

R3.A.09

Real-Time Identification of Simple and Extended Musical Chords using Artificial Neural Networks

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Musical Chords

BACKGROUND



2 or more
notes



Played
together



Follow “rules of
harmony”

(Leino, Brattico, Tervaniemi, & Vurst, 2007)

Musical Chords

BACKGROUND

Each
has a
name

C5
G
C

Amaj
E
C#
A

D7
C
A
F#
D

Musical Chords

BACKGROUND

Each
has a
root
note

C5
G
C

A ^{maj}
E
C [#]
A

D7
C
A
F [#]
D

Musical Chords

BACKGROUND

Each
has a
type

C ⁵
G
C

A ^{maj}
E
C [#]
A

D ⁷
C
A
F [#]
D

Musical Chords

BACKGROUND

Simple vs
Extended

Chord types

Am

E

C

A

Simple

More common chord type

Musical Chords

BACKGROUND

Simple vs
Extended

Chord types



Extension

Extended

Less common chord type

Chord Identification DEFINITION

The determination of the name of the chord from the notes that constitute it

Definition of chord identification

Chord Identification

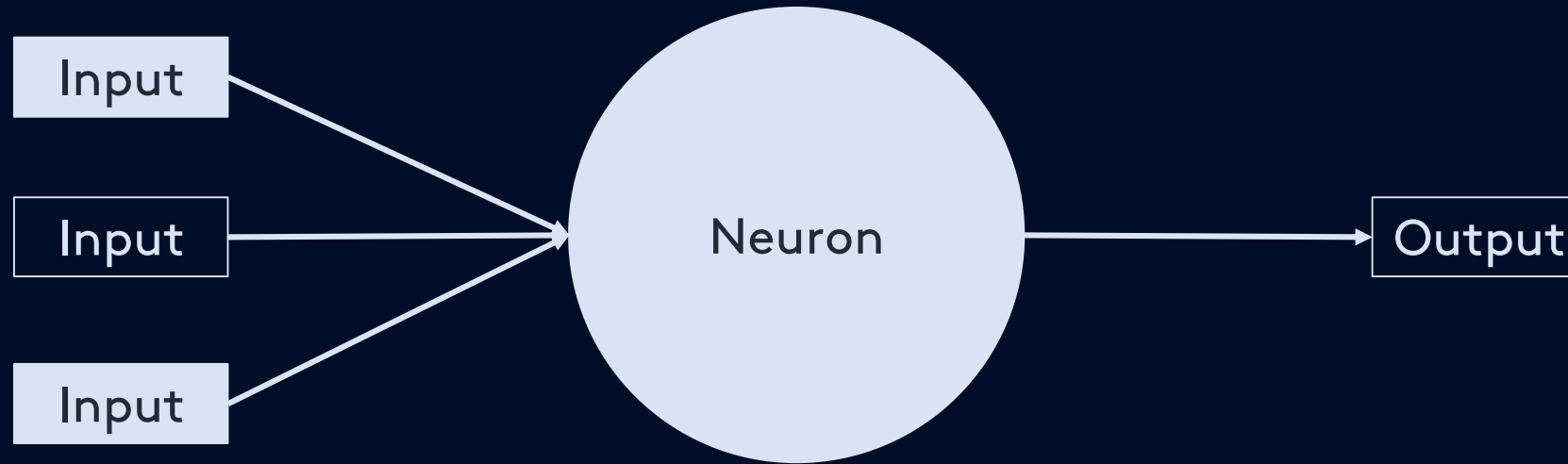
PROBLEM

Majority of general music learning public **can't do this by themselves** due to **lack of skill** or training

Situation with chord identification

Neural networks

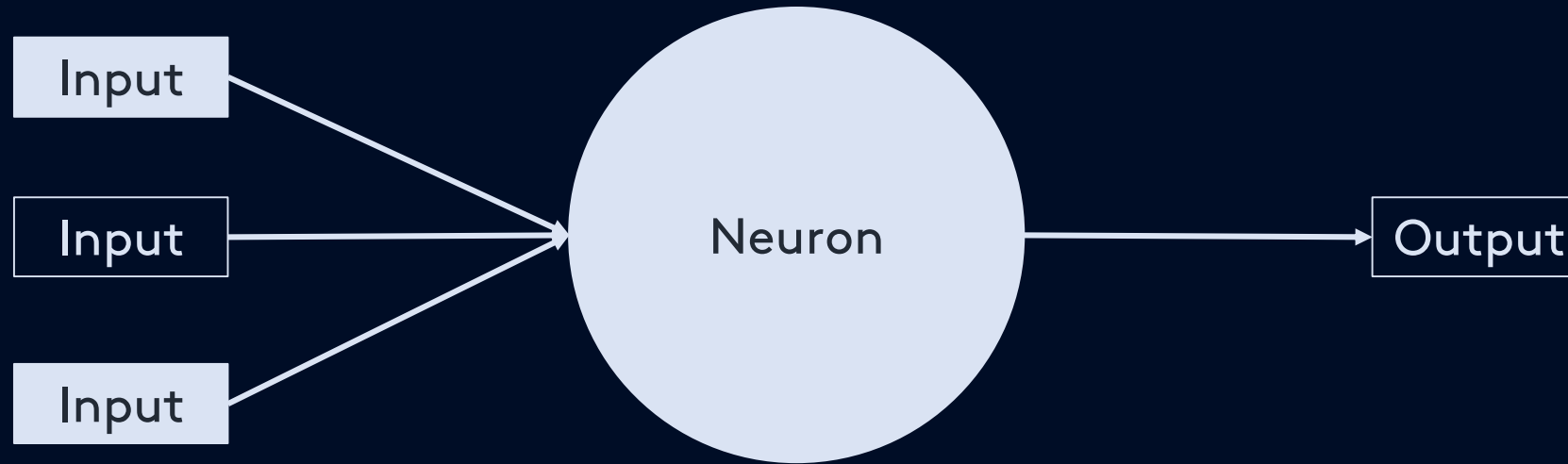
DEFINITION



Computational model of neurons in a brain

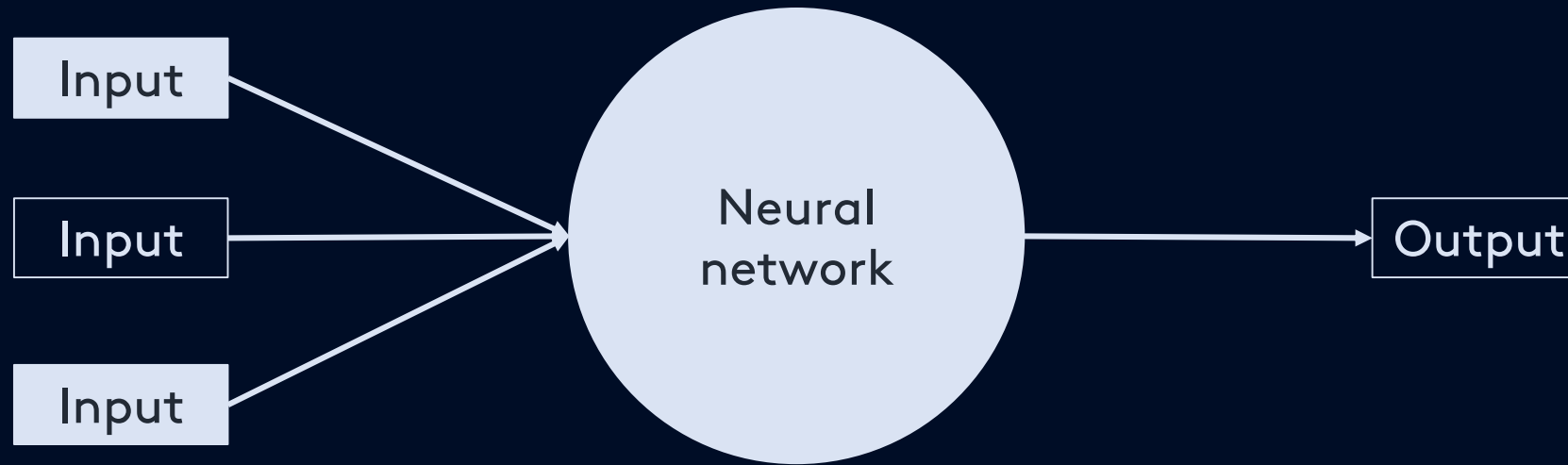
Neural networks

DEFINITION



Many neurons = neural network

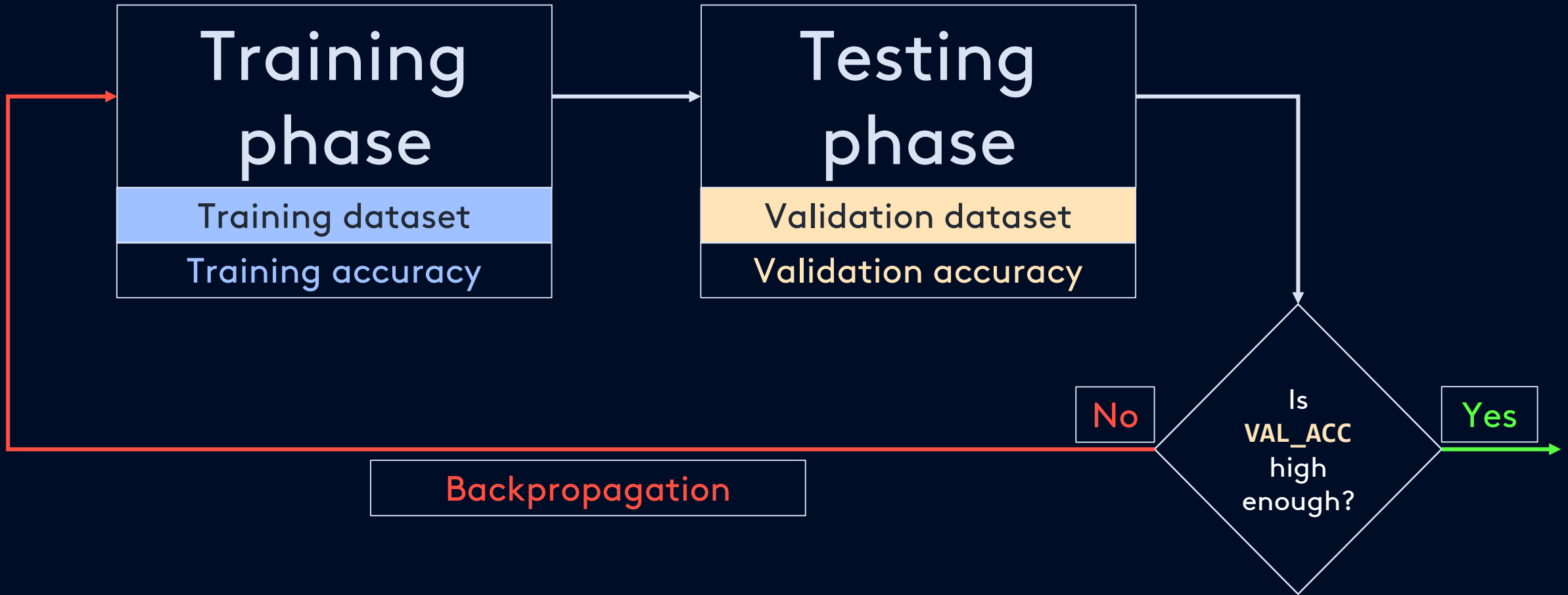
Artificial Neural Networks (ANNs)



ANN learns by repetitive training

Colina, Perez, & Paraan, 2017

ANN training & testing



Why neural networks? PROBLEM

Previous studies with neural network implementations have **not included extended chords in their research**

Osmalskyj, Embrechts, Piérard, & Van Droogenbroeck, 2012
Perera & Kodithuwakku, 2005
Zhou & Lerch, 2015

Using neural networks to
identify both common and
extended chords is
unexplored

Osmalskyj, Embrechts, Piérard, & Van Droogenbroeck, 2012

Perera & Kodithuwakku, 2005

Zhou & Lerch, 2015

Develop a neural network
that **quickly** identifies
simple and extended
musical **chords**

Input is a group of **3 or more**
MIDI note signals played in
real-time

Input chords have **one root note** and are **not inverted**

Identification must be quick
enough to be used in **live
performance (<40ms)**

Greeff, 2016

Implemented in
programming languages
with **neural network, real-
time MIDI, and GPU
processing** libraries

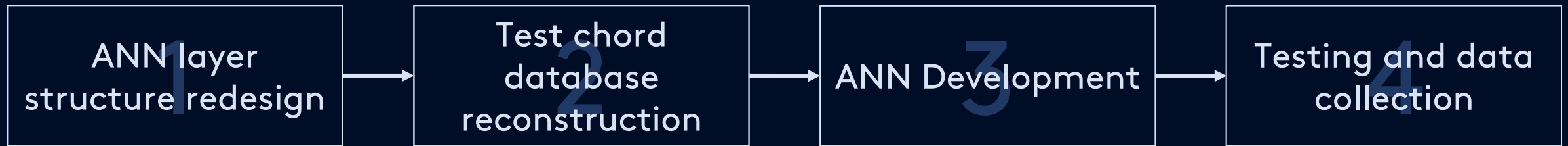
thestk, 2017; Bretschneider, 2017

Neural network must be run
on a GPU for efficient
processing

Nickolls, Buck, Garland, & Skadron, 2008

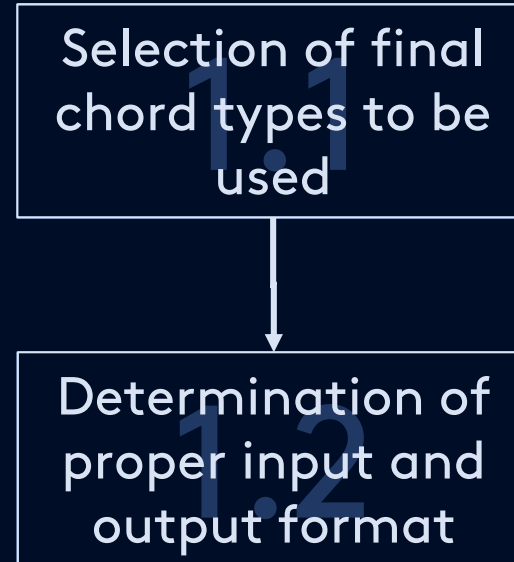
Level 0

PROCESS



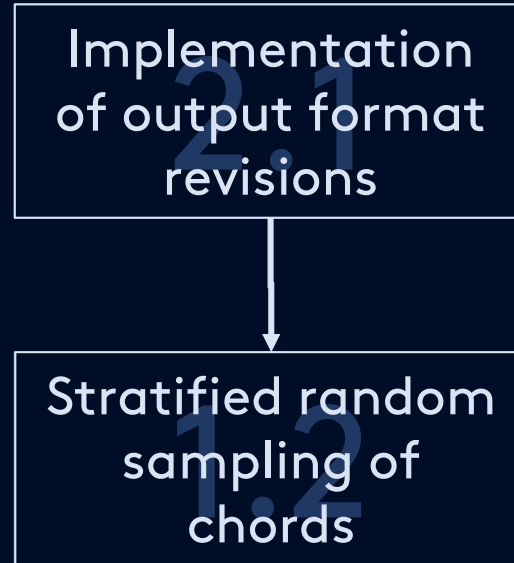
1 Redesign

PROCESS



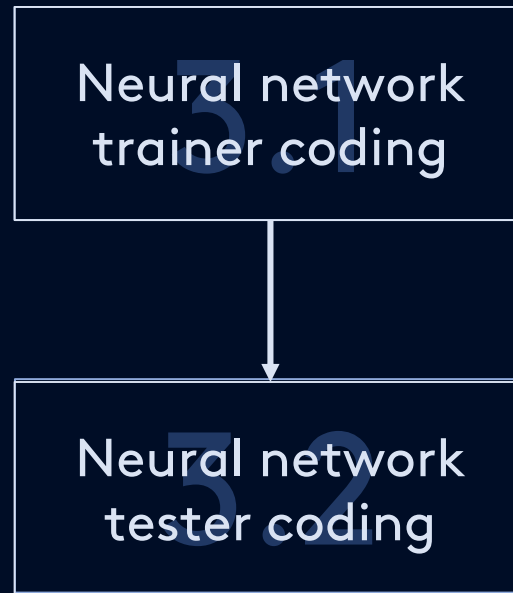
2 Database Reconstr.

PROCESS



3 ANN Development

PROCESS



4 Training, Testing, DC PROCESS



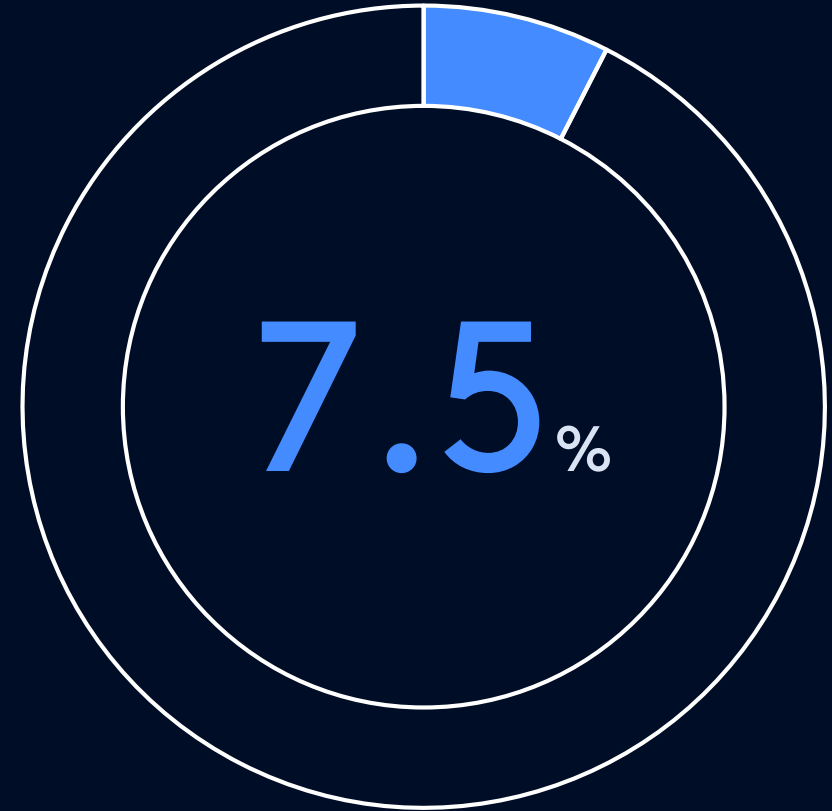
Performance

Peak validation accuracy after 30K epochs



RESULTS

Peak training accuracy after 30K epochs



Real-Time Identification of
Simple and Extended Musical Chords
using Artificial Neural Networks

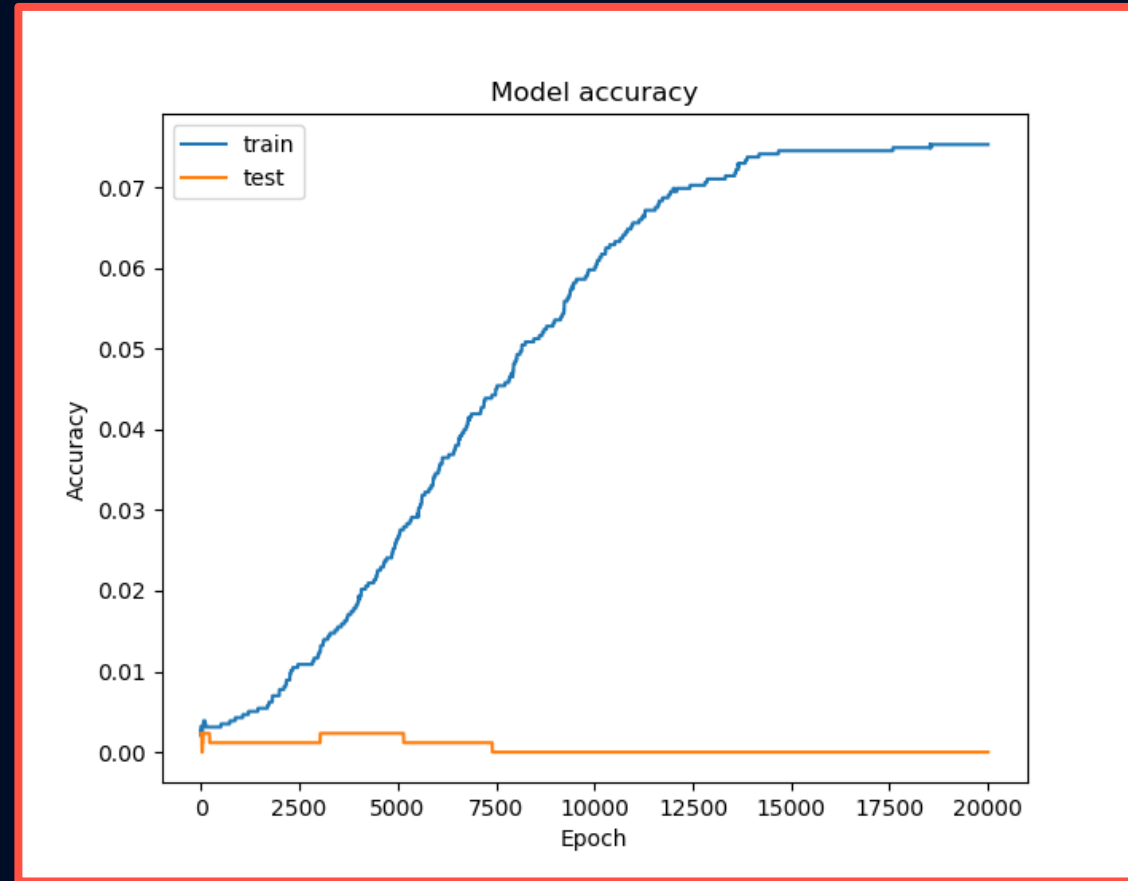
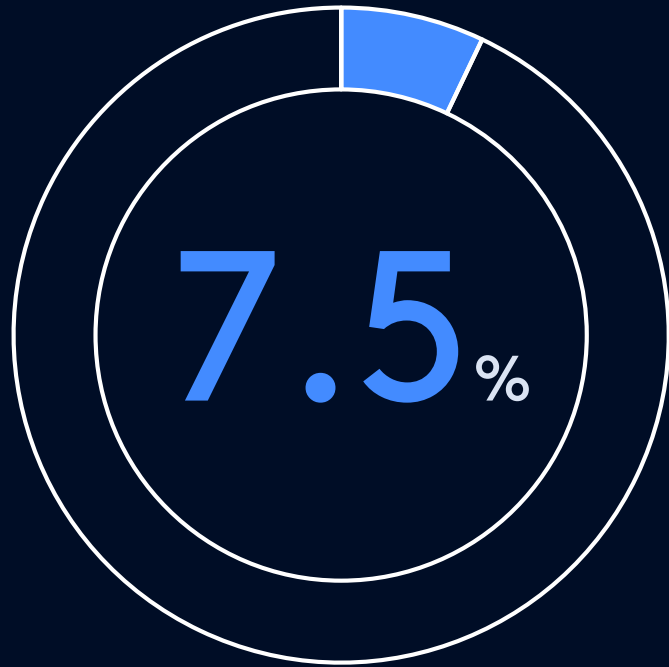
Coronel
Navarro

R3.A.09

Performance

RESULTS

Peak training accuracy
after 30K epochs



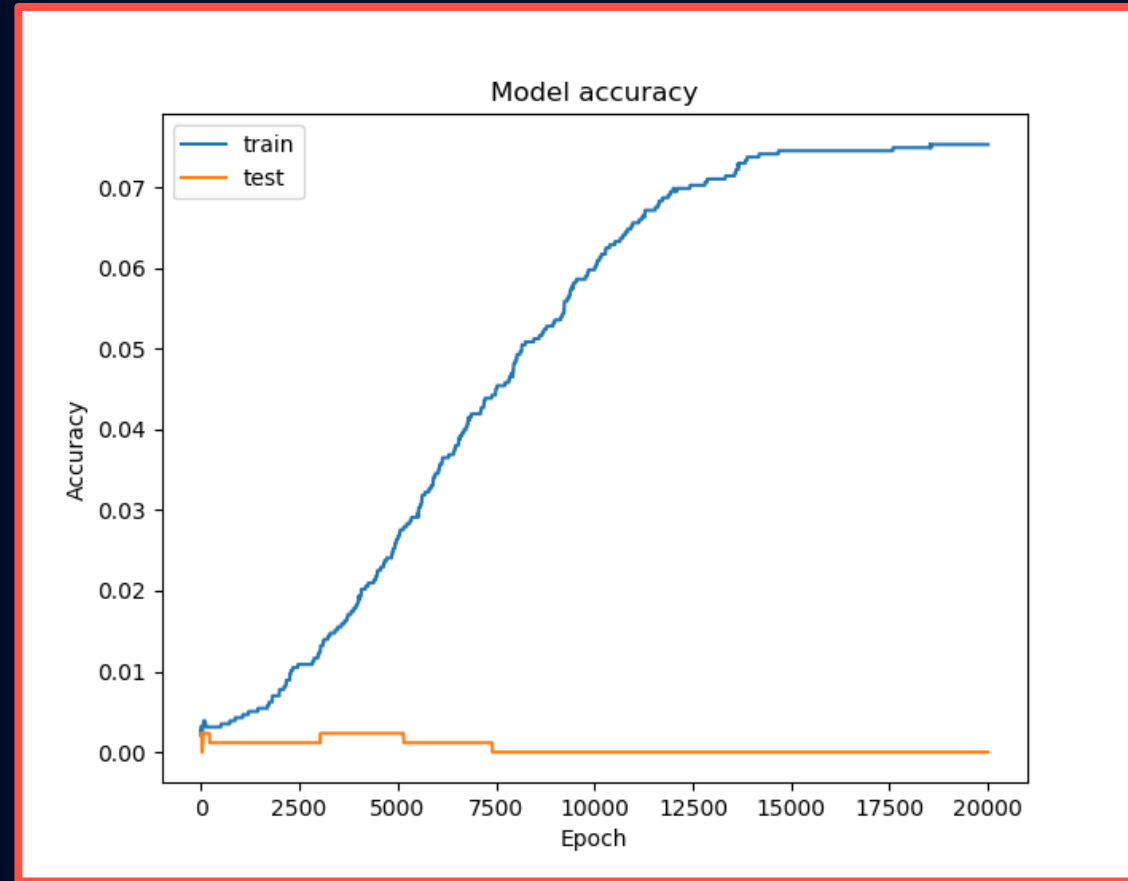
Plateaus
on
learning
training
dataset

Trend

Performance

RESULTS

Peak validation accuracy
after 2800 epochs

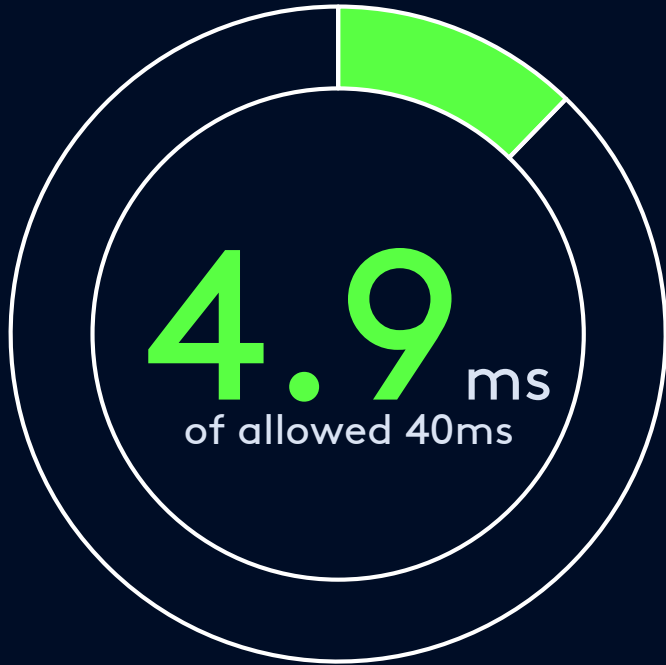


Over-
fitting on
training
dataset

Reason

Performance

Mean total response time,
30 samples



RESULTS

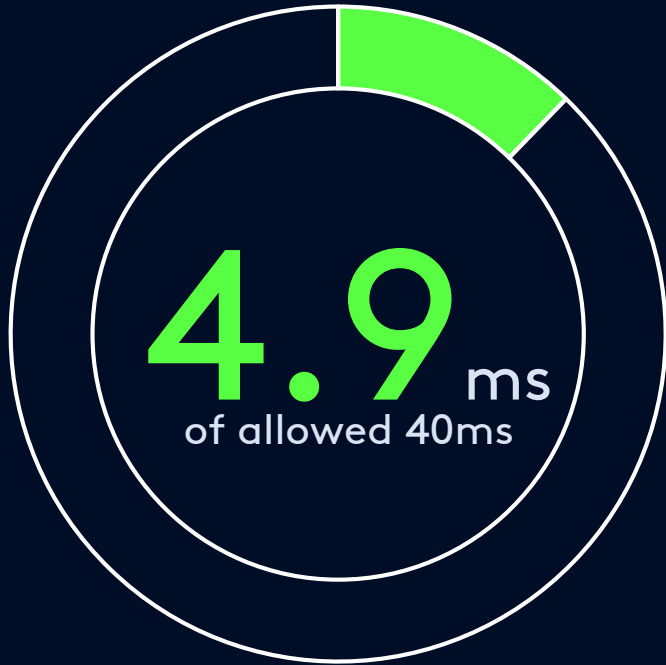
Null hypothesis	Alternative hypothesis
$r \geq 40\text{ms}$	$r < 40\text{ms}$

T-test for one mean

Sample size = 30; Significance = 5%

Performance

Mean total response time,
30 samples



RESULTS

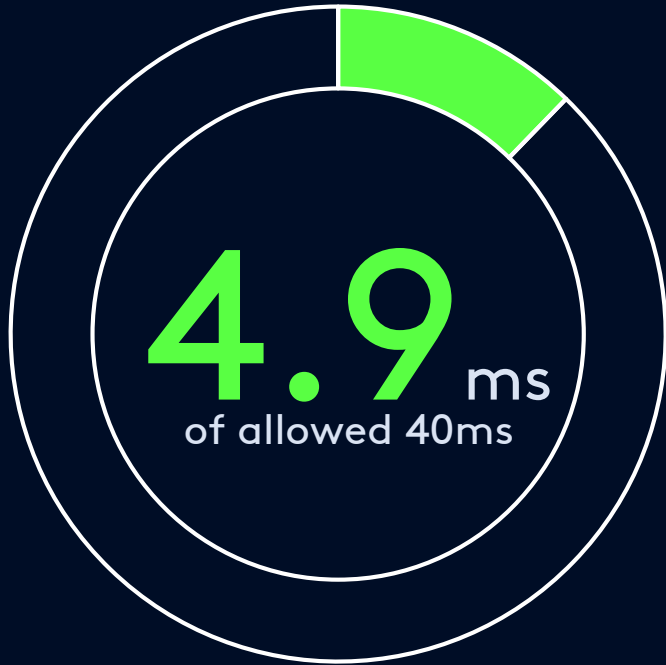
Null hypothesis	Alternative hypothesis
$t \geq -1.699$	$t < -1.699$

T-test for one mean

Sample size = 30; Significance = 5%

Performance

Mean total response time,
30 samples



RESULTS

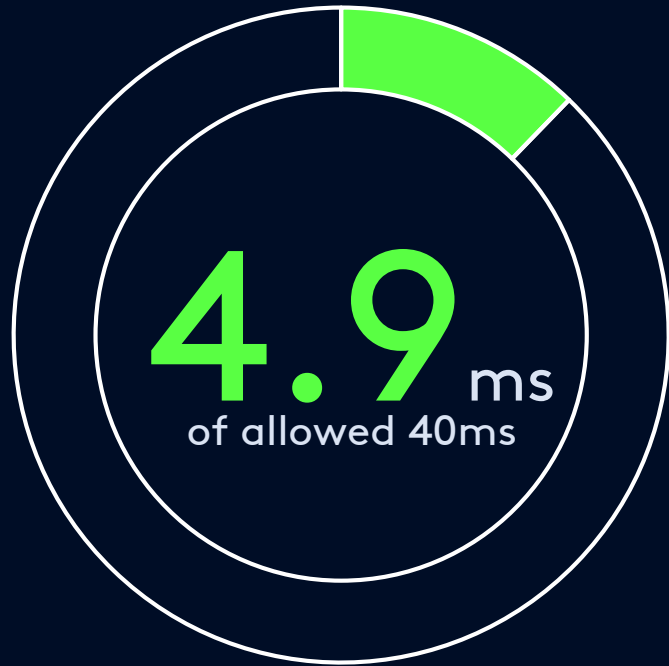
Null hypothesis	Alternative hypothesis
$t \geq -1.699$	$t < -1.699$
$t_{4.9\text{ms}} = -3.17$	

T-test for one mean

Sample size = 30; Significance = 5%

Performance

Mean total response time,
30 samples



RESULTS

Null hypothesis	Alternative hypothesis
$t \geq 1.699$	$t < -1.699$
REJECT NN is faster than standard!	

T-test for one mean

Sample size = 30; Significance = 5%

Conclusion

Our chords are too complex for NN...



CLOSING

...but NNs are fast enough



Recommendations

CLOSING

Other
machine
learning
algorithms

1

Simplified
set of
chords

2

Use audio
rather than
MIDI as
input

3

T	H	E	Rev. C1	E	N	D
Thank you!						

References

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