

R2.B.09

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

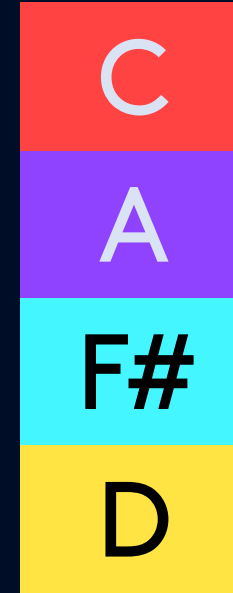
A LITERATURE REVIEW

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

Musical Chords

“Any simultaneous combination of notes, but usually of not fewer than 3”

Chord, 2004, p. 147
from The Concise Oxford Dictionary of Music



Musical Chords

“The use of chords is
the basic foundation of
harmony” in music

Chord, 2004, p. 147
from The Concise Oxford Dictionary of Music



Musical Chords: Names

This name is dictated
by two parameters

-

D7

C

A

F#

D

Each chord has a name

Musical Chords: Root Notes

A root note is “the note from which a chord originates”

Chord, 2004, p. 147
from The Concise Oxford Dictionary of Music

D7
C
A
F#
D

Each chord has a root note

Musical Chords: Types

Determined by the
distances between the
notes that comprise
the chord

This concept is common knowledge
in the field

D ⁷
C
A
F [#]
D

Each chord has a **type**

Chord Identification

The determination of the
name of the chord from the
notes that constitute it

This concept is common knowledge in the field

Chord Identification

“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

Demonstrated by the
proliferation of online
websites that provide user-
determined chords

Humphrey, Bello, & Cho, n.d., par. 1

Chord Identification

No guarantee of chord
identification accuracy in
these websites

The chords are generated by a user base

Chord Identification

Chord identification relies
on this next rare ability

An important dependency

Absolute pitch



Ability to identify note by hearing it

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

Absolute pitch



Ability to identify note by hearing it

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

Absolute pitch

Rare amongst music-learning individuals

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

Absolute pitch

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

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

Absolute pitch

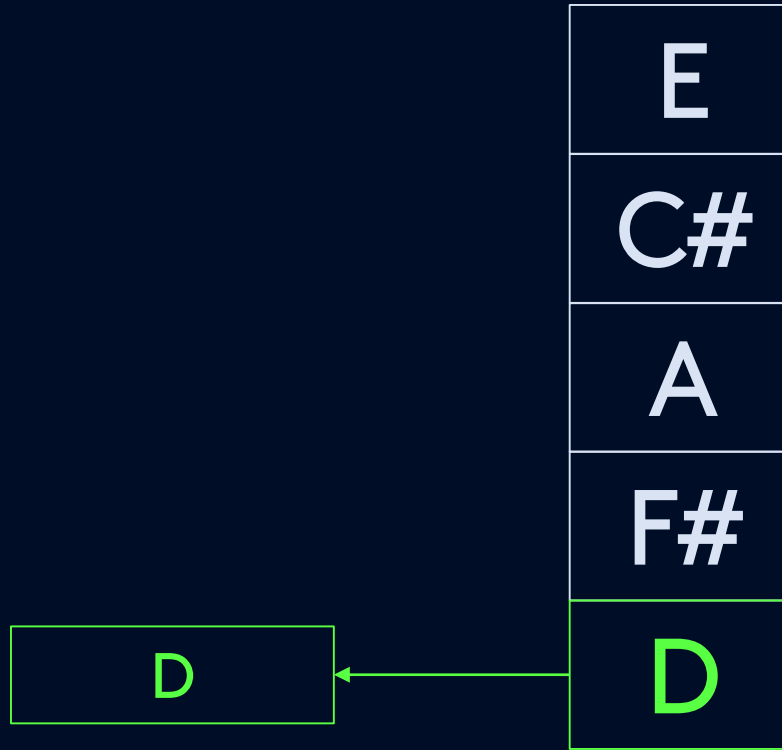
Can be acquired through
**favorable genes and early
music training**

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

Chord Id'n and A.P.

Chords
based on
root note
(absolute)

With AP



Previous chord identification res.

1999

Fujishima

2009

Stark & Plumbley

Classical algorithms

Previous chord identification res.

2005	2012	2015
Perera & Kodithuwakku	Osmalskyj et al.	Zhou & Lerch
Neural networks		

The gap

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

The gap

Using neural networks to
identify both common and
extended chords in real-
time is **unexplored**

Osmalskyj, Embrechts, Piérard, & Van Droogenbroeck, 2012

Perera & Kodithuwakku, 2005

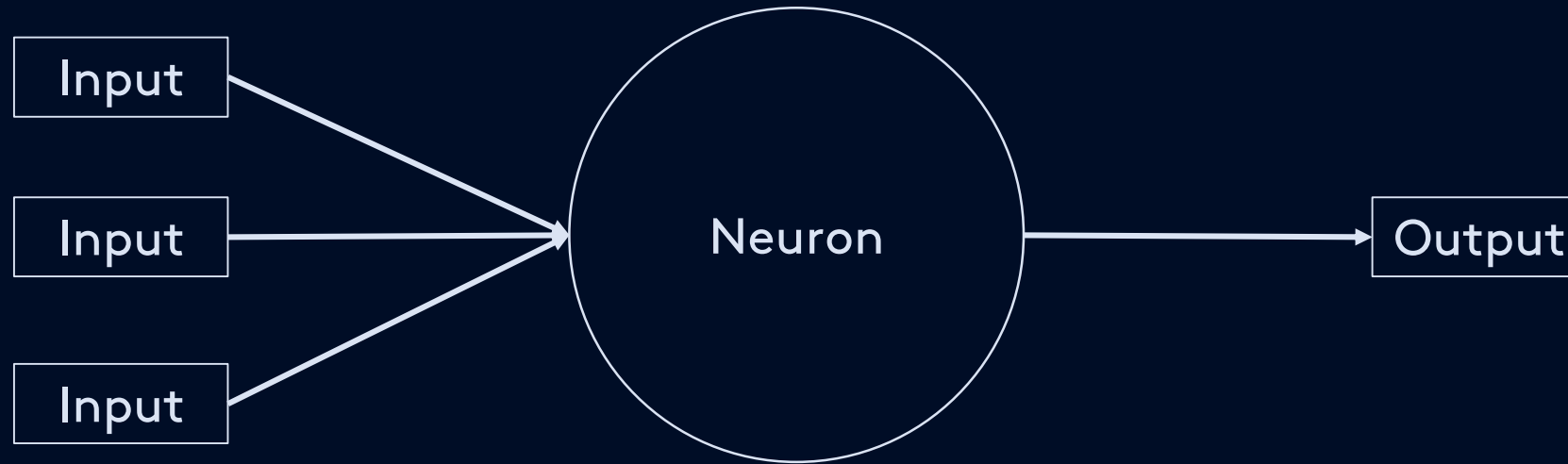
Zhou & Lerch, 2015

Artificial Neural Networks (ANNs)



Computational model of neurons in a brain

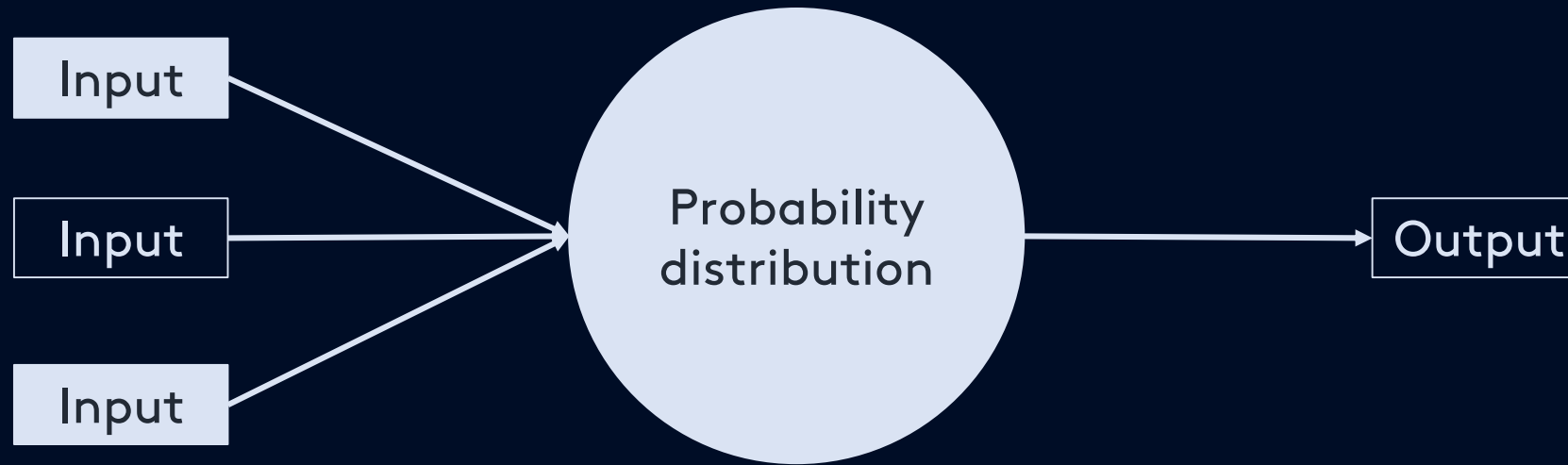
Artificial Neural Networks (ANNs)



Self-organizing, adaptable, simple

Daniel, 2013

Artificial Neural Networks (ANNs)



ANN learns by repetitive training

Colina, Perez, & Paraan, 2017

Hardware

GPU

Graphics Processing Unit

Parallel processor

Nickolls, Buck, Garland, & Skadron, 2008

Hardware

GPU

Graphics Processing Unit

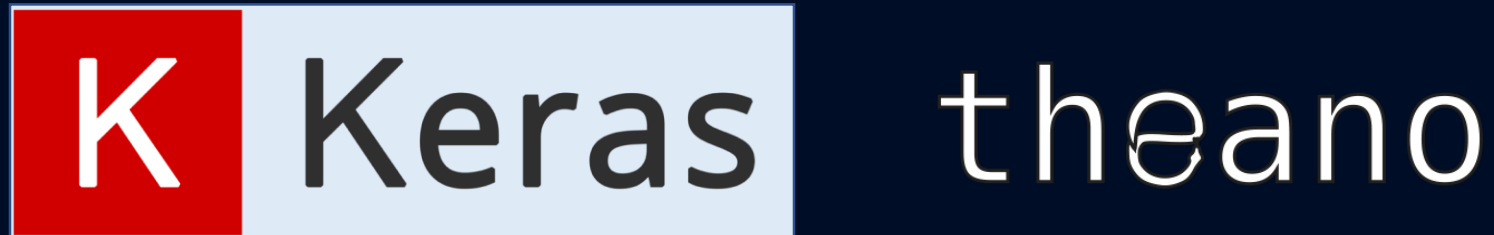
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CPU	CPU	CPU	CPU	CPU
CPU	CPU	CPU	CPU	CPU
CPU	CPU	CPU	CPU	CPU
CPU	CPU	CPU	CPU	CPU
CPU	CPU	CPU	CPU	CPU
CPU	CPU	CPU	CPU	CPU

Up to **30x** faster than a CPU in ANN

Colina, Perez, & Paraan, 2017

Software



ANN prototyping in Python

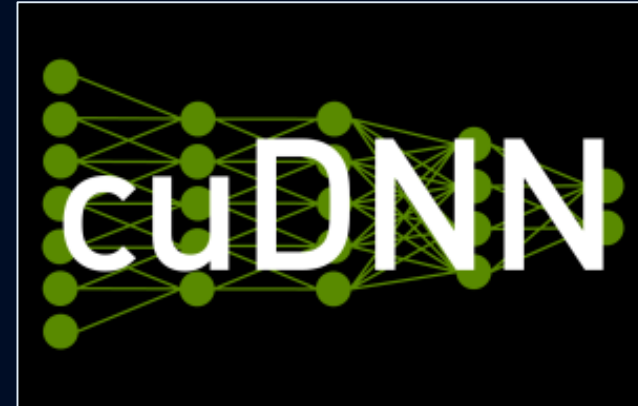
Colina, Perez, & Paraan, 2017

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Software



ANN Computation on the GPU

Nickolls, Buck, Garland, & Skadron, 2008

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Software



pyrtmidi

Kidd, 2017

Coding essentials

Python, IDE, and MIDI I/O library

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