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

R3 A09

Brain Blast 2019

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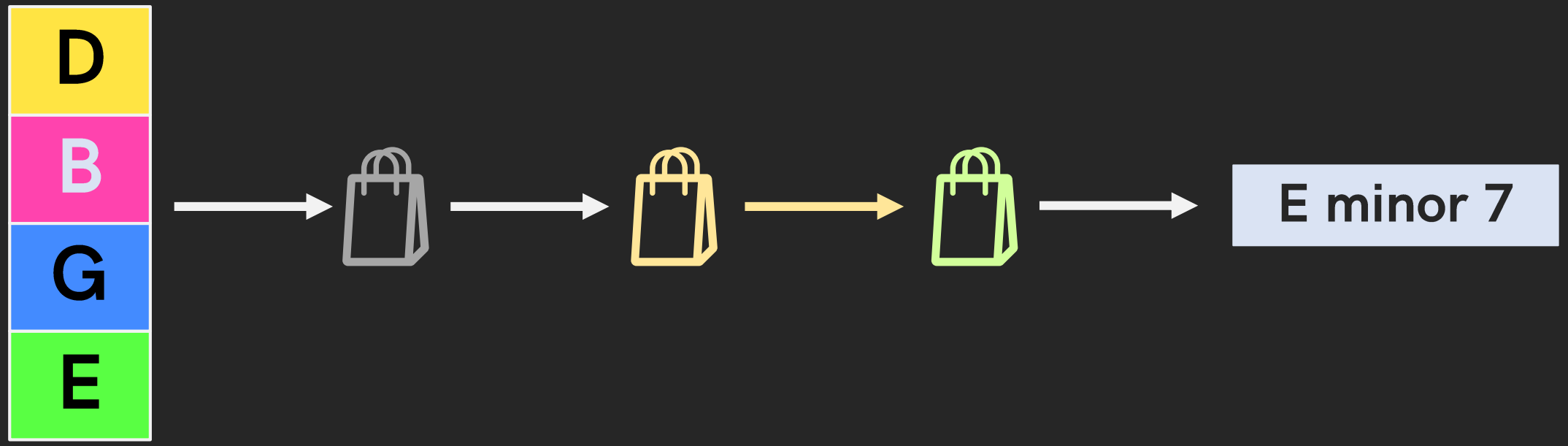
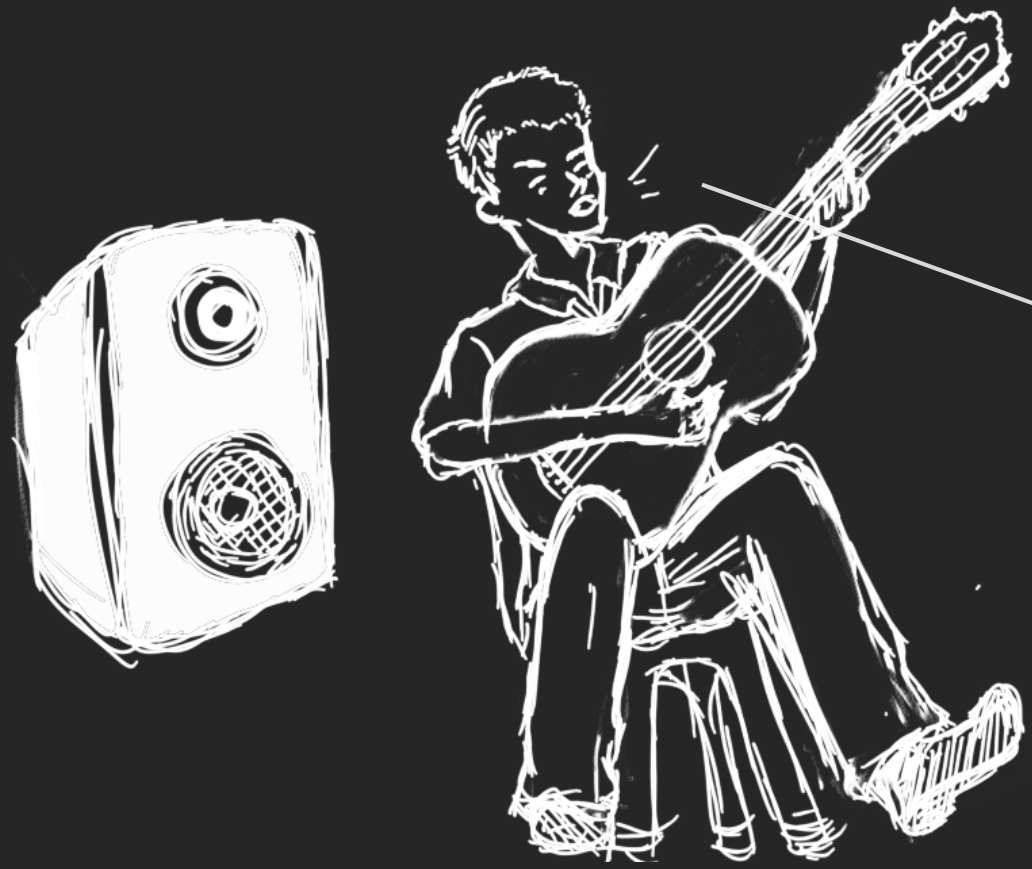
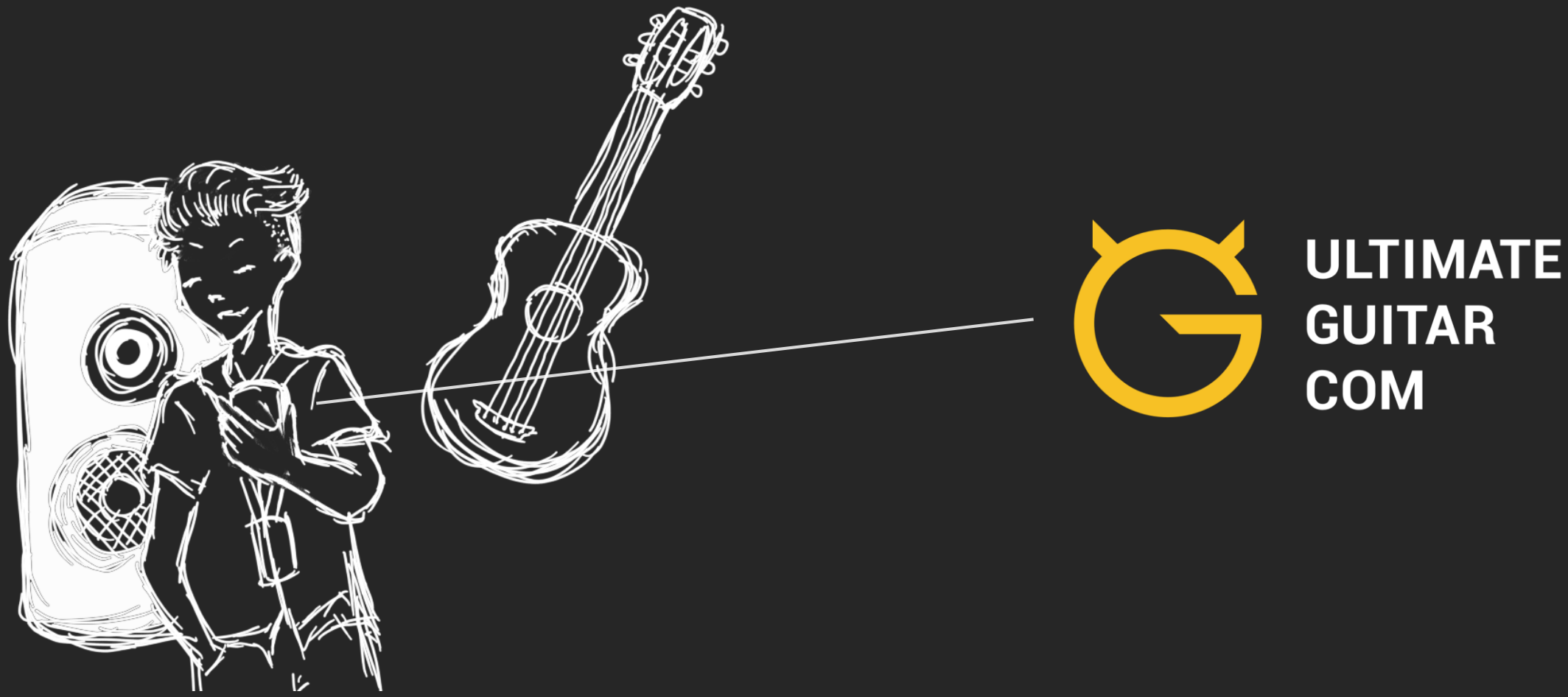


Has this ever happened to you?



What's the chords of this song?

We do what we have to do

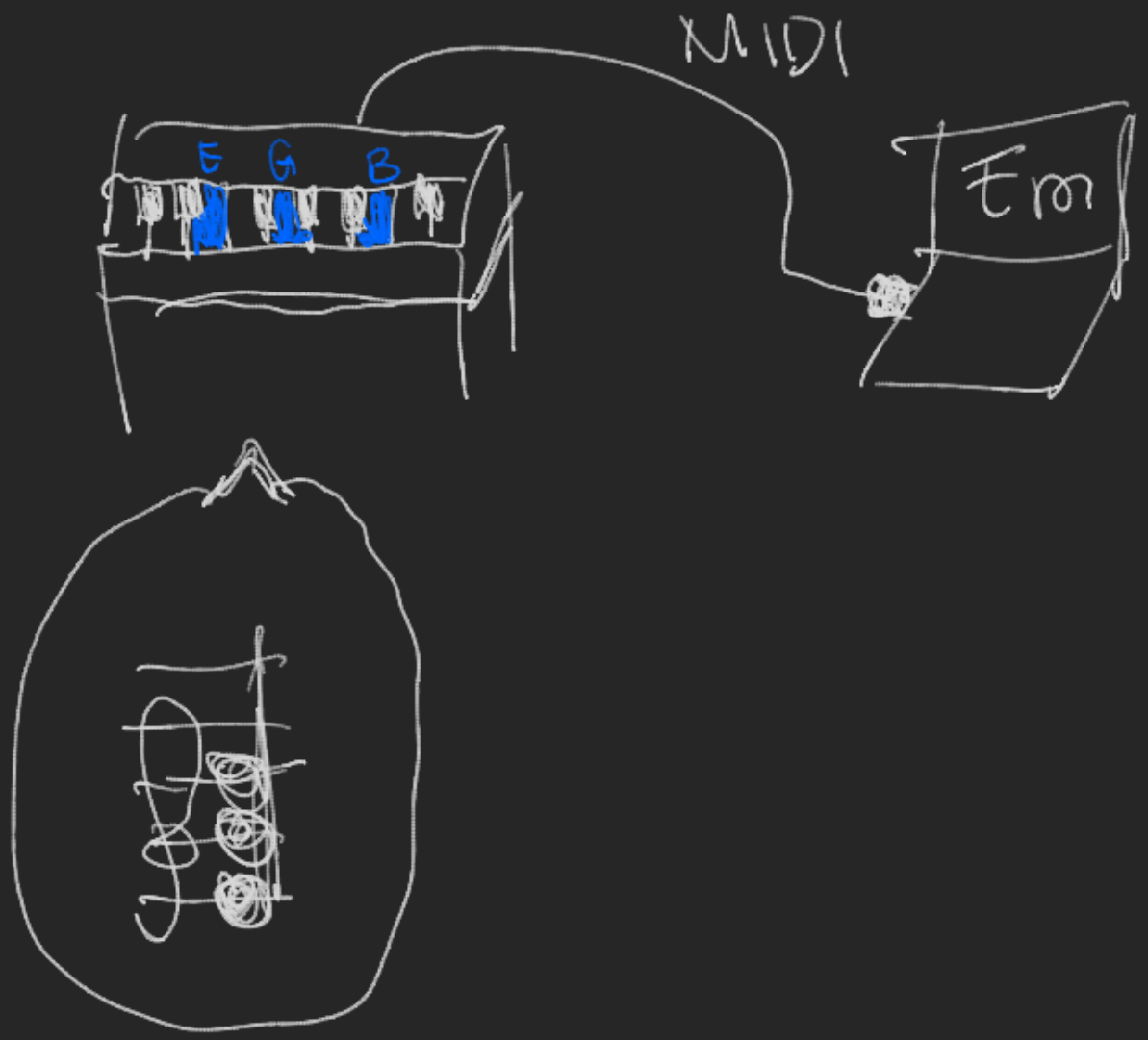


What if the song wasn't too popular?

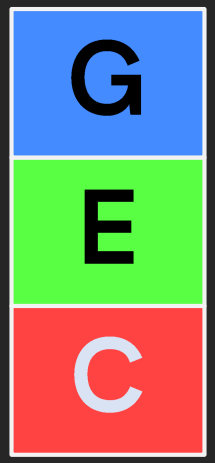
OK Google, what are the chords of this song?

My apologies...
I don't understand.

What if a machine could do it?



What is a chord?



C major

Collection of

two or more notes

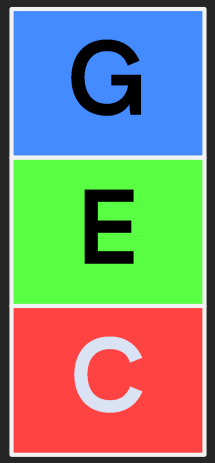
What is a chord?

C major

Collection of
two or more notes

Usually
played together

What is a chord?

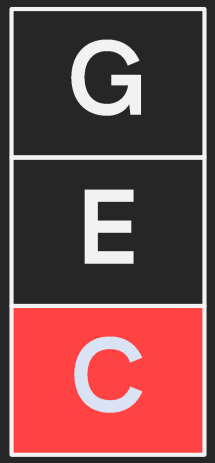


C major

Sound like they
make sense

Leino, Brattico, Tervaniemi, & Vurst, 2007

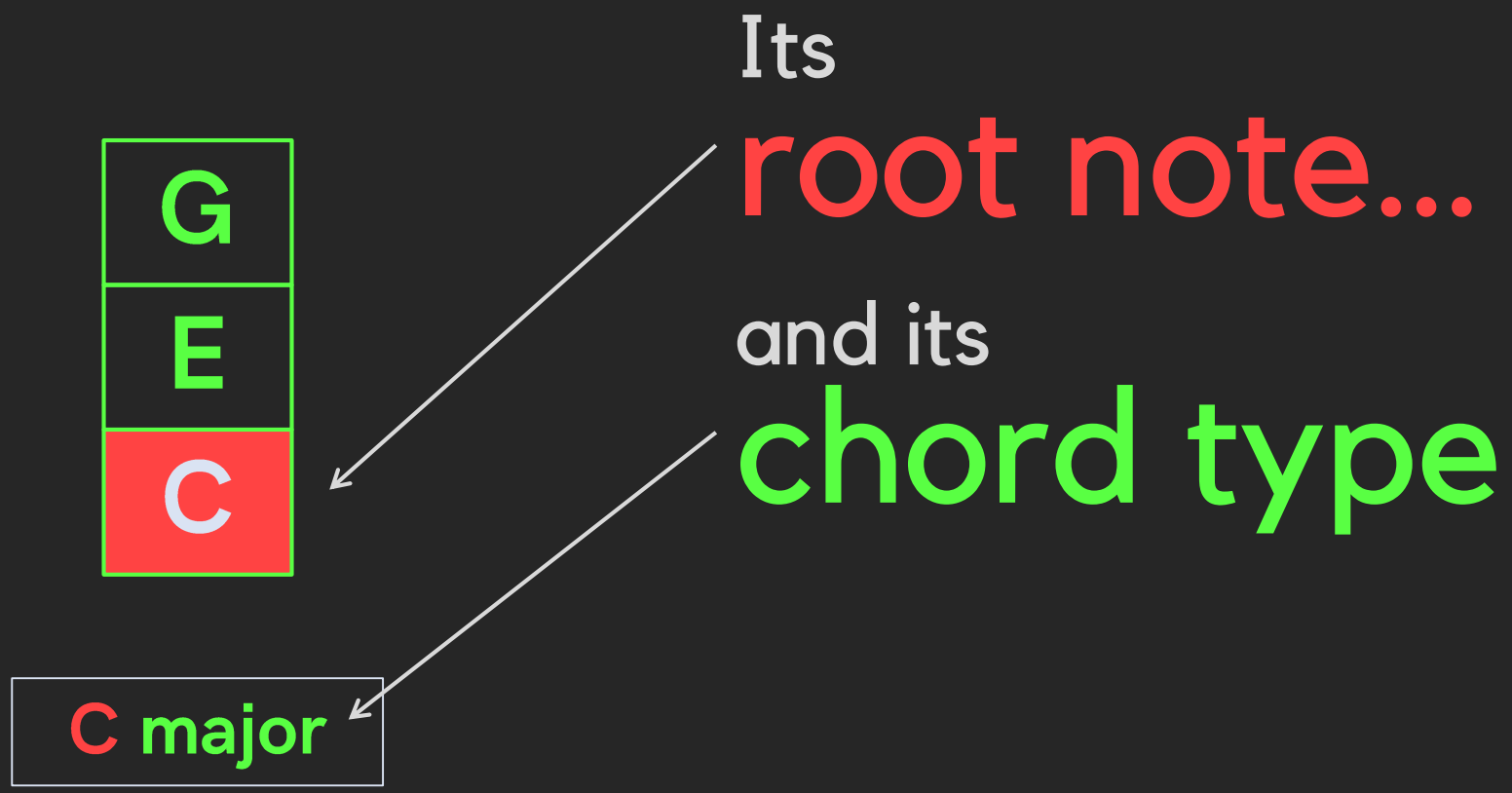
How is a chord named?



Its
root note...

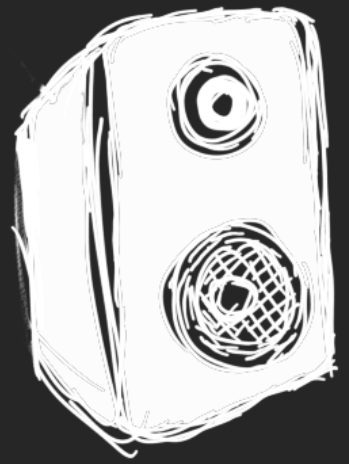
C major

How is a chord named?



Chord identification:

Naming chords by knowing their notes



D

B

G

E

C

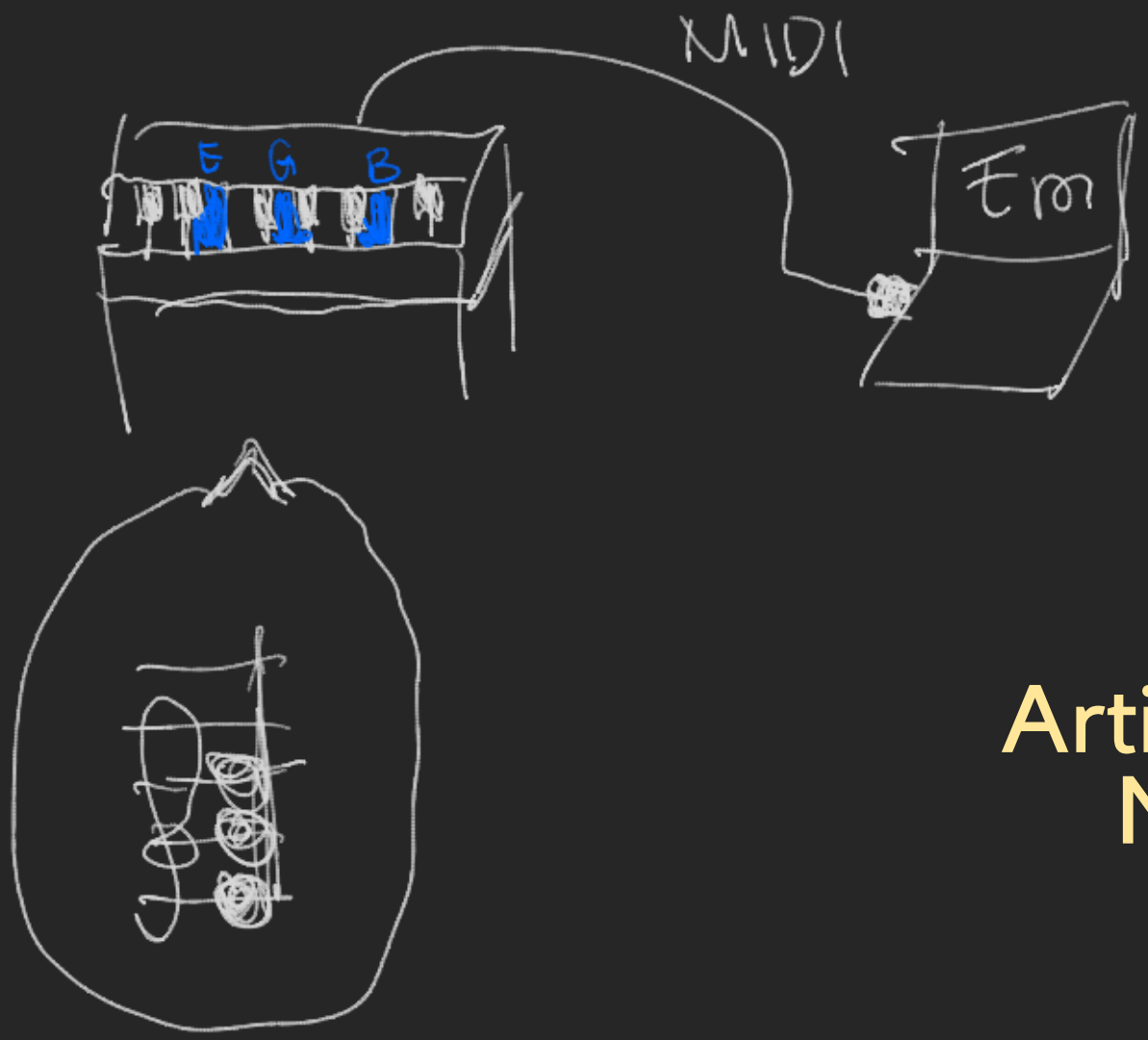
A

F

That's an

F major 13 (#11)

...And we're expecting a computer to do that?

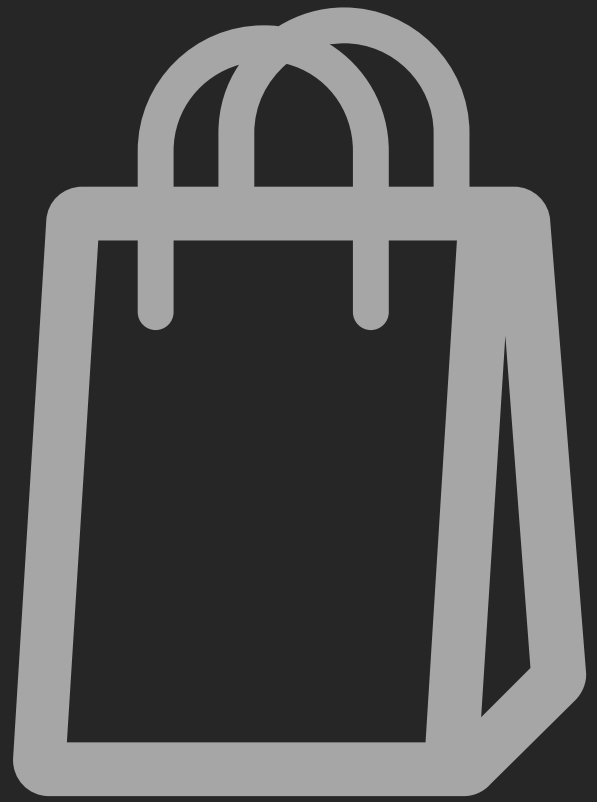


Artificial Neural Networks!

Artificial Neural Networks (ANNs)

Artificial Neural Networks (ANNs)

Sanderson, 2017 | Nielsen, 2015 | Colina, Perez, & Paraan, 2017



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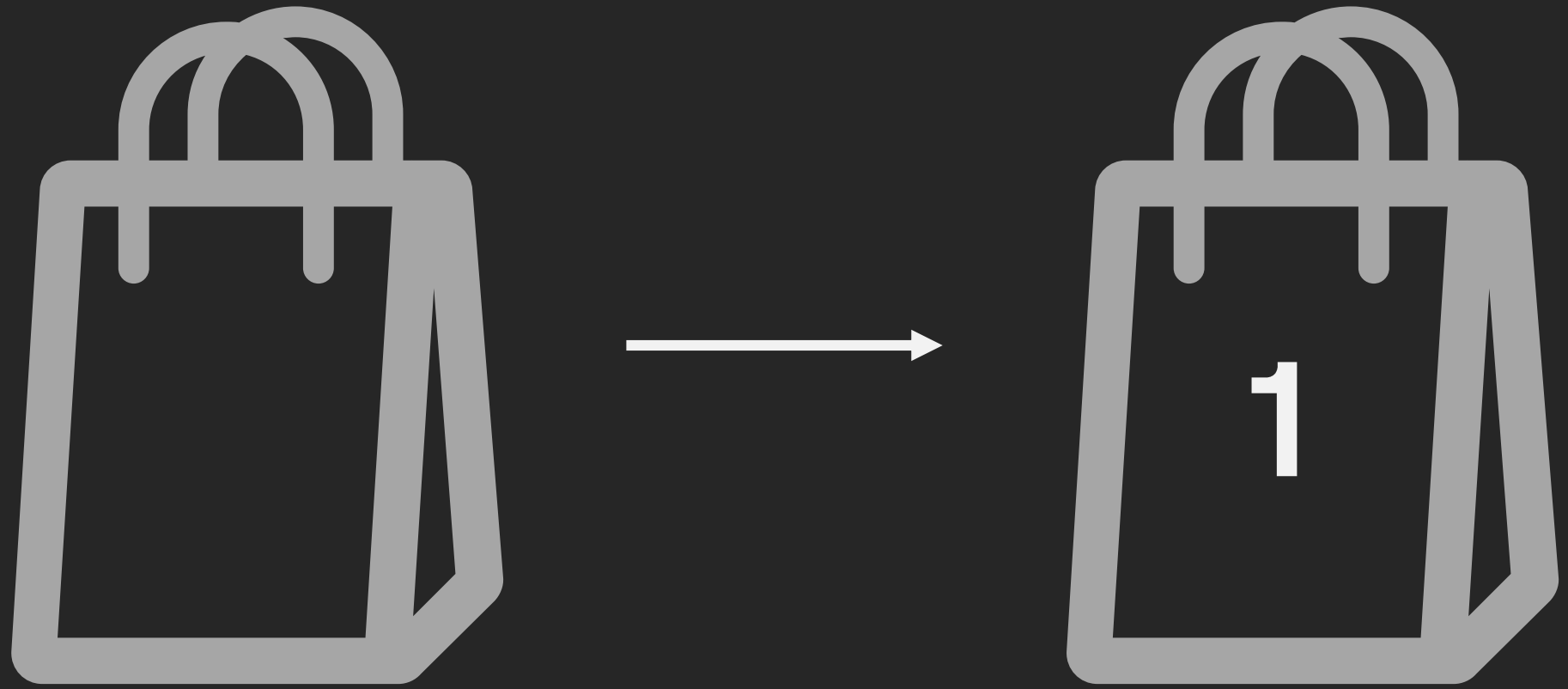

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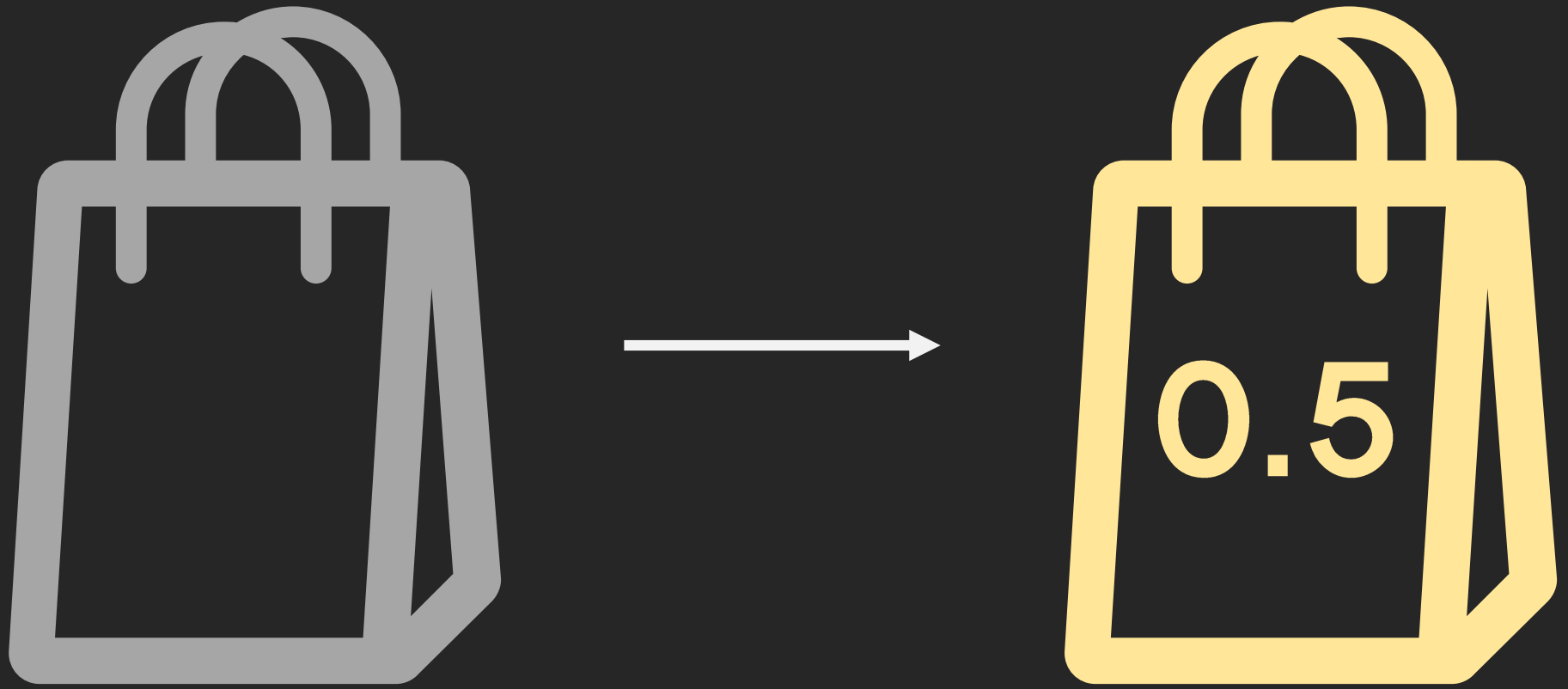

Magic math bag

Artificial Neural Networks (ANNs)

Sanderson, 2017 | Nielsen, 2015 | Colina, Perez, & Paraan, 2017

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This layout is a simple neural network

Artificial Neural Networks (ANNs)

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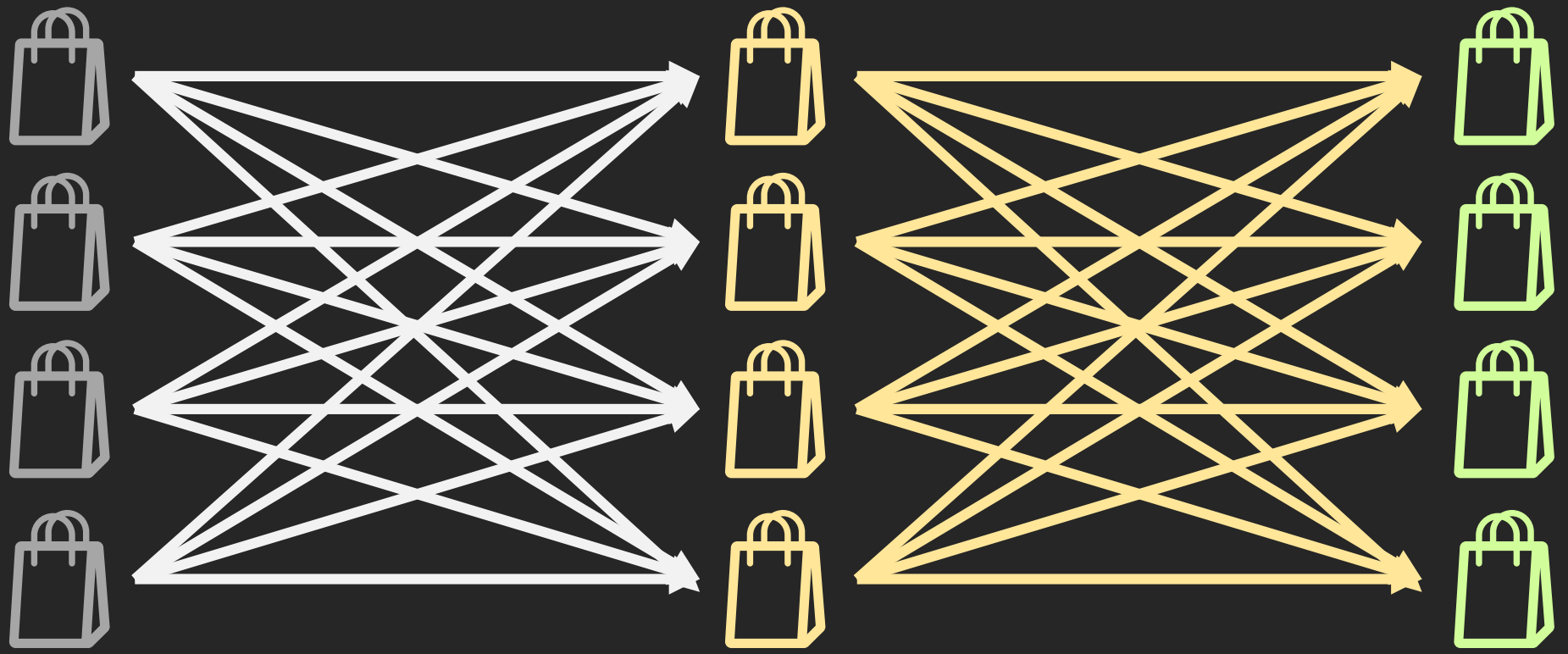

But real ones look more like this

Artificial Neural Networks (ANNs)

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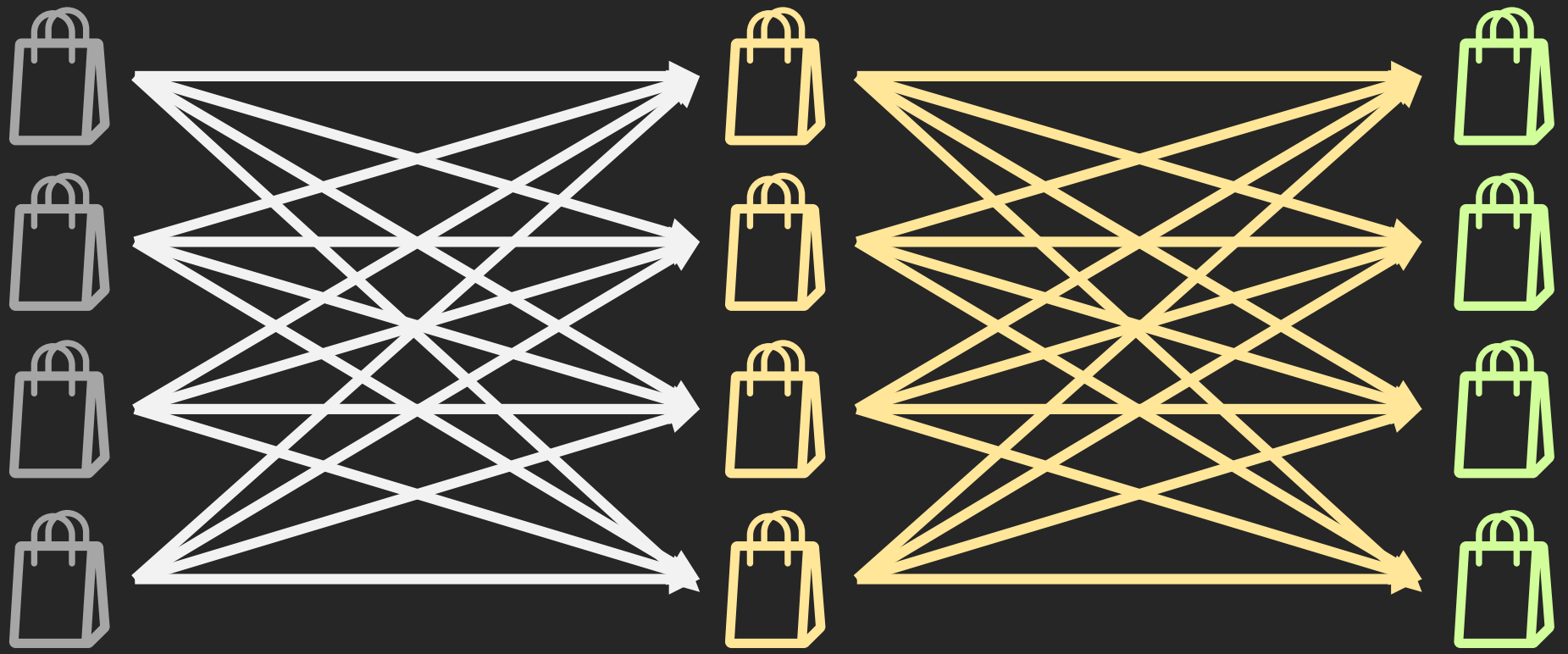

This neural network can be **trained...**

Artificial Neural Networks (ANNs)

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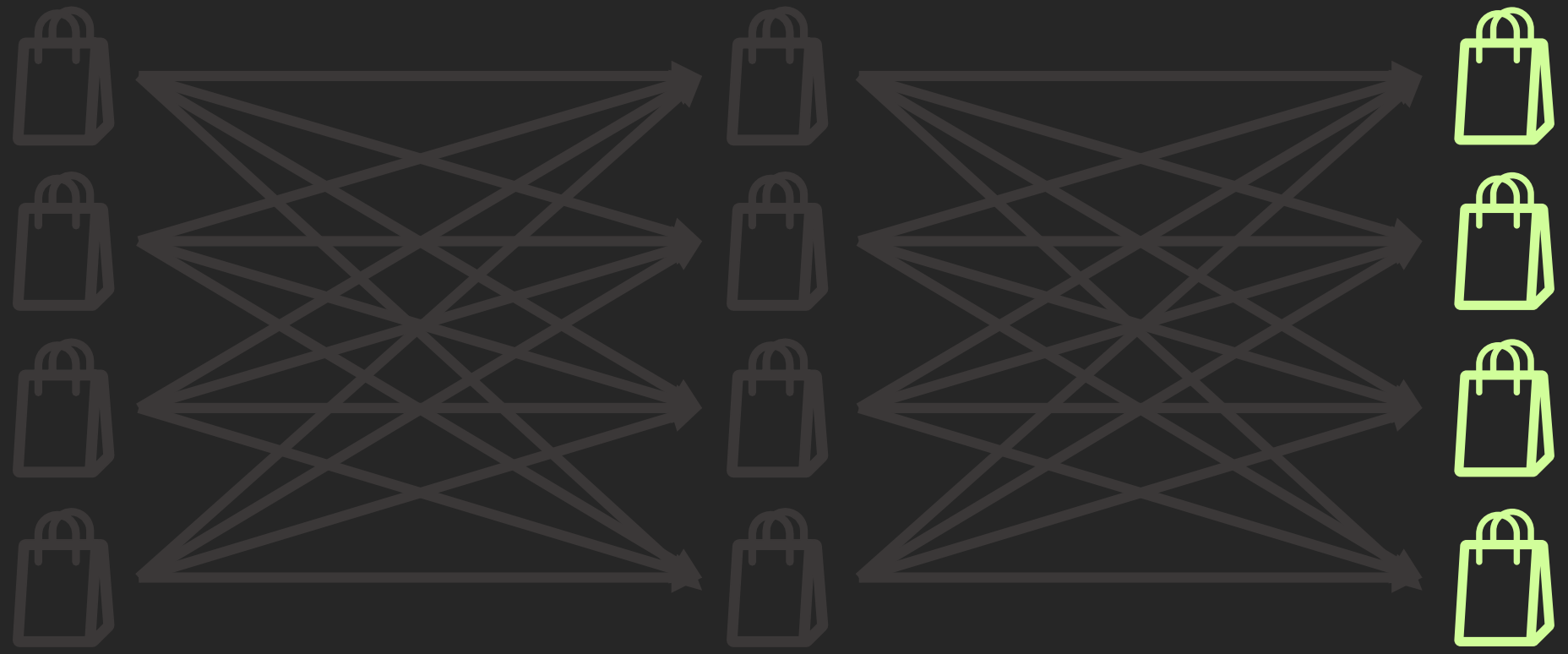


to output certain **numbers...**

Artificial Neural Networks (ANNs)

Sanderson, 2017 | Nielsen, 2015 | Colina, Perez, & Paraan, 2017

First bag

Input	Correct output
1	0.7
0.9	0.3
0.8	0.6
...	...

using a **training dataset**

Artificial Neural Networks (ANNs)

Sanderson, 2017 | Nielsen, 2015 | Colina, Perez, & Paraan, 2017

Second bag

Input	Correct output
1	0.2
0.9	0.4
0.8	0.1
...	...

which contains **answers** for all "bags".

Artificial Neural Networks (ANNs)

Sanderson, 2017 | Nielsen, 2015 | Colina, Perez, & Paraan, 2017

QUIZ!
First bag

Input 	Correct output 
1	
0.9	
0.8	
...	...

The network is then **tested** using a **validation dataset**

Artificial Neural Networks (ANNs)

Sanderson, 2017 | Nielsen, 2015 | Colina, Perez, & Paraan, 2017

QUIZ!
First bag

33%
accuracy

Input	Correct output
1	0.4
0.9	0.7
0.8	0.3
...	...

The network tries to answer
and may get wrong answers.

Artificial Neural Networks (ANNs)

Sanderson, 2017 | Nielsen, 2015 | Colina, Perez, & Paraan, 2017

So it trains **again and again...**

Artificial Neural Networks (ANNs)

Sanderson, 2017 | Nielsen, 2015 | Colina, Perez, & Paraan, 2017

until its score is high enough.

Artificial Neural Networks (ANNs)

Sanderson, 2017 | Nielsen, 2015 | Colina, Perez, & Paraan, 2017

1 train-test cycle = 1 epoch

Why use ANNs for chord identification?

Osmalskyj, Embrechts, Piérard, & Van Droogenbroeck, 2012

Perera & Kodithuwakku, 2005

Zhou & Lerch, 2015

only used

Major

Minor

Successfully implemented their chord-identifying ANNs

Can an ANN handle these 37 chord types?

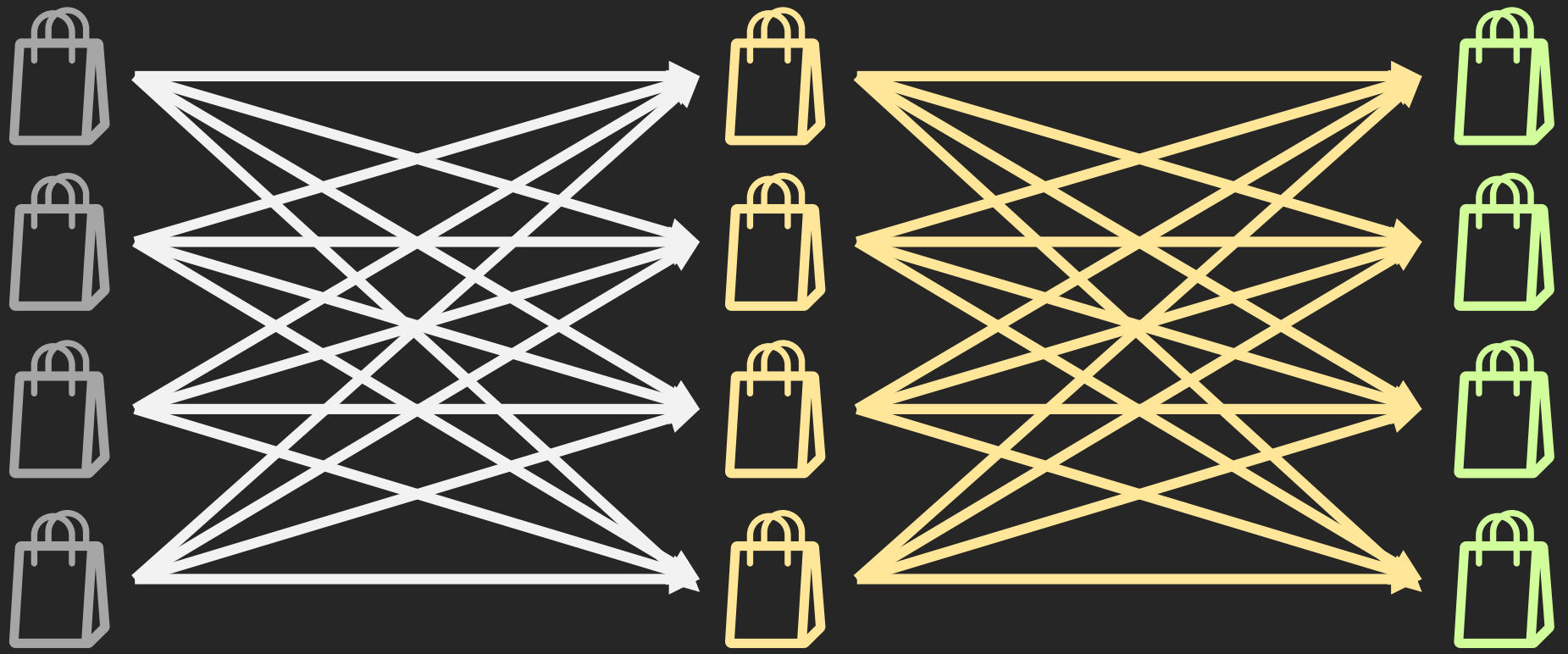
Major	Major 7	Major 9	Major 11	mM7	M6
Minor	Minor 7	Minor 9	Minor 11	mM9	m6
Dom 7	Dom 9	Dom 11	M11sus2	M9sus2	M9sus4
sus2	sus4	7sus2	7sus4	M7sus2	M7sus4
aug	aug7	aug9	aug11	M6(9)	m6(9)
dim	dim7	ø7	dim9	11sus2	9sus2
					9sus4

Esp. when songs can use many chord types?

“Slide”
Calvin Harris ft. Frank Ocean & Migos

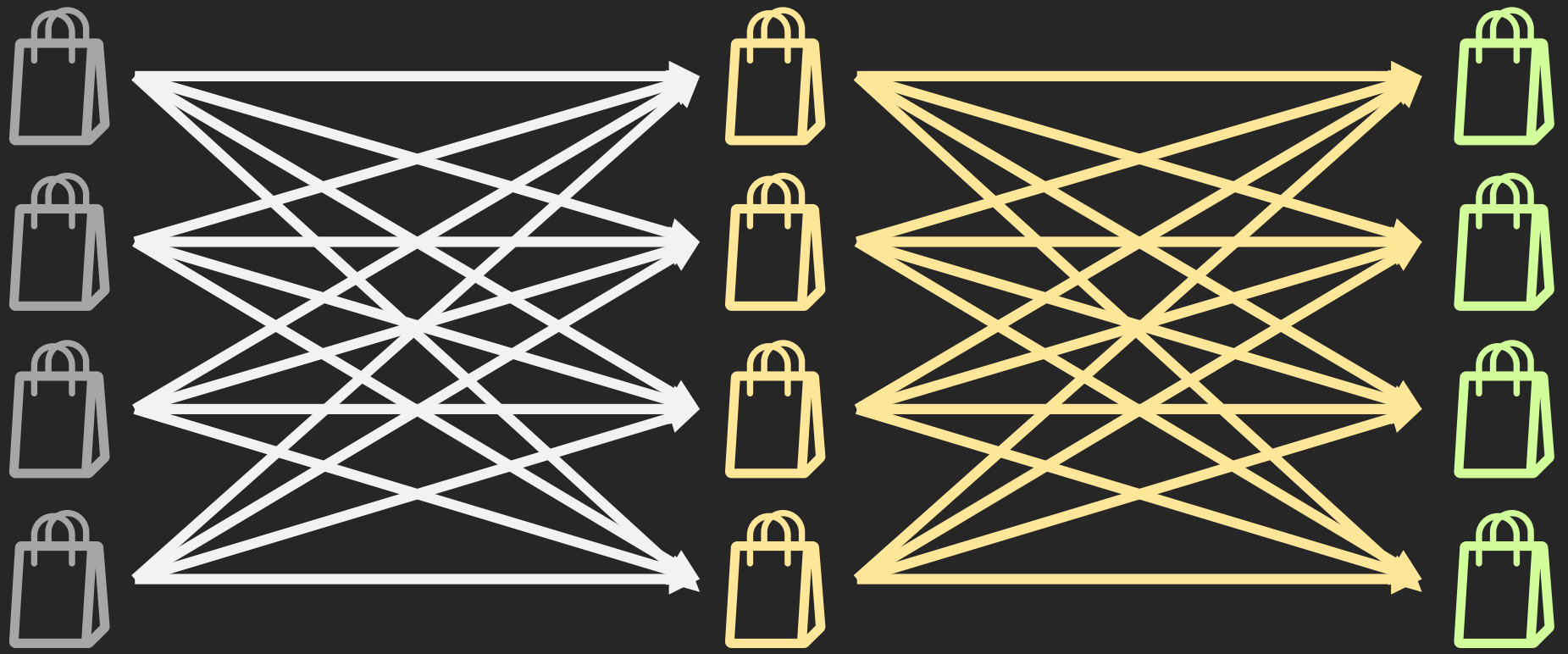
Amaj7	G#min7	C#min11	F#min9	G#min7	Amaj9

Objectives



Create an **ANN** capable of identifying our 37 chord types

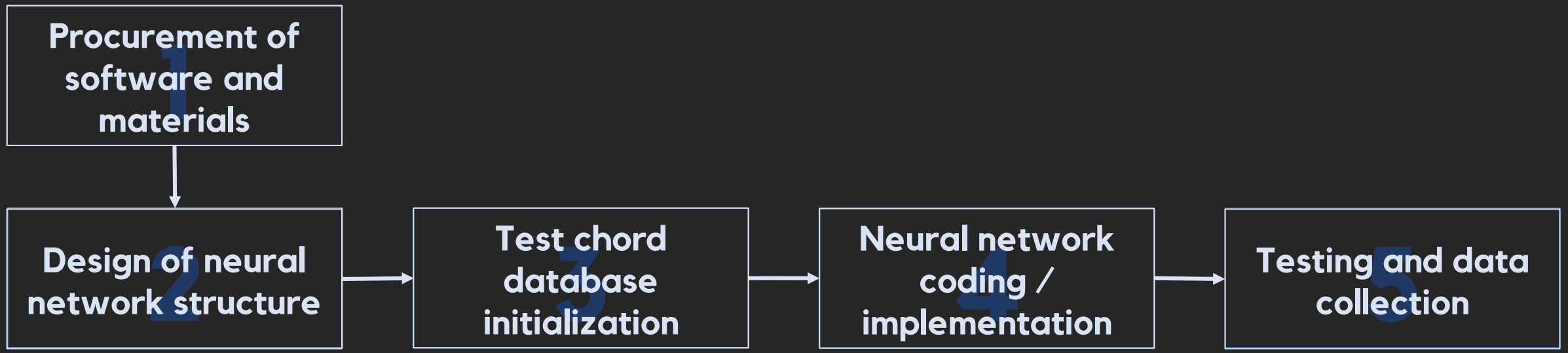
Objectives



...and can respond within **40 ms**

Greeff, 2016

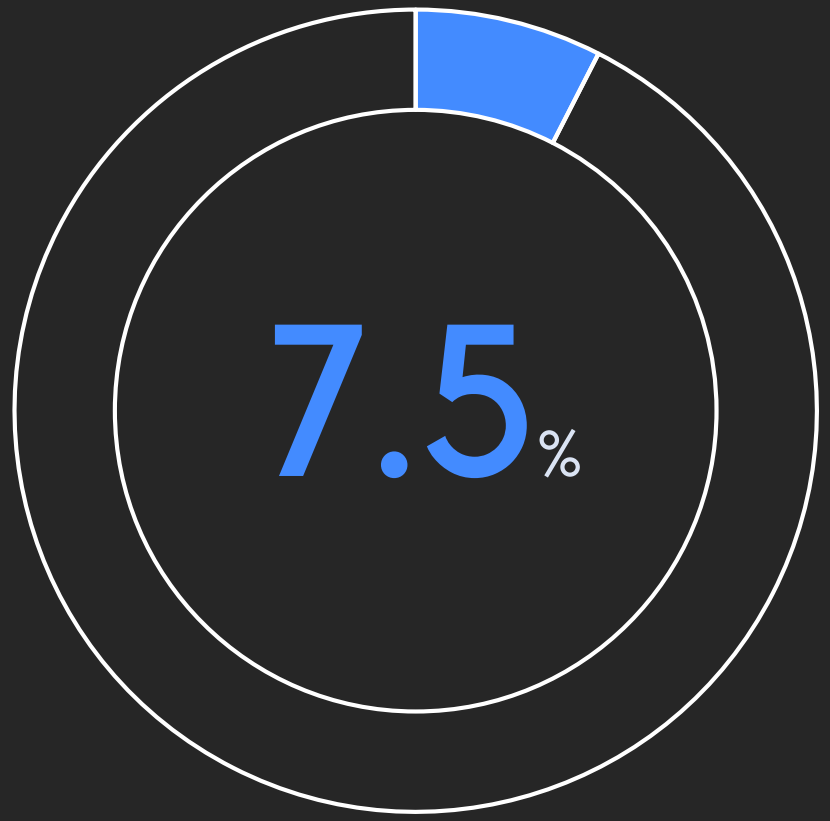
Methodology



How did our neural network do?

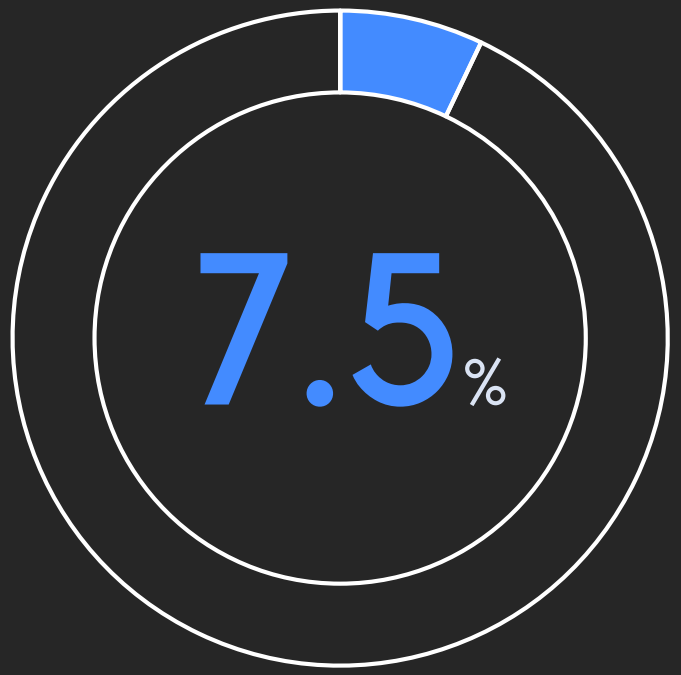
Accuracy on the **validation** dataset "questions"

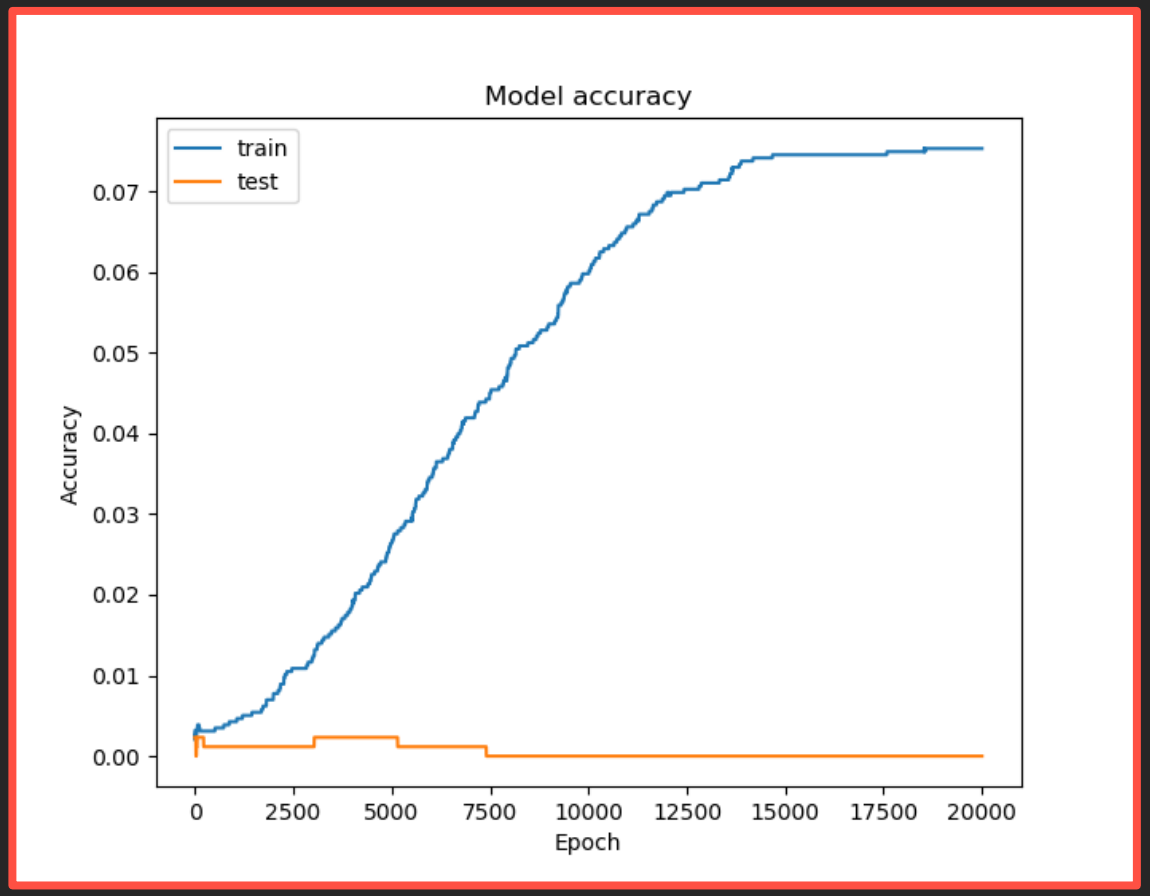
Accuracy on the **training** dataset "questions"



How did our neural network do?

Peak training accuracy after 20K epochs



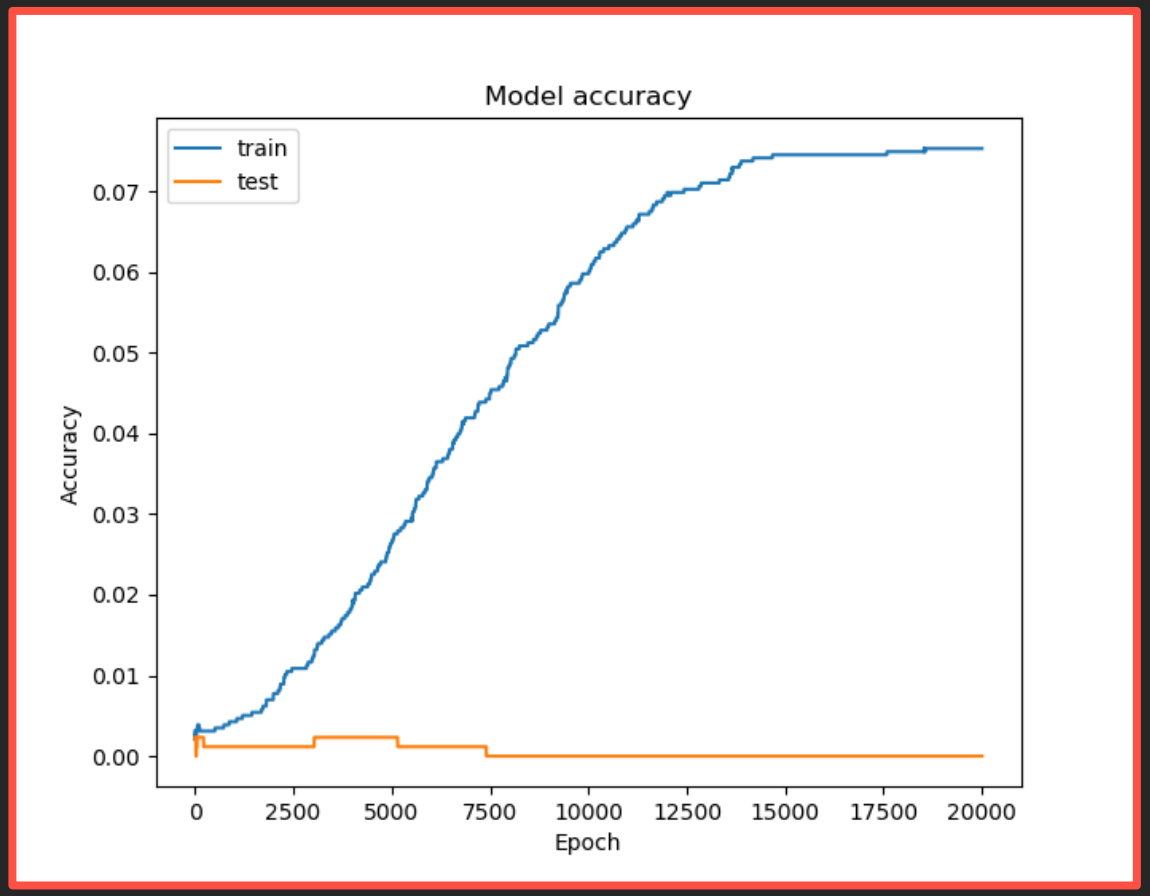


Can't learn training dataset very well

Gives up at 7.5%

How did our neural network do?

Peak validation accuracy after 20K epochs

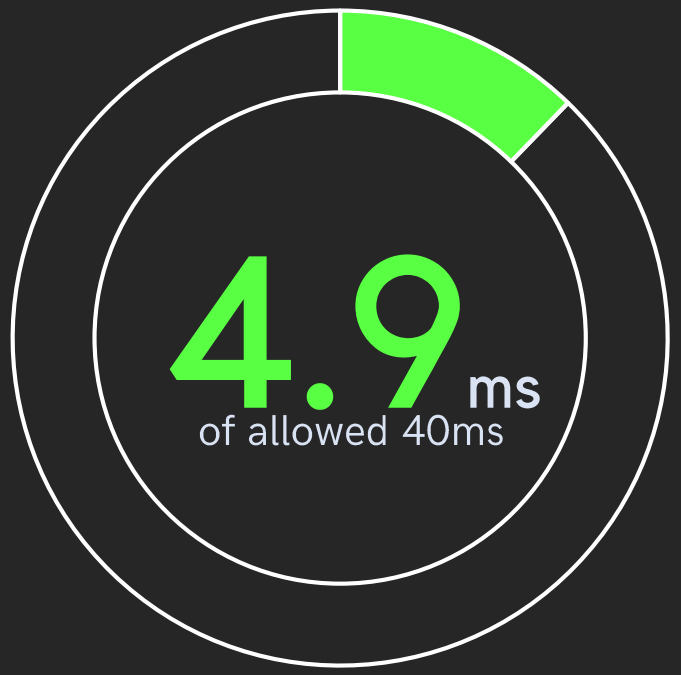


Learns just the training dataset

"Overfitting"

How did our neural network do?

Mean total response time,
30 samples

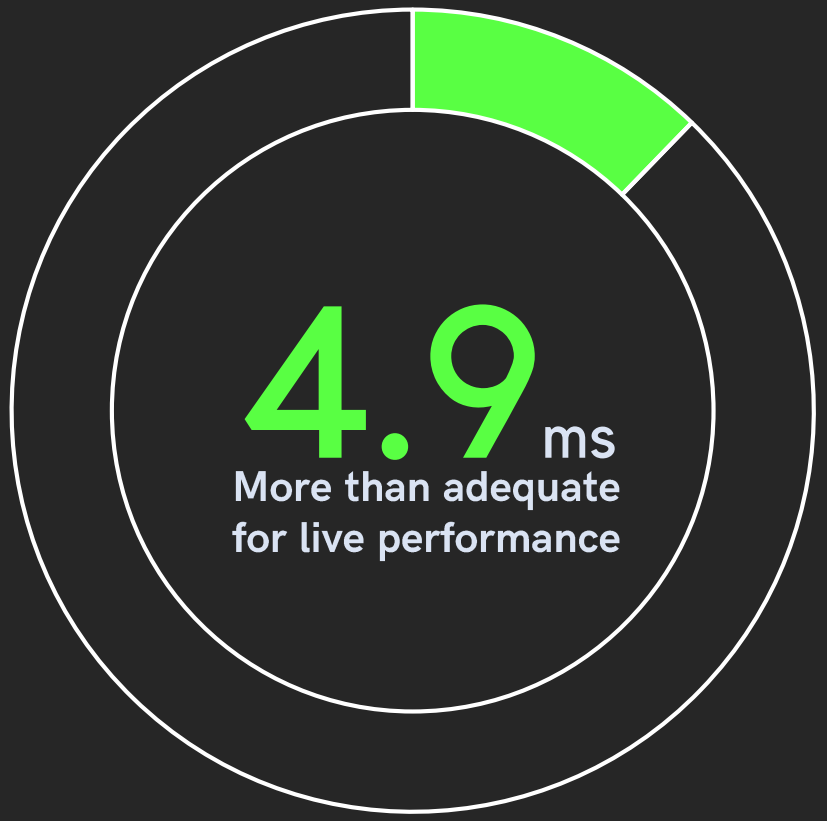


Significantly better than the 40ms standard

Conclusion

Our chords are too complex for ANNs...

...but they are fast enough for chord ID'n



Recommendations

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

References

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Illustrations by Lesli Coronel