

R2.B.09

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

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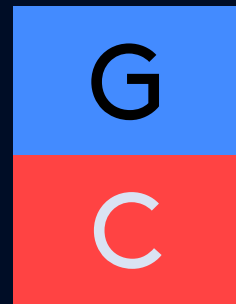
Pitch Classes / Notes

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)

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

Each
has an
inversion
number

| |
|----|
| C5 |
| G |
| C |
| 0 |

| |
|------|
| Amaj |
| E |
| C# |
| A |
| 0 |

| |
|----|
| D7 |
| C |
| A |
| F# |
| D |
| 0 |

0th 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?

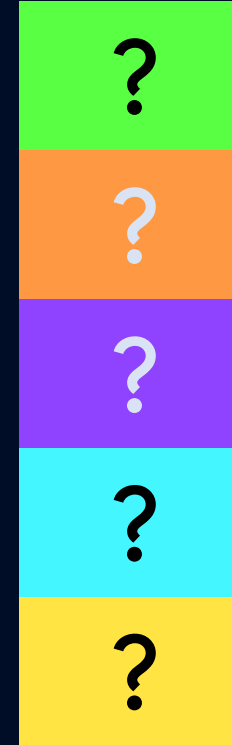
Question

Chord Id'n and A.P.

PROBLEM

Notes of
chord
cannot be
identified

Without AP

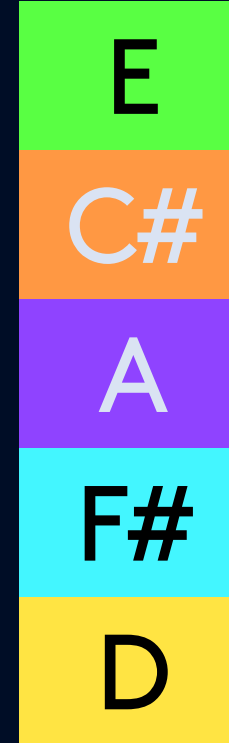


Chord Id'n and A.P.

PROBLEM

Notes of
chord are
identified
exactly

With AP

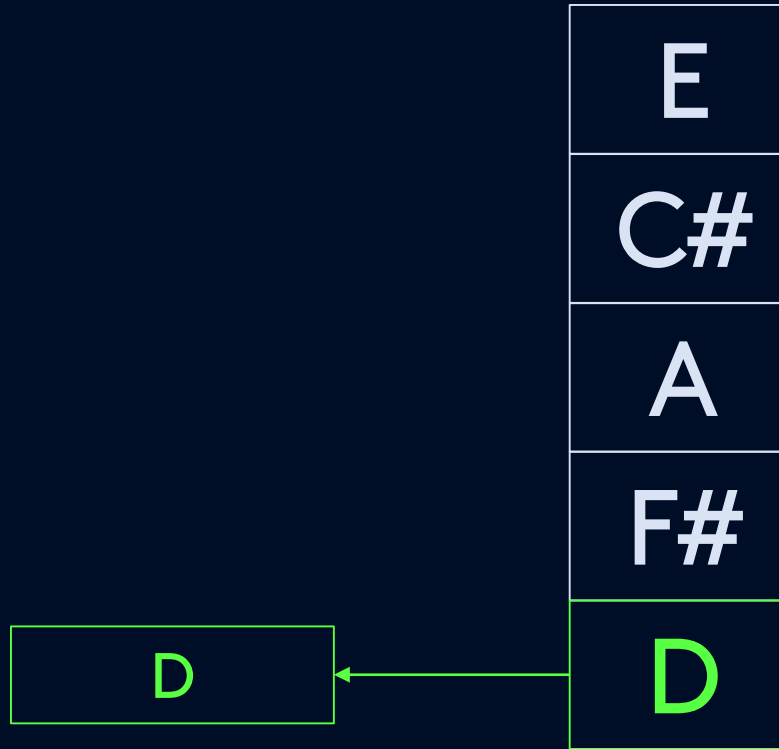


Chord Id'n and A.P.

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#

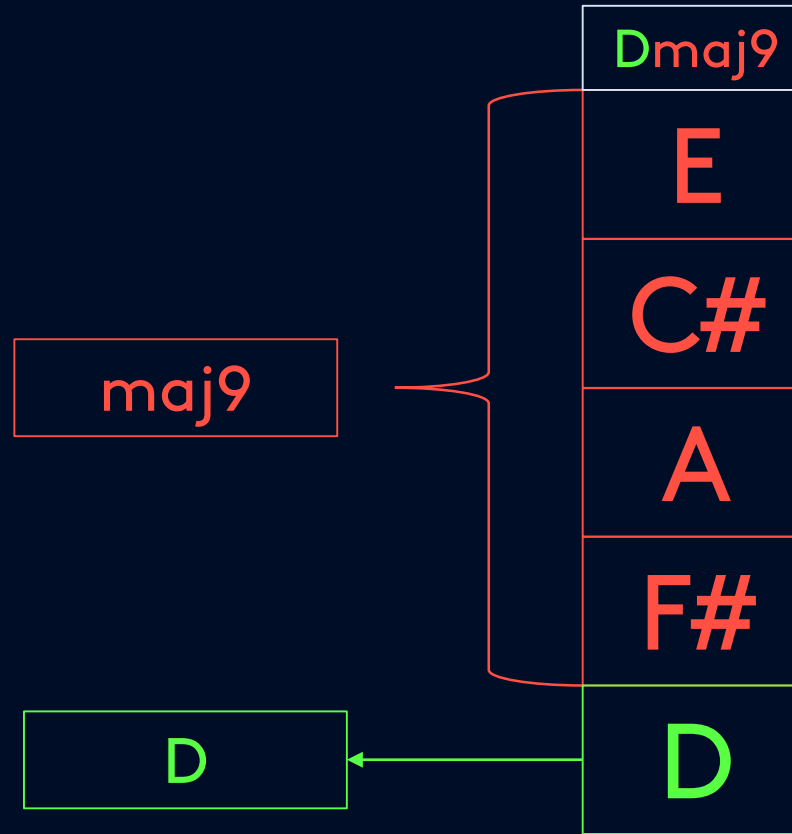
D

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

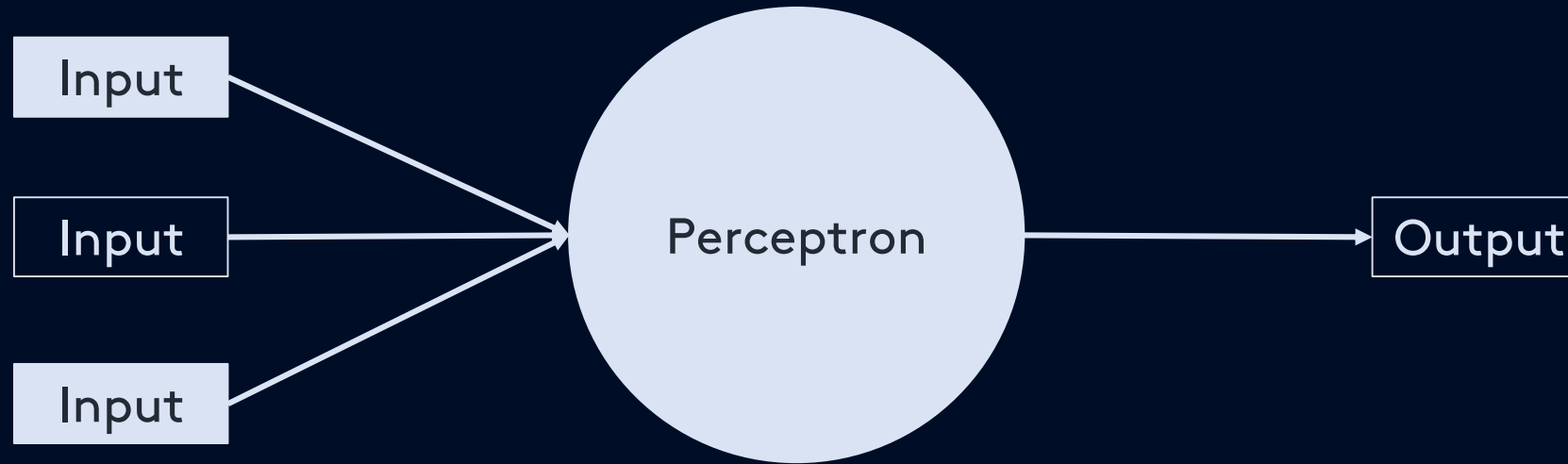
F#

D

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

Neural networks

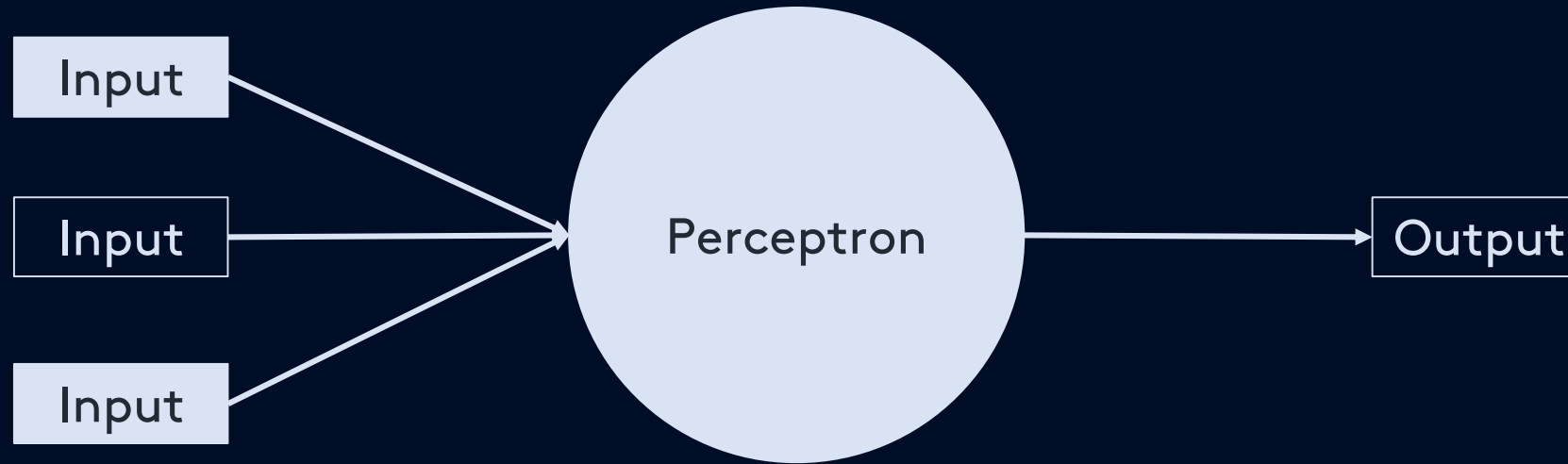
DEFINITION



Computational model of neurons in a brain

Neural networks

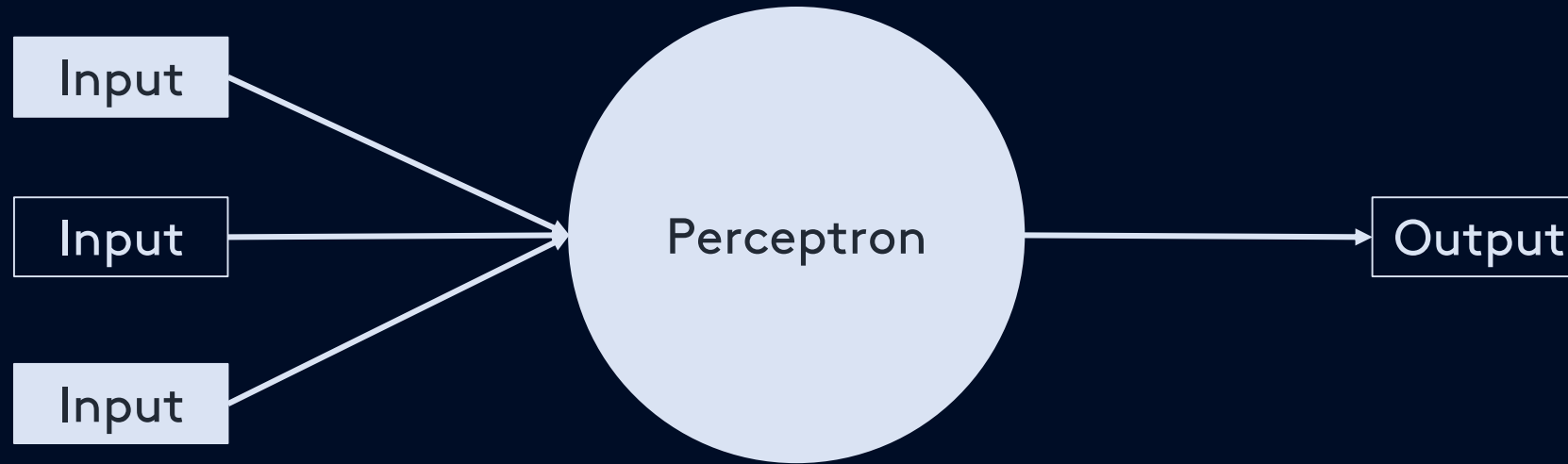
DEFINITION



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 **0th 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

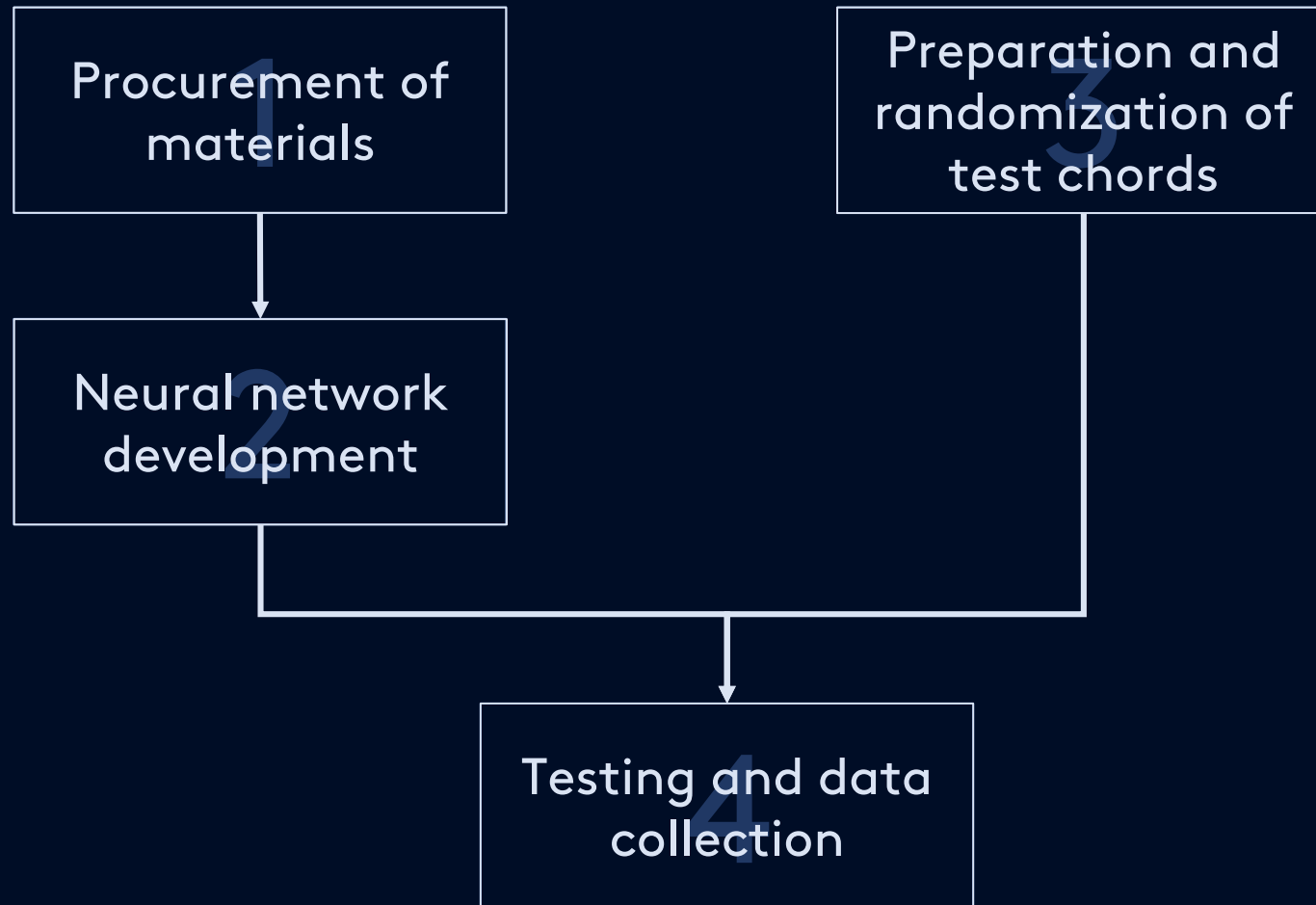
thestk, 2017; Bretschneider, 2017

Neural network must be run
on a GPU for efficient
processing

Nickolls, Buck, Garland, & Skadron, 2008

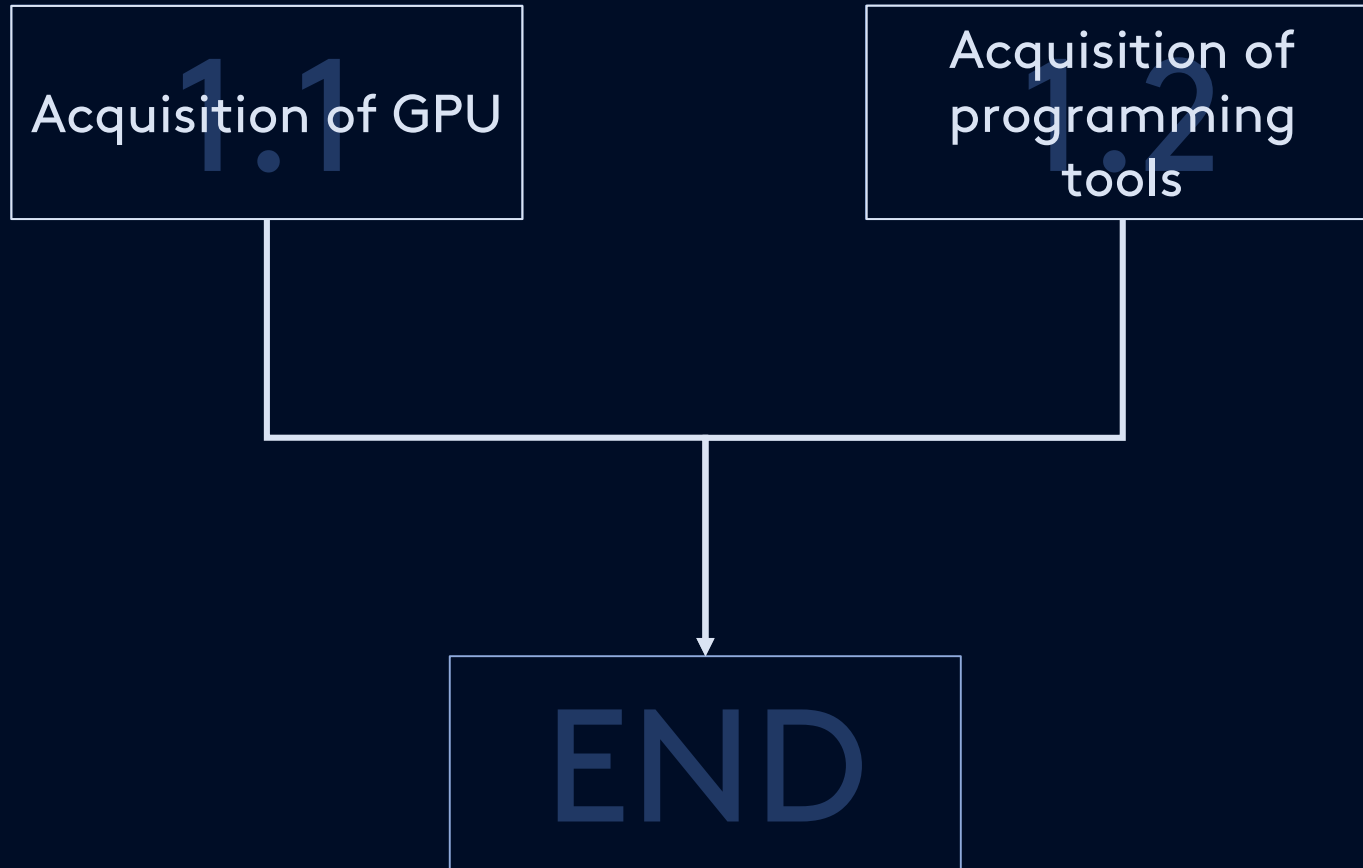
Level 0

PROCESS



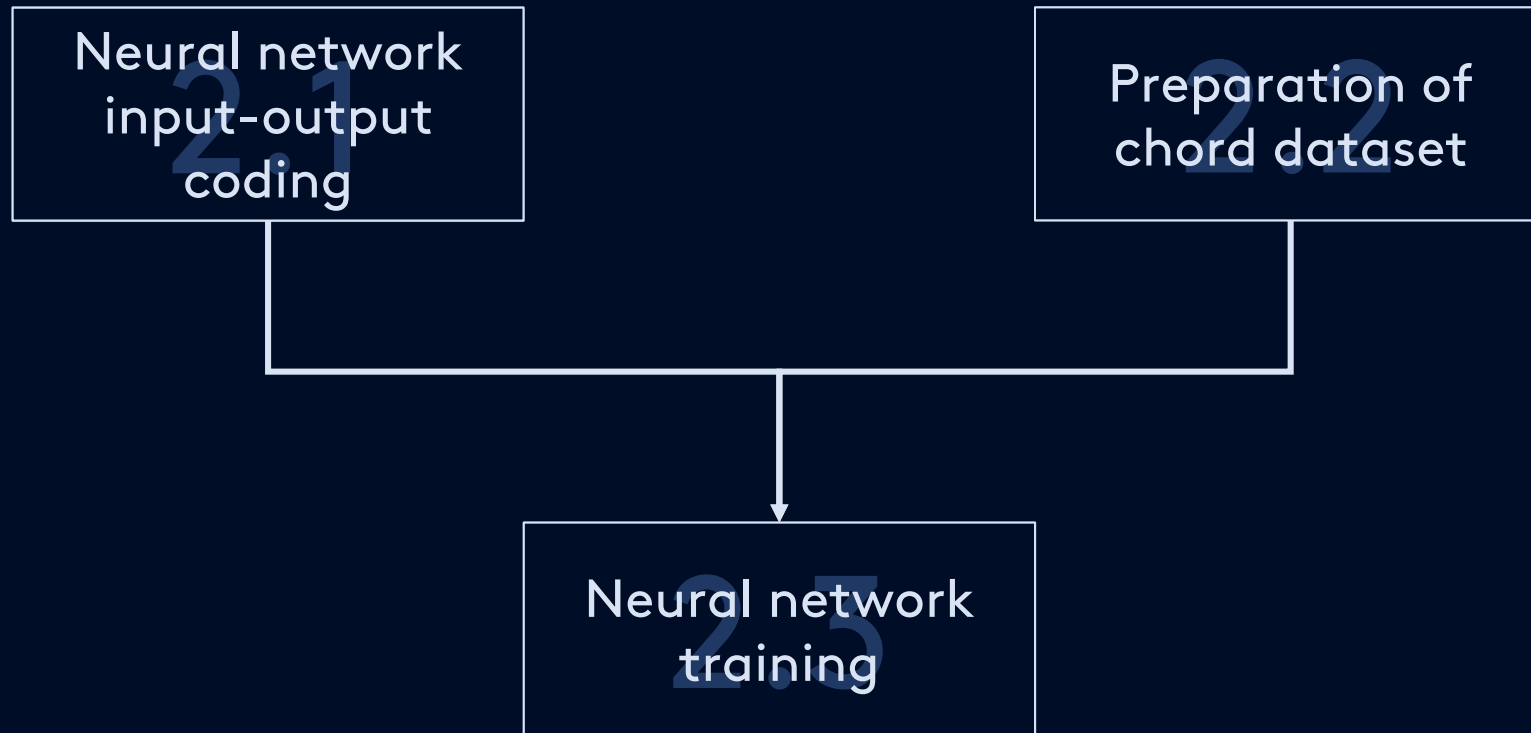
1 Procurement

PROCESS

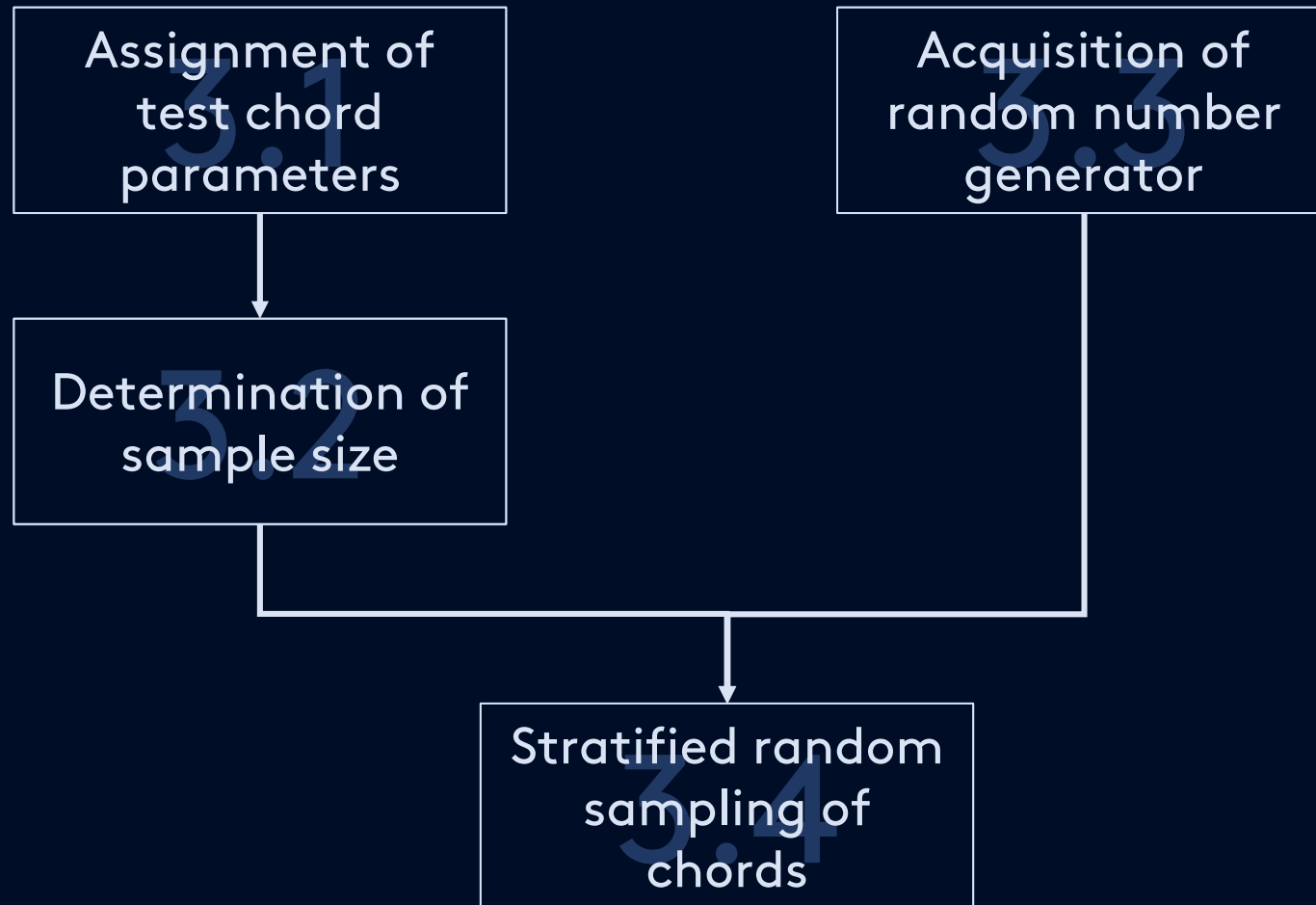


2 ANN Development

PROCESS



3 Test Chord Prep & Rn PROCESS



4 Testing & DC

PROCESS



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