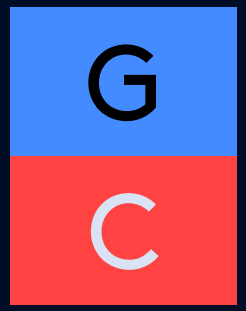
R3.A.09

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

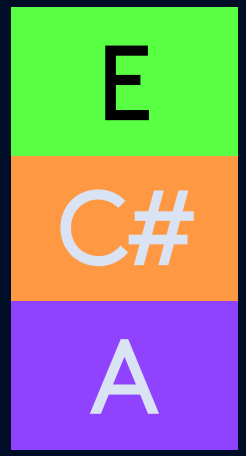
Coronel, Lesli Natasha A.
Navarro, Joachim Alfonso A.

Musical Chords

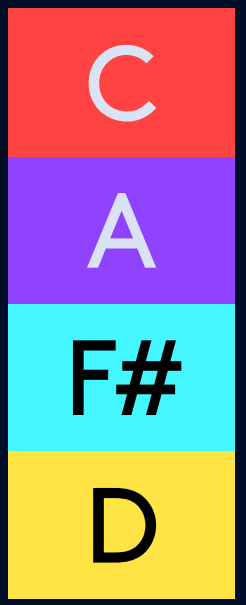
BACKGROUND



2 or more notes



Played together



Follow “rules of harmony”

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

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Musical Chords

BACKGROUND

Each has a name

C5
G
C

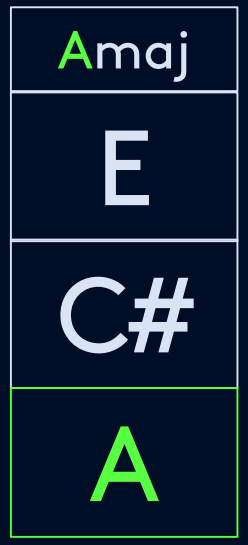
Amaj
E
C#
A

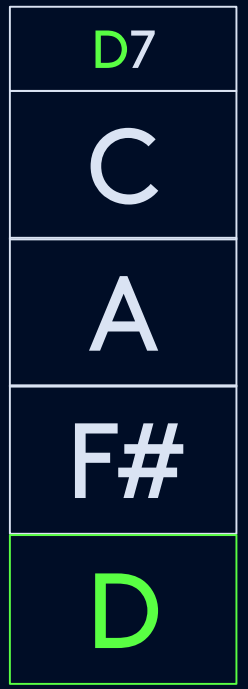
D7
C
A
F#
D

Musical Chords

BACKGROUND

Each has a root note

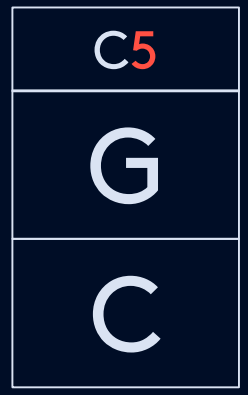


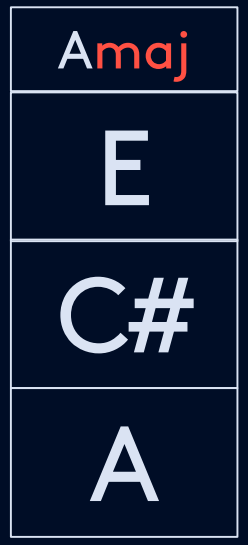


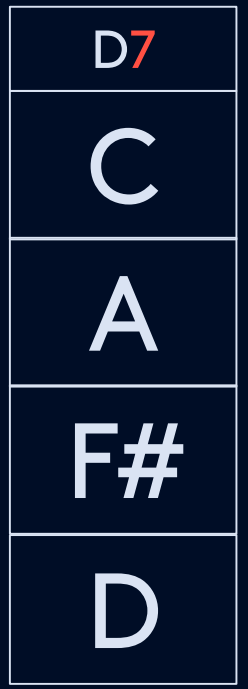
Musical Chords

BACKGROUND

Each has a type





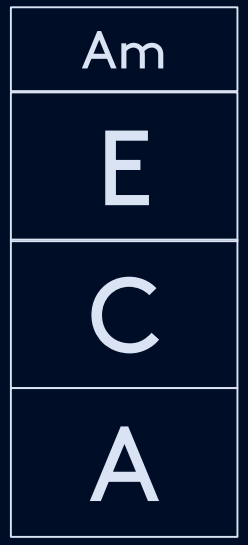


Musical Chords

BACKGROUND

Simple vs Extended

Chord types

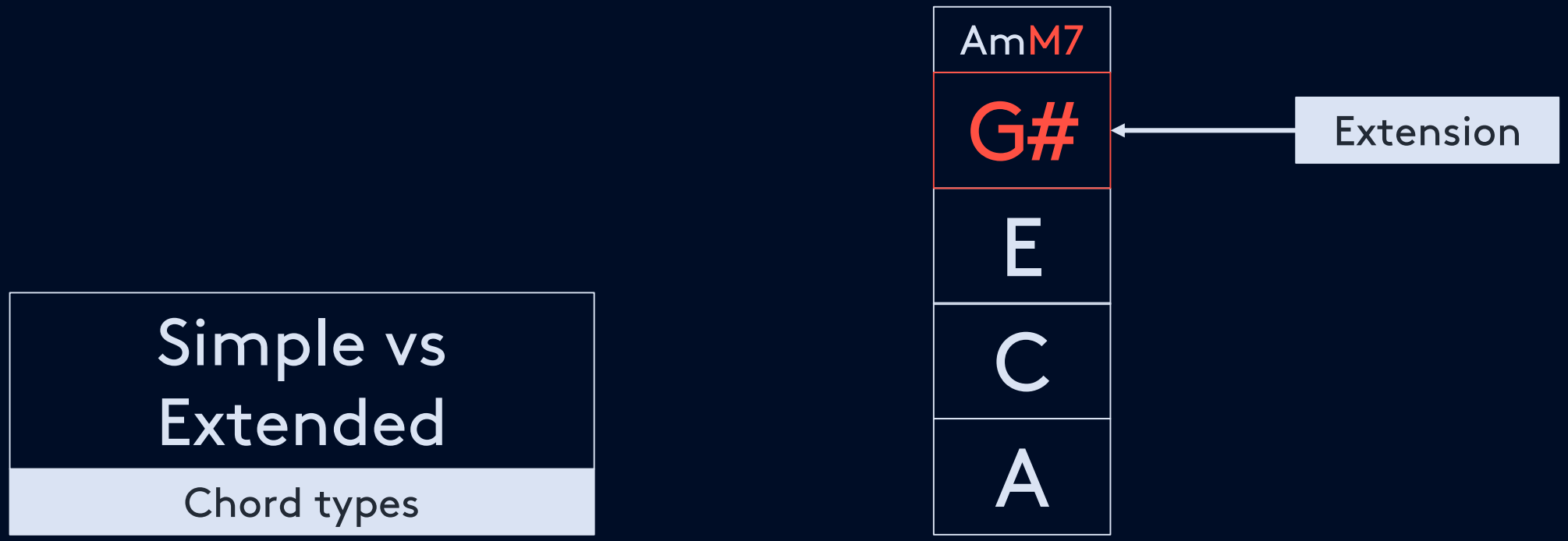


Simple

More common chord type

Musical Chords

BACKGROUND



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

Inference

Neural networks

DEFINITION

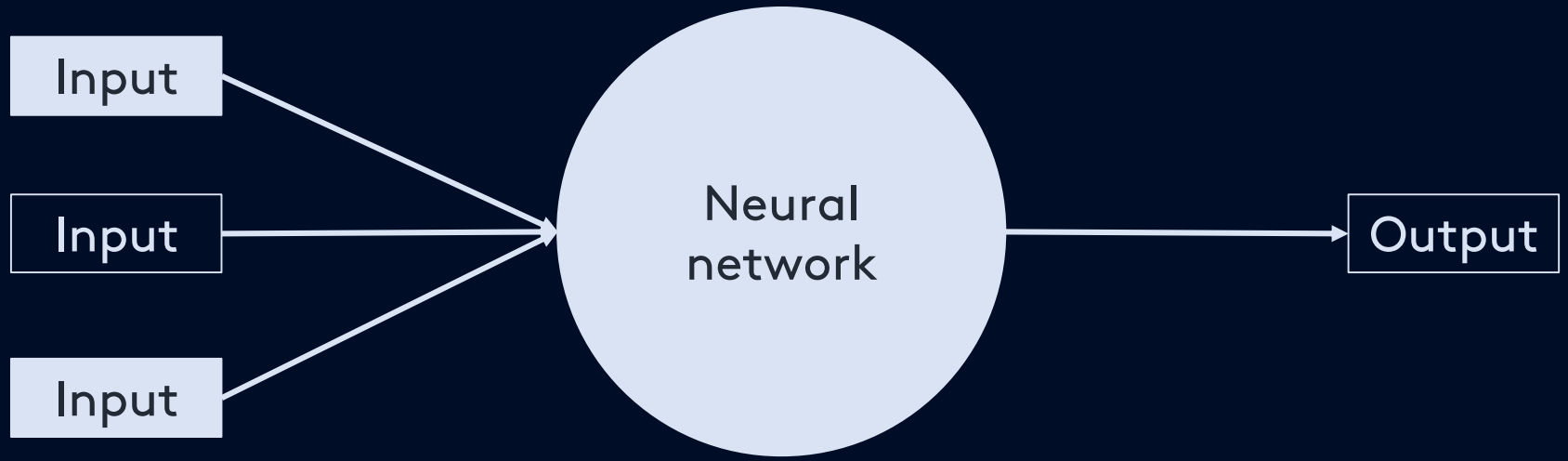
Computational model of neurons in a brain

Neural networks

DEFINITION

Many neurons = neural network

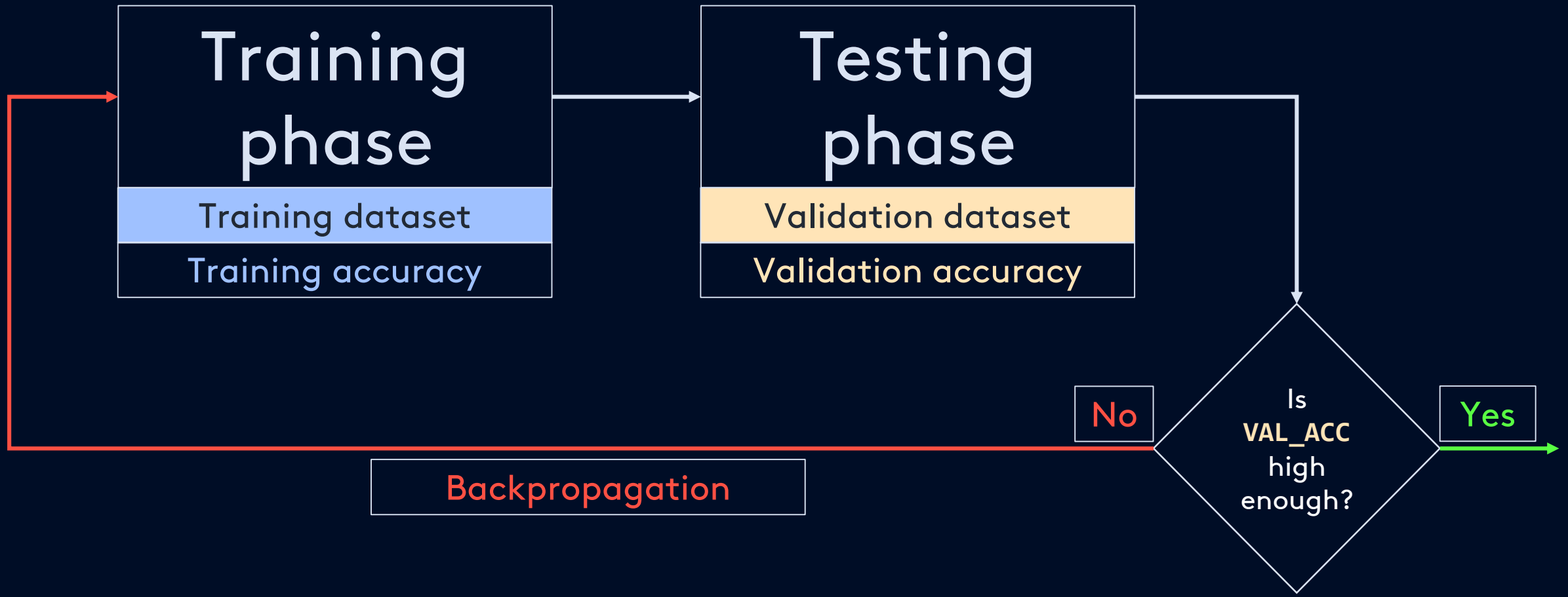
Artificial Neural Networks (ANNs)



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

Problem statement

PROBLEM

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

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

OBJECTIVE

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

Minor

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

Minor

Input chords have one root note and are not inverted

Minor

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

Greeff, 2016

Minor

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

thestk, 2017; Bretschneider, 2017

Minor

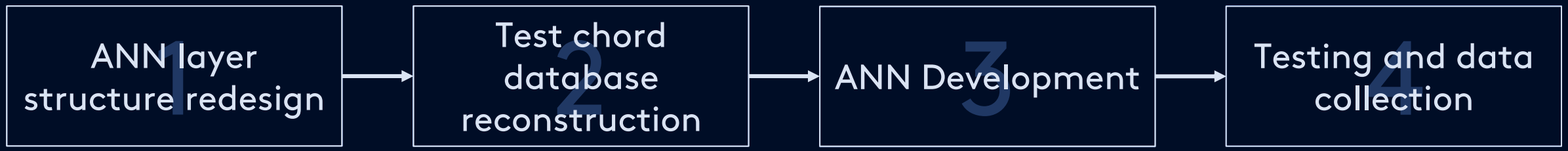
OBJECTIVES

Neural network must be run on a GPU for efficient processing

Nickolls, Buck, Garland, & Skadron, 2008

Level 0

PROCESS

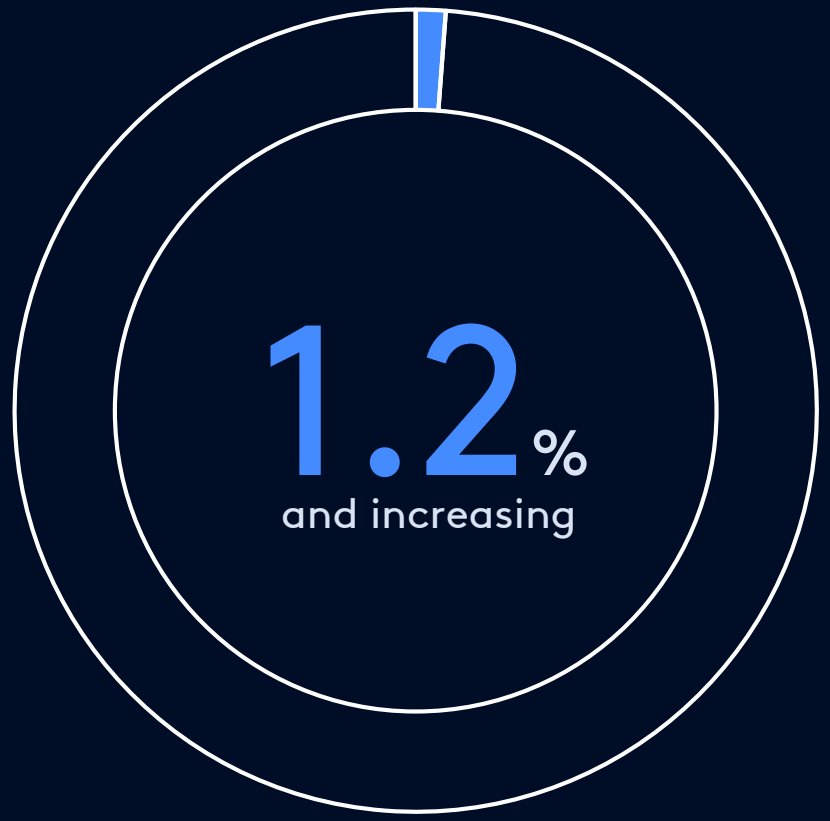


Performance

RESULTS

Peak validation accuracy after 2800 epochs

Peak training accuracy after 2800 epochs



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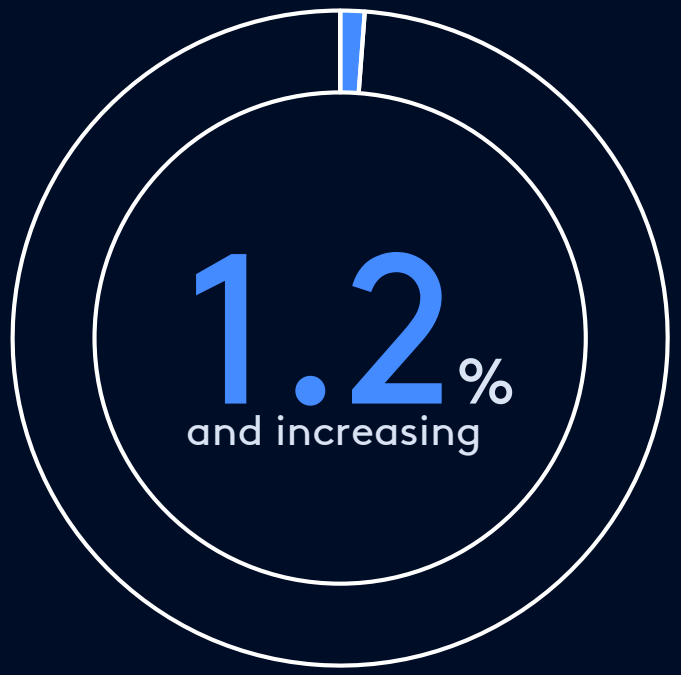
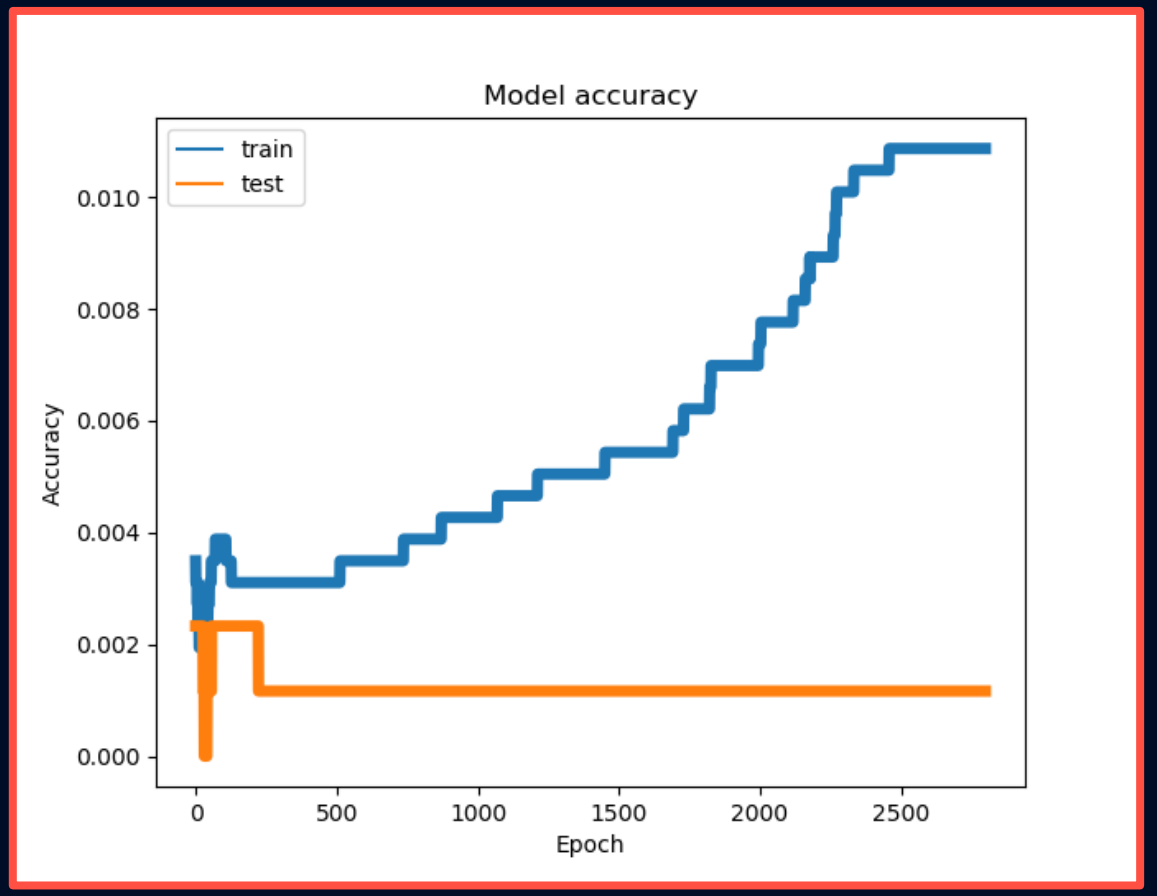
Performance

RESULTS

Peak training accuracy
after 2800 epochs





Learning the training dataset

Trend

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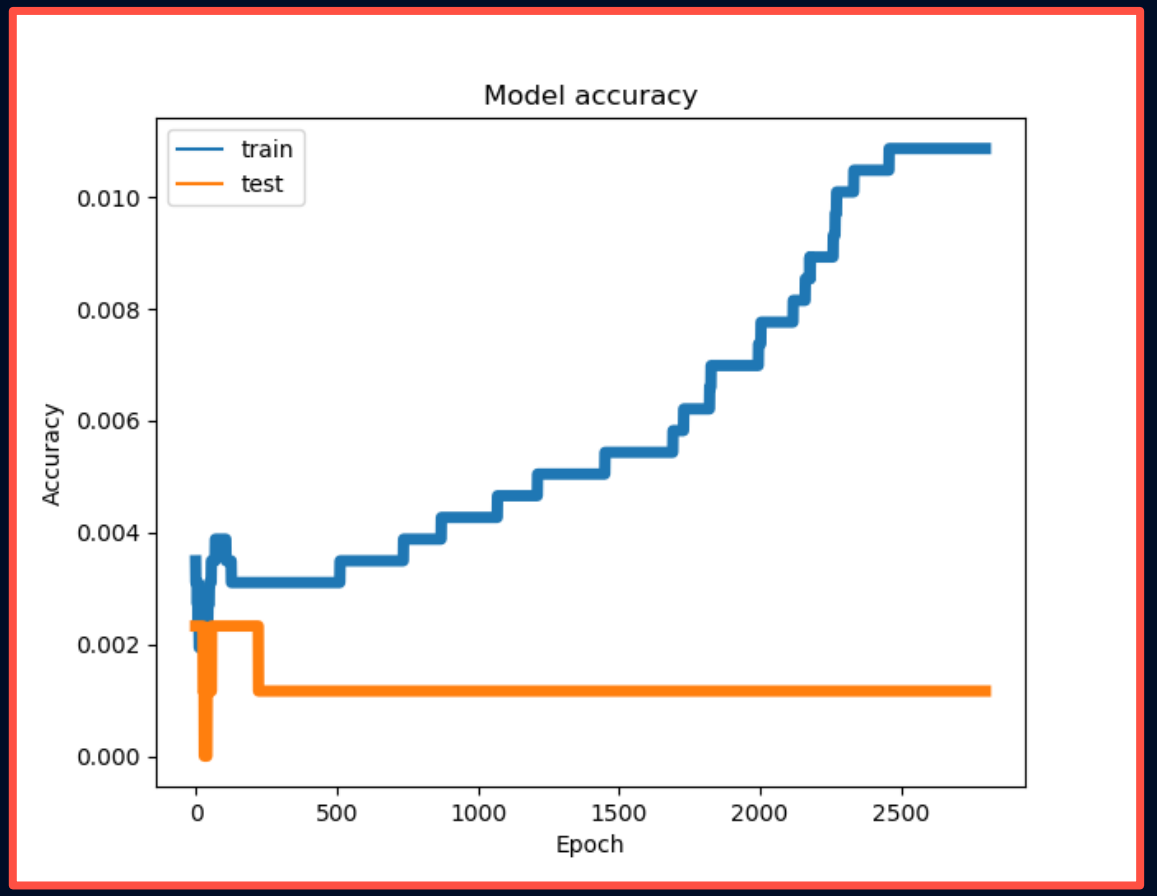
Performance

RESULTS

Peak validation accuracy after 2800 epochs



Over-fitting on training dataset

Reason

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

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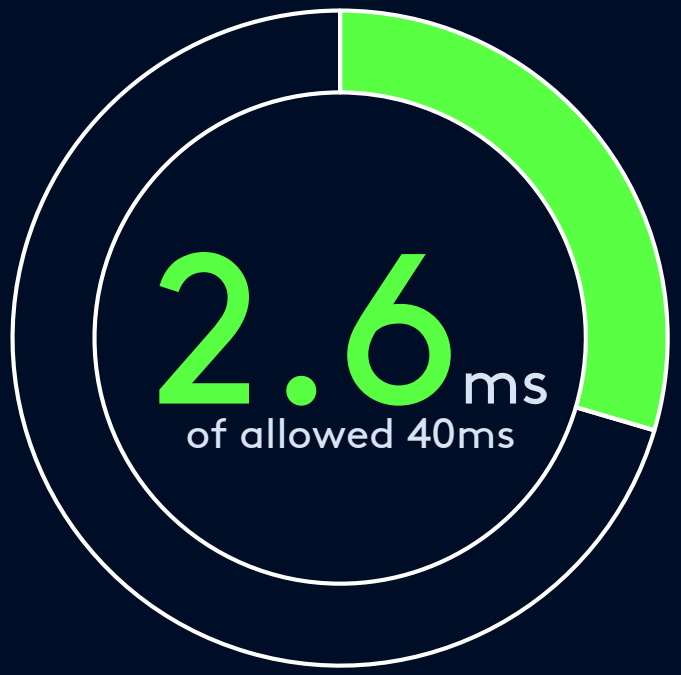
Performance

RESULTS

Mean total response time,
30 samples



Null hypothesis	Alternative hypothesis
$r \geq 40ms$	$r < 40ms$

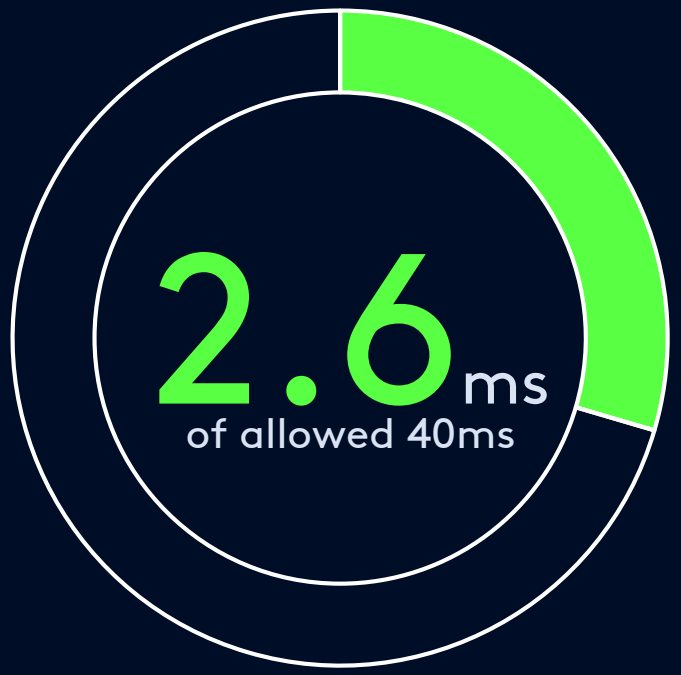
T-test for one mean

Sample size = 30; Significance = 5%

Performance

RESULTS

Mean total response time,
30 samples



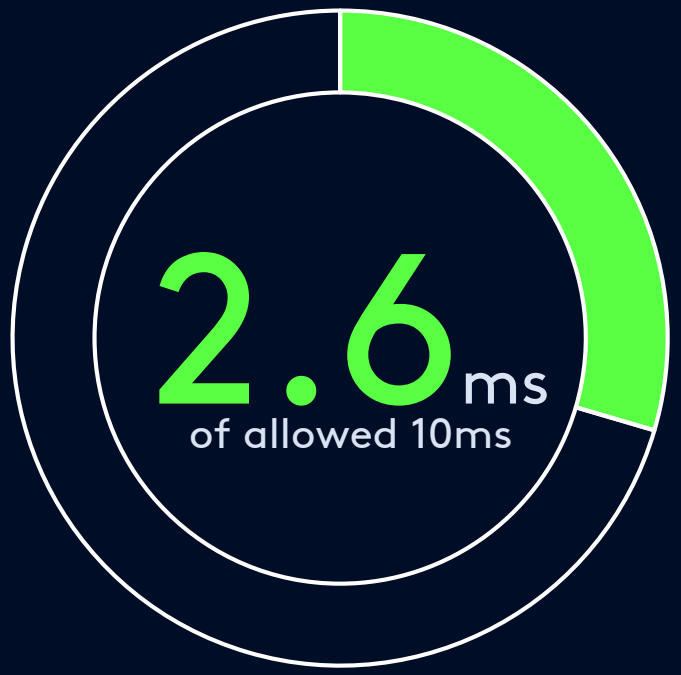
Null hypothesis	Alternative hypothesis
$t \geq -1.6_{99}$	$t < -1.6_{99}$

T-test for one mean

Sample size = 30; Significance = 5%

Performance

Mean total response time,
30 samples



Null hypothesis	Alternative hypothesis
$t \geq -1.6_{99}$	$t < -1.6_{99}$
$t_{3ms} = -34.54$	

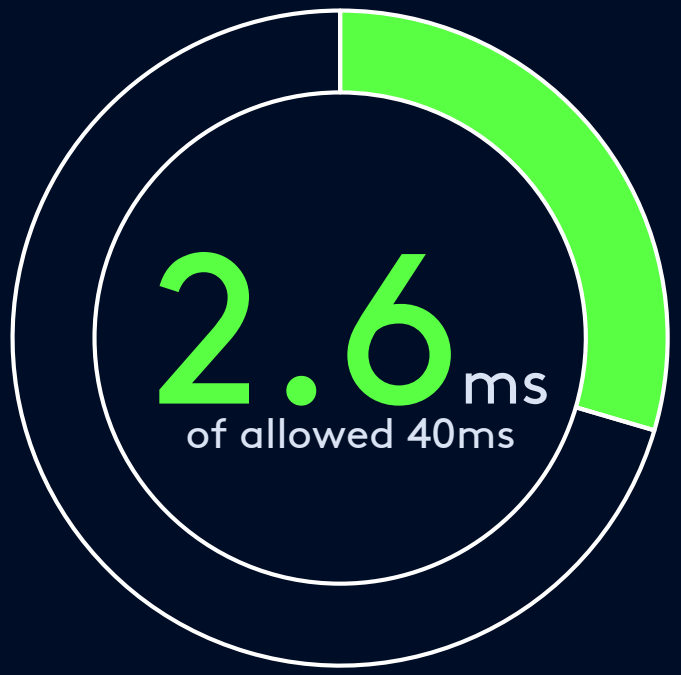
T-test for one mean

Sample size = 30; Significance = 5%

Performance

RESULTS

Mean total response time,
30 samples



Null hypothesis	Alternative hypothesis
$t \geq -1.6_{99}$	$t < -1.6_{99}$

REJECT

NN is faster than standard!

T-test for one mean

Sample size = 30; Significance = 5%

Conclusion

CLOSING

The revised ANN design can learn the dataset...

and is even faster than last year's version

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Recommendations

Use entire dataset for training	More training epochs
1	2

T	H	E	Rev. B1	E	N	D

Thank you!

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