Color Extraction from Lyrics

Gen Hori

Faculty of Business Administration

Asia University

Tokyo 180-8629, Japan

hori@asia-u.ac.jp

ABSTRACT

We establish a procedure for color extraction from lyrics based on the distributed semantic representation obtained by word2vec. To extract colors from lyrics, we exploit the fact that the cosine similarities between words and color names tend to reflect the actual colors of the things the words indicate. We select important words that characterize the lyrics according to the tf-idf statistic and estimate the colors of the important words using the cosine similarities between the words and color names. For evaluation of the color extraction procedure, we implement a software system that automatically generate images based on the colors extracted from given English lyrics. We conduct a subjective evaluation of the color extraction procedure using the software system and the lyrics of three Beatles songs.

CCS CONCEPTS

• **Computing methodologies** → **Natural language processing**.

KEYWORDS

natural language processing, word2vec, tf-idf, color, lyrics

1 INTRODUCTION

From the viewpoint of artificial intelligence and music creation, although there have been an enormous amount of works on automatic composition and lyrics generation[1][2][3][4], almost no work has been done on automatic cover art generation in spite of its importance and relevance to music production. The purpose of the present study is to introduce a procedure of color extraction from lyrics exploiting the distributed semantic representation obtained by the word2vec algorithm[5][6] with a view of future development of automatic cover art generation systems. We start with an observation that the cosine similarities between words and color names tend to reflect the actual colors of the things the words indicate. Based on the observation, we can estimate the color of a given word by calculating the cosine similarities between the given word and color names and choosing the color that gives the largest value of the cosine similarity. At the same time, we can select important words that characterize the lyrics using the classical tf-idf (term

frequency-inverse document frequency) statistic[7]. By combining these two approaches, we can extract the important colors that characterize the lyrics by selecting important words from the lyrics using tf-idf and estimating the colors of the important words exploiting word2vec. Although we use English lyrics to illustrate our method in the present study, the color extraction procedure readily extends for other languages if an adequate corpus and basic color names are given in the language because the procedure does not exploit any specific language structure. Furthermore, for evaluation of the color extraction procedure, we implement a software system that automatically generate images based on the colors extracted from given English lyrics and conduct a subjective evaluation using the software system.

The rest of the paper is organized as follows. Section 2 introduces the color extraction procedure exploiting word2vec and tf-idf. Section 3 describes our software system for evaluation of the color extraction procedure and the result of a subjective evaluation using images generated from the lyrics of three Beatles songs. Section 4 concludes the paper.

2 COLOR EXTRACTION

2.1 Distributed semantic representation

The distributed semantic representation is a method of embedding words into a vector space. Comparing to the one-hot representation of words, it embeds words into a vector space of a relatively lower dimension of a few hundred. If two words are semantically close to each other, then the corresponding two vectors are close to each other in the vector space. The word2vec algorithm introduced by Mikolov[5][6] is widely used for learning the distributed semantic representation from a corpus. It has been reported that recently developed methods exploiting word2vec outperform previous methods in many natural language processing tasks. We denote the vectors obtained by word2vec representing two words w_i, w_j by $\mathbf{w}_i, \mathbf{w}_j$. Then the cosine similarity, or the cosine of the angle between the two vectors,

$$\text{cs}(\mathbf{w}_i, \mathbf{w}_j) = \frac{\mathbf{w}_i \cdot \mathbf{w}_j}{\sqrt{\|\mathbf{w}_i\| \cdot \|\mathbf{w}_j\|}},$$

reflects the semantic similarity of the two words; it takes a large value when the two words are semantically close to each other. The semantic similarity between two words is simply defined in word2vec as the probability of the appearance of two words in proximity in the corpus. Then the cosine similarity is a measure

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of the appearance of two words in proximity. In the present study, we use Mikolov’s own implementation of word2vec written in C and the text8 corpus¹ accompanied in the distribution of the implementation for learning. Applying word2vec to the text8 corpus produces the distributed semantic representations of 75761 English words.

2.2 Cosine similarity with color names

We extract colors from lyrics based on an observation that the cosine similarities between words and color names tend to reflect the actual colors of the things the words indicate. This is a natural consequence of the fact that the cosine similarity is a measure of the appearance of two words in proximity in the corpus. Table 1 gives the values of the cosine similarities of three words (“fire,” “grass” and “sky”) with three color names (“red,” “green” and “blue”). For example, the cosine similarity of “sky” with “blue” is larger than that with “red” or “green”, which follows the fact that the phrase “blue sky” appears more often than “red sky” or “green sky” in the corpus. Similarly, the cosine similarity of “fire” with “red” and that of “grass” with “green” give the largest values in the first and second rows of Table 1, respectively. We should notice, however, that this does not always hold true. For example, in Table 2, the cosine similarity of “river” with “red” is larger than that with “green” or “blue” following the fact that there are many rivers called “red river” in the world although the actual colors of such rivers are not literally red but closer to blue or green.

Table 1: The cosine similarities between words and color names

	“red”	“green”	“blue”
“fire”	0.146	0.105	0.098
“grass”	0.201	0.358	0.259
“sky”	0.200	0.235	0.418

Table 2: A counterexample in the cosine similarity and the actual color

	“red”	“green”	“blue”
“river”	0.194	0.115	0.090

Based on the assumption that such counterexamples are few, we estimate the color of a given word by calculating the cosine similarities of the word with color names and choosing the color that gives the largest value of the cosine similarity.

2.3 Selection of important words

To extract colors that describe the lyrics, we select important words that characterize the lyrics and then estimate the colors of the

selected words. The tf-idf (term frequency-inverse document frequency) [7] is a statistic widely used for estimating how important a word w_i is to a document d_j in a set of documents D . The tf-idf of the word w_i to the document d_j is defined as a product of the term frequency and the inverse document frequency,

$$tf_{i,j} \times idf_i,$$

where the term frequency is defined as,

$$tf_{i,j} = \frac{n_{i,j}}{\sum_k n_{k,j}},$$

where $n_{i,j}$ is the frequency of the word w_i in the document d_j , and the inverse document frequency is defined as,

$$idf_i = \log \frac{|D|}{|\{d|w_i \in d\}|},$$

where $|D|$ is the total number of the documents in the set D and $|\{d|w_i \in d\}|$ is the number of the documents in D that contain the word w_i . The inverse document frequency is used to reduce the score of common words. We sort the words in lyrics according to the values of tf-idf and select the top words for color extraction from lyrics.

2.4 Color extraction from lyrics

For color extraction from lyrics, we use nine fundamental color names, “black,” “gray,” “white,” “red,” “green,” “blue,” “cyan,” “magenta” and “yellow,” which are the vertices and the center of the RGB color cube. We calculate the cosine similarities of each word in lyrics² with the nine fundamental colors and estimate that the color of the word is the one that gives the largest value of the cosine similarity. If the largest value is less than a predetermined threshold³, we estimate that the word is colorless. We sort all the colored words in descending order of tf-idf and name the colors of the top words as the extracted colors from the lyrics. The color extraction procedure readily extends for other languages if an adequate corpus and basic color names are given in the language because tf-idf and word2vec do not use any specific language structure.

3 SOFTWARE SYSTEM FOR EVALUATION

3.1 Implementation

We implement a software system that automatically generate images from English lyrics based on the color extraction procedure. It extracts the primary and secondary colors from given English lyrics and generate an image based on the two extracted colors. The primary color is the color of the top word in the list of the colored words in the descending order of tf-idf. The secondary color is the color of the second word. To generate images, we use the ImageMagick library, a standard library for image generation and format conversion. Specifically, we give the primary and secondary colors as the inputs to the library and choose plasma option of the library to generate images like oil paintings.

¹The first 10⁸ bytes of the cleaned text data extracted from the English Wikipedia dump on Mar. 3, 2006

²We remove stopwords before we calculate the cosine similarity in our software system.

³We set the threshold to 0.1 in our software system.

Figure 1: An image generated from the lyrics of “Let It Be”

Figure 2: An image generated from the lyrics of “Helter Skelter”

3.2 Examples

Figures 1-3 exhibit images automatically generated by our software system from lyrics of three Beatles songs, “Let It Be,” “Helter Skelter” and “Free As A Bird.” Tables 3-5 list the tf-idf, the estimated colors and the cosine similarities with color names used in generating the

Figure 3: An image generated from the lyrics of “Free As A Bird”

three images where the values of the cosine similarities displayed in red text are the largest ones that give the estimated colors. In the lyrics of “Let It Be,” the word “whisper” has the largest tf-idf among the colored words and the largest cosine similarity with “yellow” which makes the primary color of the lyrics yellow. The word “music” has the second largest tf-idf with a slight margin with the word “wake” and makes the secondary color cyan. In the lyrics of “Helter Skelter,” the title word is divided into two which give the same color. If the colors in the first place and the second place are the same, we take the color in the third place as the secondary color. In the lyrics of “Free As A Bird,” the primary color is blue by the word “bird” and the secondary color is white by the word “home.” We note that the primary color is shared by the words “bird,” “wings” and “fly” which are related to each other.

3.3 Subjective evaluation

We conducted a subjective evaluation of the generated images and thus the proposed color extraction procedure. A total of 43 subjects in the age range of 18-22 participated in the evaluation, among which 23 are males and 20 females. The subjects looked at the printed lyrics of the three Beatles songs and the three images of Figures 1-3 generated from the lyrics of the three songs, and then answered the following questionnaire. The images were shown to subjects in random order and the subjects answered the questionnaire without knowing the correspondence between the lyrics and the images. They did not listen to the audio of the songs before answering the questionnaire.

Table 3: The tf-idf and estimated colors of words from the lyrics of “Let It Be”

color name			black	gray	white	red	green	blue	cyan	magenta	yellow
color											
tf-idf	word	color	cosine similarity								
0.244	whisper		0.199	0.141	0.177	0.185	0.220	0.203	0.124	0.111	0.248
0.075	music		0.070	-0.108	0.069	-0.120	-0.055	0.044	0.101	-0.088	-0.017
0.075	wake		0.066	0.068	0.047	0.173	0.093	0.117	-0.017	0.003	0.074
0.071	night		0.182	0.049	0.177	0.162	0.188	0.242	0.002	-0.004	0.115
0.071	light		0.164	0.134	0.079	0.165	0.205	0.239	0.369	0.223	0.371
0.069	see		0.059	-0.021	-0.008	0.007	0.104	0.116	0.155	0.081	0.060
0.059	right		-0.024	0.038	0.041	0.095	0.137	0.033	0.043	0.054	0.096
0.051	shines		0.269	0.241	0.292	0.334	0.246	0.313	0.278	0.210	0.407
0.050	cloudy		0.146	0.129	0.176	0.222	0.205	0.281	0.196	0.201	0.259
0.047	parted		0.004	-0.049	0.003	0.142	-0.009	0.038	-0.070	-0.129	0.023
0.046	shine		0.184	0.210	0.210	0.214	0.263	0.327	0.254	0.185	0.307
0.042	tomorrow		0.056	0.059	0.034	0.020	0.095	0.213	0.088	-0.011	0.040
0.036	darkness		0.269	0.160	0.156	0.139	0.203	0.191	0.132	0.044	0.185
0.034	comes		0.046	-0.009	0.022	-0.003	0.017	0.124	0.146	0.080	0.022
0.022	standing		-0.023	-0.014	0.119	0.072	0.073	0.094	-0.133	-0.009	-0.006
0.020	sound		0.095	0.013	0.053	-0.005	-0.030	0.136	0.183	0.016	0.076
0.018	front		0.109	0.008	0.200	0.246	0.075	0.120	-0.030	0.063	0.120

Table 4: The tf-idf and estimated colors of words from the lyrics of “Helter Skelter”

color name			black	gray	white	red	green	blue	cyan	magenta	yellow
color											
tf-idf	word	color	cosine similarity								
0.526	skelter		0.245	0.167	0.184	0.045	0.004	0.051	0.014	0.024	0.030
0.526	helter		0.253	0.186	0.214	0.110	0.047	0.083	0.023	0.064	0.070
0.141	turn		0.037	-0.075	-0.005	0.041	0.043	0.027	-0.041	-0.103	0.104
0.129	see		0.059	-0.021	-0.008	0.007	0.104	0.116	0.155	0.081	0.060
0.129	top		0.119	0.012	0.094	0.191	0.122	0.190	-0.023	-0.030	0.122
0.124	dancer		0.052	-0.000	0.139	0.013	-0.023	0.059	0.065	0.084	0.040
0.096	bottom		0.152	0.125	0.200	0.217	0.184	0.236	-0.007	0.046	0.202
0.078	look		0.105	0.092	0.111	0.081	0.092	0.112	0.079	0.033	0.201
0.074	slide		0.045	-0.100	-0.052	-0.039	0.110	0.050	0.011	-0.011	0.071
0.067	hey		0.101	0.017	0.162	0.061	0.148	0.158	-0.018	-0.017	0.171
0.065	ride		0.177	0.106	0.141	0.134	0.121	0.170	0.005	0.027	0.137
0.061	head		0.099	0.113	0.126	0.139	0.046	0.136	-0.093	0.049	0.041
0.061	blisters		0.060	0.112	0.048	0.048	0.034	0.037	-0.011	0.148	0.149
0.034	till		0.119	0.122	0.012	0.105	-0.009	0.043	0.055	0.095	0.056
0.016	comes		0.046	-0.009	0.022	-0.003	0.017	0.124	0.146	0.080	0.022
0.015	won		0.021	-0.053	0.070	0.109	0.075	0.045	-0.033	0.047	-0.001

Table 5: The tf-idf and estimated colors of words from the lyrics of “Free As A Bird”

color name			black	gray	white	red	green	blue	cyan	magenta	yellow
color											
tf-idf	word	color	cosine similarity								
1.301	bird		0.136	0.193	0.153	0.192	0.118	0.240	0.035	0.105	0.097
0.384	home		0.035	0.024	0.163	0.123	0.105	0.038	-0.092	-0.027	-0.021
0.353	like		0.135	0.063	0.109	0.043	0.093	0.108	0.039	-0.068	0.214
0.260	best		0.077	-0.087	0.022	0.017	0.063	0.075	0.114	-0.008	-0.072
0.236	dry		0.064	0.083	0.060	0.101	0.099	0.080	-0.027	0.007	0.176
0.103	really		0.023	0.002	-0.059	-0.040	-0.053	-0.008	0.106	-0.045	-0.018
0.093	wings		0.119	0.220	0.146	0.250	0.240	0.333	0.067	0.107	0.214
0.084	fly		0.051	0.112	0.098	0.122	0.121	0.213	-0.023	0.045	0.107
0.045	touch		0.165	0.183	0.176	0.154	0.187	0.168	0.204	0.106	0.254
0.028	mean		0.029	0.058	0.024	-0.022	0.051	0.078	0.180	0.094	0.138

Table 6: Results of subjective evaluation

	Fig.1 (Generated from “Let It Be”)	Fig.2 (Generated from “Helter Skelter”)	Fig.3 (Generated from “Free As A Bird”)
Q1. (Suitable for “Let It Be”)	61.9%	9.5%	28.6%
Q2. (Suitable for “Helter Skelter”)	22.0%	58.5%	19.5%
Q3. (Suitable for “Free As A Bird”)	38.1%	7.1%	54.8%

- Q1. Which of the following is most suitable for “Let It Be”? (Single option)
- Q2. Which of the following is most suitable for “Helter Skelter”? (Single option)
- Q3. Which of the following is most suitable for “Free As A Bird”? (Single option)

Table 6 gives the results of the subjective evaluation. First of all, we note that the diagonal elements give the largest values for all the rows, which means that, for each lyrics, the largest number of subjects chose the image generated from the lyrics in question. Also the diagonal elements give the largest values for all the columns, which means that each image was chosen mostly for the lyrics used to generate it. Those results imply that the proposed color extraction procedure works appropriately for the lyrics of those three songs.

4 CONCLUSION

We introduced a novel procedure of color extraction from lyrics exploiting tf-idf and word2vec. The procedure is based on the fact that the cosine similarities between words and color names tend to

reflect the actual colors of the things the words indicate. We also implemented a software system that automatically generates images from given English lyrics and conducted a subjective evaluation of the color extraction procedure using the software system and the lyrics of three Beatles songs. The results of the evaluation imply that the proposed color extraction procedure works appropriately for the lyrics of those three songs. Our future study plan is to develop a system that automatically generates cover arts from lyrics for which we have two directions. One direction is to employ recently developed text-to-image techniques based on GAN (generative adversarial network) such as StackGAN[8] to generate more concrete images from lyrics. In this direction, the color extraction procedure introduced in the present work will be also useful for setting color tone for generated images. Another direction is to extract colors or other elements from the melodies and chord progressions of given songs and use them for cover art generation.

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