Running Title of the Project: Should not Exceed 250 Characters

Mark Louie D. Lopez (Student 1), Mc Jervis S. Villaruel (Student 2), Donna Salve C. Hipolito (Student 3),

Riel Carlo O. Ingeniero ([[1]](#footnote-1)Research 2 teacher), Ana Victoria R. Lloren ([[2]](#footnote-2)Research 3 teacher) and Rose Mary B. Butaran (2Research adviser)

Philippine Science High School – Main Campus, Department of Science and Technology, Agham Road, Diliman, Quezon City, 1101, Philippines

**ABSTRACT**

**It should summarize the background and scope of the work, the principal results, and note the implications of these results or main conclusions. References and acronyms should be avoided. Since the abstract will be published separately by indexing services, it should concisely capture the basic content of the paper and be understandable without the text. It must not exceed 300 words.**

Keywords: three to six words (preferably words not found in the title)

INTRODUCTION

Chords are groups of individual notes often played together and are an integral part of harmony in many forms of music. Their names are determined by at least two parameters: the root note and the chord type. While “the general music-learning public places a high demand on chord-based representations of popular music” (Humphrey, Bello, & Cho n.d.), identifying the parameters of a certain chord takes certain skills obtained naturally or through special training (Zatorre, Perry, Beckett, Westbury, & Evans 1998), limiting the number of people who can correctly name chords by hearing them. Current neural network implementations of chord identification such as that of Perera and Kodithuwakku (2005) are limited to simpler chord types, and exploration of real-time chord identification is limited if at all existent. To explore this possibility, we designed an Artificial Neural Network (ANN)-based real-time algorithm that aims to correctly identify the names of one of 444 unique chords over 37 simple and extended chord types using integer representations of MIDI note signals as inputs. Such an algorithm could be useful in creating and/or implementing computer programs with chord recognition functions and would be particularly useful in the fields of music education and production. This paper details the design and performance of the ANN in terms of accuracy and latency.

METHODOLOGY

*Procurement of materials*

A graphics processing unit (GPU) was acquired and utilized to facilitate neural network computations, which are highly parallel in nature (Nickolls, Buck, Garland, & Skadron 2008). The NVIDIA GeForce GTX 1070 GPU, as prescribed by Dettmers (2017), was used.

The necessary software, including a Python distribution, Python IDE, and various libraries, were then installed according to the methods in mustgoplay (2016).

*Test chord dataset preparation and randomization*

A series of programs that generates a dataset of 444 chords from 37 selected chord types and all 12 possible notes and converts them to combinations of MIDI note numbers was written. The output of these programs was a database that contained MIDI note number combinations with each combination representing a particular chord. This database was then split into training and validation datasets with 60% and 40% of the chords respectively (Kolassa 2015).

*Artificial Neural Network (ANN) design*

After the dataset of chords was generated, the configuration of the neural network was defined. A structure of 128 input neurons, each representing MIDI notes 0 through 127, and 444 output neurons, each representing one unique chord in the dataset, was chosen.

*Neural network development*

The neural network design was then implemented in Python using the Keras (Keras Team 2018) framework running on TensorFlow. Both input and output layers used ReLU activation functions and orthogonal matrix weight initializations to improve performance (Colina, Perez, & Paraan 2017).

*Neural network training, testing, and data collection*

The neural network was then repeatedly trained on the training dataset and tested on the validation dataset using the built-in functions of Keras (Keras Team 2018) until the accuracy of the network on the validation dataset (called “validation accuracy”) stopped significantly increasing. Training and validation accuracy and loss parameters were collected over the training and testing runs and recorded.

The neural network was then tested for response time. Thirty randomly selected chords were played manually on a MIDI controller, and data from the MIDI controller was automatically handled by a script that passed it to the inputs of the neural network. Response times for each chord were recorded. A statistical left-tailed T-test for one mean with Greeff (2016)’s standard of 40 milliseconds as a benchmark was carried out on the 30 collected response times.

RESULTS

*Subheading for result 1*

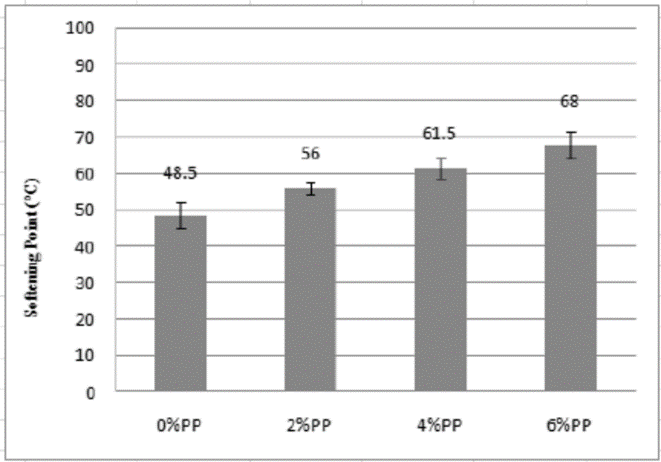
In Results, present data in only one of the following: text, table, or figure. Results should preferably have no more than five illustrations (tables and/or figures). Do not use tables or figures to present data that can be more concisely stated in the text. Discussion should interpret results in relation to previously published work. Do not repeat results or reiterate the introduction.

**Table 1.** Type each table on a separate sheet. Never use vertical lines to separate columns. Prepare tables so that compared data read down, not across. Columns that show no significant variations should be omitted. Do not use tables for word lists. Titles should be clear, and column headings should be brief with units of measurements in parenthesis. Symbols and abbreviations should be defined below the table. Indicate table footnotes with a, b, c, etc. Do not present the same data in both graphical and tabular form. Tables should be self-explanatory or understandable without reference to the text.

|  |  |  |  |
| --- | --- | --- | --- |
| Criteria | A | B | C |
| 1 | 1 ± 0.01 | 1 ± 0.01 | 1 ± 0.01 |
| 2 | 1 ± 0.01 | 1 ± 0.01 | 1 ± 0.01 |
| 3 | 1 ± 0.01 | 1 ± 0.01 | 1 ± 0.01 |
| 4 | 1 ± 0.01 | 1 ± 0.01 | 1 ± 0.01 |

DISCUSSION

Literature citations should be selective, not to exceed 30 references for a research paper.



**Figure 1.** Each figure should have a legend or caption typed on a separate sheet and should be self-explanatory. Figure legends should be in lowercase print-type, except for the first letter of first word. Abbreviations and symbols on figures should be defined in the legend. Figures include line drawings, photographs, and computer plots. They should be clear. Magnification of figures if needed should be given by scale. The size should not exceed a full manuscript page. Glossy prints of photographs should be sent mounted on regular bond paper, with lettering about 3 mm high. Write lightly with a soft pencil on the back or margin of figures, or use self-adhesive label, indicating the figure number and name of lead author. For guidance in the preparation of figures and manuscripts in general, authors are urged to refer to a good style manual, such as Robert Day’s How to write and publish a scientific paper, 4th ed. (1994) or The Chicago Manual of Style, 14th ed. (1993).

Avoid citing gray literature or references not accessible through indexes or obtainable via regular library channels. Cite references in the text as follows: single author, White (1998) or (White 1998); two authors, White & Gray (1998) or (White & Gray 1998); more than two authors, Green et al. (1998) or (Green et al. 1998). Cite multiple references in chronological order (e.g., White & Gray 1990, Green 1992, Brown 1994, 1996). Do not cite unpublished work. Note that most of the abstract, methods, and results will be in the past tense, whereas most of the introduction, some of the discussion, and all conclusions will be in the present tense.

SUMMARY & CONCLUSION

This part must include the summary of findings and the generalization all the collected results. Discuss how it relates to your objectives and make the necessary conclusion. Conclusion must be written in present tense. State the impact and significance of your project as well suggested recommendations for future study.

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1. Should be included by Case 1 and Case 2 groups s/he has contributed, even in a supervisory or consultative capacity, to at least two of the following stages in the research process: (1) ***Conceptualization*** – research design, protocol formulation, testing plan, (2) ***Collection*** – experimentation, data gathering, testing, project implementation, (3) ***Analysis*** – interpretation of results, and/or (4) ***Composition*** – data organization and presentation, literature review, editing of manuscript [↑](#footnote-ref-1)
2. Should be included by Case 1, 2 and 3 if it satisfies the prerequisites specified in 1 [↑](#footnote-ref-2)