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

**R2-B09** CORONEL / NAVARRO


## ABSTRACT

Musical chords are **fundamental** to musical harmony and have their **own names** due to their importance. For most people, accurately identifying or naming musical chords is a **difficult task** requiring high levels of skill. With this in mind, a **neural network** that aimed to **identify musical chord names** from their component notes **in real-time** was programmed in Python using the Keras framework running on the TensorFlow library. **Validation accuracy** data was obtained after every training session, and manual MIDI inputs were used to obtain response time data. It was found that the current number of training iterations (2,400) provided an **insufficient** peak validation accuracy of **5.5%**, but showed steadily decreasing values of the loss function. Increasing validation accuracies can be thus expected as the number of training iterations is raised. A left-tailed T-test for one mean was carried out on 30 randomly selected chords from the dataset and showed that the neural network responded significantly faster than the generally accepted standard of 10 milliseconds for real-time use. Further development of the neural network is recommended to increase validation accuracy. Such a neural network may be implemented on devices or software for the purposes of music education.


## INTRODUCTION

1. **Chords are groups of musical notes.** Leino, Brattico, Tervaniemi, & Vurst, 2007

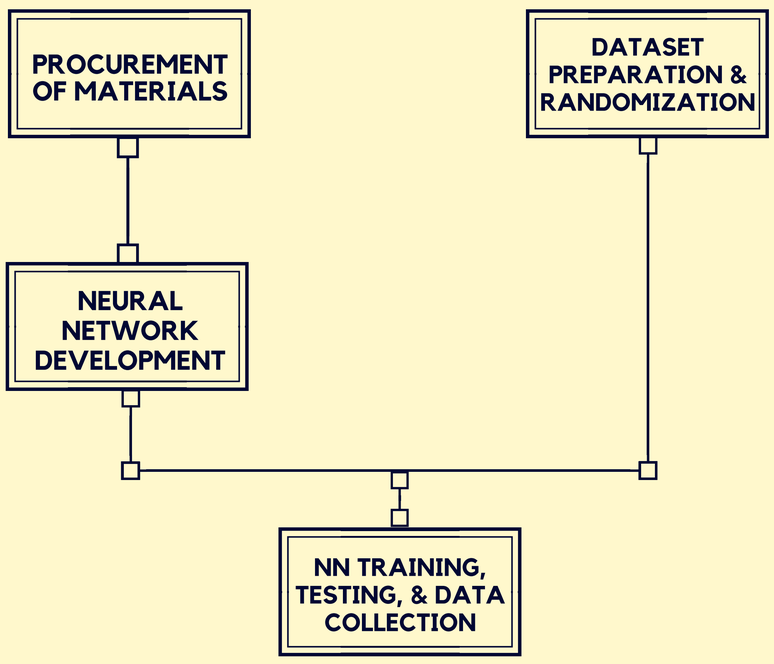
2. **Chords are named by the notes they have.**

   Cmaj7 = C E G B

3. **Naming chords takes significant skill.** Zatorre, Perry, Beckett, Westbury, & Evans, 1998

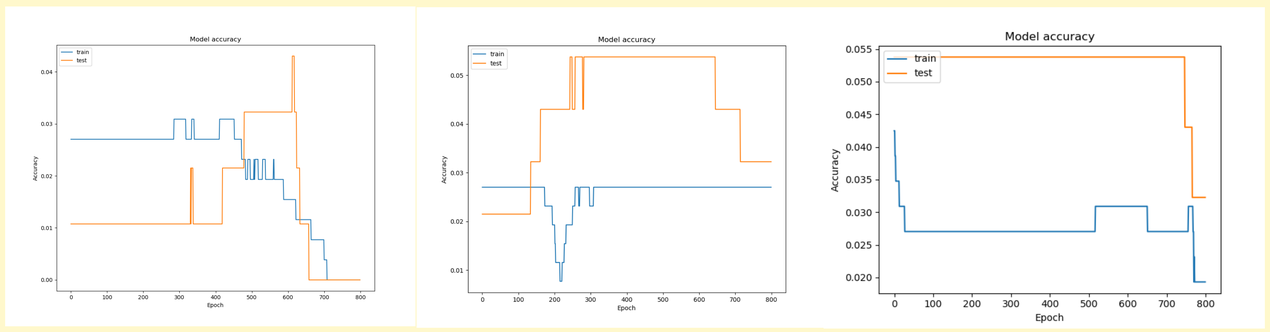
4. **Neural networks allow a computer to learn a task "by itself".** Nielsen, 2015; Sanderson, 2017

## METHODOLOGY



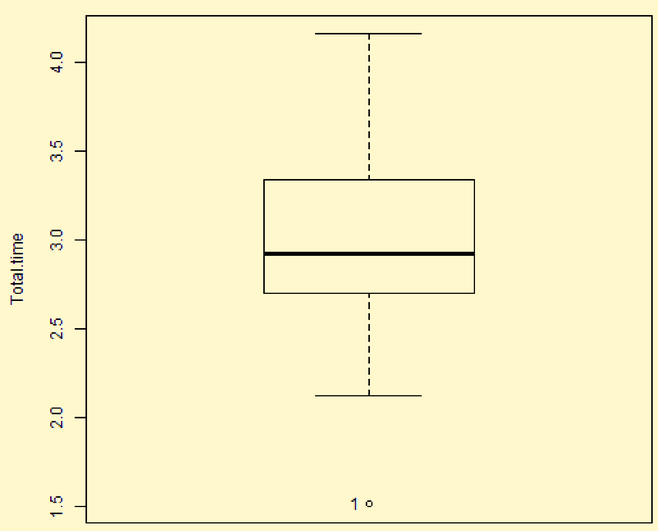

## RESULTS AND DISCUSSION

After 2400 epochs of training, the neural network is still **far from accurate** at predicting the right chords.




Graphs of neural network **learning accuracy** over time. Epoch numbers displayed per graph.
Orange = validation dataset, Blue = training dataset

The network 's response time is **significantly quicker** than the generally accepted standard of **10 miliseconds**.




Boxplot of **time taken** for neural network to respond to user input

It is clear that **2400 epochs** is **not enough** to train this network, but it is expected that its prediction abilities will **improve as it is trained**.

## CONCLUSION & RECOMMENDATIONS

**WE RECOMMEND:**

- increase training iterations
- simplify NN input and output formats

Using neural networks to identify musical chords is **infeasible with short training times**; however, their **low latency** allows them to be theoretically used in real-time situations.


**References**

Leino, S., Brattico, E., Tervaniemi, M., & Vurst, P. (2007). Representation of harmony rules in the human brain: Further evidence from event-related potentials. *Brain Research*, *1142*, 169-177. doi:10.1016/j.brainres.2007.01.049.

Nielsen, M. A. (2015). Neural networks and deep learning. Determination Press.

Sanderson, G. [3Blue1Brown]. (2017, October 5). *But what *is* a Neural Network? | Chapter 1, deep learning*. Retrieved from https://www.youtube.com/watch?v=aircAruvnKk.

Zatorre, R. J., Perry, D. W., Beckett, C. A., Westbury, C. F., & Evans, A. C. (1998). Functional anatomy of musical processing in listeners with absolute pitch and relative pitch. *Proceedings of the National Academy of Sciences*, *95*, 3172-3177. Retrieved at http://www.pnas.org/content/95/6/3172.full.



## Acknowledgements

**We would like to thank the following for their invaluable expertise and guidance:**

**PROJECT MANAGEMENT**
Mr. Mc Jervis Villaruel
Ms. Kiel F. Granada
Ms. Maria April Rose A. Andaca

**NEURAL NETWORKS**
Ms. Maria April Rose A. Andaca
Mr. Edge Angeles
Mr. Maded Batara III