\}$

Chord sequence  $C_{1:t} = \{C_1, C_2, \dots, C_t\}$

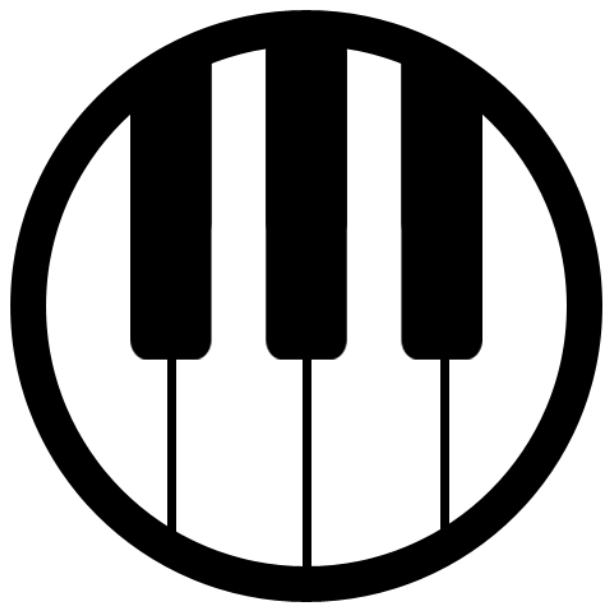
## Output

Alto sequence:  $A_{1:t} = \{A_1, A_2, \dots, A_t\}$

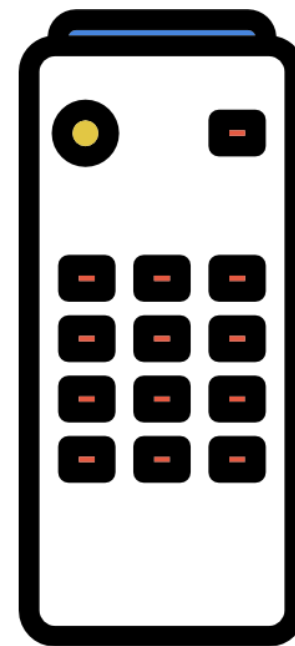
Tenor sequence:  $T_{1:t} = \{T_1, T_2, \dots, T_t\}$

Bass Sequence:  $B_{1:t} = \{B_1, B_2, \dots, B_t\}$

# Motivation



**Chord conditioning**



**Controllability**

# Music Representation

Gm D G G

Soprano

Alto

Tenor

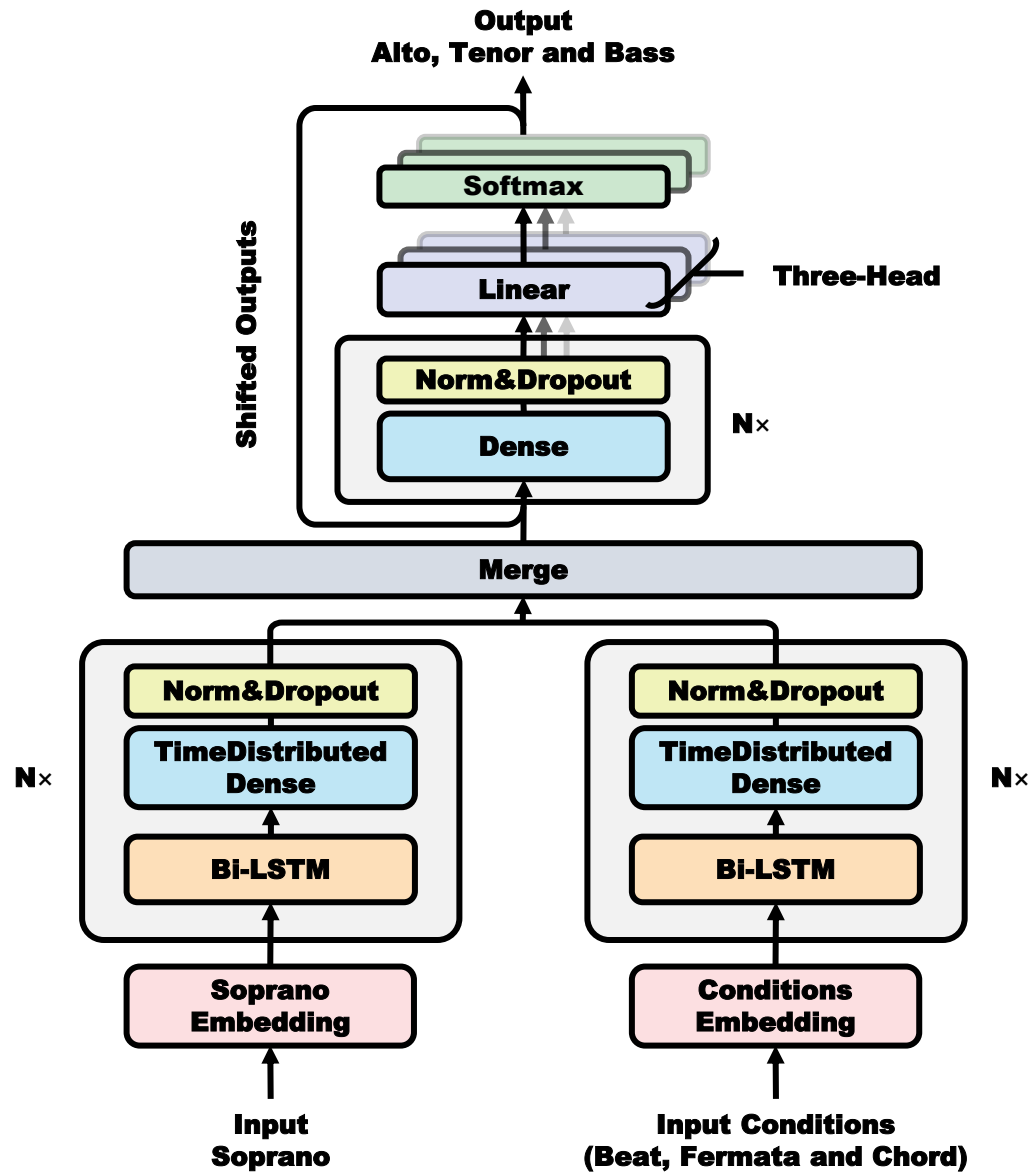
Bass

(a) Excerpt of a Bach chorale

<b>Soprano</b>	$S_{69}$	$S_{129}$	$S_{68}$	$S_{129}$	$S_{66}$	$S_{129}$	$S_{73}$	$S_{129}$
<b>Alto</b>	$A_{66}$	$A_{129}$	$A_{65}$	$A_{129}$	$A_{61}$	$A_{129}$	$A_{70}$	$A_{129}$
<b>Tenor</b>	$T_{61}$	$T_{129}$	$T_{129}$	$T_{59}$	$T_{58}$	$T_{129}$	$T_{66}$	$T_{129}$
<b>Bass</b>	$B_{54}$	$B_{129}$	$B_{49}$	$B_{129}$	$B_{42}$	$B_{129}$	$B_{54}$	$B_{129}$
<b>Fermata</b>	$f_{off}$	$f_{off}$	$f_{off}$	$f_{off}$	$f_{on}$	$f_{on}$	$f_{off}$	$f_{off}$
<b>Beat</b>	$b_3$	$b_0$	$b_1$	$b_0$	$b_2$	$b_0$	$b_1$	$b_0$
<b>Chord</b>	$c_{Gm}$	$c_{Gm}$	$c_D$	$c_D$	$c_G$	$c_G$	$c_G$	$c_G$

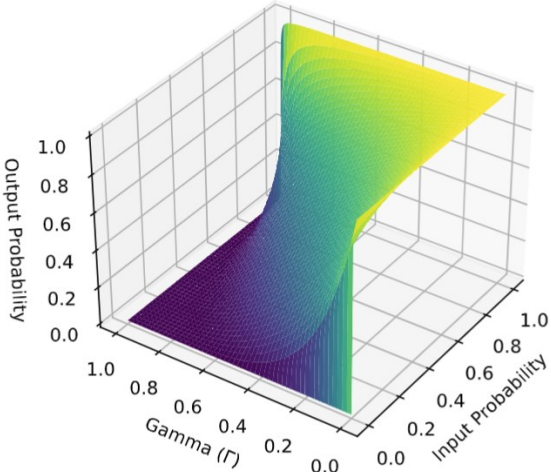
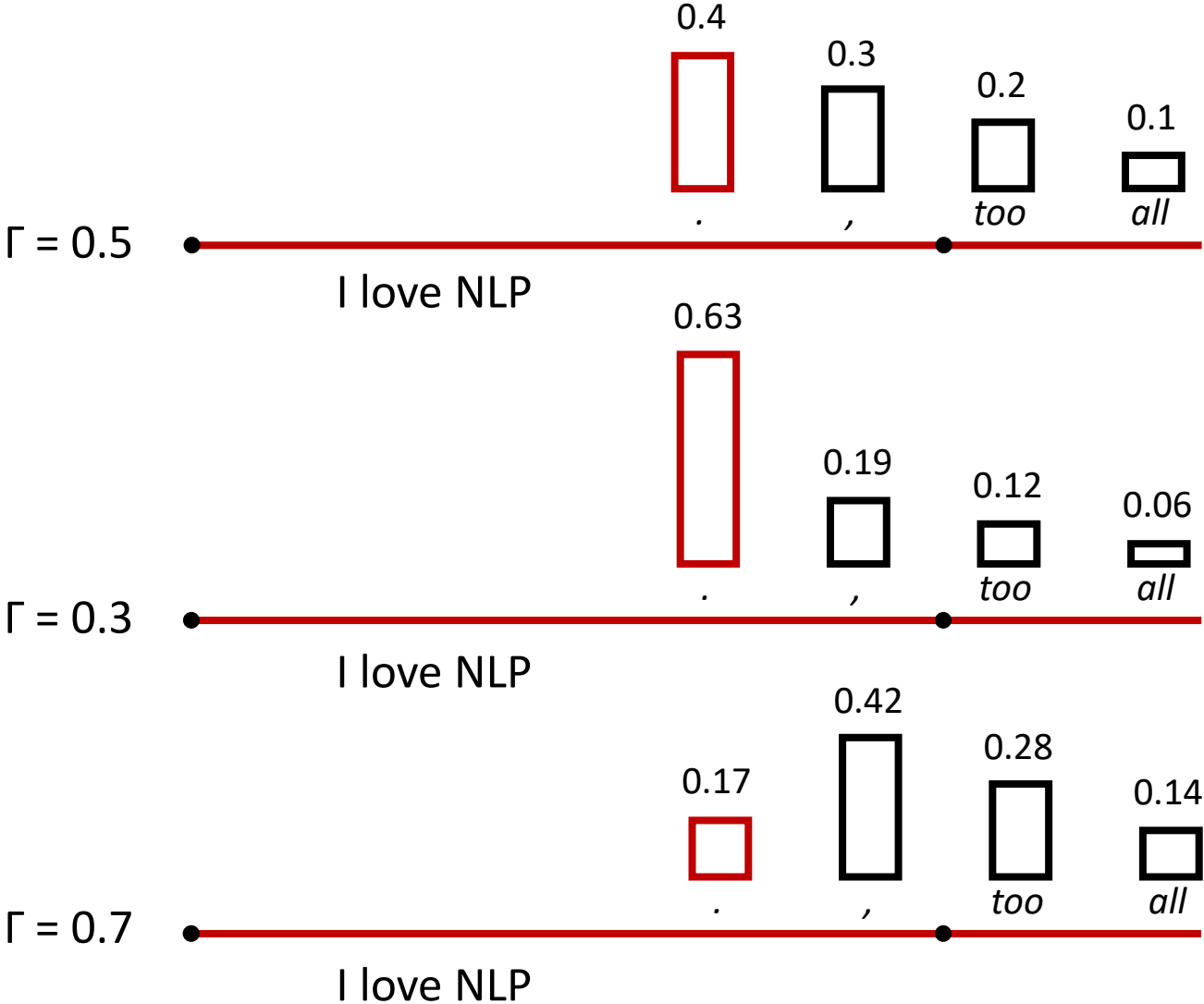
(b) Our data representation

# Model Design

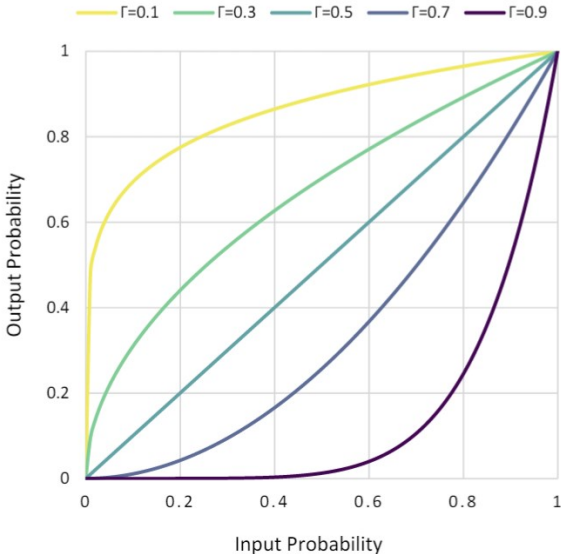


- Autoregressive model
- Encoder-decoder structure
- Two encoders: soprano encoder and conditions encoder
- Encoders use stacked Bi-LSTM with time-distributed dense layers
- Decoder uses stacked dense layer
- Generates ATB voices frame-by-frame

# Controllable Harmonicity



(a) 3D surface plot of GAMMA SAMPLING



(b) GAMMA SAMPLING with different  $\Gamma$

# JSB Dataset

3

C CM7/B Am C/E CM9/E F Faddb5 D/F#

Gm D D7/C G G C Bm/D D C/E Em7/D C6

Figure (a) displays a musical score in 4/4 time, consisting of two staves. The first staff is a treble clef with a key signature of one flat (B-flat). The second staff is a bass clef with a key signature of one flat. The score is annotated with chord symbols above the notes. The first staff has chords: C, CM7/B, Am, C/E, CM9/E, F, Faddb5, and D/F#. The second staff has chords: Gm, D, D7/C, G, G, C, Bm/D, D, C/E, Em7/D, and C6. The number '3' is written at the beginning of the second staff.

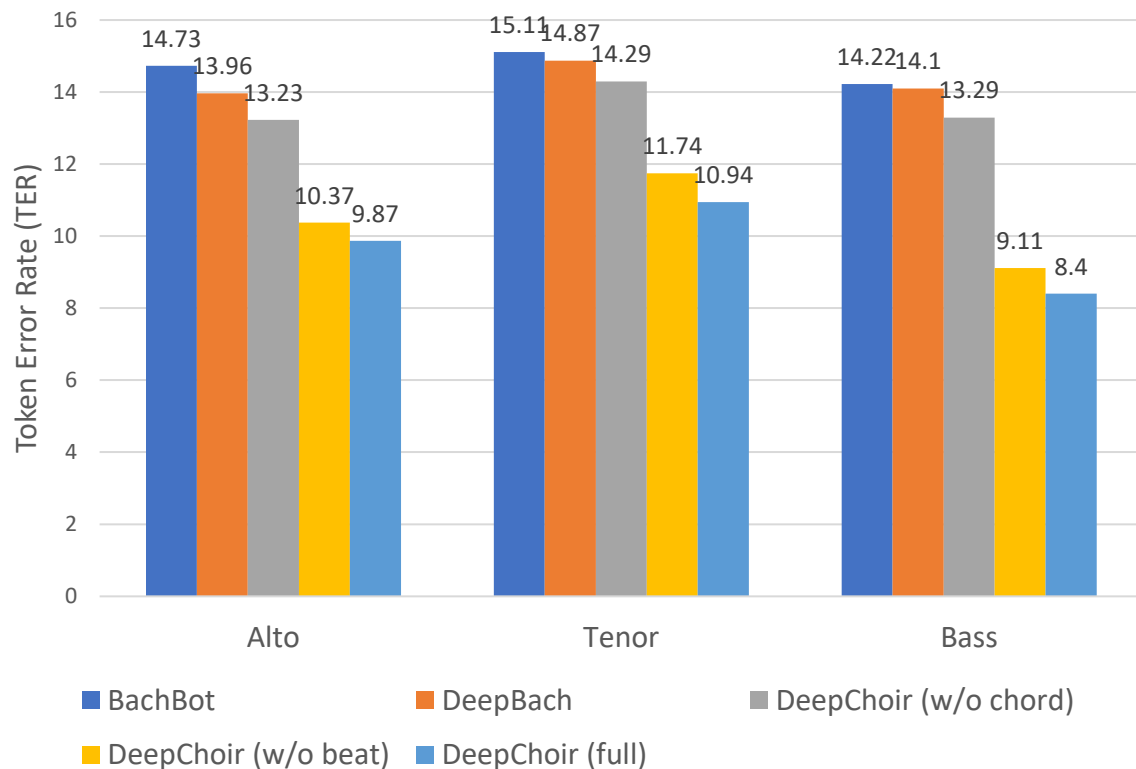
(a) Chordified chorale by music21 toolkit

C Am C/E F D/F# Gm D G G C Bm/D C/E Em7/D

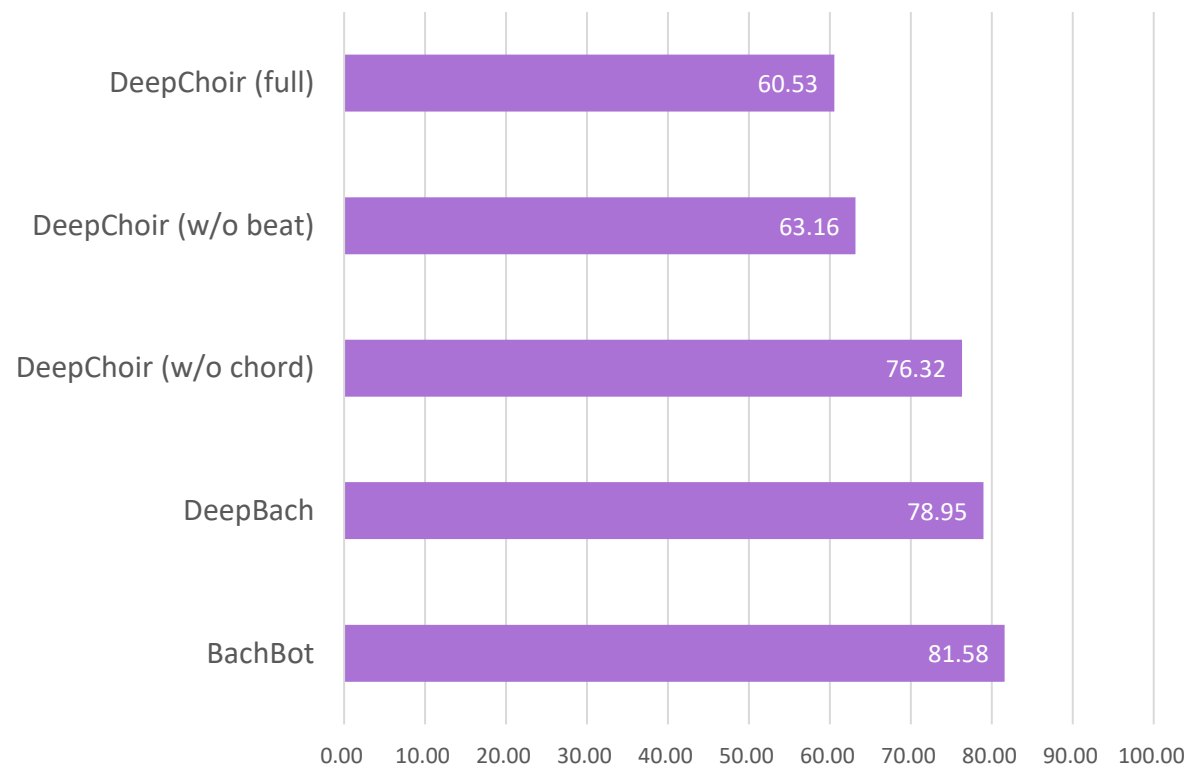
Figure (b) displays a musical score in 4/4 time, consisting of four staves. The first staff is a treble clef with a key signature of one flat. The second and third staves are also treble clefs with a key signature of one flat. The fourth staff is a bass clef with a key signature of one flat. The score is annotated with chord symbols above the notes. The chords are: C, Am, C/E, F, D/F#, Gm, D, G, G, C, Bm/D, C/E, and Em7/D.

(b) Chorale with automatically labelled chord symbols

# Evaluations of Music Representation



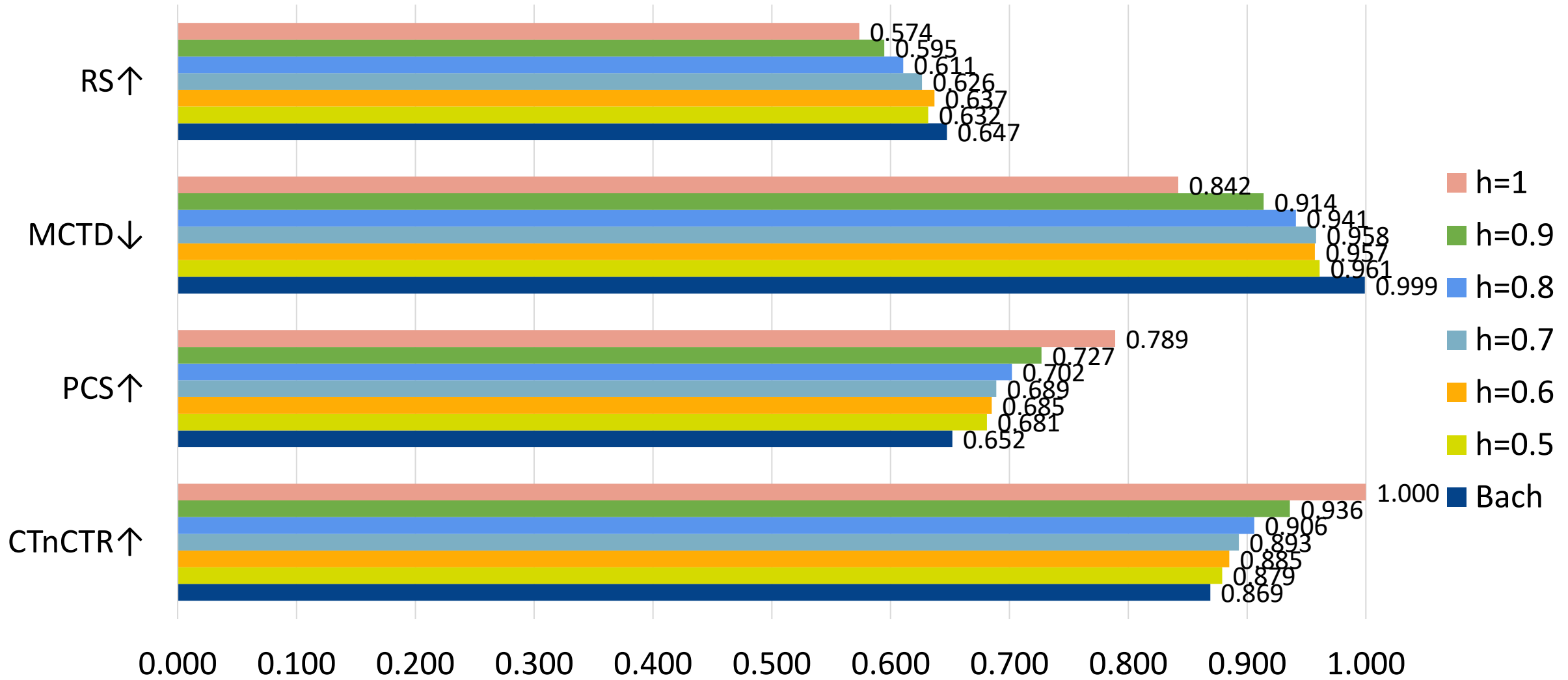
(a) Token error rate (TER) of various music representations



(b) Discrimination accuracy of the "Bach or Computer" experiment



# Evaluations of Controllability



# Generation Examples



**Input**



**Output**



**Input**



**Output**

# Conclusions

- DeepChoir is a chord-conditioned melody harmonization system.
- Generates chorales with controllable harmonicity.
- Promising results in generating chorales consistent with ground truth.
- Controlling parameter allows significant changes in harmonicity.
- Potential beyond Bach-style chorales to compose general polyphonic music.

# Thank You!



**GitHub Code**



**arXiv Paper**



**SoundCloud**