Generating song lyrics using recurrent neural networks

Project for the course *Neural Networks* at Faculty of Electrical Engineering and Computing, University of Zagreb

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***Abstract*—This document is a project report for the Neural Networks course at Faculty of Electrical Engineering and Computing in Zagreb. It describes an implementation of a recursive neural network which is used for generating song lyrics based on given set of song lyrics.**

***Index Terms*—RNN, neural networks, generating song lyrics**

I. Introduction

Writing meaningful lyrics has always been a challenge even to the best of songwriters. Since more and more jobs are being automated, especially now with rise of popularity of various machine learning methods, there is also an initiative aimed at computers writing songs. The goal is to feed a model with lyrics of existing songs and then to use it for generating new lyrics. Those generated song lyrics aren't supposed to be word-for-word equal to those used for training the model. Still, it wouldn't be sensible having it generate random words, either. The goal is having the model memorize the lyrics of the songs it is trained on (motifs) and then combine them *sensibly*, i.e. having the model memorize "relationships" between the words through their relative order. In this project, it is being done using recursive neural networks (RNN), which are able to take in account previous outputs when generating new one, thus adding temporality.

II. Existing solutions and brief literature overview

A. Automatic Rap Lyrics Generation

Variation of RNN called LSTM architecture creates a better language model than a regular RNN. [1] According to Potash, Romanov and Rumshisky, Long Short-Term Memory (LSTM) language model produces better lyrics than a baseline model. They attempted to piece together lyrics for a specific artist, but their model was limited in generating lyrics for a genre. As a result of training their model with sets of lyrics, they noticed corresponding rhyming words.

Another example of A Rap Lyrics Generator was developed by Nguyen and Sa [2]. They used database of approximately 40000 existing rap lyrics. After failure to get profound results when using linear-interpolated trigram model approach, they shifted to a quadgram model. Also, they succeeded to generate sentences that rhyme with each other. At the end, generator worked decently, but the content of the lyrics did not relate to a specific theme.

B. Automatic Generation of Poems

Wishful Automatic Spanish Poet was the first generating program for poems which used artificial intelligence and natural language generation techniques together. The whole system of WASP is based on a forward reasoning ruled-based system. Users were asked for inputs which were then used as seeds and results recieved were not very efficient in generating lyrics [3].

C. Rhyme Detection

Hirjee and Brown have developed a probabilistic model and in addition to it they have built up a rhyme detection tool based on that model [4] [5]. Tool analyzes phoneme patterns in words and model is trained on a set of lyrics that were manually annotated for rhyming words.

D. Classification of Lyrics

Mayer, Neumayer and Rauber used rhyme and style features to classify and process lyrics [6]. They followed the fact that a rhyme is two words that when spelt sound similar and generally used it for words at the end of verses.

E. Natural Language Processing and Lyrics Generation

With basic natural language processing tools, song lyrics can be analysed by using a Naive Bayes classifier. Mahedero, Cano and Martinez used that to identify languages. Also, they used it for classification based on themes and to search for similarities between them. The languages which were used for the experiment: English, Spanish, German, French and Italian. Given results were approximately 94% accurate. The conclusion they came to is that the identification of languages was easier task compared to the others.

III. Prepare Your Paper Before Styling

Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections III-A–III-E below for more information on proofreading, spelling and grammar.

Keep your text and graphic files separate until after the text has been formatted and styled. Do not number text heads—LaTeX will do that for you.

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Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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Please don't use the `{eqnarray}` equation environment. Use `{align}` or `{IEEEeqnarray}` instead. The `{eqnarray}` environment leaves unsightly spaces around relation symbols.

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- Be aware of the different meanings of the homophones "affect" and "effect", "complement" and "compliment", "discreet" and "discrete", "principal" and "principle".
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- The abbreviation "i.e." means "that is", and the abbreviation "e.g." means "for example".

An excellent style manual for science writers is [7].

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TABLE I
TABLE TYPE STYLES

Table Head	**Table Column Head**		
	Table column subhead	***Subhead***	***Subhead***
copy	More table copy[a]		

[a]Sample of a Table footnote.

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Fig. 1. Example of a figure caption.

ACKNOWLEDGMENT

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REFERENCES

Please number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first ..."

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Unless there are six authors or more give all authors' names; do not use "et al.". Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

REFERENCES

[1] P. Potash, A. Romanov, and A. Rumshisky, GhostWriter: Using an LSTM for Automatic Rap Lyric Generation. In: *Proceedings of the 2015 Conference on Empirical Methods in Natural Language Processing*, 2015.

[2] H. Nguyen, and B. Sa, Rap Lyrics Generator, unpublished, 2009.

[3] H. Manurung, G. Ritchie, and H. Thompson, Towards a Computational Model of Poetry Generation. In: *Proceedings of AISB Symposium on Creative and Cultural Aspects and Applications of AI and Cognitive Science*, pp. 79-86, April 2000.

[4] H. Hirjee, and D. Brown, Using automated rhyme detection to characterize rhyming style in rap music, 2010.

[5] H. Hirjee, and D. Brown, Rhyme analyzer: An analysis tool for rap lyrics. In: *Proceedings of the 11th International Society for Music Information Retrieval Conference*, 2010.
[6] R. Mayer, R. Neumayer, and A. Rauber, Rhyme and Style Features for Musical Genre Classification by Song Lyrics. In: *ISMIR 2008, 9th International Retrieval, 14-18 September, 2008, Drexel University, Philadelphia, PA, USA*.
[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.
[8] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
[9] K. Elissa, "Title of paper if known," unpublished.
[10] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.
[11] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

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