R2.B.09

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

A LITERATURE REVIEW

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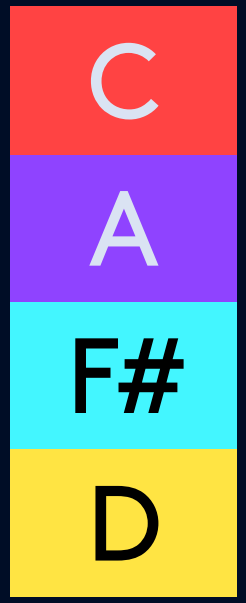
Musical Chords

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

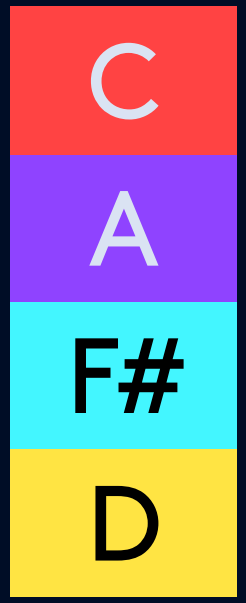
Chord, 2004, p. 147
from The Concise Oxford Dictionary of Music



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

-

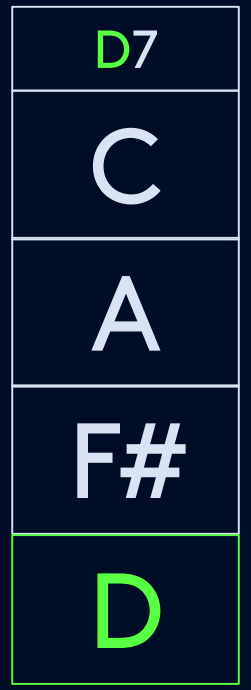
D7
C
A
F#
D

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



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

D7
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	2009
Fujishima	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)

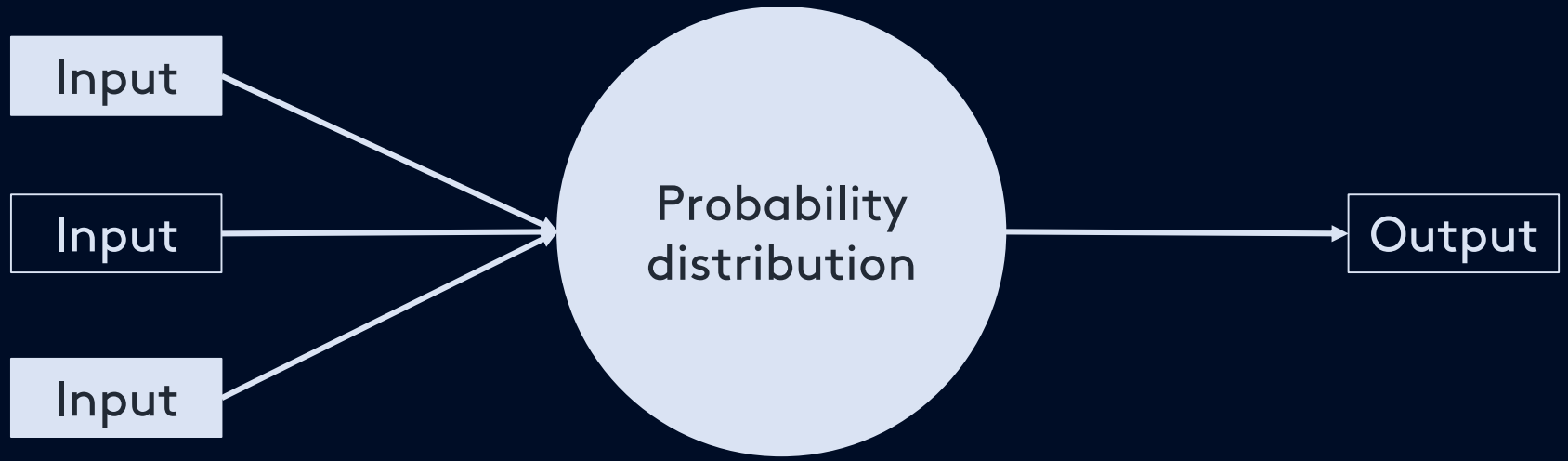
Computational model of neurons in a brain

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

=

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

theano

ANN prototyping in Python

Colina, Perez, & Paraan, 2017

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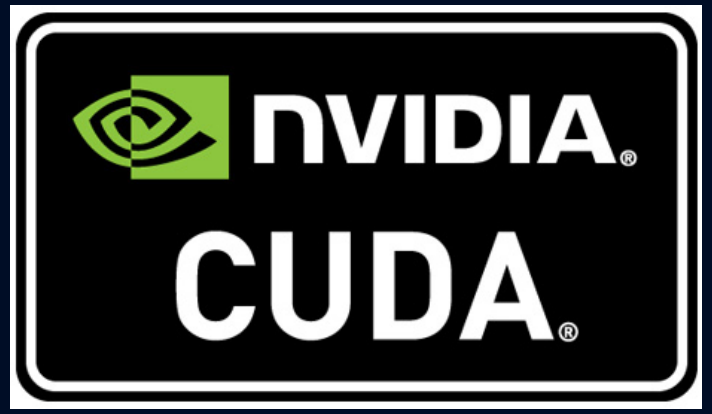
Software



ANN Computation on the GPU

Nickolls, Buck, Garland, & Skadron, 2008

Software

pyrtmidi

Kidd, 2017

Coding essentials

Python, IDE, and MIDI I/O library

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