

R2.B.09

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

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

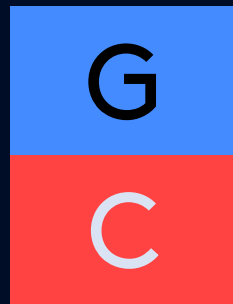
# Pitch Classes / Notes

BACKGROUND

C	C#	D	D#	E	F
B	A#	A	G#	G	F#
Used almost universally					

# Musical Chords

# BACKGROUND



2 or more  
notes



Played  
together



Follow “rules of  
harmony”

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

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

Coronel  
Navarro

R2.B.09

# 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 <sup>maj</sup>
E
C#
A

D7
C
A
F#
D

# Musical Chords

# BACKGROUND

Each  
has a  
type

C <sup>5</sup>
G
C

A <sup>maj</sup>
E
C <sup>#</sup>
A

D <sup>7</sup>
C
A
F <sup>#</sup>
D

# Musical Chords

# BACKGROUND

Each  
has an  
inversion  
number

C5
G
C
0

Amaj
E
C#
A
0

D7
C
A
F#
D
0

0<sup>th</sup> inversion only included in scope of study

# Chord Identification DEFINITION

The determination of the  
name of the chord

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

A majority of the general  
music learning public **can't**  
**do this by themselves.**

Why?

Inference

# Absolute pitch

PROBLEM



# Absolute pitch

PROBLEM



# Absolute pitch

# PROBLEM

**Rare** amongst music-learning individuals

Zatorre, Perry, Beckett, Westbury, & Evans, 1998

# Absolute pitch

# PROBLEM

Expressed in a **low percentage** of the human population

Baharloo, Service, Risch, Gitschier, & Freimer, 2000

# Absolute pitch

# PROBLEM

Acquired through **favorable  
genes and early music  
training**

Baharloo, Service, Risch, Gitschier, & Freimer, 2000

**What role** does absolute  
pitch play in **chord**  
**identification?**

Question

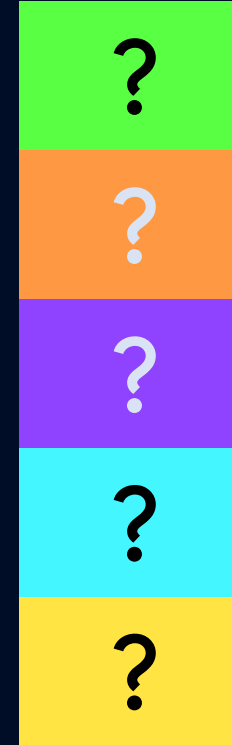


# Chord Id'n and A.P.

# PROBLEM

Notes of  
chord  
cannot be  
identified

Without AP

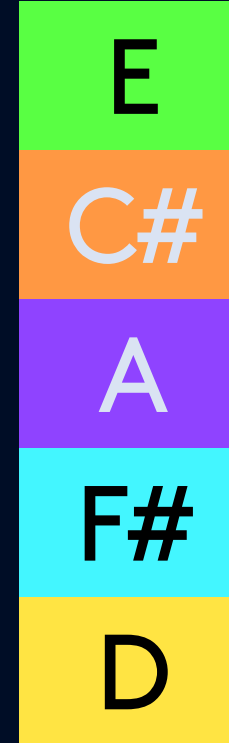


# Chord Id'n and A.P.

PROBLEM

Notes of  
chord are  
identified  
exactly

With AP

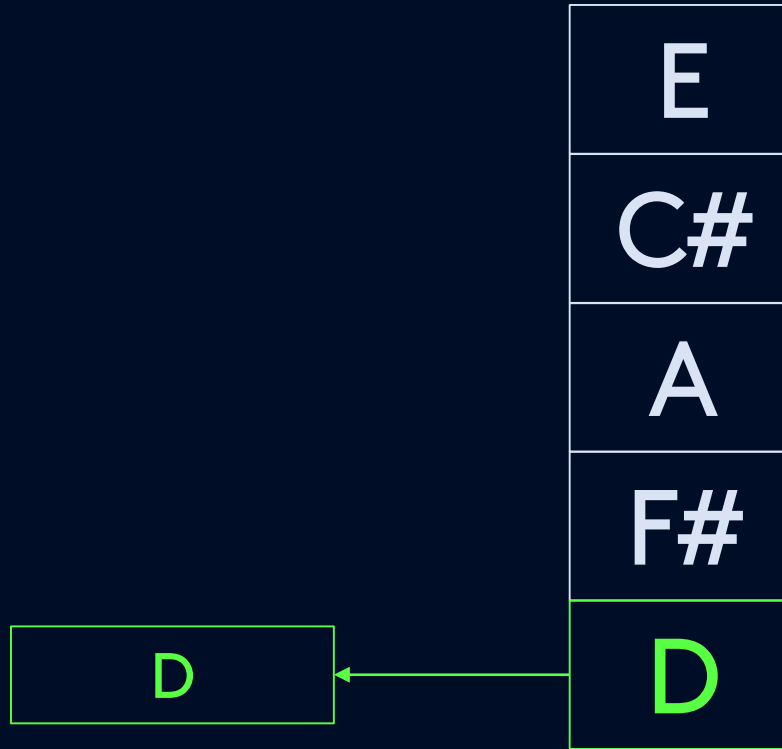


# Chord Id'n and A.P.

# PROBLEM

Root note  
is identified

With AP



# Chord Id'n and A.P.

# PROBLEM

Chord type  
is identified

With AP & common RP

maj9

E

C#

A

F#

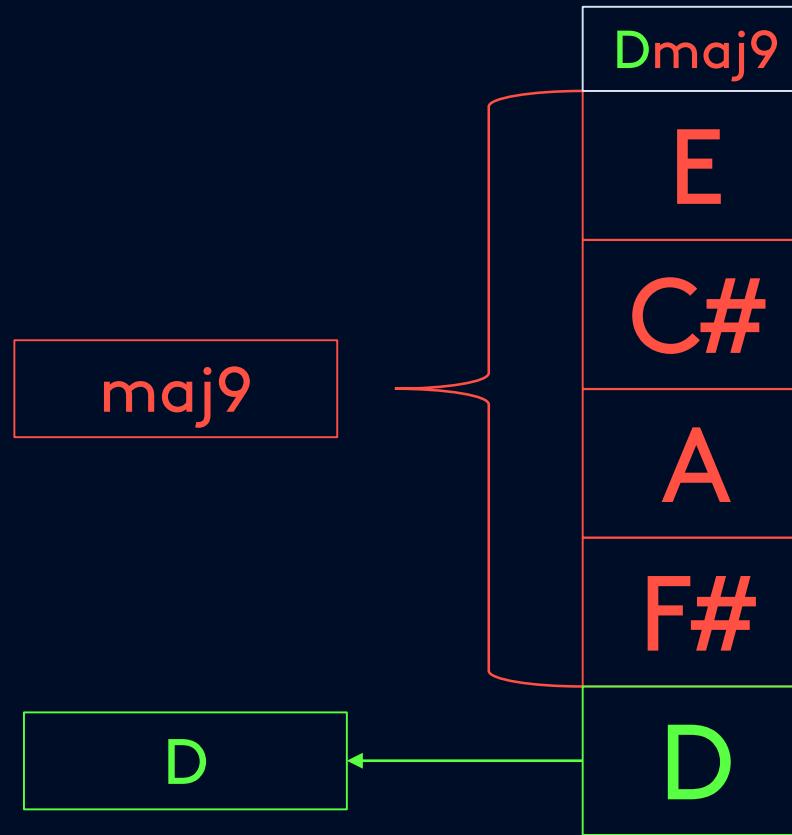
D

# Chord Id'n and A.P.

# PROBLEM

Chord  
name is  
identified

With AP & common RP



\*The process of determining the name of a chord is called chord identification.

# Chord Id'n and A.P.

# PROBLEM

Chord  
name is  
identified

With AP & common RP

Dmaj9

E

C#

A

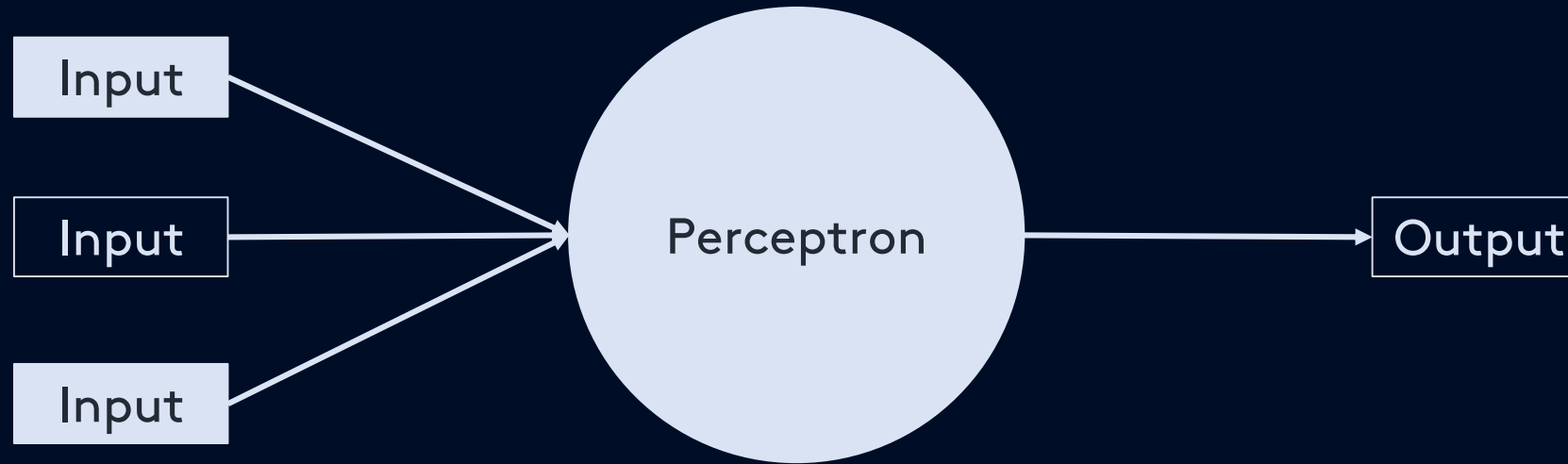
F#

D

\*The process of determining the name of a chord is called chord identification.

# Neural networks

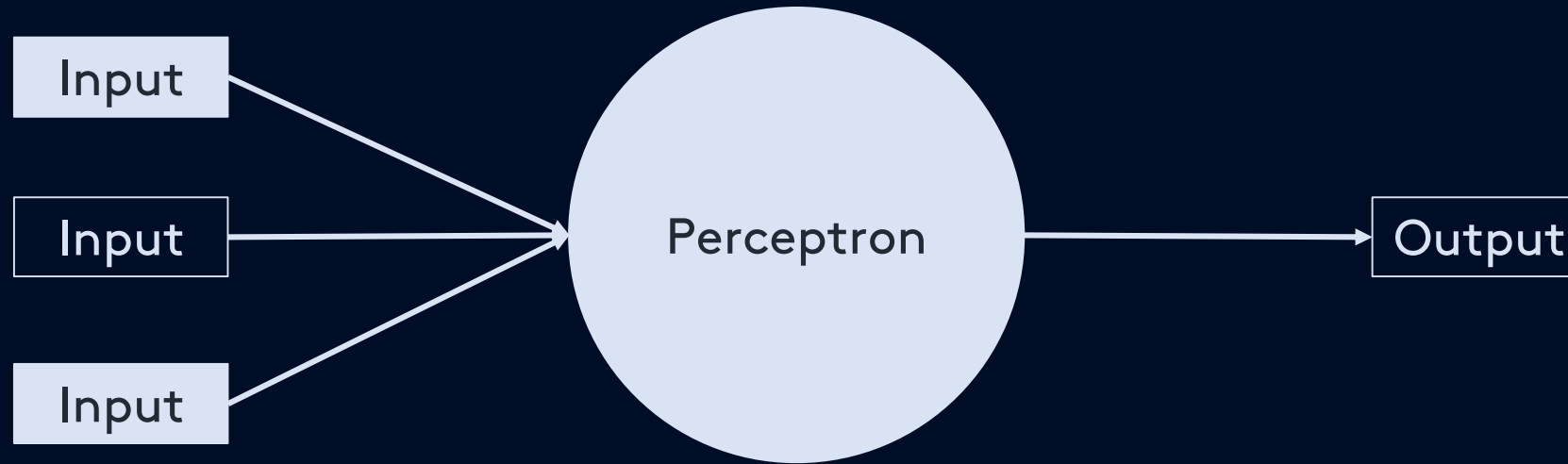
# DEFINITION



Computational model of neurons in a brain

# Neural networks

# DEFINITION

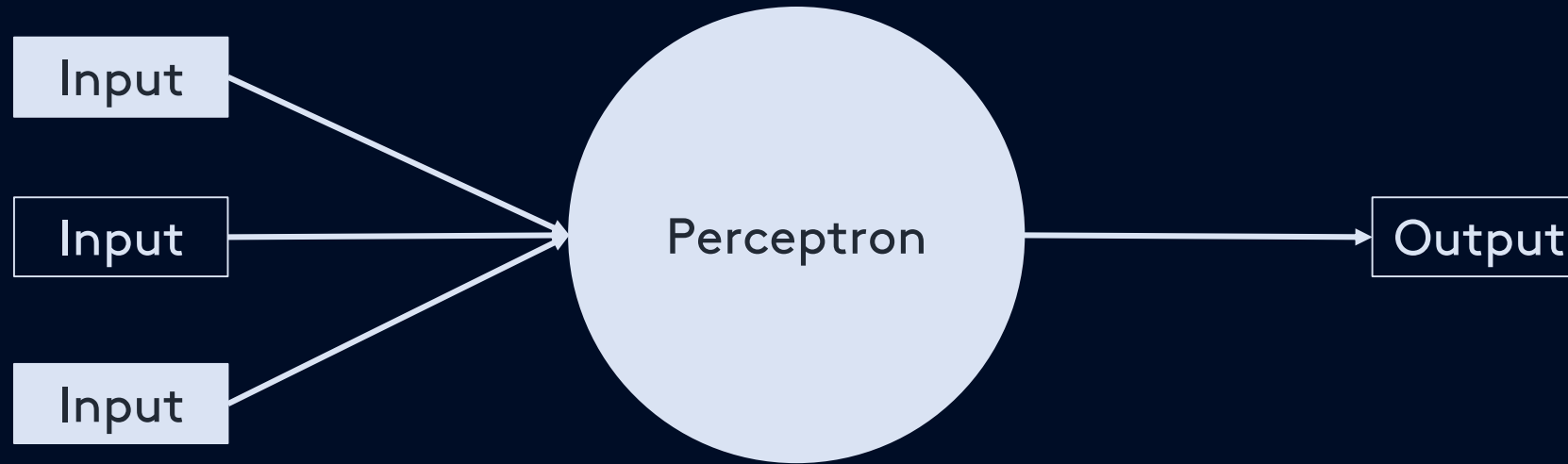


Many of these make up a neural network



# Neural networks

# DEFINITION



Are trained, just like neurons in a brain

# 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

Develop a neural network  
that **quickly** identifies  
**common 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 in the **0<sup>th</sup> inversion** (i.e. not inverted)

Identification must be quick  
enough to be used in **live  
performance**

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

thestk, 2017; Bretschneider, 2017

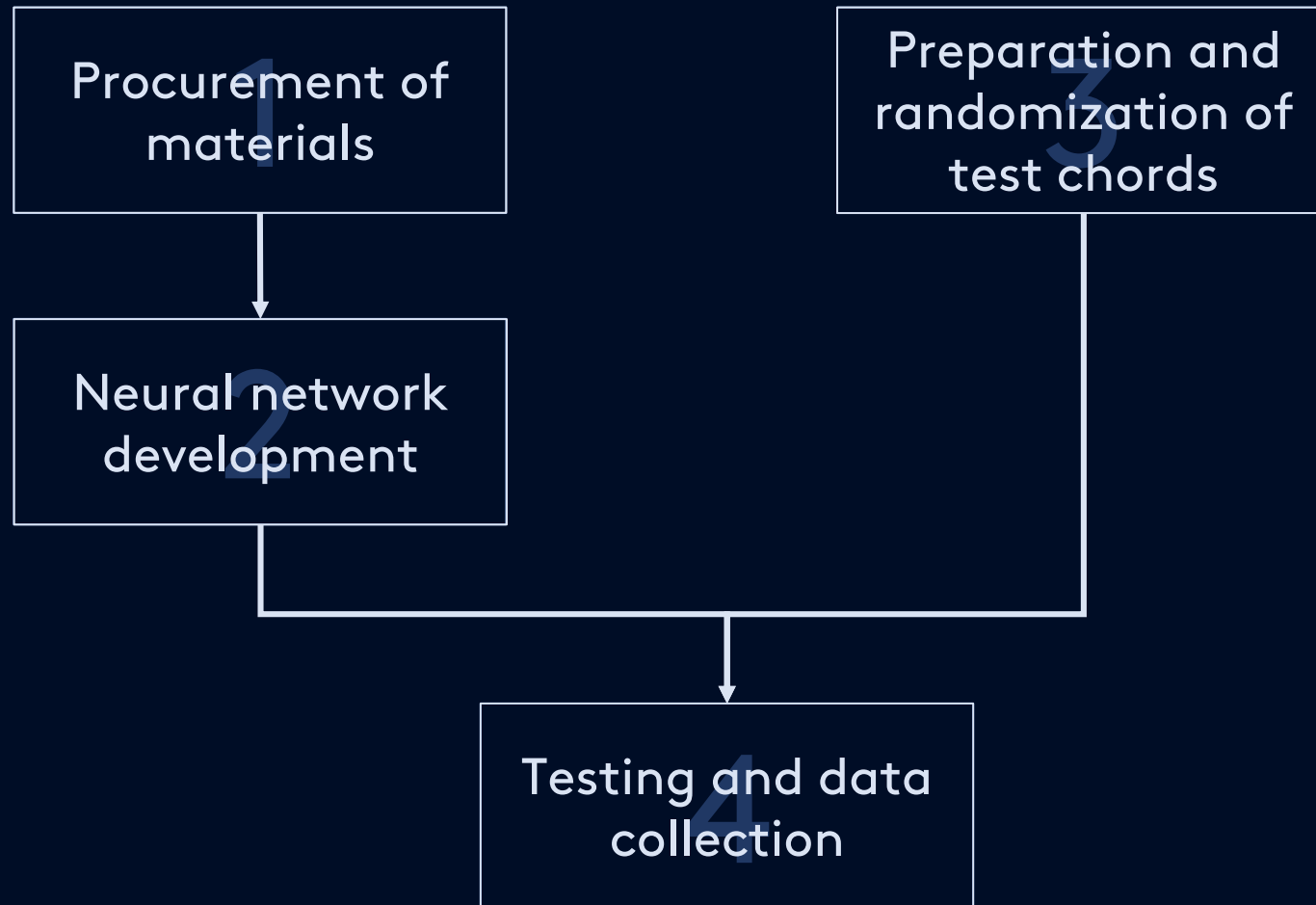


Neural network must be run  
on a GPU for efficient  
processing

Nickolls, Buck, Garland, & Skadron, 2008

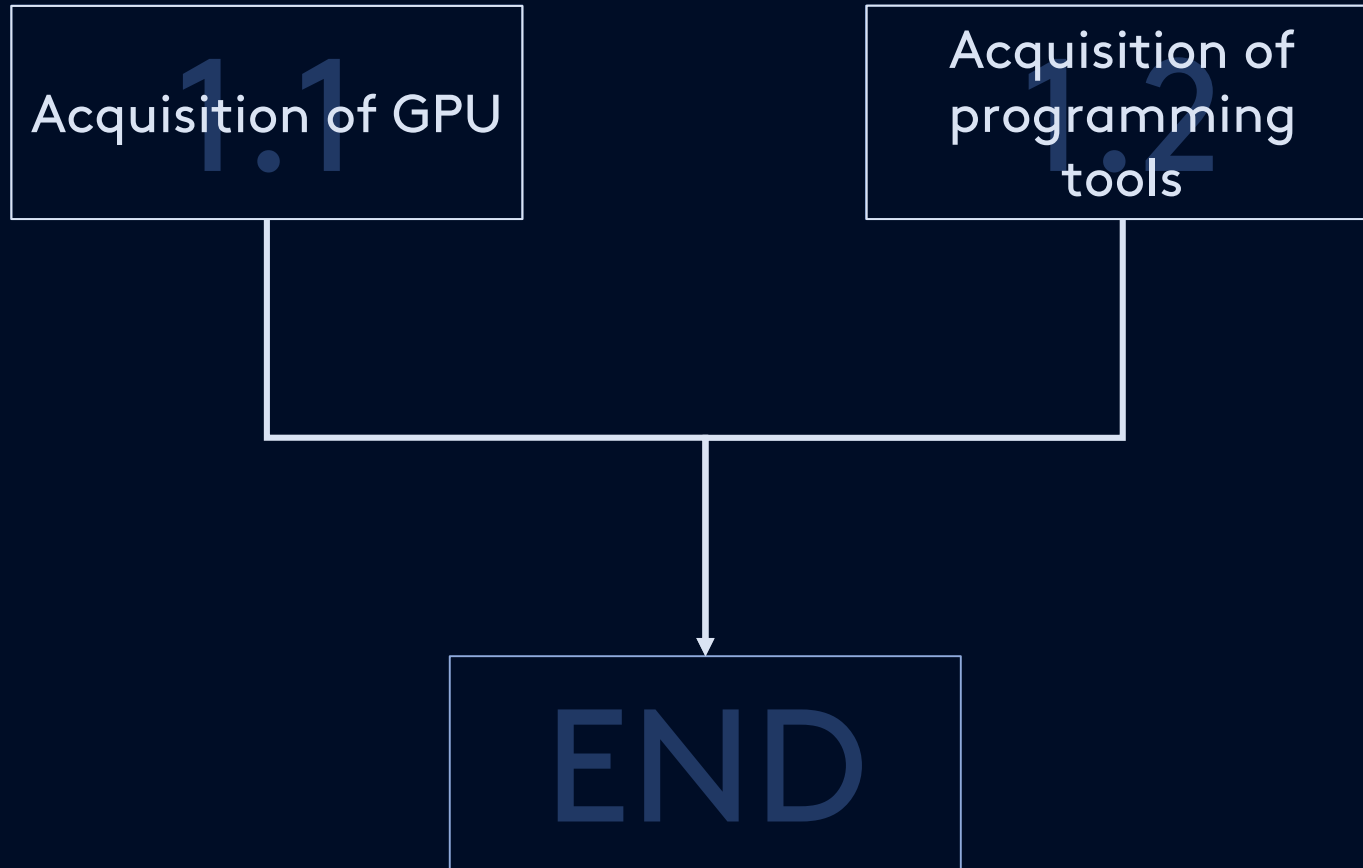
# Level 0

# PROCESS



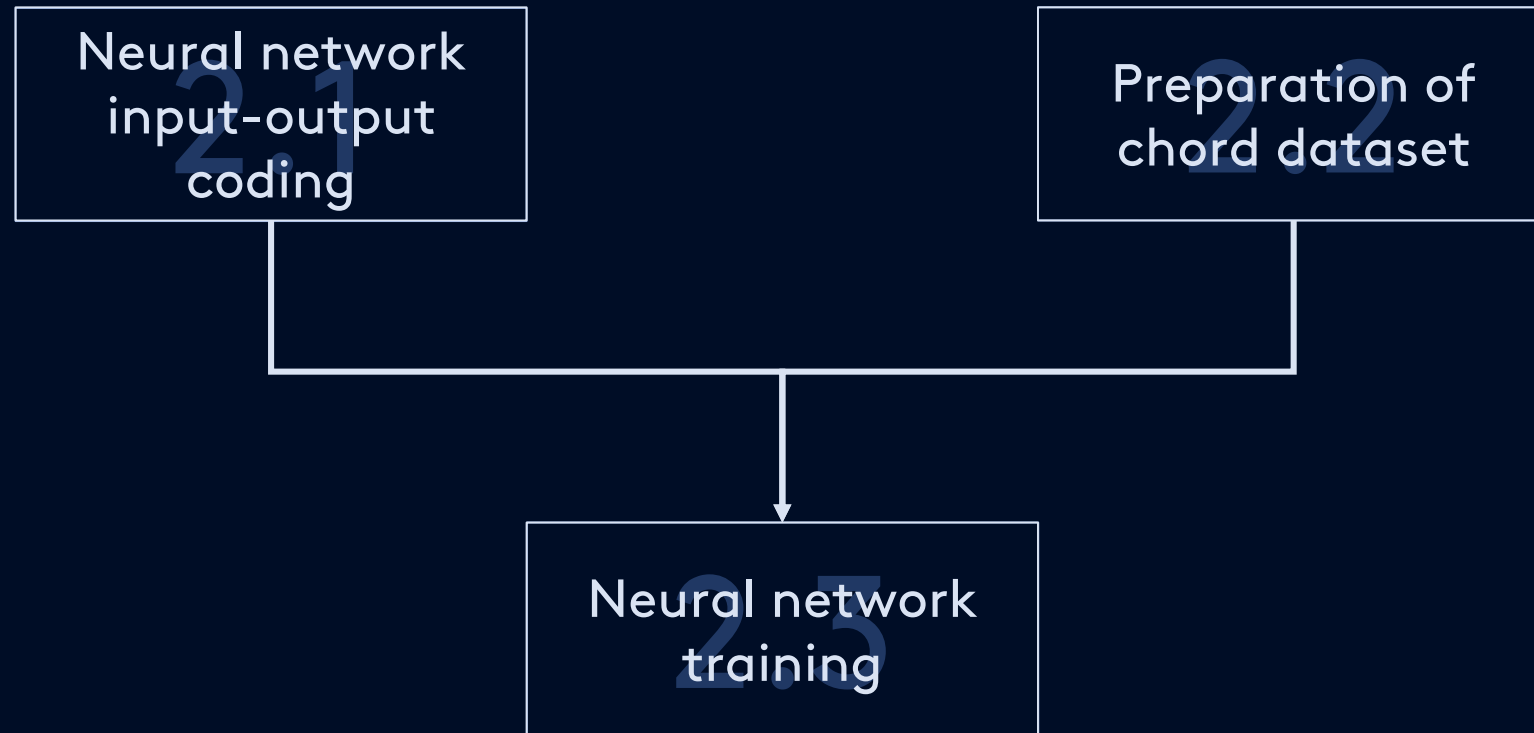
# 1 Procurement

# PROCESS

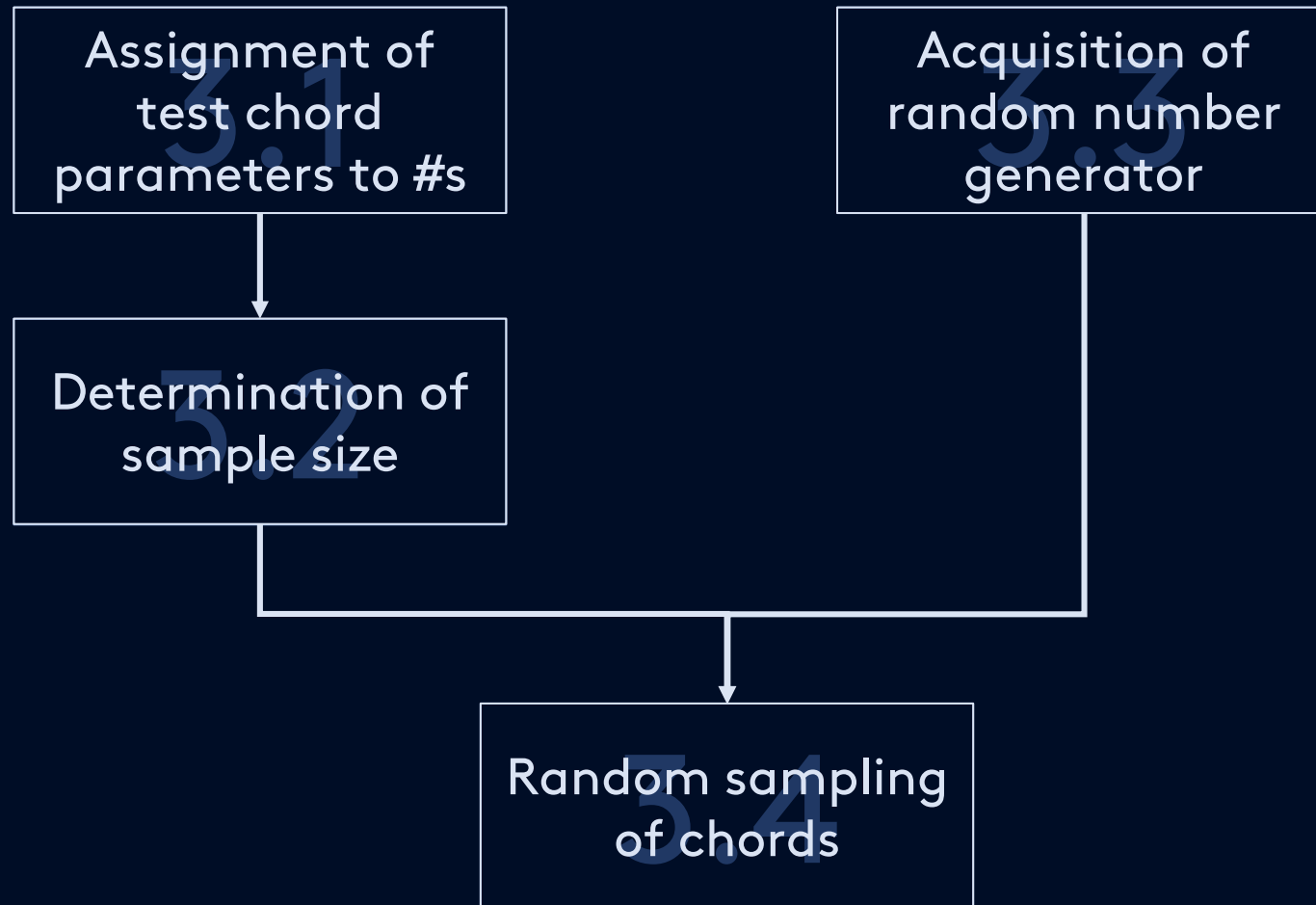


# 2 ANN Development

## PROCESS



# 3 Test Chord Prep & Rn PROCESS



# 4 Testing & DC

PROCESS



T	H	E	Rev. 2	E	N	D
---	---	---	--------	---	---	---