

AugmentedNet

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technische universität
dortmund

Input

The musical score is in 2/4 time. The treble staff contains a melodic line with a slur over the first four measures and a dashed line with an '8' above it for the next two measures, followed by a 'loco.' marking. The bass staff features a continuous eighth-note accompaniment. Chord labels are placed below the bass staff for each measure.

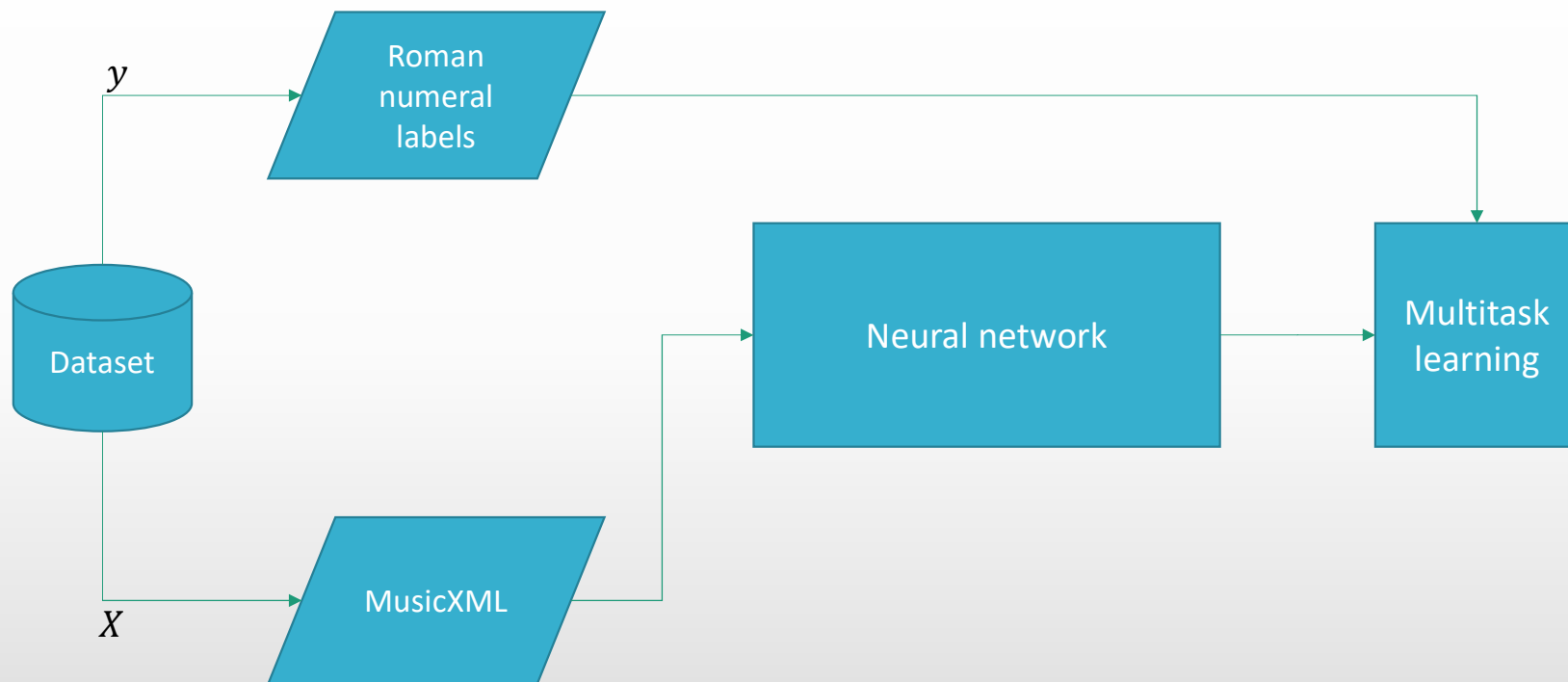
Measure	Chord Label
1	F:I
2	vi
3	V ⁶ /V
4	V ⁶ /V
5	I ⁶
6	vii ^o ₄ /ii
7	vii ^o ₄ /ii
8	V ⁷

Input

The musical score is in 2/4 time. The treble staff contains a melodic line with a sequence of eighth and sixteenth notes, including a triplet of eighth notes and a triplet of sixteenth notes. The bass staff contains a harmonic accompaniment with chords and triplets. The chords are labeled as follows:

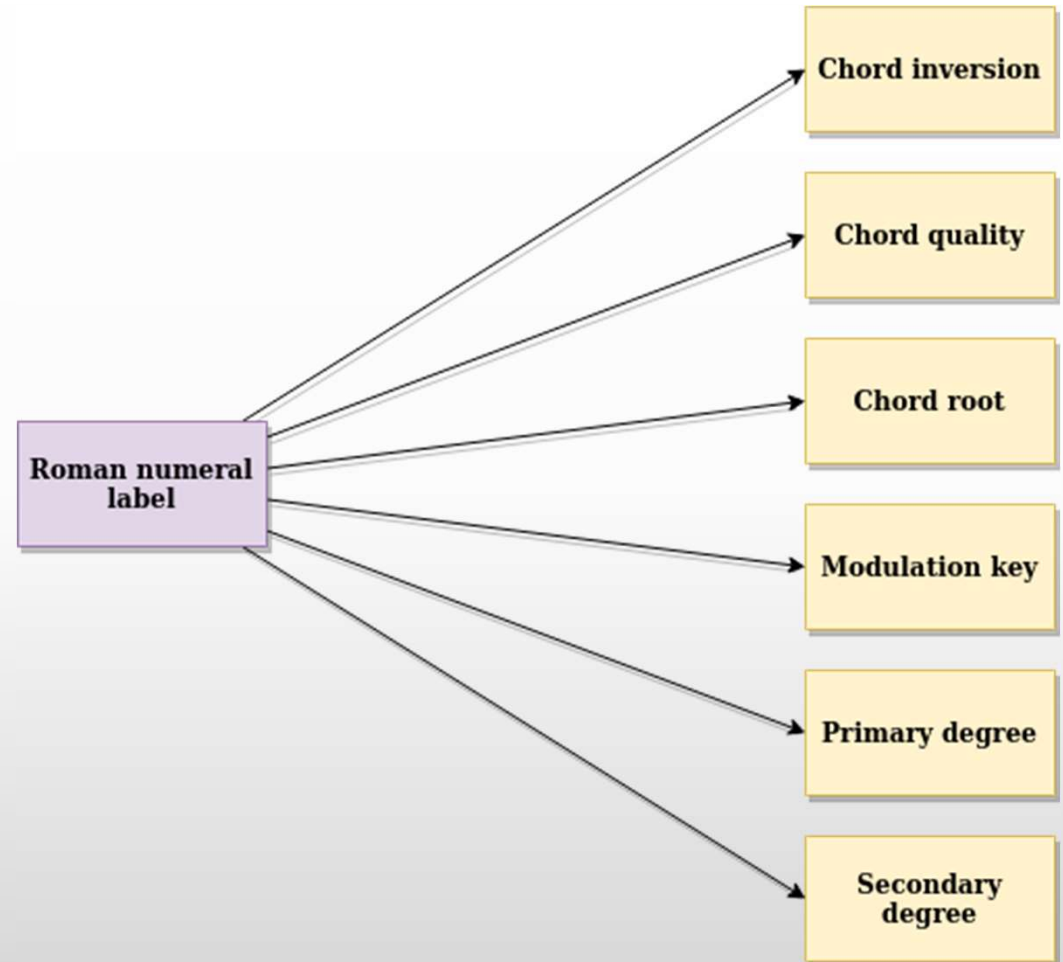
- F:I
- vi
- V⁶/V
- V⁶/V
- I⁶
- vii^o₄/ii
- vii^o₄/ii
- V⁷

Dynamic markings include *pp* (pianissimo) and *loco.* (loco). Articulation includes accents and slurs.



Chen and Su (2018)

- Divided the problem into 6 sub-tasks
- Each task was learned independently
- Then, the tasks were learned simultaneously using *multitask learning*



Multitask learning

- Hard (or soft) parameter sharing
- Figure taken from Ruder (2017)

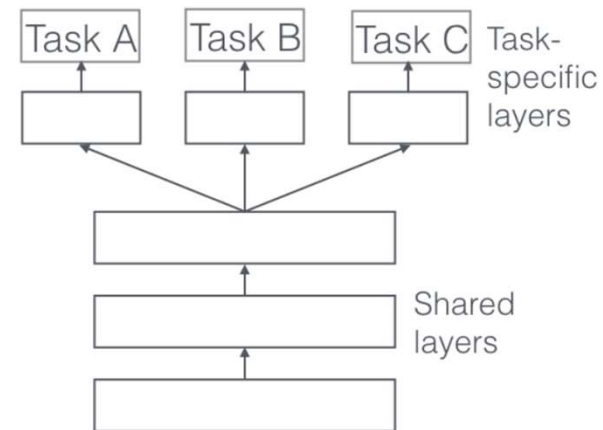
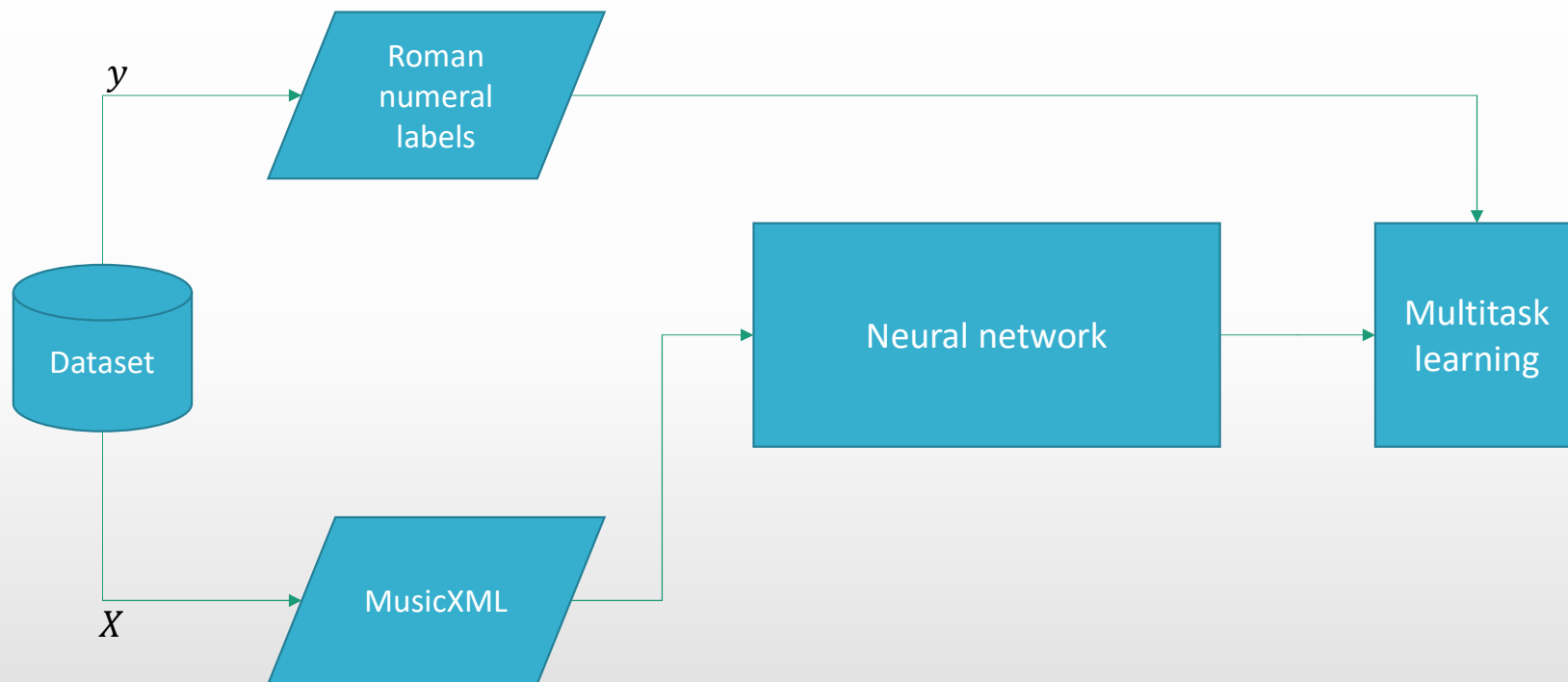
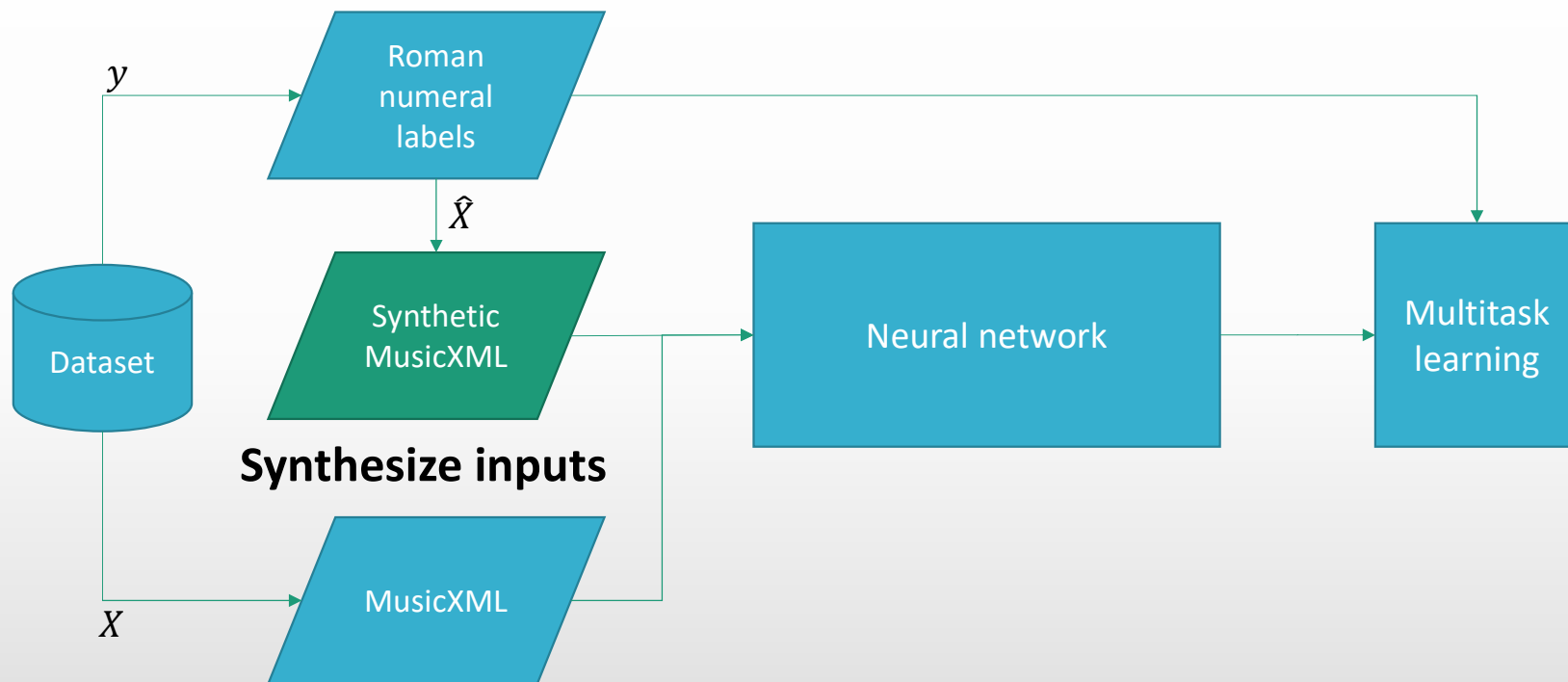
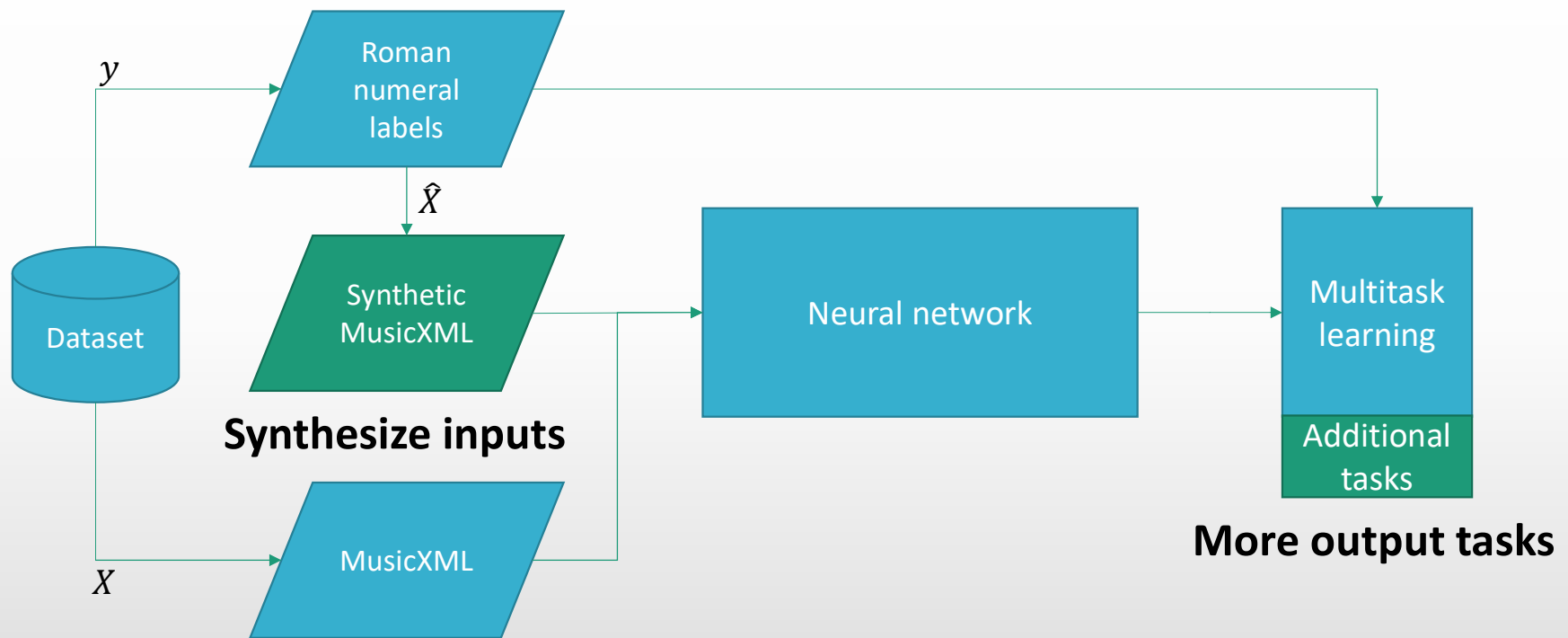


Figure 1: Hard parameter sharing for multi-task learning in deep neural networks







Input

The musical score is for a piano piece in 2/4 time. It consists of a right-hand melody and a left-hand accompaniment. The right hand starts with a half note F4, followed by a half note G4, then a quarter note A4, and a quarter note B4. It then has a trill on A4, followed by a quarter note G4, a quarter note F4, and a quarter note E4. The left hand has a triplet of eighth notes (F3, G3, A3), followed by a quarter note B3, a quarter note A3, and a quarter note G3. The score continues with various chords and a melodic line that includes a trill and a loco passage. The chords are labeled with Roman numerals and figured bass notation, and the melodic line is labeled with Roman numerals and figured bass notation.

pp

loco.

8

3 3

3

F:I vi V⁶/V V⁶/V I⁶ vii^{o4}/ii vii^{o4}/ii V⁷

Fmaj Dmin G⁷/B G⁷/B Fmaj/C F^{#dim7}/C F^{#dim7}/C C⁷

Slide 10

NNL1

Néstor Nápoles López, 2021-10-19

Roman numeral analysis

Music theory:
An analytical framework

Music Information Retrieval:
A compact annotation
system

Input

The musical score is for a piano piece in 2/4 time. It consists of two staves: a treble staff and a bass staff. The key signature has one flat (B-flat). The piece begins with a piano (*pp*) dynamic. The bass staff features a triplet of eighth notes in the first measure. The treble staff has a melodic line with a trill in the fifth measure, marked with a '3' and a bracket. The piece concludes with a final chord in the eighth measure. The following table summarizes the harmonic progression and associated markings:

Measure	Chord	Markings
1	F:I	Triplet in bass
2	vi	
3	V ⁶ /V	
4	V ⁶ /V	
5	I ⁶	Trill in treble
6	vii ^o ₄ /ii	Loco in treble
7	vii ^o ₄ /ii	Triplet in bass
8	V ⁷	

Input

pp

8

loco.

3

3

3

3

F:I vi V⁹/V V⁹/V I₆ vii[°]₄/ii vii[°]₄/ii V⁷

Tonal feature

Chord root

Chord quality

Chord inversion

Local key

Primary degree

Secondary degree

Roman numeral

F#

Diminished seventh

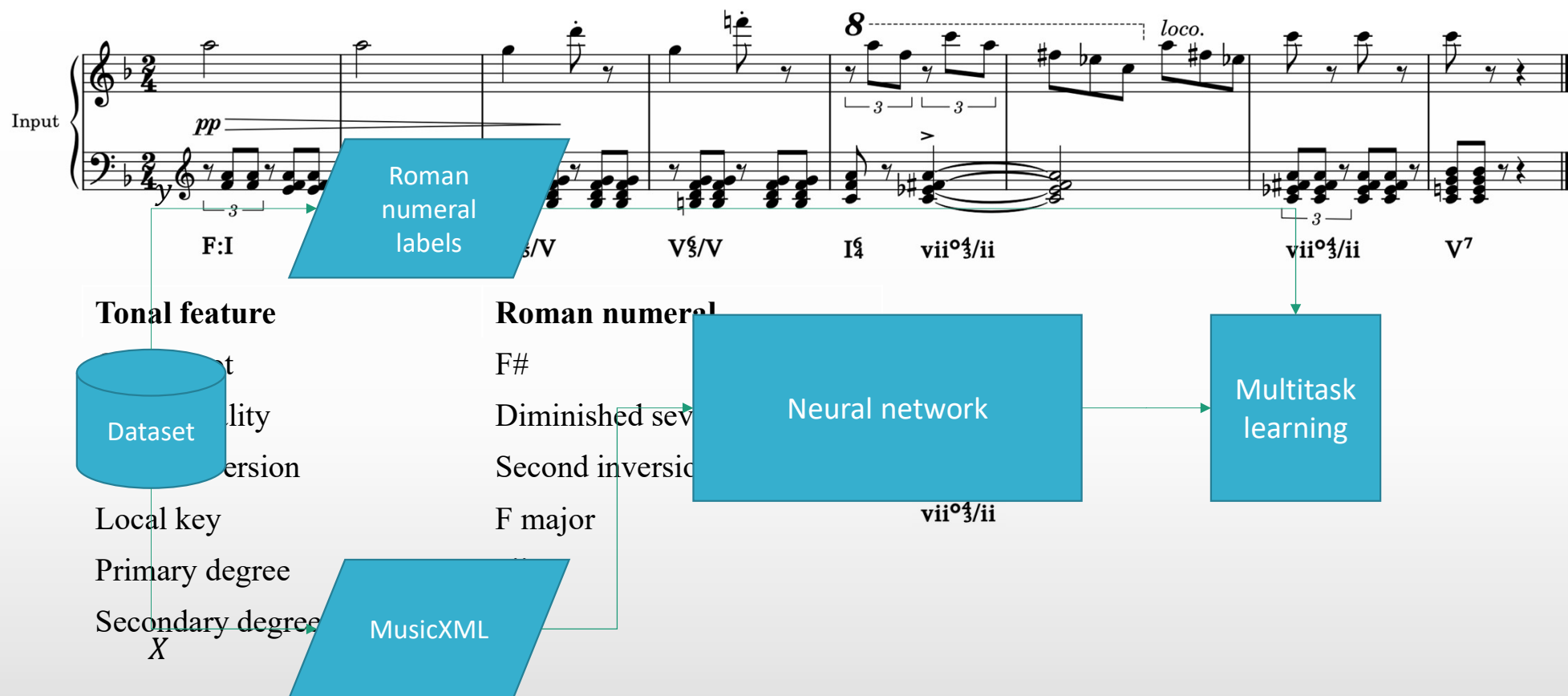
Second inversion

F major

vii

ii

vii[°]₄/ii



Input

pp

8

loco.

3

3

3

F:I vi V⁹/V V⁹/V I₆ vii[°]₄/ii vii[°]₄/ii V⁷

Tonal feature

Chord root

Chord quality

Chord inversion

Local key

Primary degree

Secondary degree

Roman numeral

F#

Diminished seventh

Second inversion

F major

vii

ii

vii[°]₄/ii

Input

pp

8

loco.

3

3

F:I

vi

V⁵/V

V⁵/V

I₄

vii[°]₄/ii

vii[°]₄/ii

V⁷

Tonal feature

Chord root

Chord quality

Chord inversion

Local key

Primary degree

Secondary degree

Bass

Tonicized key

Pitch class set

Roman numeral class
(minus inversion)

Roman numeral

F#

Diminished seventh

Second inversion

F major

vii[°]₄/ii

vii

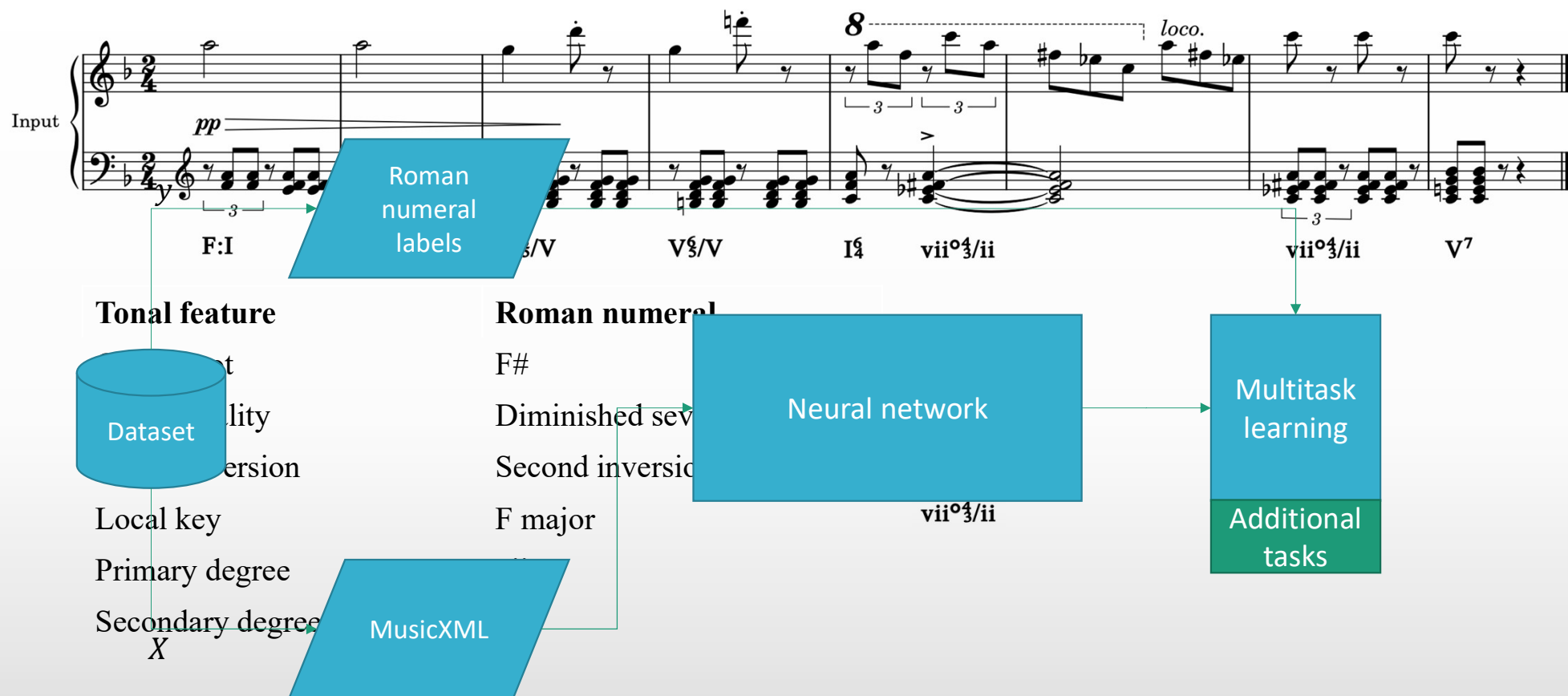
ii

C

G minor

{ 0, 3, 6, 9 }

vii[°]/ii



Chords

F:I
 vi
 V^9/V
 V^9/V
 I^4
 $\text{vii}^\circ\frac{4}{3}/\text{ii}$
 $\text{vii}^\circ\frac{4}{3}/\text{ii}$
 V^7

Piano

Chords

F:I vi V⁹/V V⁹/V I₄ vii[°]₄/ii vii[°]₄/ii V⁷

Piano
Synthetic

Chords

F:I vi V⁹/V V⁹/V I₄ vii[°]₄/ii vii[°]₄/ii V⁷

Josephine Lang (1815–1880)



Allegretto

Input

tr *pp* *loco.* *3* *3* *3* *3* *3*

Synthetic

Chords

2/4 F:I vi V⁹/V V⁹/V I⁹ vii^{o4}/ii vii^{o4}/ii V⁷

Josephine Lang (1815–1880)



Allegretto

Input

tr *pp* *loco.* *3* *3* *3*

8

3 3 3

Synthetic

Chords

2
4

F:I vi V⁹/V V⁹/V I₄ vii^{o4}/ii vii^{o4}/ii V⁷

Josephine Lang (1815–1880)



Allegretto

tr

pp

8

loco.

3

3

3

3

Input

TSynthoid

Separate the bass

Chords

2/4

F:I

vi

V⁵/V

V⁵/V

I₄

vii^o₃/ii

vii^o₃/ii

V⁷

Josephine Lang (1815–1880)



Allegretto

tr

pp

8

loco.

3

3

3

3

Input

Texturized

Syncopation

Chords

2/4

F:I

vi

V⁶/V

V⁶/V

I₄

vii^o₄/ii

vii^o₄/ii

V⁷

Josephine Lang (1815–1880)



Input

Allegretto

tr *pp* *loco.*

8

3 3 3

Texturized

Alberti Bass

Chords

2/4

F:I vi V⁹/V V⁹/V I₄ vii^{o4}/ii vii^{o4}/ii V⁷

Josephine Lang (1815–1880)



Allegretto

tr *pp* *loco.*

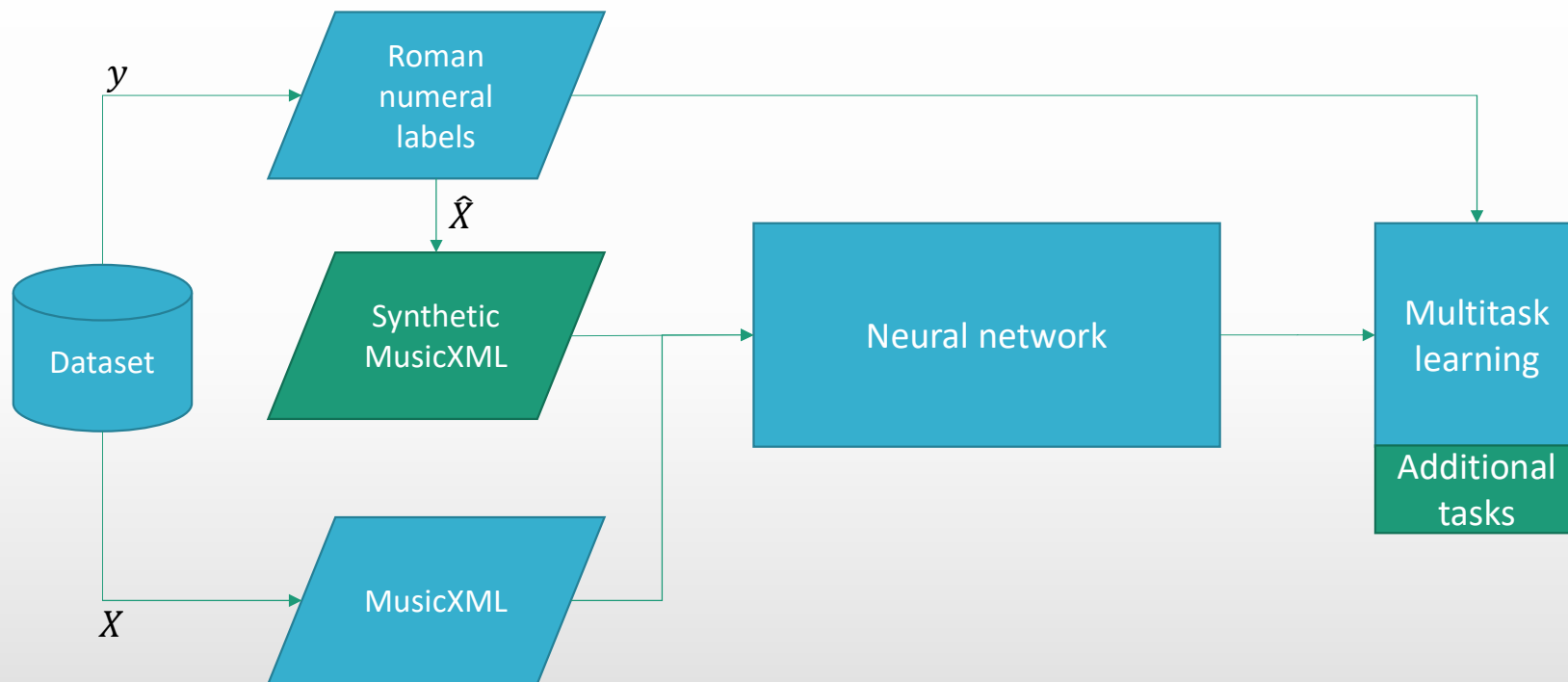
Input

Texturized

Chords

2/4

F:I vi V⁹/V V⁹/V I₄ vii^o₄/ii vii^o₄/ii V⁷



Datasets

Annotated Beethoven Corpus (Neuwirth et al., 2018)

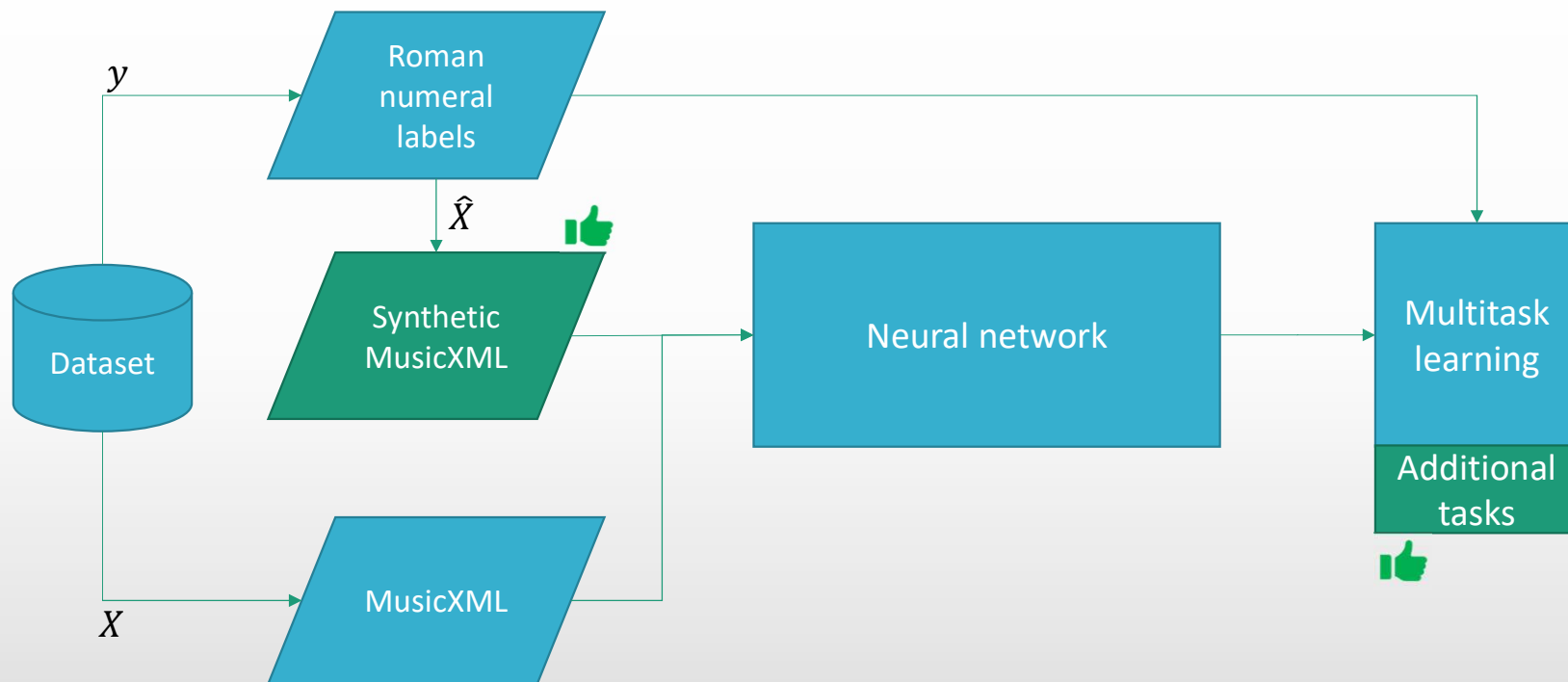
Beethoven Piano Sonatas (Chen and Su, 2018)

Haydn Sun String Quartets (Nápoles López, 2017)

TAVERN (Devaney et al., 2015)

When-in-Rome (Gotham, 2021)

The Well-Tempered Clavier (Tymoczko et al., 2019)



Model	Key	Degree	Quality	Inversion	Root	Roman Numeral
AugmentedNet ₆	82.7	64.4	76.6	77.4	82.5	43.3
AugmentedNet ₆₊	83.0	65.1	77.5	78.6	83.0	44.6
AugmentedNet ₁₁	81.3	64.2	77.2	76.1	82.9	43.1
AugmentedNet ₁₁₊	83.7	66.0	77.6	77.2	83.2	45.0

AugmentedNet vs. previous models

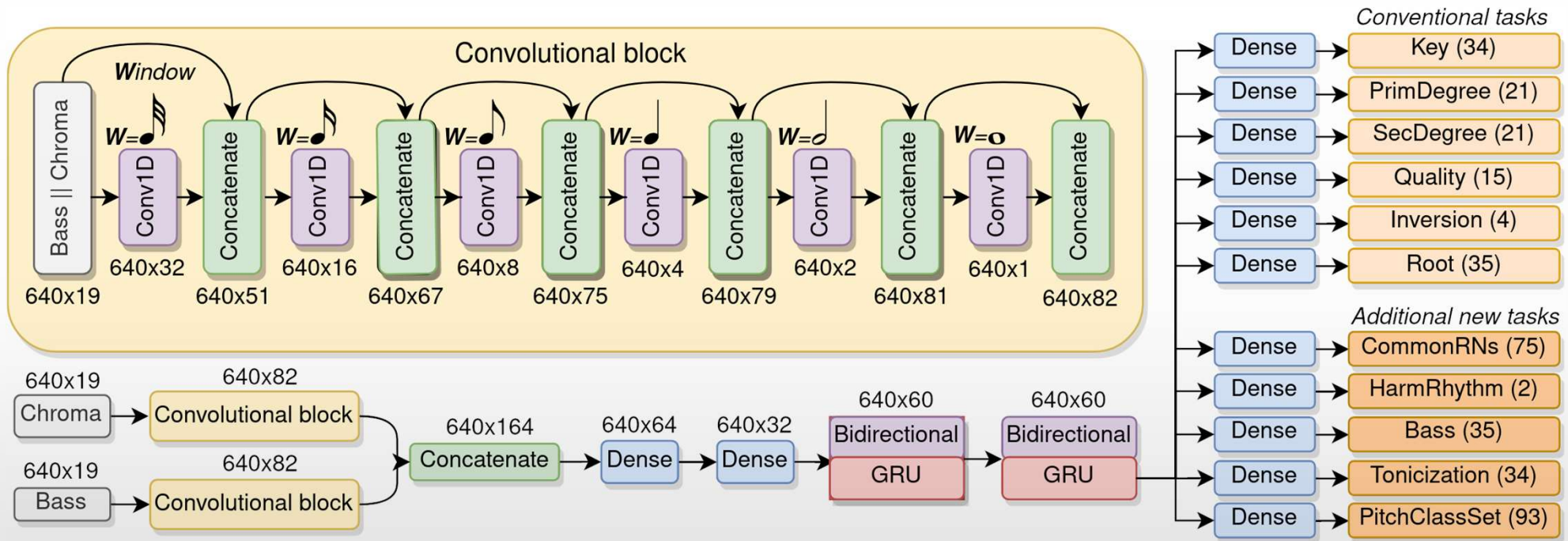
Test set	Training set	Model	RN (accuracy)
Well-Tempered Clavier	All available data (2021)	AugmentedNet	46.2
Well-Tempered Clavier _{crossval}	BPS+WTC	AugmentedNet	42.9 _(4.2)
Well-Tempered Clavier _{crossval}	BPS+WTC	Chen and Su (2021)	26.0 _(1.7)
Beethoven Piano Sonatas	All available data (2021)	AugmentedNet	45.4
Beethoven Piano Sonatas	All available data (2020)	Micchi et al. (2020)	42.8
Beethoven Piano Sonatas	BPS+WTC	AugmentedNet	44.1
Beethoven Piano Sonatas	BPS+WTC	Chen and Su (2021)	41.7
Beethoven Piano Sonatas	BPS	AugmentedNet	44.0
Beethoven Piano Sonatas	BPS	Micchi et al. (2020)	39.1
Beethoven Piano Sonatas	BPS	Chen and Su (2019)	-
Beethoven Piano Sonatas	BPS	Chen and Su (2018)	25.7

AugmentedNet vs. previous models

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Paper - Code - Video - Experiments - Data

<https://napulen.github.io/publication/augmentednet/>



Thank you!