R3.A.09

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

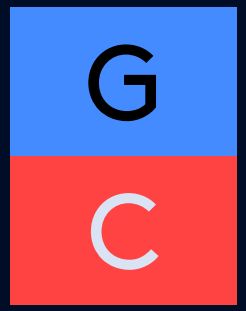
Coronel, Lesli Natasha A.
Navarro, Joachim Alfonso A.

# Pitch Classes / Notes

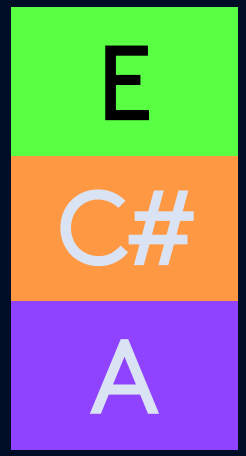


# Musical Chords

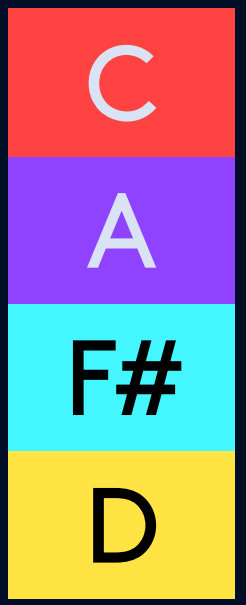
BACKGROUND




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 |

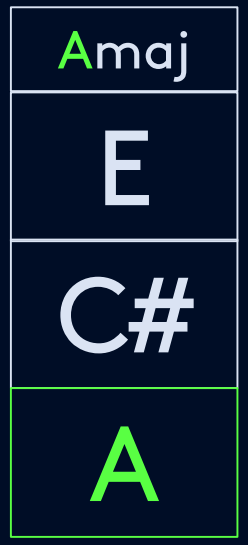
| Amaj |
| --- |
| E |
| C# |
| A |

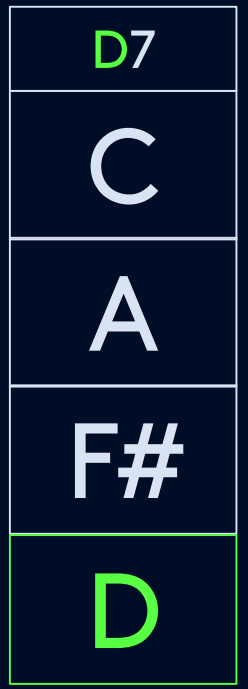
| D7 |
| --- |
| C |
| A |
| F# |
| D |

# Musical Chords

BACKGROUND

Each has a root note

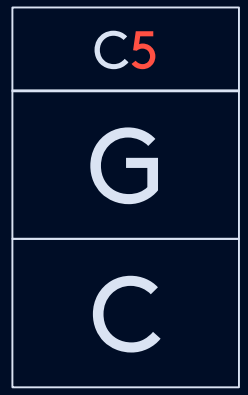



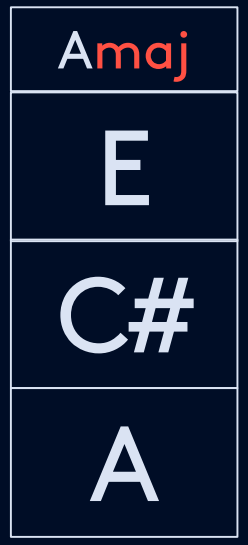



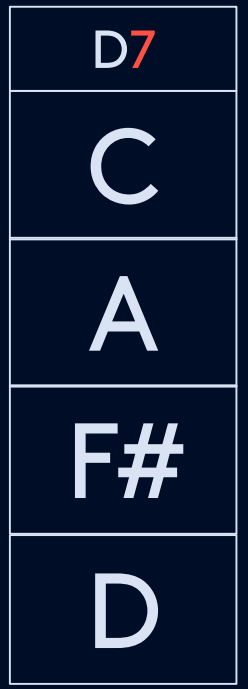
# Musical Chords

BACKGROUND

Each has a type



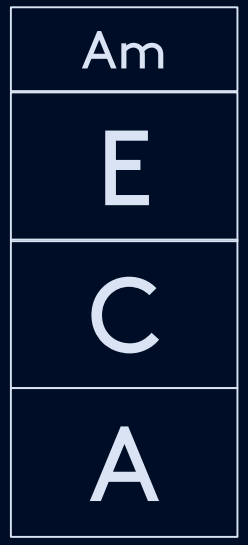



# Musical Chords

BACKGROUND

Simple vs Extended

Chord types

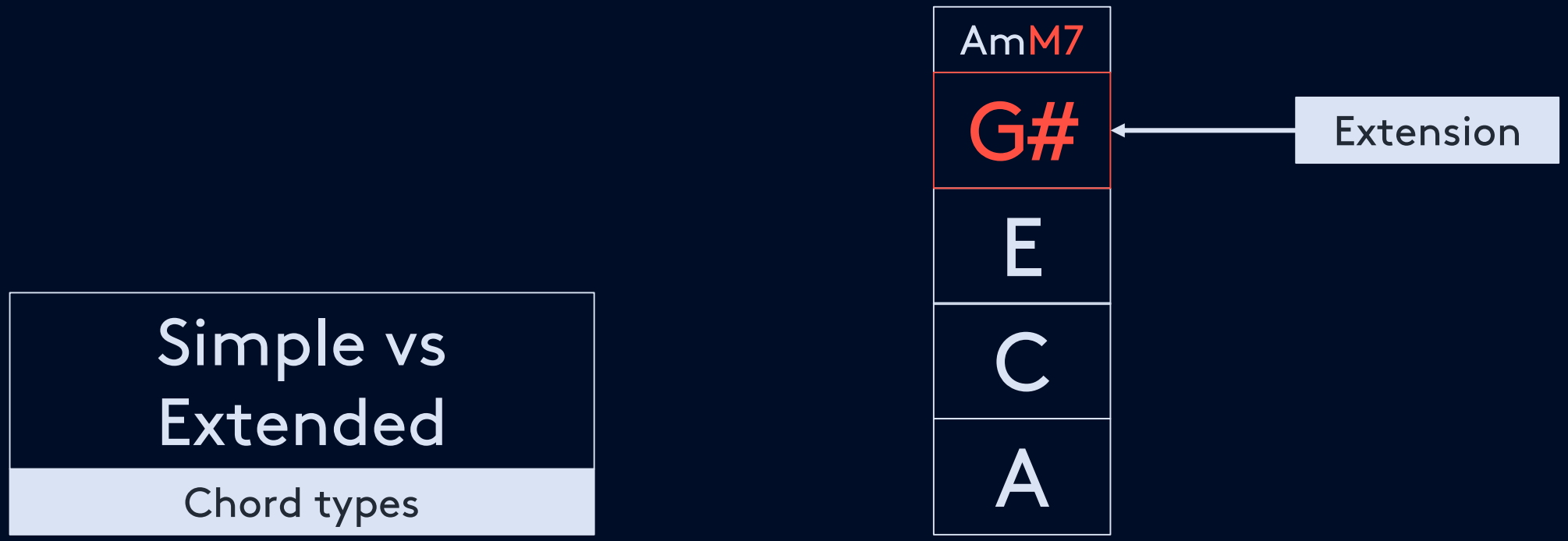



Simple

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

> "The general music learning public places a high demand on chord-based representations of popular music."
>
> Humphrey, Bello, & Cho, n.d., par. 1

# 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

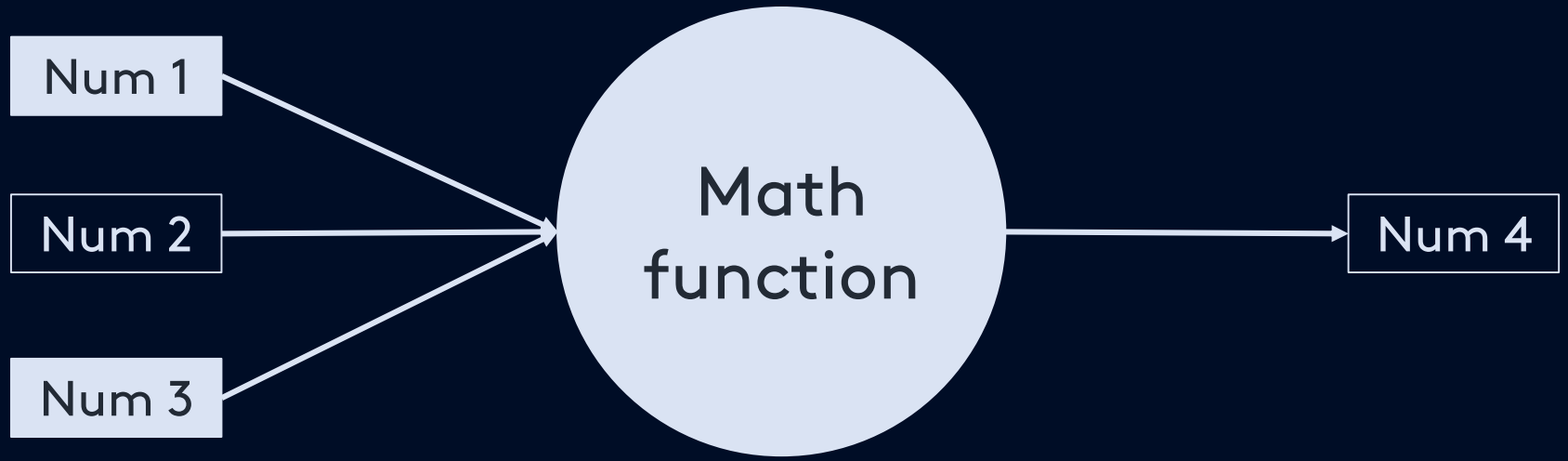
# Neural networks

DEFINITION


Computational model of neurons in a brain

# Neural networks

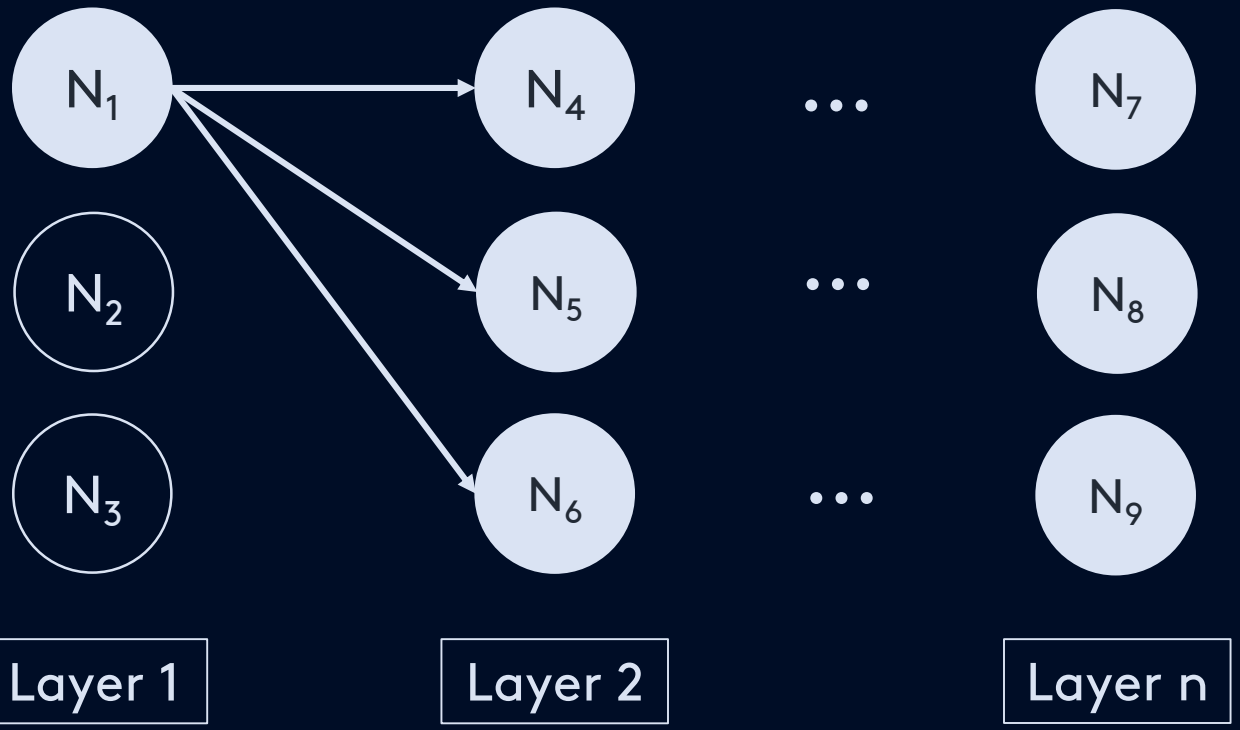
DEFINITION




Many neurons passing and manipulating numbers

# Neural networks

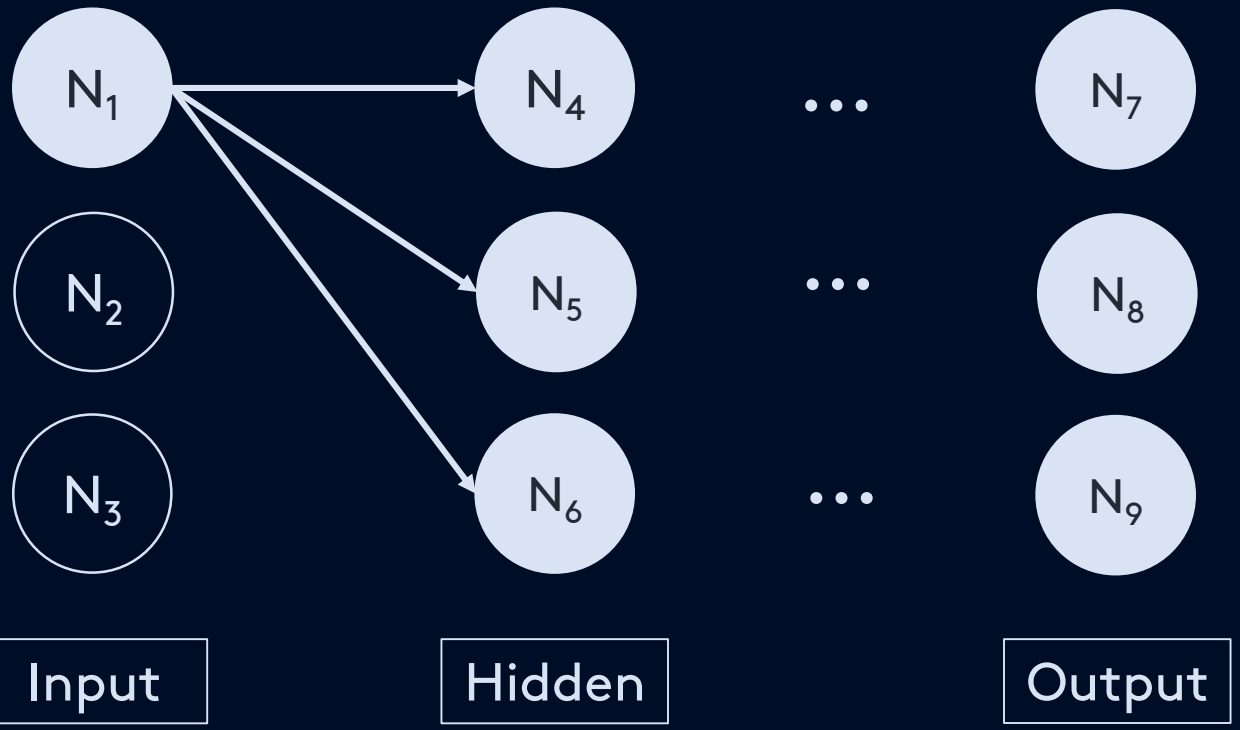
DEFINITION




Neurons arranged in “layers”

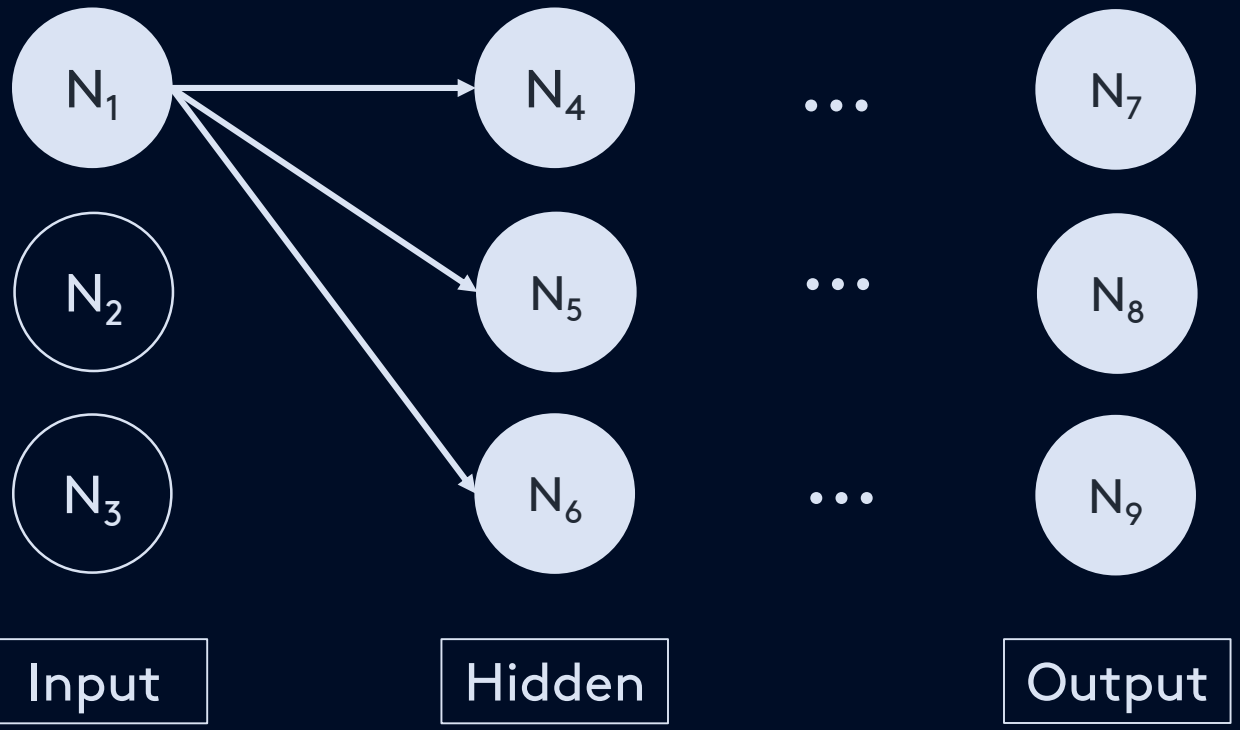
# Neural networks

DEFINITION




Neurons arranged in “layers”

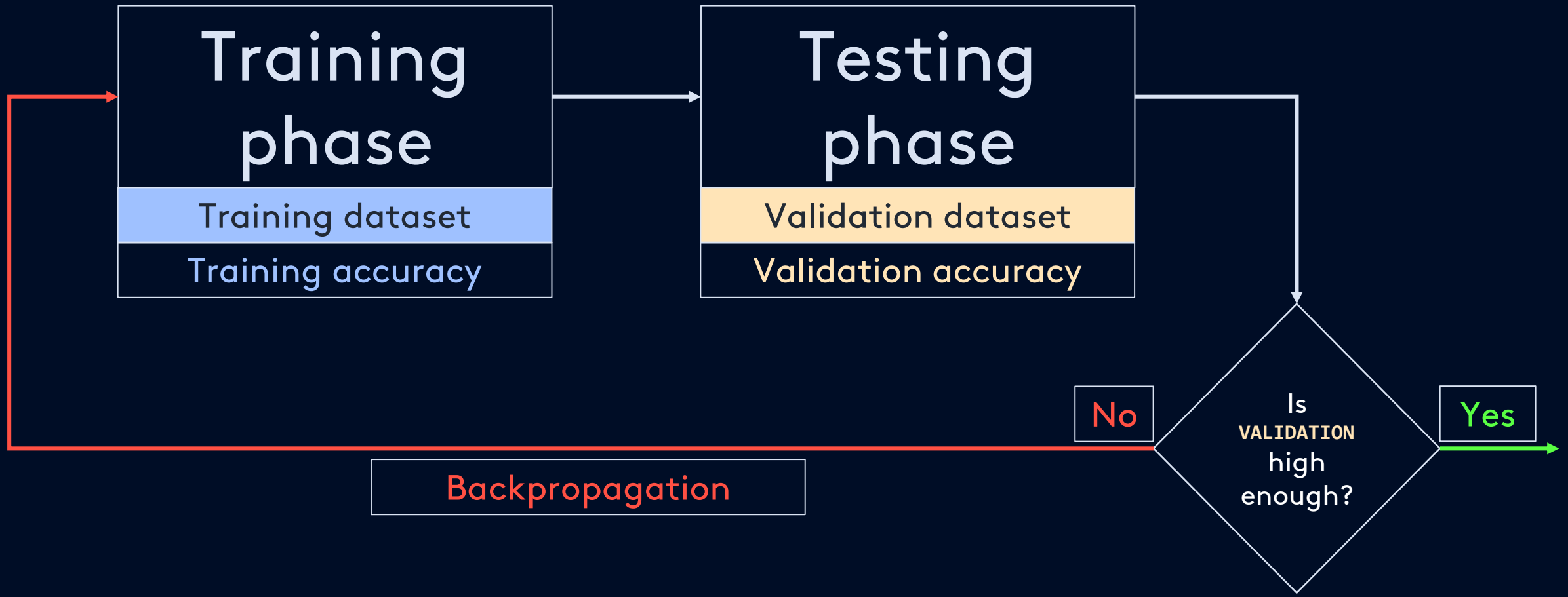
# Artificial Neural Networks (ANNs)




**NNs learn by repetitive training**

Colina, Perez, & Paraan, 2017

# ANN training & testing



# Why ANNs?

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 simple and extended chord types is **unexplored**

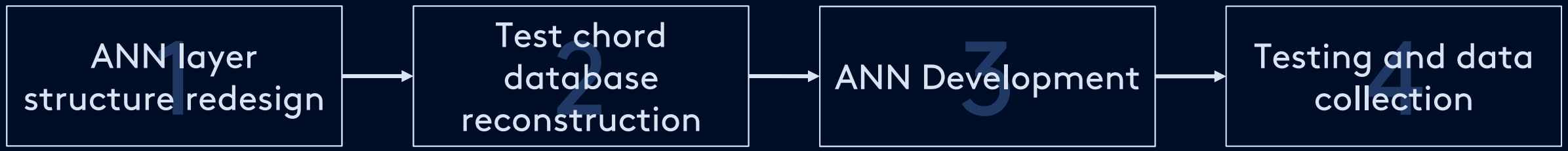
Osmalskyj, Embrechts, Piérard, & Van Droogenbroeck, 2012
Perera & Kodithuwakku, 2005
Zhou & Lerch, 2015

# MAJOR OBJECTIVE

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

# Level 0

PROCESS



# Performance

RESULTS

Accuracy on the validation dataset questions


Accuracy on the training dataset questions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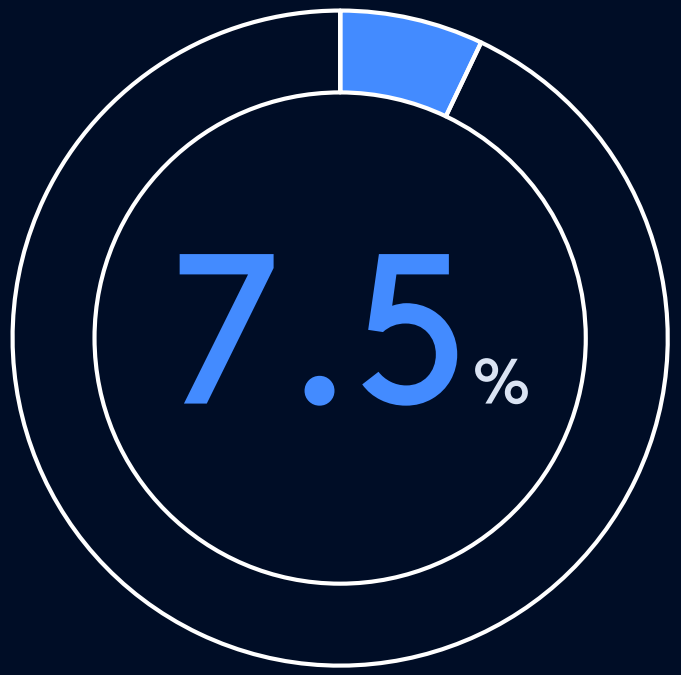
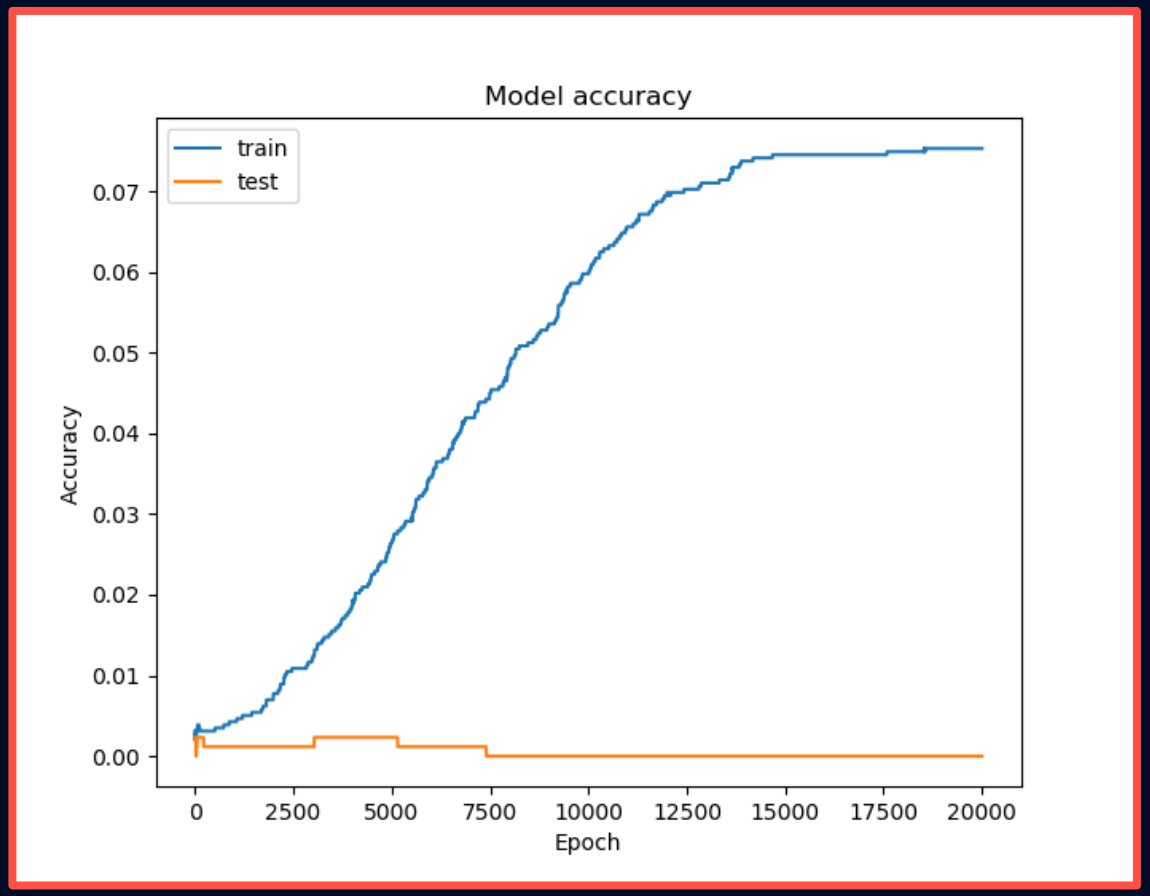
# Performance

RESULTS

Peak training accuracy after 30K epochs




Can't learn training dataset very well

Gives up at 7.5%

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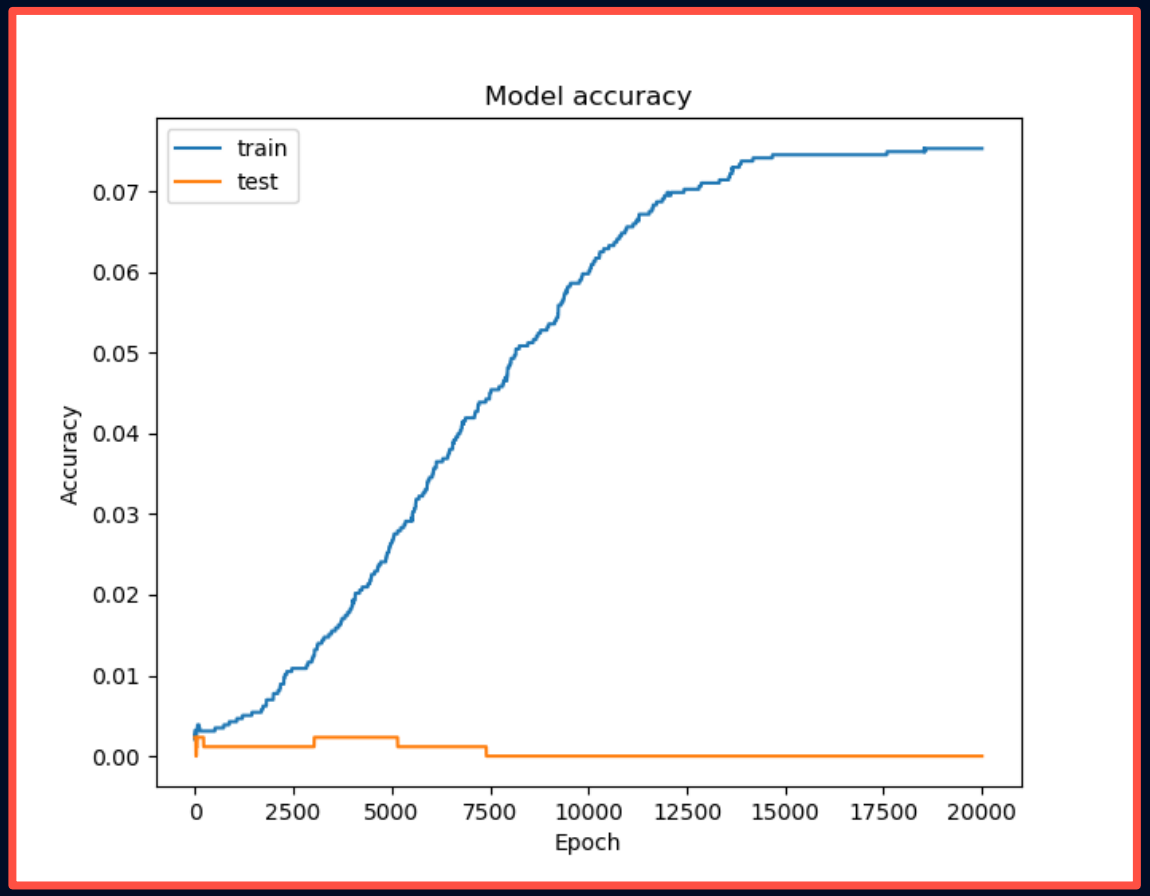
# Performance

RESULTS

Peak validation accuracy after 2800 epochs


Learns just the training dataset

"Overfitting"

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# Performance



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 |
| --- | --- |
| $t \geq -1.6_{99}$ | $t < -1.6_{99}$ |

REJECT

NN is faster than standard!

## T-test for one mean

Sample size = 30; Significance = 5%

# Conclusion

CLOSING

Our chords are too complex for NN...


...but NNs are fast enough

# Recommendations



| Other machine learning algorithms | Fewer and simpler chords | Use audio rather than MIDI as input |
|---|---|---|
| 1 | 2 | 3 |

| T | H | E | Rev. C1 | E | N | D |
|---|---|---|---|---|---|---|

Thank you!

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