MuseGAN: Multi-track Sequential Generative Adversarial Networks for Symbolic Music Generation and Accompaniment

Hao-Wen Dong*, Wen-Yi Hsiao*, Li-Chia Yang, Yi-Hsuan Yang

Research Center of IT Innovation, Academia Sinica

**these authors contributed equally to this work*

Outlines

- Goals & Challenges
- Data
- Proposed Model
- Results & Evaluation
- Recent Work
- Future Works

Source Code https://github.com/salu133445/musegan

Demo Page https://salu133445.github.io/musegan/

Goals & Challenges

Goals

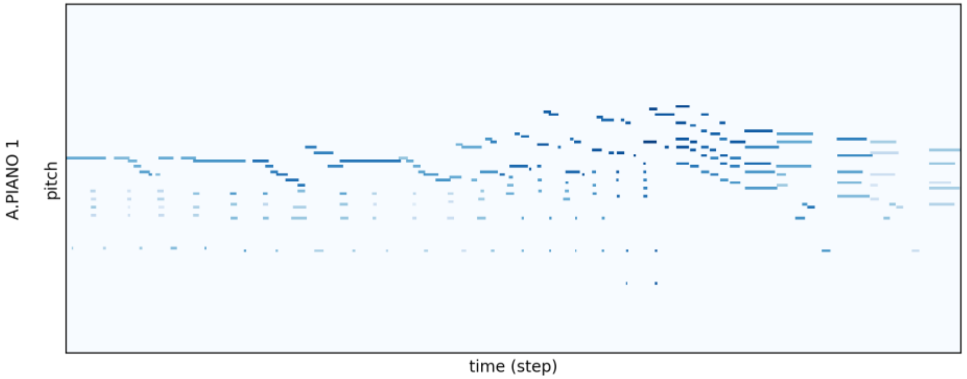
[Source Code]
https://github.com/salu133445/musegan

[Demo Page]
https://salu133445.github.io/musegan/

Generate pop music

- of **multiple tracks**

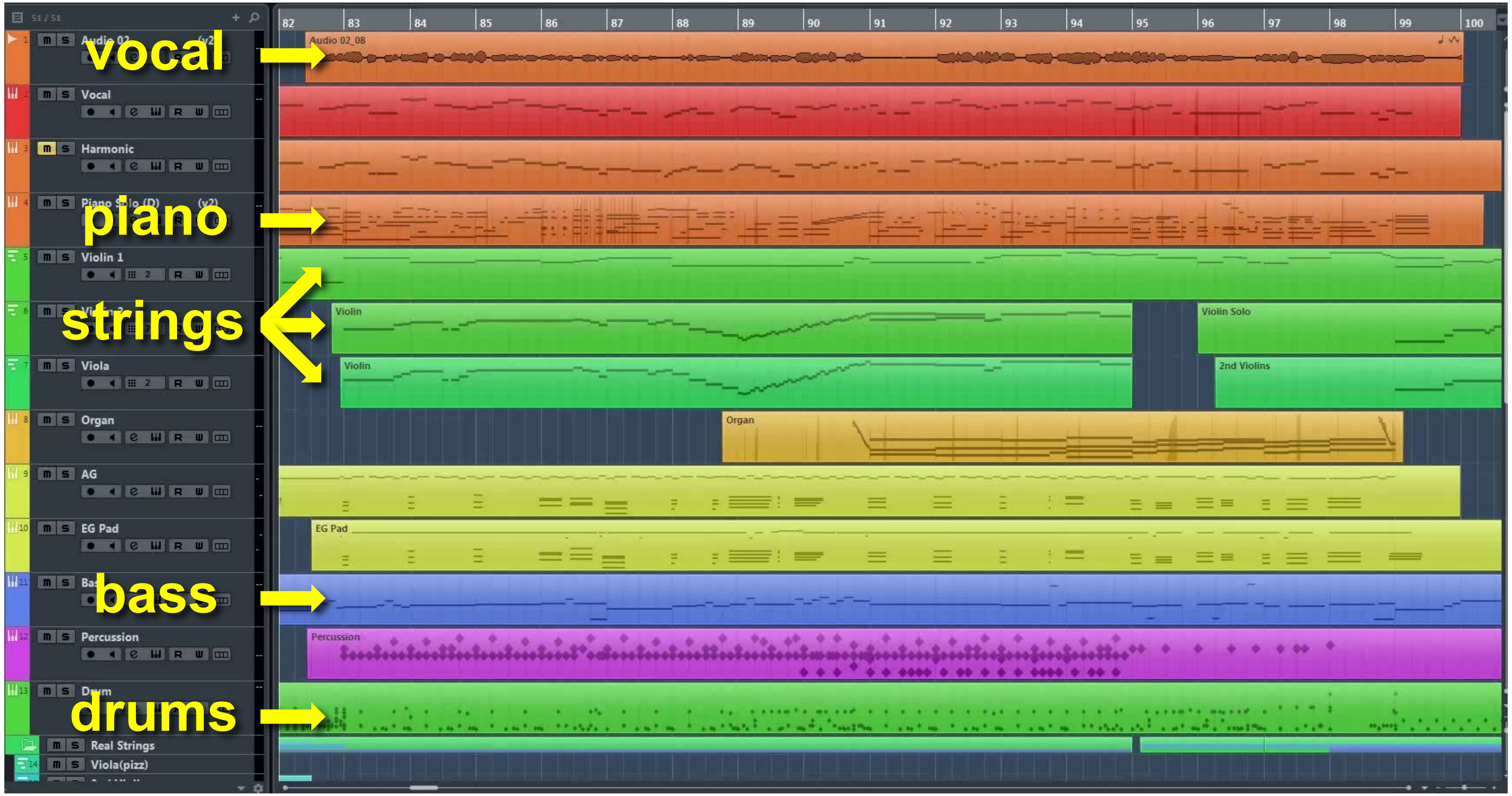
- in **piano-roll** format



- using **GAN** with **CNNs**

Challenge I

Multitrack Interdependency

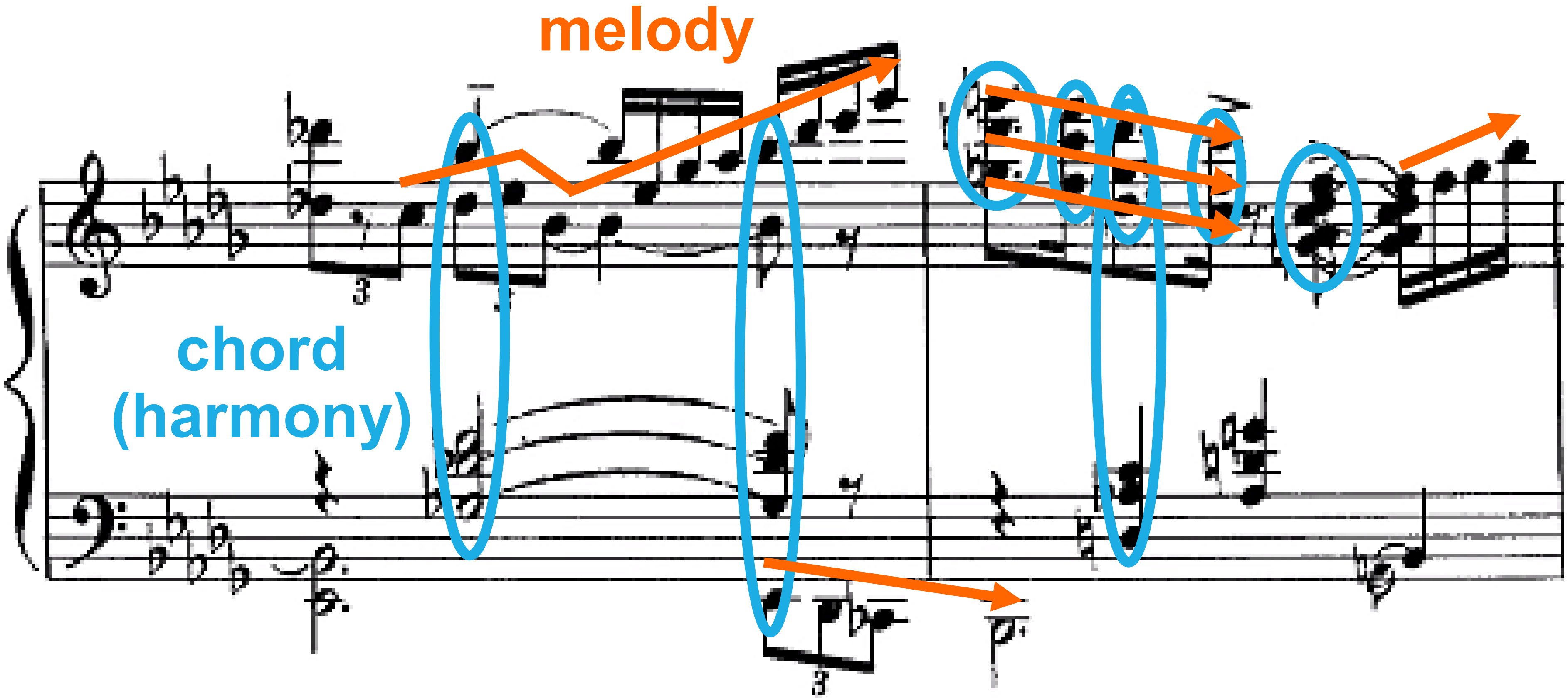


music & clip by
phycause

Challenge II

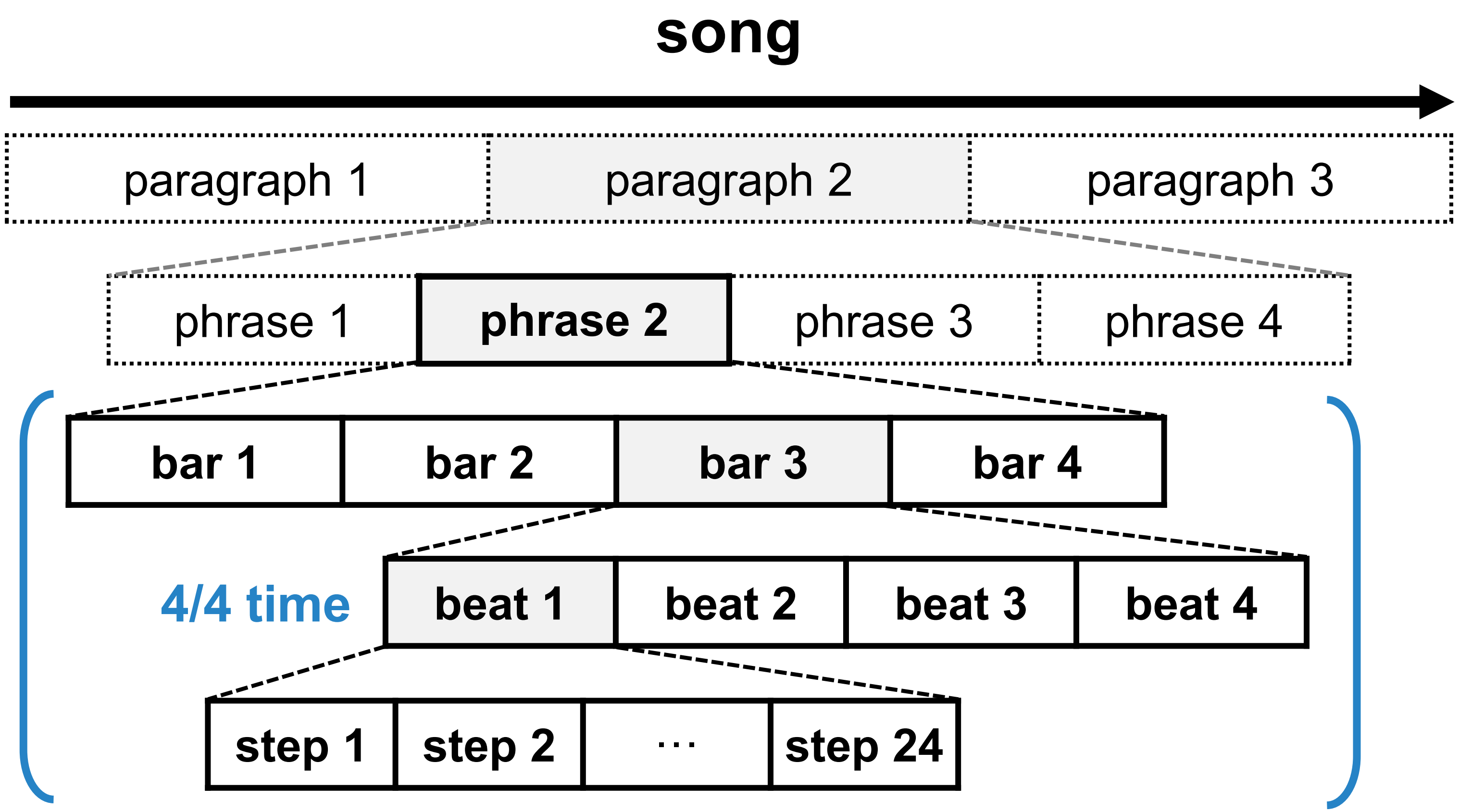
Convolutional Neural Networks

Music Texture



Challenge III

Temporal Structure



song

paragraph 1 | paragraph 2 | paragraph 3

phrase 1 | **phrase 2** | phrase 3 | phrase 4

bar 1 | **bar 2** | **bar 3** | **bar 4**

4/4 time

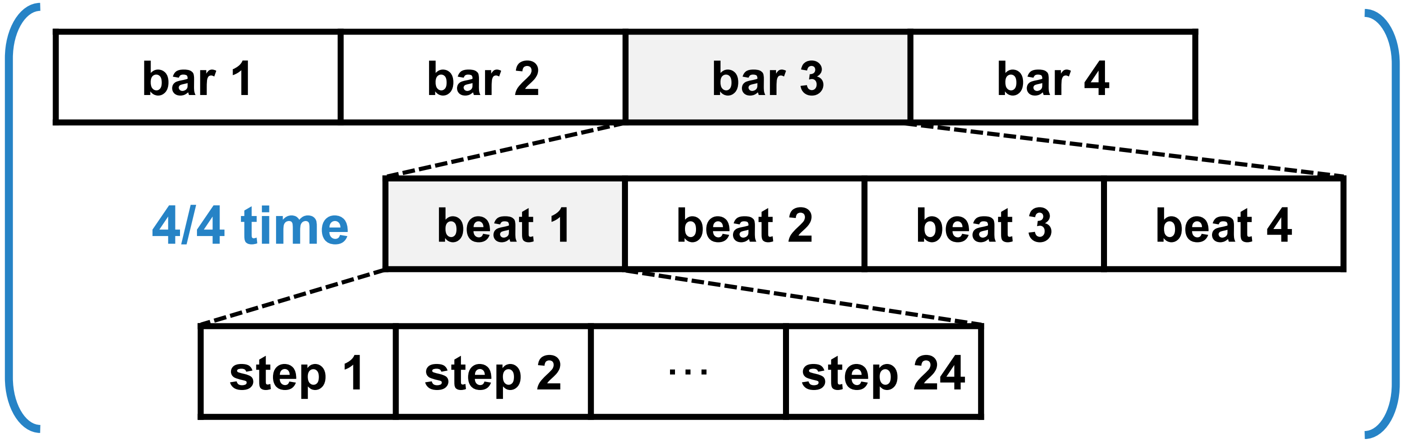
beat 1 | **beat 2** | **beat 3** | **beat 4**

step 1 | **step 2** | ··· | **step 24**

Challenge III

Convolutional Neural Networks

Temporal Structure



bar 1 | bar 2 | bar 3 | bar 4

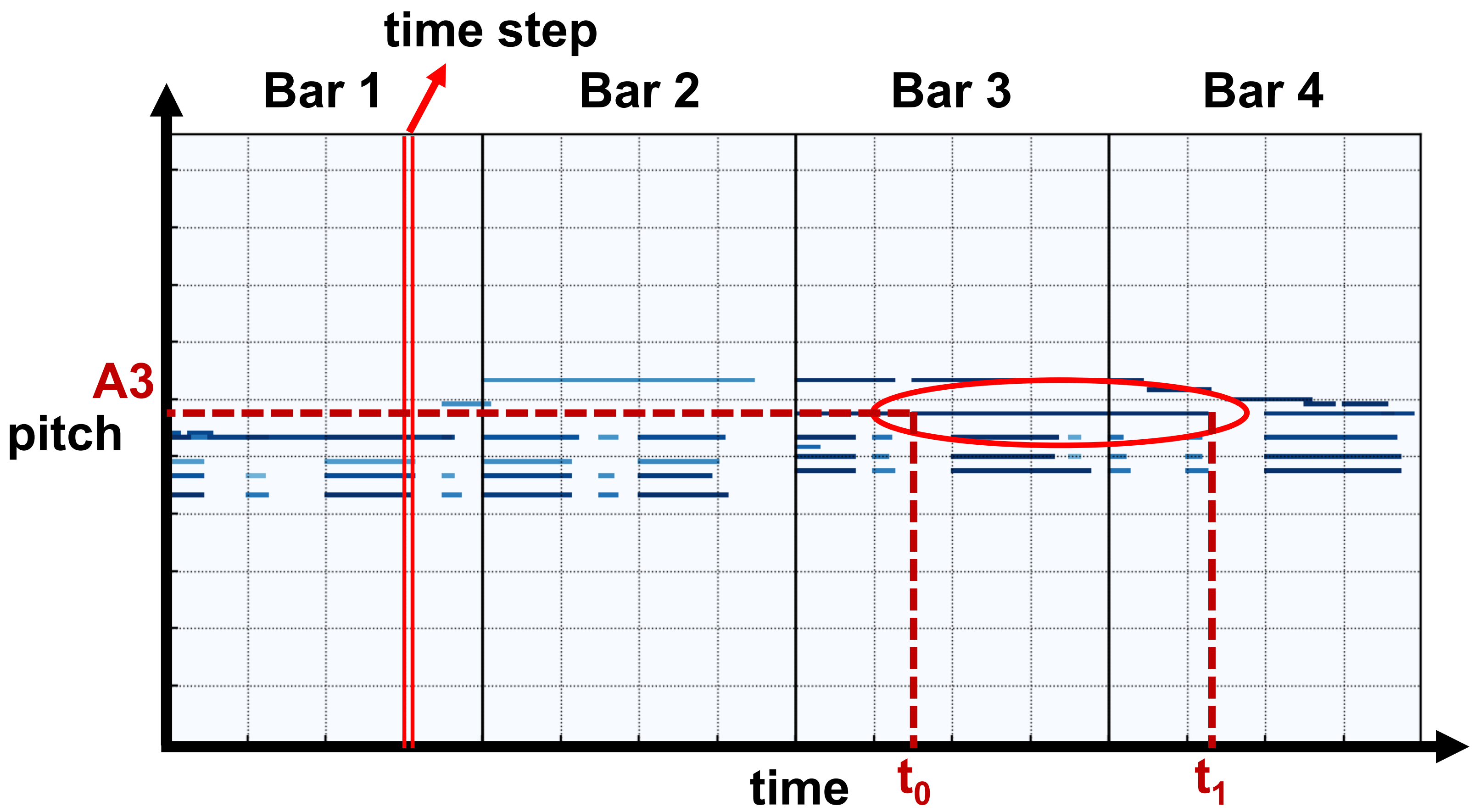
4/4 time

beat 1 | beat 2 | beat 3 | beat 4

step 1 | step 2 | ··· | step 24

Data

Data Representation



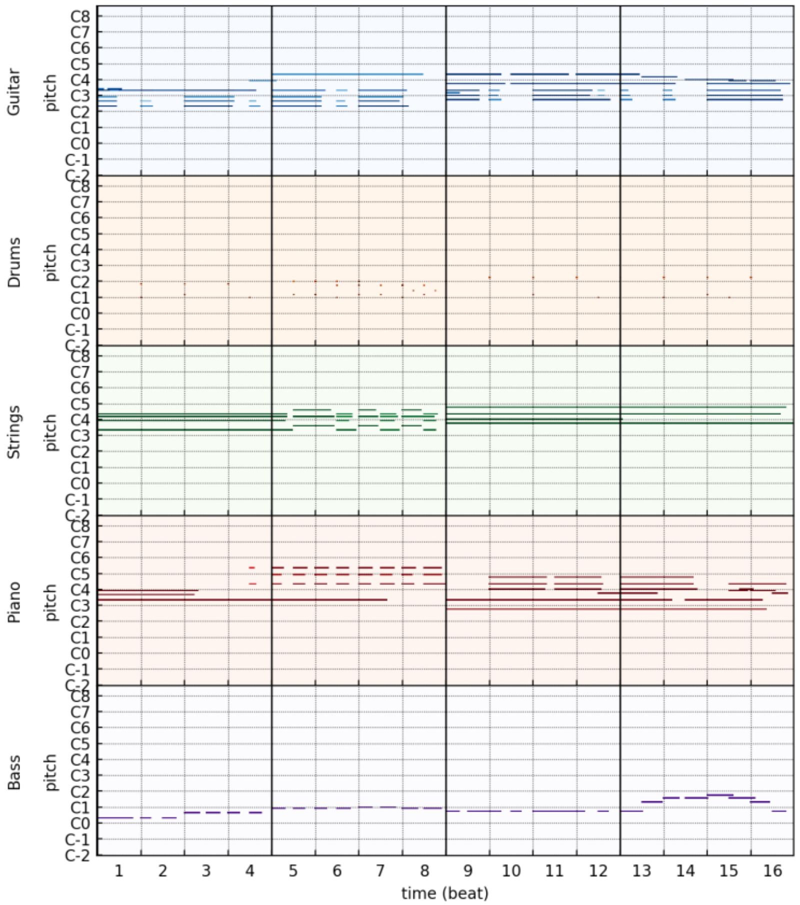
Piano-roll

(with symbolic timing)

polyphonic ✓

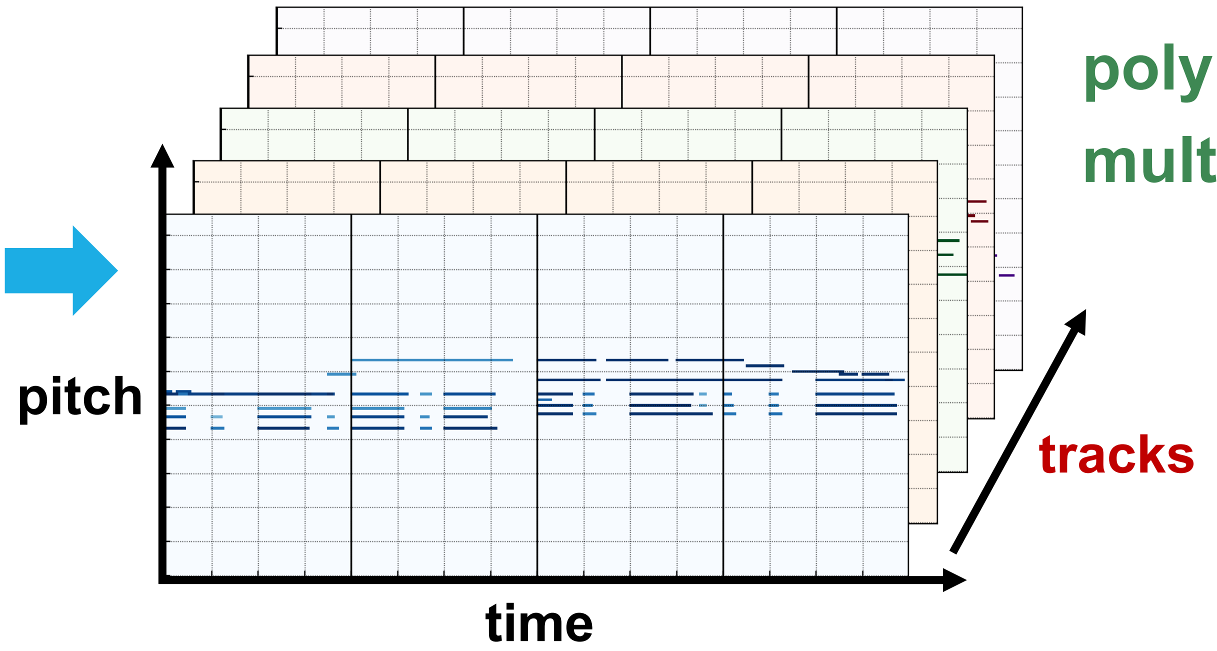
multi-track ✗

Data Representation



Multi-track Piano-roll

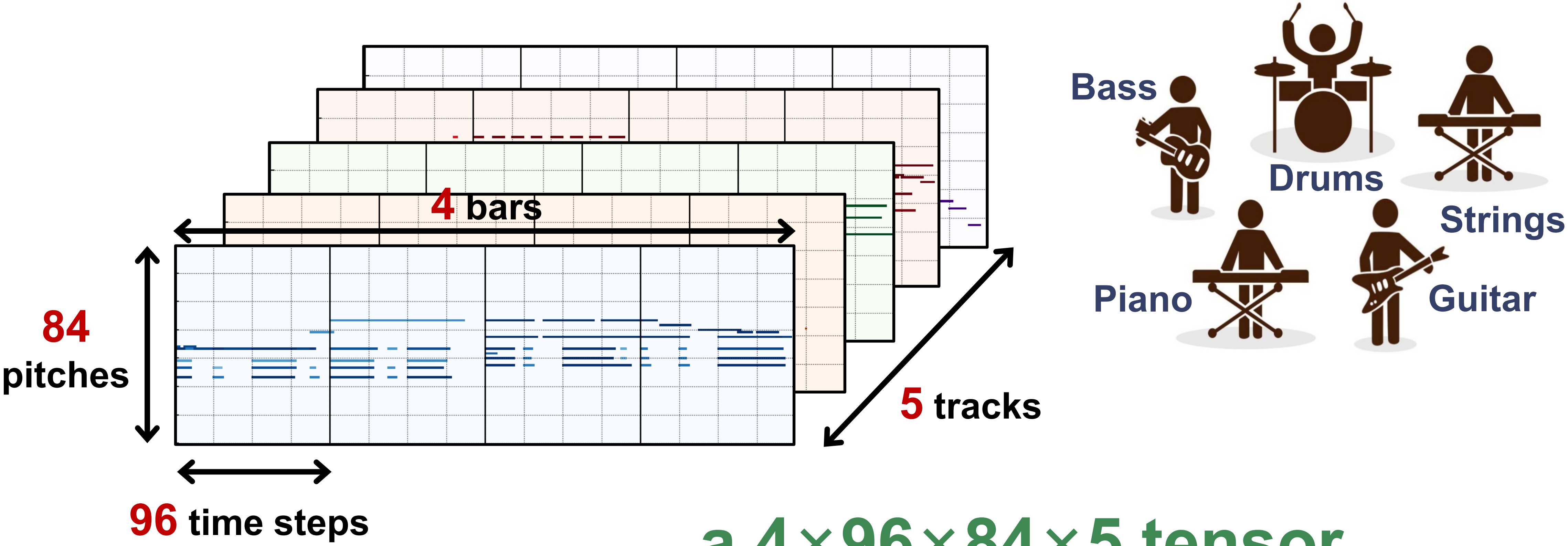
(with symbolic timing)



polyphonic ✓

multi-track ✓

Data Representation



4 bars

84 pitches

96 time steps

5 tracks

Bass

Drums

Strings

Piano

Guitar

a 4×96×84×5 tensor

Data

[Dataset]
https://salu133445.github.io/lakh-pianoroll-dataset

[Pypianoroll]
https://salu133445.github.io/pypianoroll/

LPD (Lakh Pianoroll Dataset)

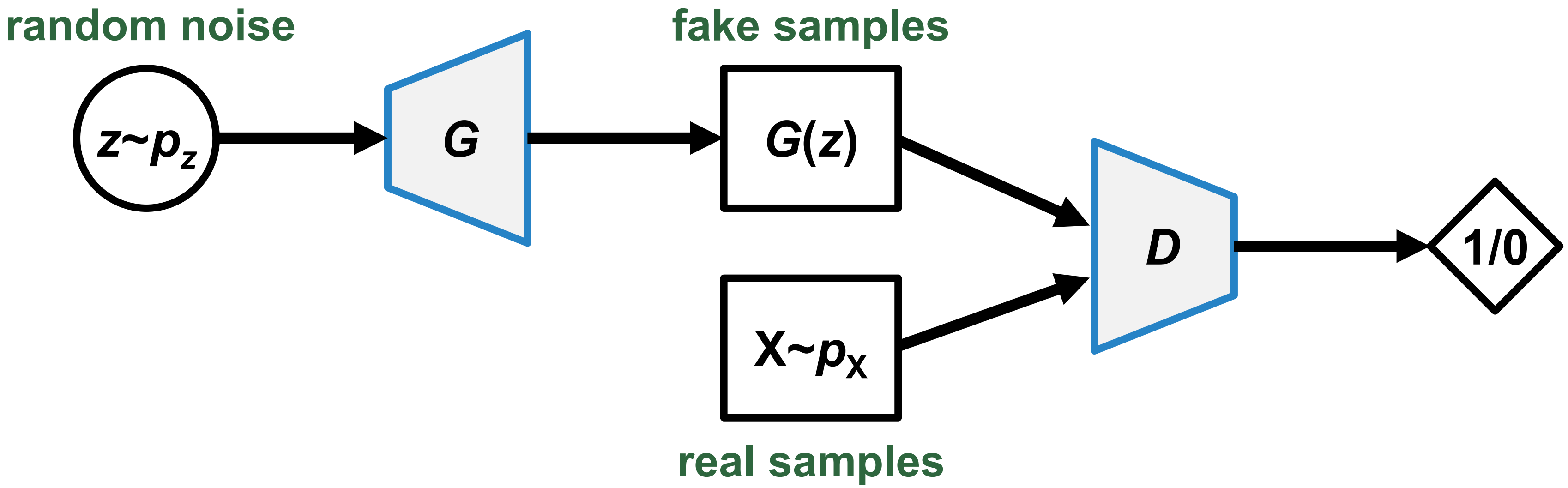
- **>170,000** multi-track piano-rolls
- Derived from Lakh MIDI Dataset
- Mainly pop songs

Pypianoroll (Python package)

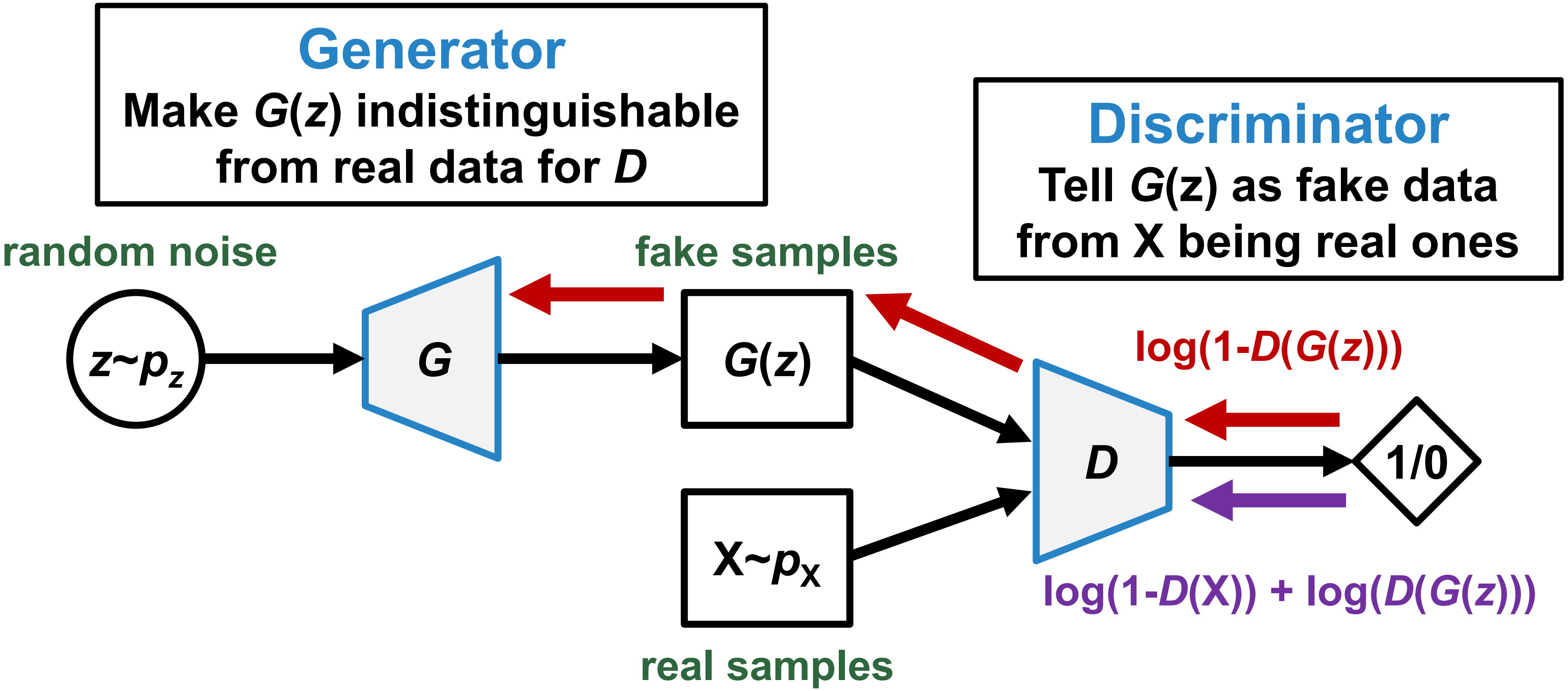
- Manipulation & Visualization
- Efficient I/O
- Parse/Write MIDI files
- On **PYPI** (pip installable)

Proposed Model

Generative Adversarial Networks



Generative Adversarial Networks



Generator

Make G(z) indistinguishable from real data for D

Discriminator

Tell G(z) as fake data from X being real ones

random noise

fake samples

real samples

$z \sim p_z$

G

$G(z)$

$X \sim p_X$

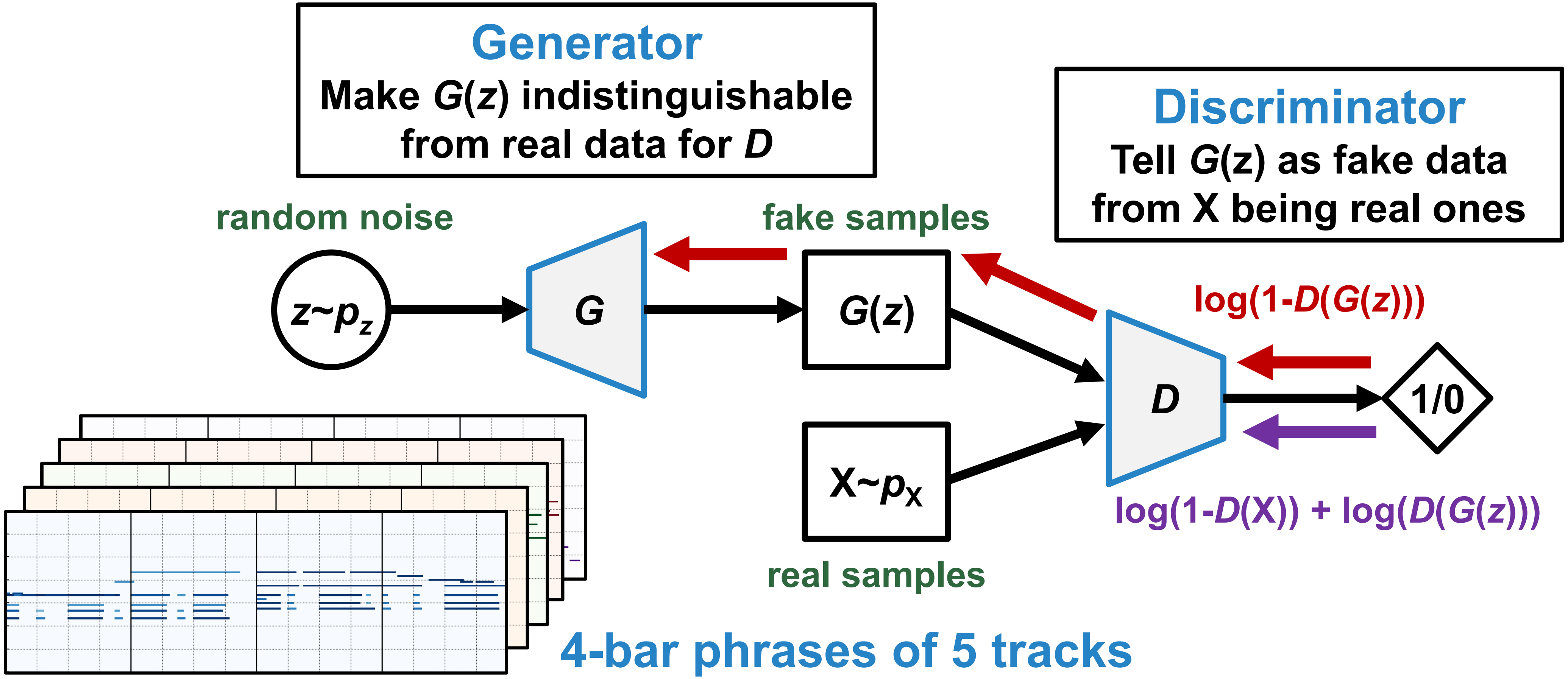
D

1/0

log(1-D(G(z)))

log(1-D(X)) + log(D(G(z)))

Generative Adversarial Networks



Generator

Make $G(z)$ indistinguishable from real data for D

Discriminator

Tell $G(z)$ as fake data from X being real ones

random noise

$z \sim p_z$

G

fake samples

$G(z)$

$\log(1-D(G(z)))$

D

1/0

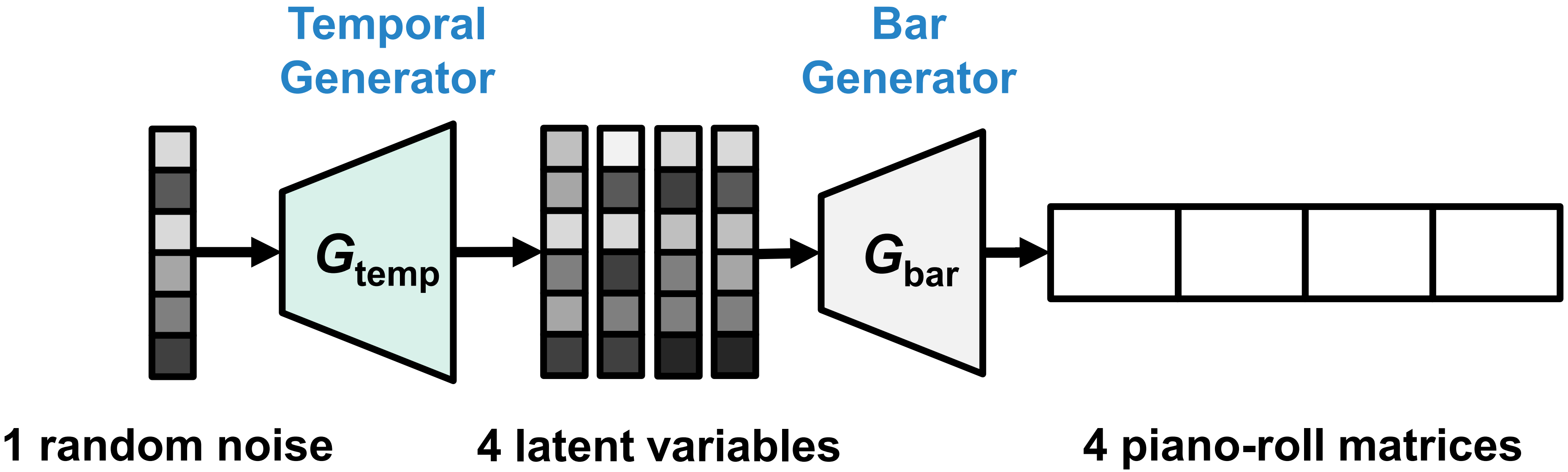
$X \sim p_X$

real samples

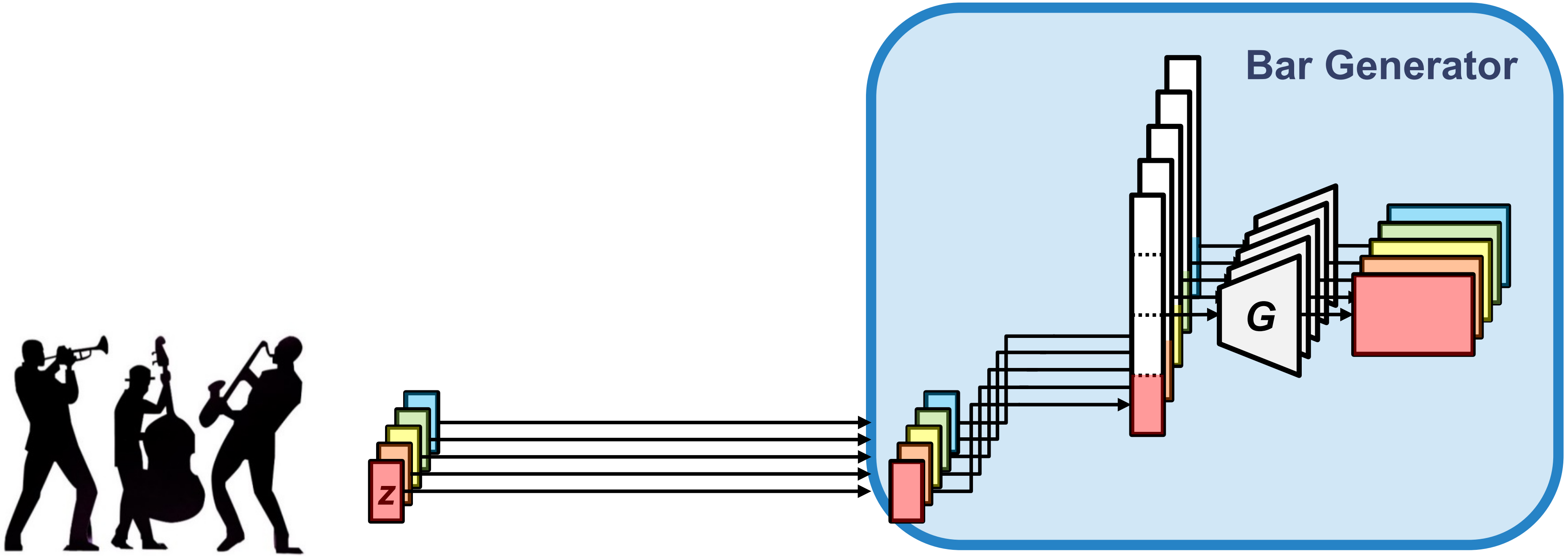
$\log(1-D(X)) + \log(D(G(z)))$

4-bar phrases of 5 tracks

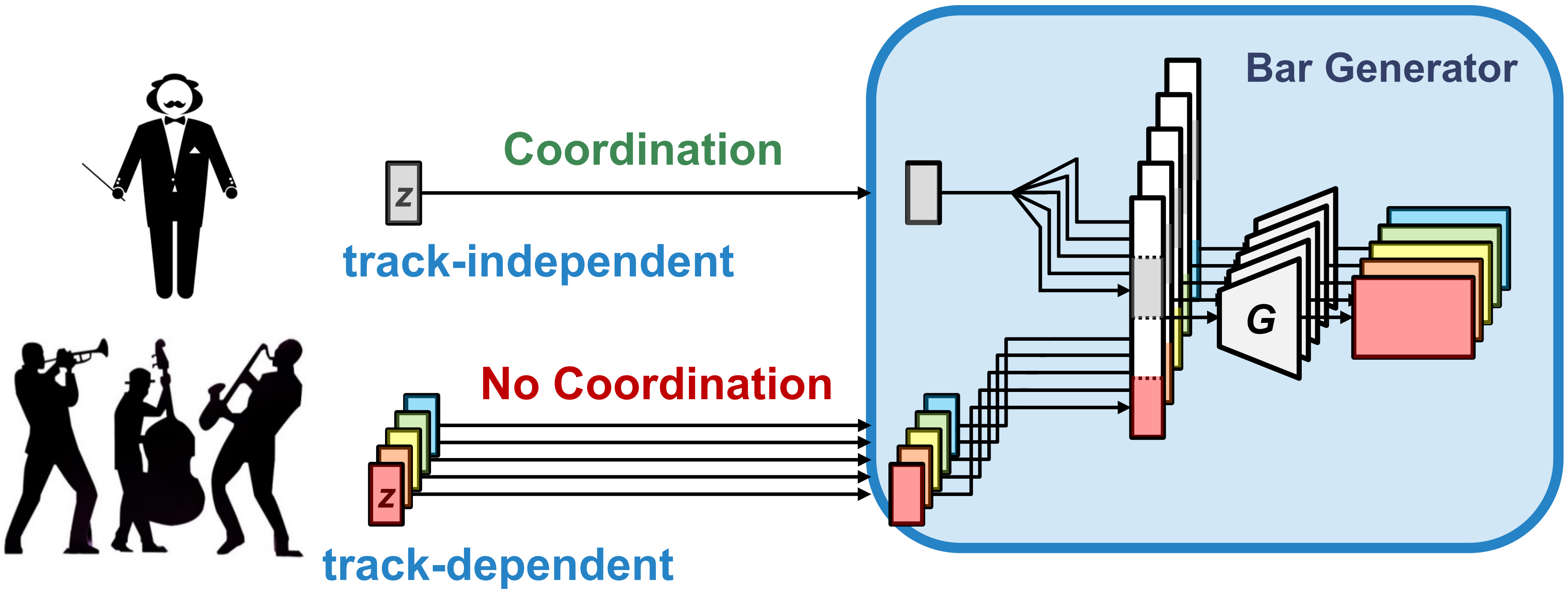
MuseGAN – An Overview



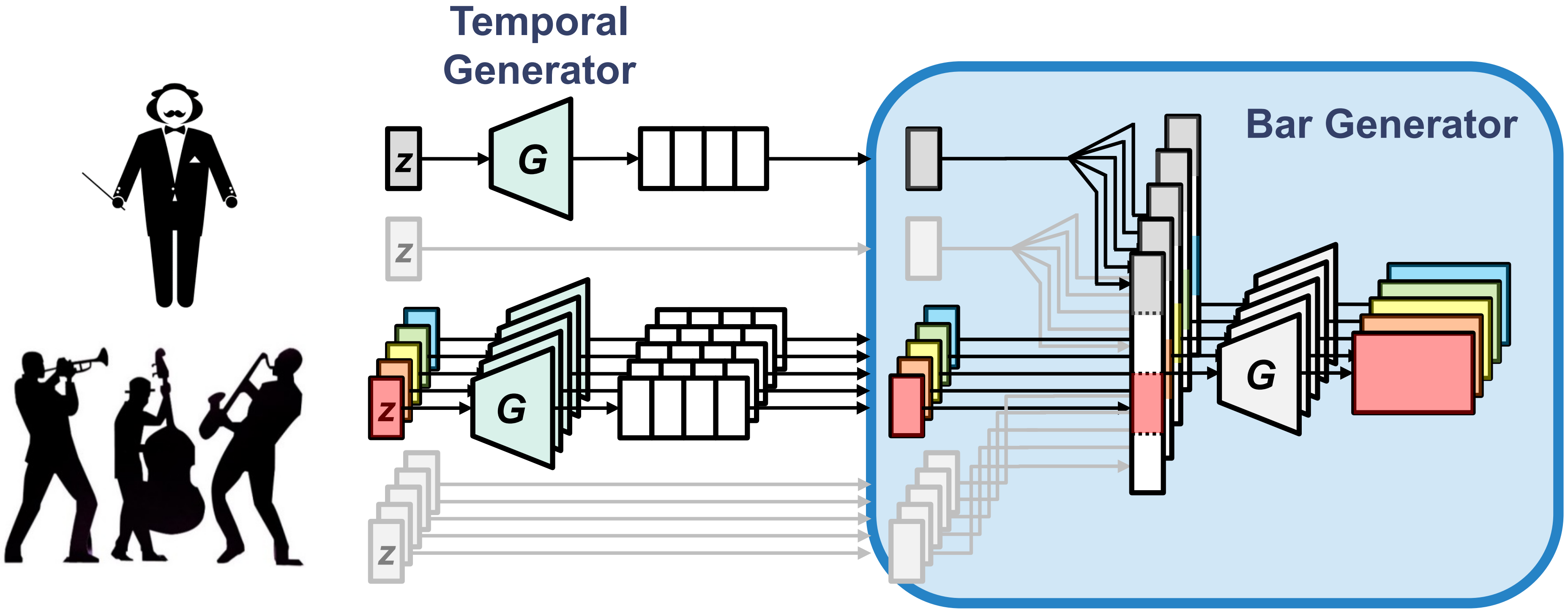
Generator



Generator

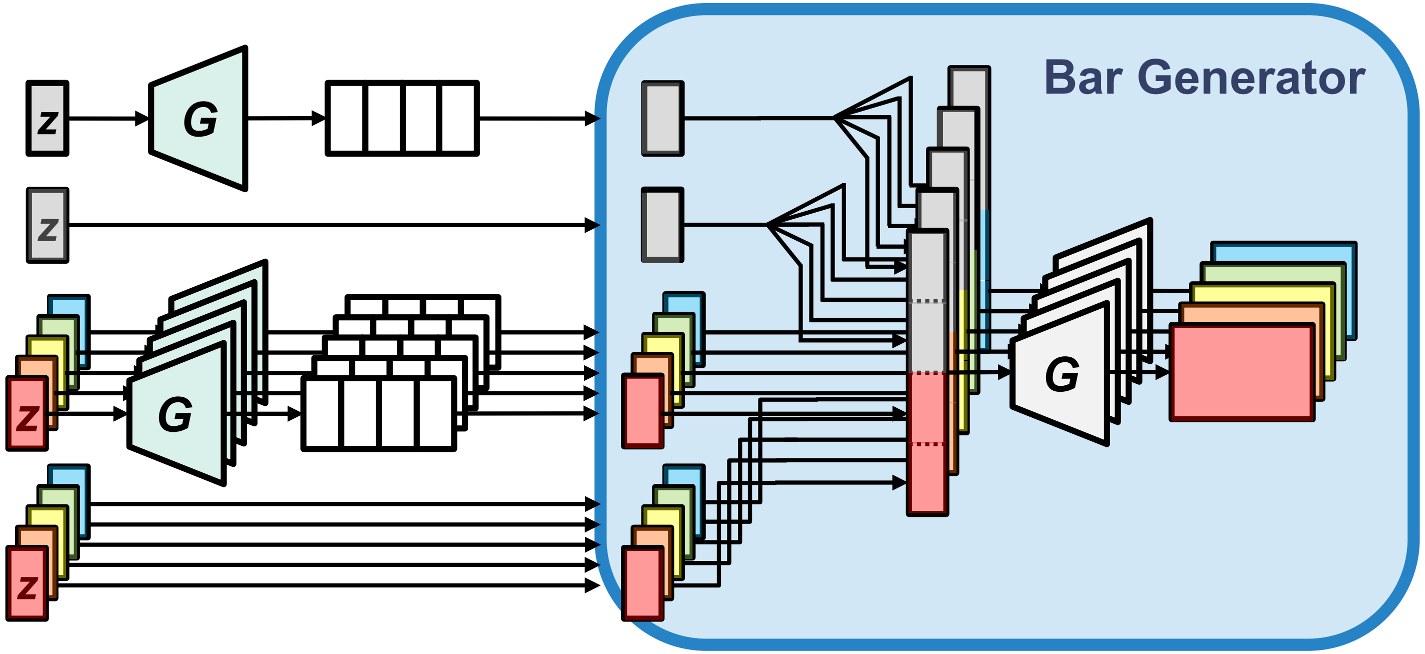

Bar Generator
Coordination
z
track-independent
No Coordination
z
track-dependent
G

Generator

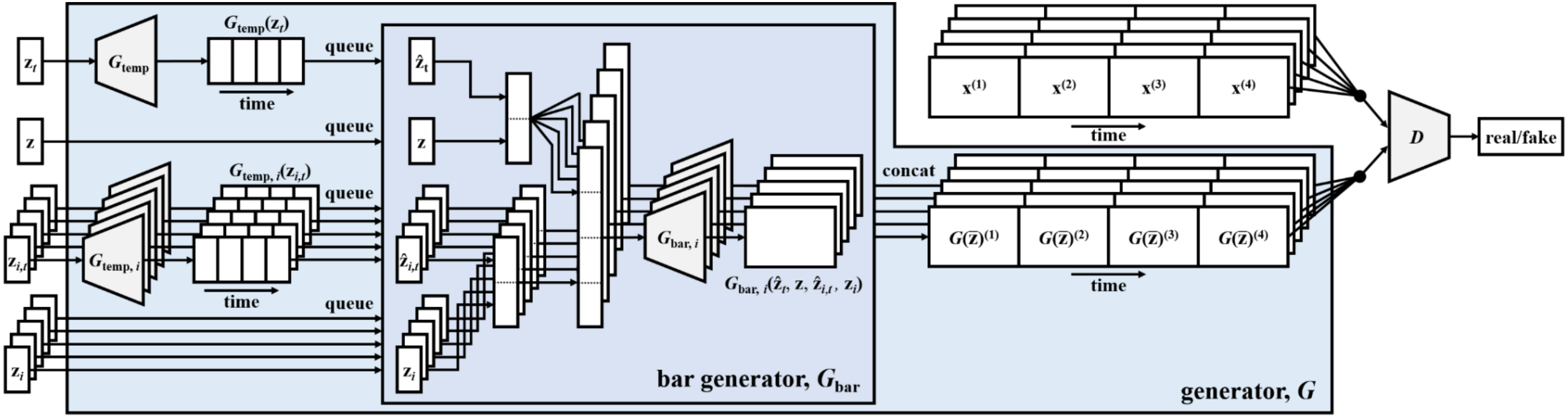


MuseGAN

		Time	
		Dependent	Independent
Track	Dependent	**Melody**	**Groove**
	Independent	**Chords**	**Style**



MuseGAN

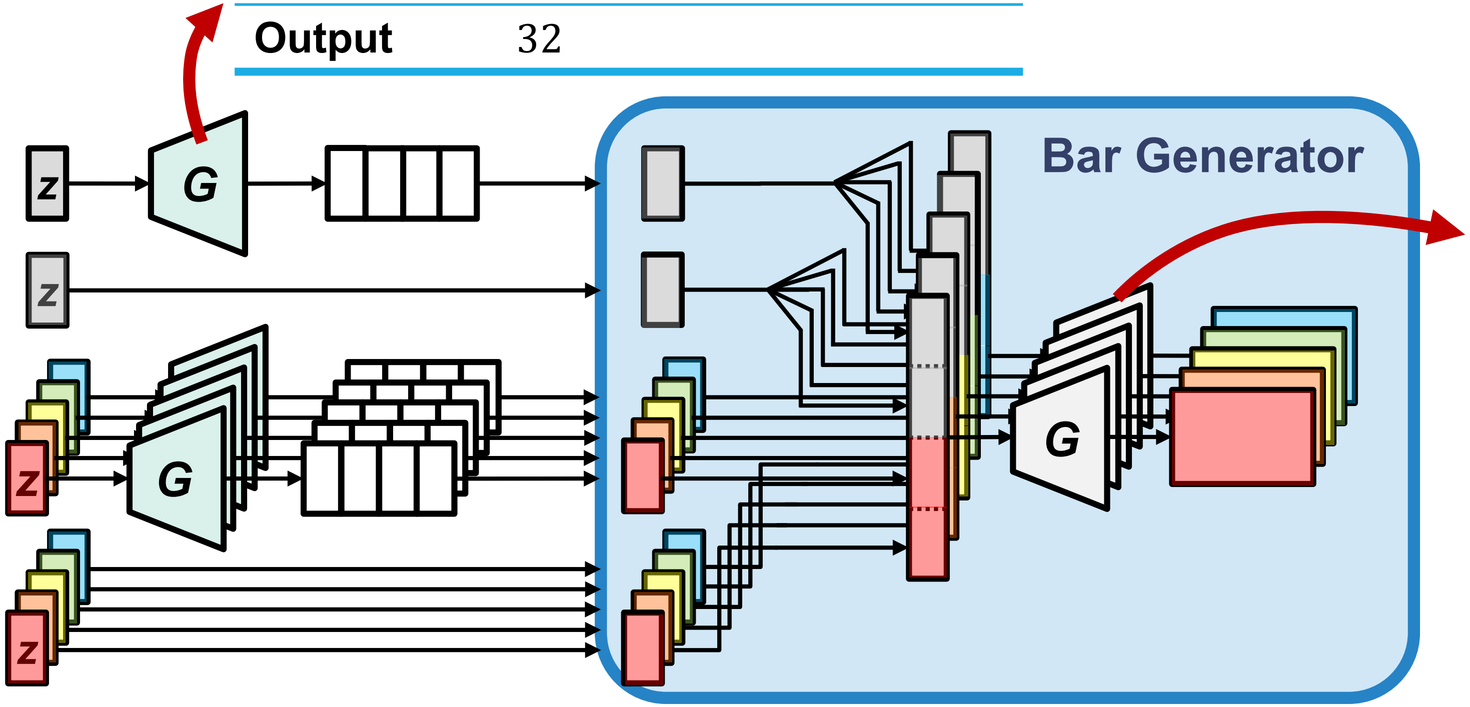


z_t
G_{temp}
$G_{\text{temp}}(z_t)$
queue
time
z
queue
$G_{\text{temp},\,i}(z_{i,t})$
queue
$z_{i,t}$
$G_{\text{temp},\,i}$
time
queue
z_i
$\hat{z}_t$
z
$\hat{z}_{i,t}$
z_i
$G_{\text{bar},\,i}$
$G_{\text{bar},\,i}(\hat{z}_t, z, \hat{z}_{i,t}, z_i)$
bar generator, G_{bar}
concat
$x^{(1)}$
$x^{(2)}$
$x^{(3)}$
$x^{(4)}$
time
$G(\bar{z})^{(1)}$
$G(\bar{z})^{(2)}$
$G(\bar{z})^{(3)}$
$G(\bar{z})^{(4)}$
time
generator, G
D
real/fake

Network Architectures

Temporal Generator

Input	32			
transconv	1024	2	1	(3, 1024)
transconv	32	3	1	(4, 32)
Output	32			



Input	32			
dense	1024			
reshape to (2, 1) × 512 *channels*				(2, 1, 512)
transconv	512	2 × 1	(2, 1)	(4, 1, 512)
transconv	256	2 × 1	(2, 1)	(8, 1, 256)
transconv	256	2 × 1	(2, 1)	(16, 1, 256)
transconv	128	2 × 1	(2, 1)	(32, 1, 128)
transconv	128	3 × 1	(3, 1)	(96, 1, 128)
transconv	64	1 × 7	(1, 7)	(96, 7, 64)
transconv	M	1 × 12	(1, 12)	(96, 84, M)
Output	(96, 84) × M channels			

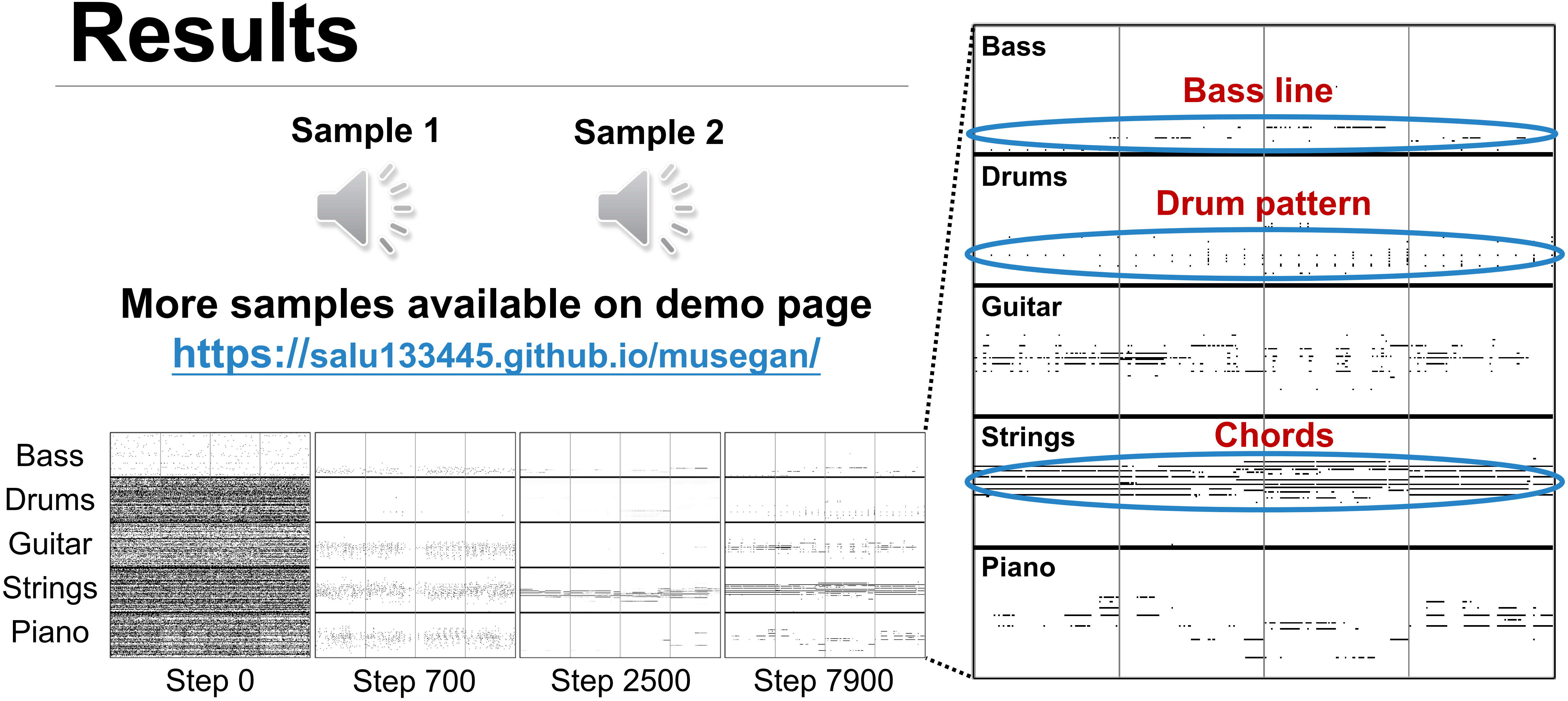
Results

Results

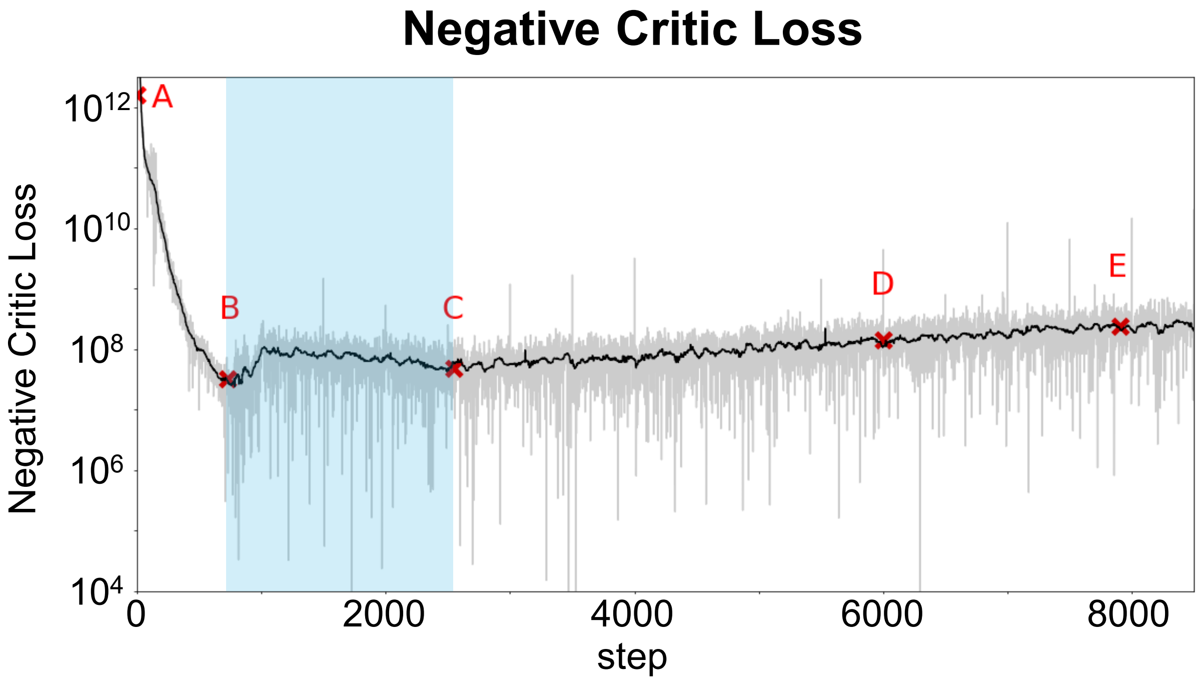
Sample 1

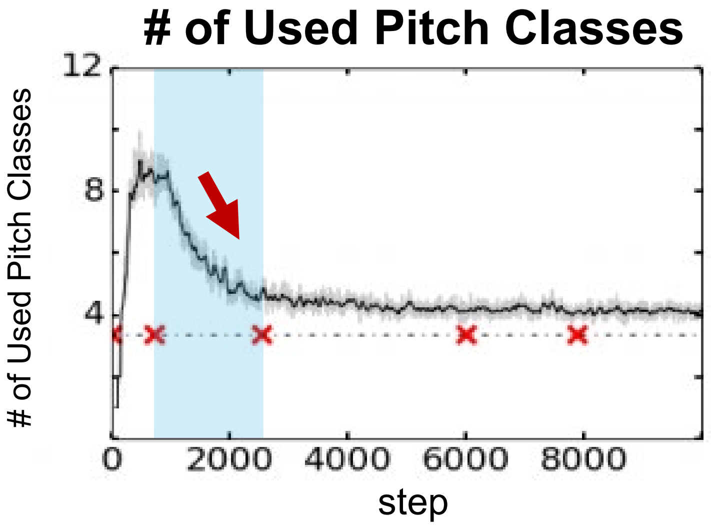
Sample 2

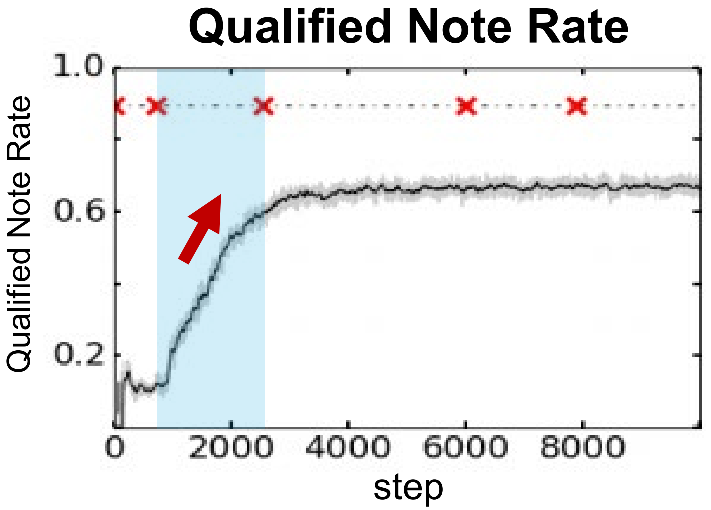
More samples available on demo page
https://salu133445.github.io/musegan/



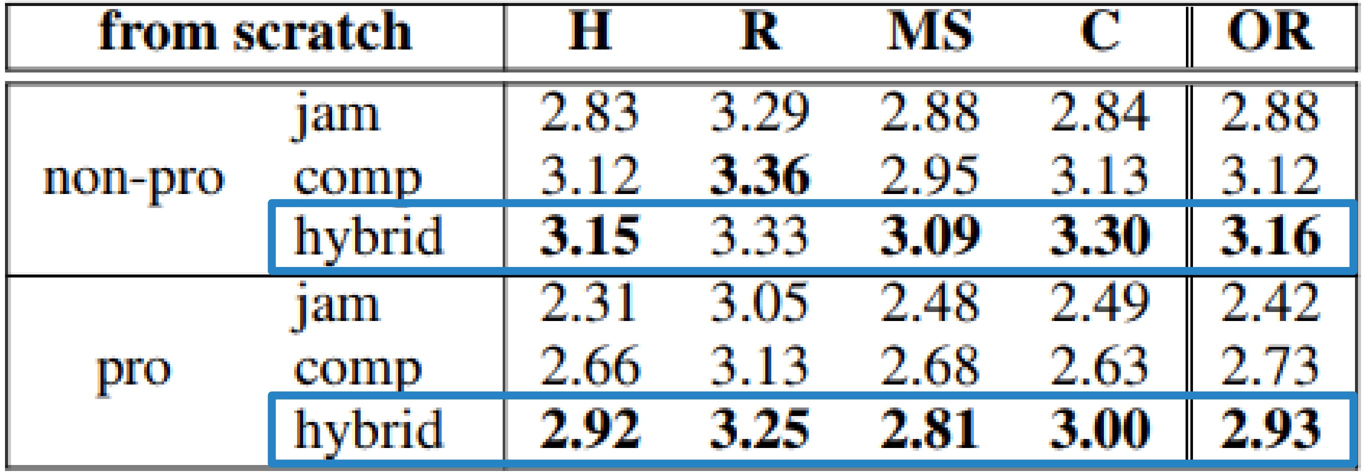
Objective Metrics







User Study



from scratch		H	R	MS	C	OR
non-pro	jam	2.83	3.29	2.88	2.84	2.88
	comp	3.12	**3.36**	2.95	3.13	3.12
	hybrid	**3.15**	3.33	**3.09**	**3.30**	**3.16**
pro	jam	2.31	3.05	2.48	2.49	2.42
	comp	2.66	3.13	2.68	2.63	2.73
	hybrid	**2.92**	**3.25**	**2.81**	**3.00**	**2.93**

H: harmonious

R: rhythmic

MS: musically structured

C: coherent

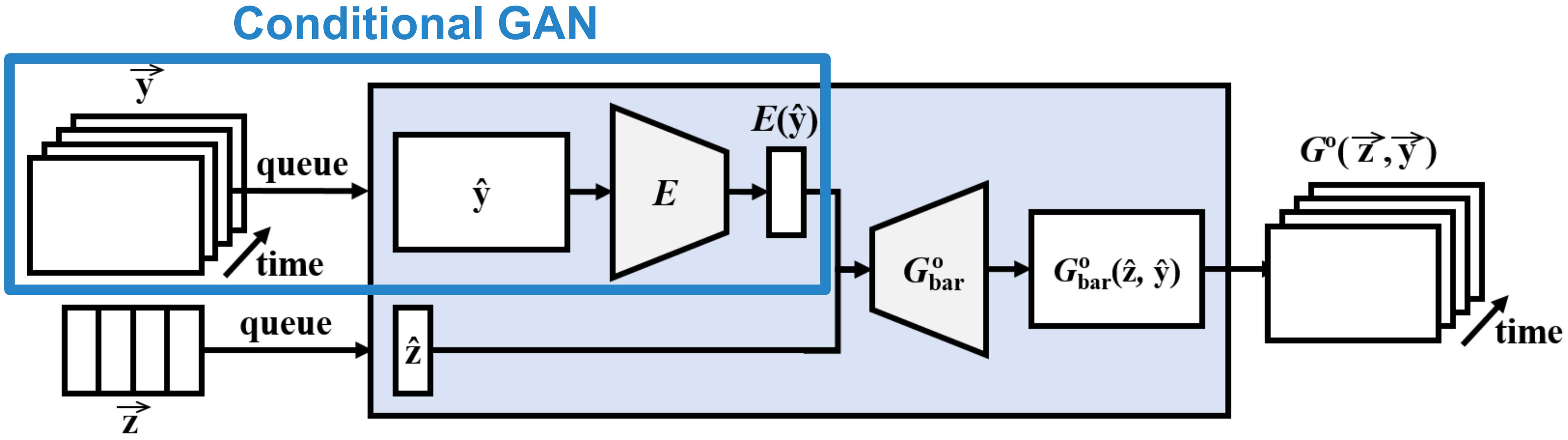
OR: overall rating

composer

jamming

hybrid

Accompaniment System



Generation from Scratch	**nothing → 5-track**
Accompaniment System	**single-track → 5-track**

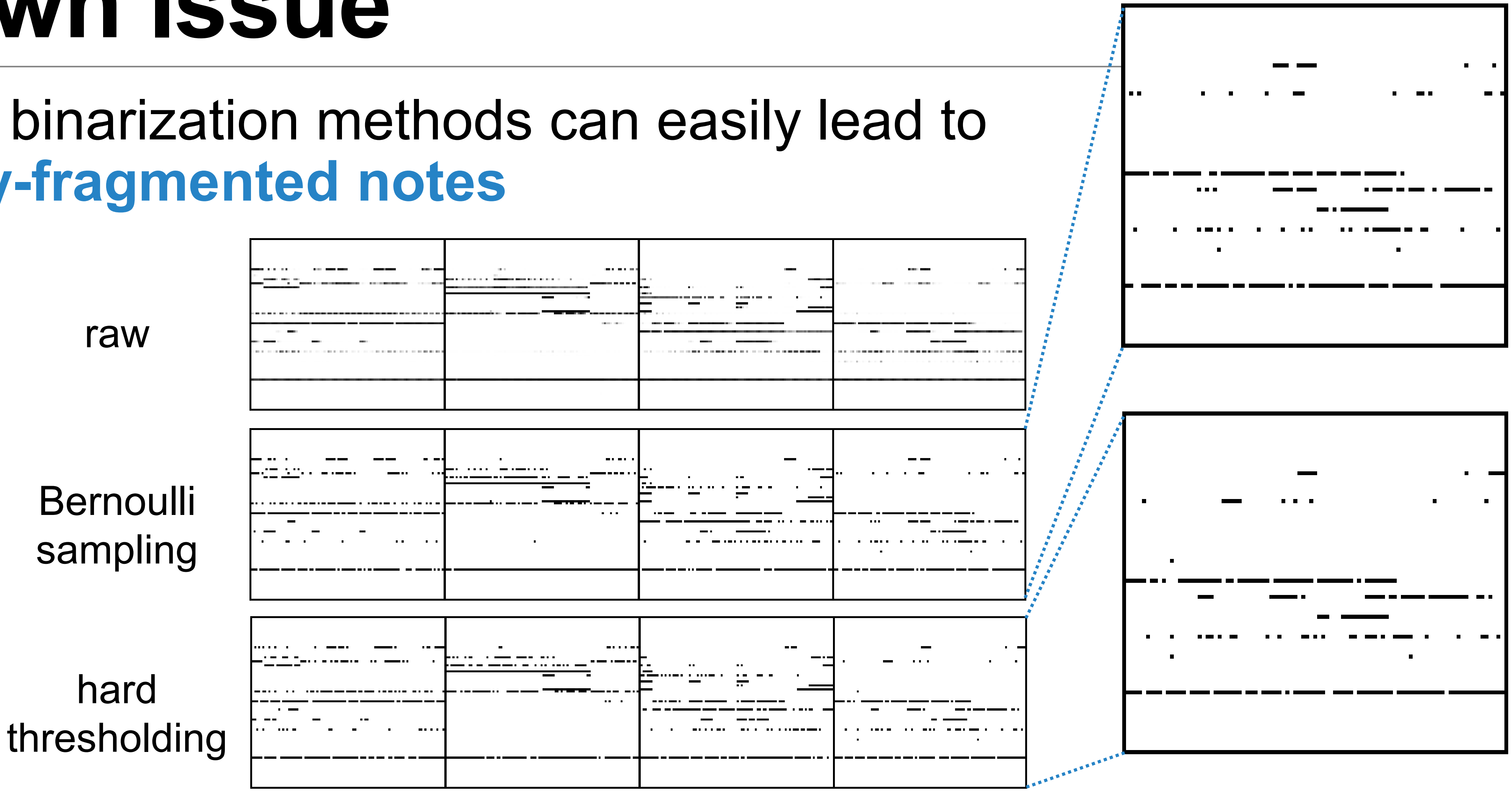
Summary

- **MuseGAN**
  - a novel GAN for **multi-track sequence** generation
  - **multi-track**, **polyphonic** music
  - **human-AI cooperative** scenario
- **Lakh Pianoroll Dataset (LPD)** (**new dataset**)
- **Pypianoroll** (**new Python package**)

Recent Work

Known Issue

- Naïve binarization methods can easily lead to **overly-fragmented notes**



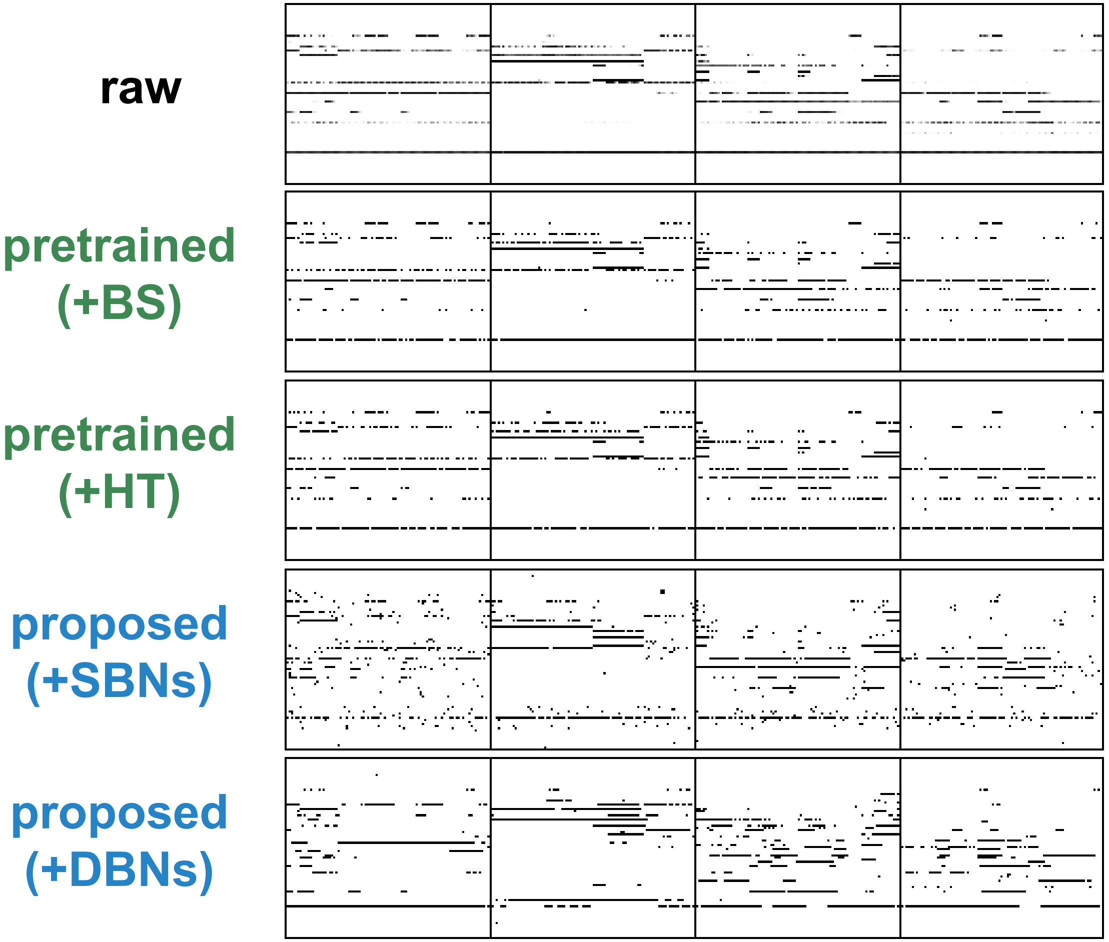
BinaryMuseGAN

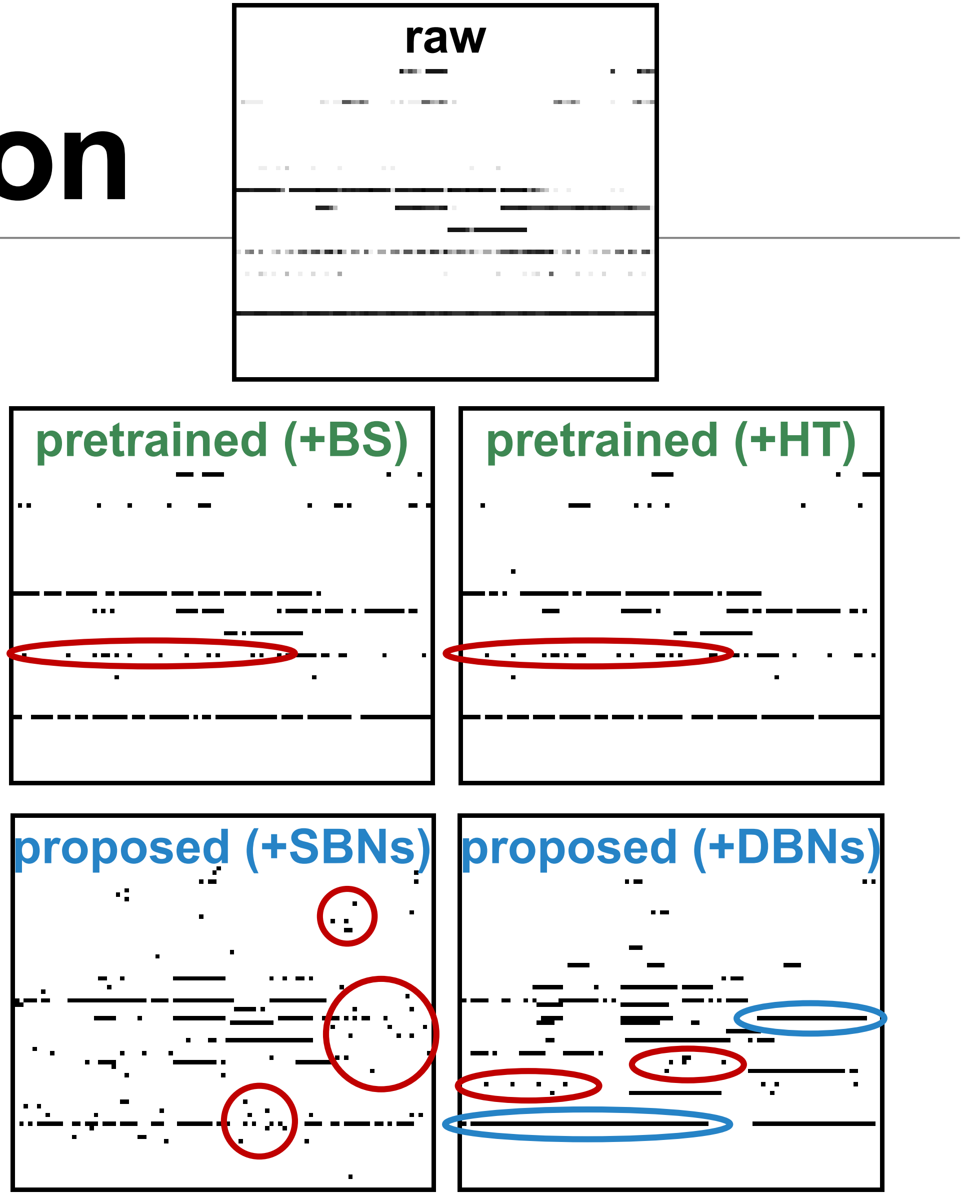
- use **binary neurons** at the output layer of the generator
- use **straight-through estimator** to estimate the gradients for the binary neurons (which involves nondifferentiable operation)

	Generator’s outputs	Real data
MuseGAN	real-valued	binary-valued
BinaryMuseGAN	binary-valued	binary-valued

Hao-Wen Dong and Yi-Hsuan Yang, "Convolutional Generative Adversarial Networks with Binary Neurons for Polyphonic Music Generation," to appear at ISMIR, 2018.

Qualitative Comparison





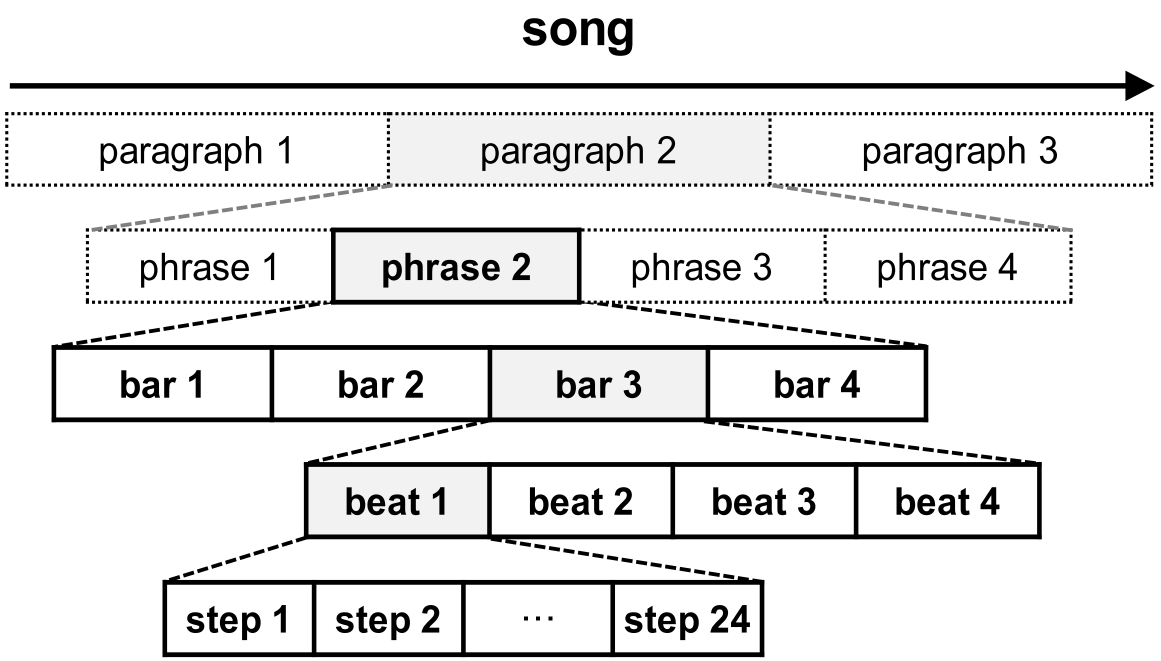
Future Works

Future Works

Full Song Generation

Challenges

- hierarchical temporal structure
- variable-length sequence generation



Future Works

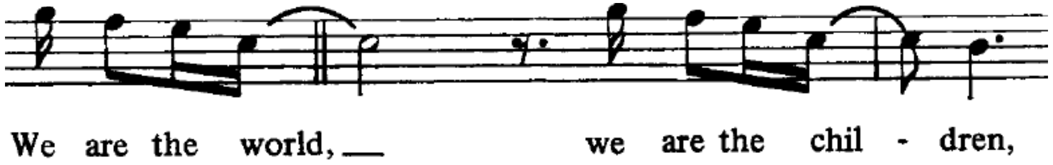
Cross-modal Generation

Challenge

- cross-modal temporal interdependency

Applications in Music

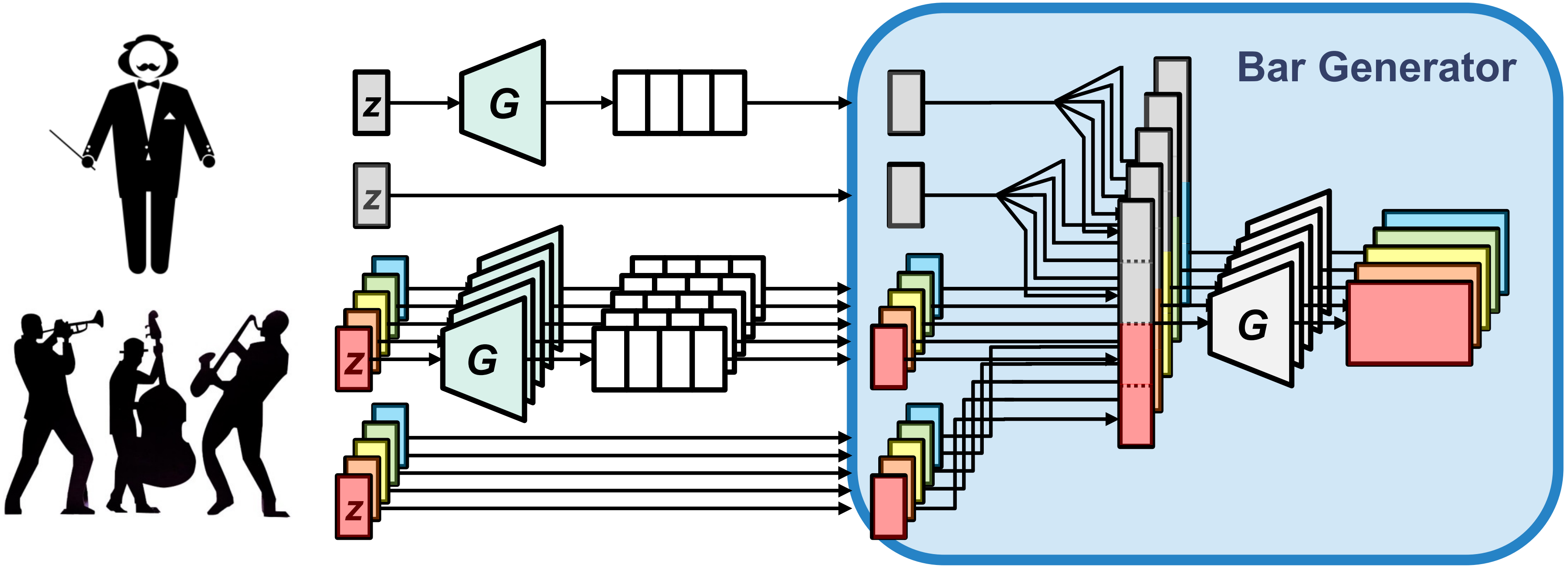
- music + lyrics



- music + video

Source Code https://github.com/salu133445/musegan

Demo Page https://salu133445.github.io/musegan/



MuseGAN: Multi-track Sequential Generative Adversarial Networks for Symbolic Music Generation and Accompaniment

Hao-Wen Dong, Wen-Yi Hsiao, Li-Chia Yang, Yi-Hsuan Yang

Convolutional Generative Adversarial Networks with Binary Neurons for Polyphonic Music Generation

Hao-Wen Dong and Yi-Hsuan Yang

Q&A