In BLOOM: Creativity and Affinity in Artificial Lyrics and Art

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Abstract

We apply a range of sampling parameters to a large multilingual language model (BLOOM-176B) in open-ended generation of Chinese song lyrics, and evaluate the resulting lyrics for coherence and creativity using human reviewers. We find that the human concept of creativity requires lyrics to be both comprehensible and distinctive — and that humans assess certain types of machine-generated lyrics to score more highly than real lyrics by popular artists. Inspired by the inherently multimodal nature of single releases, we leverage a custom fine-tuned stable diffusion model to produce high-quality lyric-guided album art, demonstrating a creative approach for an artist seeking inspiration for an album or single. Finally, we introduce the MojimLyrics dataset, a Chinese-language dataset of popular song lyrics, which allows us to identify a gap between MAUVE scores and subjective human quality assessment.

Introduction

Modern music production — which spans elements including musical composition, songwriting, album artwork, and music videos — is a tremendous domain for exploring creativity across modalities. This work focuses on better understanding subjective human assessment of creative text produced by large language models (LLM), demonstrating that mimicry of an existing sample dataset may not always be the best approach when considering human preferences.

Towards this end, we use BLOOM (BigScience 2022), a multilingual LLM with 176B parameters, to generate Chinese song lyrics with varying sampling parameters. We focus on top-p sampling, as this method has been found to outperform top-k and beam search in prior research (Holtzman et al. 2019). In order to assess the quality of the generated lyrics, we task human reviewers to provide feedback on lyrical coherence, creativity, and enjoyment. Using this data, we demonstrate the relationship between creativity and coherence in human-assessed lyric quality, and highlight differences between subjective human assessment and computational methods such as MAUVE (Pillutla et al. 2021).

Beyond comparison of creativity measures, we also dive into new emerging multimodal possibilities related to AI-driven creativity. Music today is often accompanied by cover art that evokes the aesthetic of the piece. This art, previously displayed on record covers and lyric booklets, remains prominently displayed on music apps and streaming platforms. While album cover art may reflect a collection of songs (an album, LP, or EP), digital music publishing allows for easy release of singles, and cover art is increasingly used to accompany individual tracks (Leight 2018). Using our lyrics, we use the Chinese-language Taiyi stable diffusion model (Wang et al. 2022) to generate an album image inspired by the LLM-generated lyrics. The demonstrated workflow may be used for inspiration by songwriters seeking a unified lyrical and visual concept for a single or album, as well as being a source of entertainment to music fans.

Related Work

Previous work has used LLMs to generate classical Chinese poetry (Liao et al. 2019). Work has also been performed which uses GPT-2 as a generation system for various types of creative Chinese writing, contemporary song lyrics among them (Zhang et al. 2022). Related work has used an image-generation network as an intermediate step in generating non-lyrical creative text, based on the idea of an author "visualizing" while they work (Zhu et al. 2022). In English, research has similarly been done on LLM lyric generation (Rodrigues et al. 2022), including lyrics conditioned on a song's melody (Chen and Lerch 2020).

Our work is distinct from previous work in that it focuses on zero-shot lyric generation with a massive multilingual model (BLOOM), is the first to our knowledge to benchmark lyrics against evaluation metrics that strongly correlate to human assessment (MAUVE), and most importantly, presents an investigation into the relationship between computational assessment of open-ended text quality, and subjective measurements. In this department, we are inspired by previous work on quantifying creativity that found that KL divergence has a strong correlation with human-assessed creativity for word pairs (Kuznetsova, Chen, and Choi 2013).

Finally, this work is also the first research work to apply diffusion models as part of a unified approach for generating coordinated cover art in association with song lyrics. All models and code and from our work will be made available open-source to enable future research[1].

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[1] https://github.com/ecrows/in-bloom

Methodology

We organize our methodology into three major parts: 1) collecting and cleaning Chinese lyrics found online to create a novel dataset of popular Chinese lyrics for use with MAUVE, 2) performing lyric generation effectively with the BLOOM-176B LLM, and 3) utilizing the Taiyi stable diffusion model to generate high-quality art to accompany the lyrics.

Dataset

For comparison to LLM-generated lyrics, we collect a dataset of song lyrics for popular Chinese songs from the website Mojim.com. Mojim is a popular lyrics sharing website that focuses on Chinese song lyrics. We request the top popular artists in the "male", "female", and "group" categories, fetch all the albums associated with each artist, and download the lyrics for every song in each album. Metrics on the dataset can be found in Table 1.

Data downloaded from Mojim.com is in raw HTML format and must be cleaned to extract raw lyrics. This process is summarized as follows.

- Removal of HTML tags, as well as the removal of markup symbols not typically part of the lyric text, such as "*" and "#" and various unicode equivalents.
- Removal of site-specific text characteristics, such as: a recurring line in Chinese which translates to "Find more lyrics at Mojim.com", dividing lines composed of hyphens, non-standard labels placed at the start of the song.
- Compress instances of many subsequent newline characters into just two newline characters, to reduce excess whitespace which may emerge after removing tags, annotations, and symbol markup.

Songs	Artists	Tokens	Size
39747	230	14,406,854	38.4MB

Table 1: Statistics for the MojimLyrics Dataset

Lyric Generation

We generate zero-shot samples using the multilingual BLOOM-176B model (BigScience 2022) at varying values of p for top-p nucleus sampling (Holtzman et al. 2019). By adjusting the probability mass used to sample the next token, we produce varied lyric sequences that can be used to analyze quantitative and subjective text characteristics. Our evaluation of lyrics focuses on two major approaches:

- **Computational Quality**: We measure computational quality via commonly-used metrics that target language model degeneration (repeated n-grams, diversity of tokens, distinct n-grams), as well as distributional information via MAUVE (Pillutla et al. 2021).
- **Subjective**: Subjective measures of coherence are collected via a carefully survey on Amazon Mechanical Turk. These measures include an assessment of how creative, coherent, and enjoyable the lyrics are.

Previous research on quantifying creativity indicates that for measuring perceived creativity of word pairs $\{w_1, w_2\}$, the KL divergence of $\{w_1, w_1 w_2\}$ is among the most effective measures (Kuznetsova, Chen, and Choi 2013).

MAUVE is designed to jointly capture two types of errors between the output distribution Q of a model, and the human distibution P. 1) Type I errors, where Q places high mass on text which is unlikely under P; and, 2) Type II errors, where Q cannot generate text which is plausible under P. MAUVE does this by summarizing Type I and Type II errors using Kullback–Leibler (KL) divergences, which are measured softly using a mixture distribution. Due to the similarity between MAUVE's computation and previous work on creativity quantification, it is possible that MAUVE may partially reflect subjective human creativity assessment, which may contribute to MAUVE's strong performance for evaluating generated text quality more generally.

Additional text quality metrics for assessing language model output are selected based on previous work (Zhu et al. 2022; Su et al. 2022). These metrics include rep-n = 1.0 - $\frac{|\text{unique } n\text{-grams}|}{|\text{total } n\text{-grams}|}$ measuring duplicate n-grams within each generated sequence (Welleck et al. 2020), distinct-n = $\frac{|\text{unique } n\text{-grams}|}{|\text{length of text}|}$ (Li et al. 2016), and diversity = $\prod_{n=2}^{4}(1 - \text{rep-}n)$ for measuring diversity of n-grams (Su et al. 2022).

Autoregressive language models such as BLOOM perform sampling to select a next token typically using some variation of top-k, beam search, and nucleus top-p sampling. Due to the strong documented performance of top-p sampling (Holtzman et al. 2019), we produce BLOOM generations at varying levels of $p \in [0.80, 0.85, 0.90, 0.95, 0.99]$.

高山白雪 铸剑之地
于此剑中 缘份精魂
被磨得锋锐无比
此剑出鞘 成为神剑
这把剑，是用来保护你爱的人
如果, 我的爱 因这把剑消失
我愿拼尽全力 在所不惜
如果这是为了保护你
这把剑 我的剑 就此消失
倘若神怜悯你 终会有所作为
莫失良机 听其言 行其

Figure 1: BLOOM-176B $p = 0.95$, $seed = 0$ lyrics mentioning a sword, accompanied by corresponding stable diffusion generated images selected from the resulting prompt at $CFG = 0.7$, $seed = 0$, $batch_size = 6$

Album Art Generation

We leverage our generated song lyrics to create accompanying track art inspired by the song lyrics. As a generative model, we utilize the Chinese-language Taiyi Stable Diffusion model (Wang et al. 2022; Rombach et al. 2021), which includes a Chinese-language text encoder. We use this model to produce 1000 samples of album artwork, from seeds 0-999, using the prompt "album art" in Chinese, followed by our generated lyrics. We perform this at varying settings of classifier-free diffusion guidance (CFG), where $CFG \in [4.0, 7.0, 10.0]$. Images are generated with 20 sampling steps using the Euler A method (Rombach et al. 2021). For evaluation, we utilize a dataset of approximately 4,000 album covers at 512x512 resolution (Surma 2019). We determine the quality of the generated images by calculating Fréchet Inception Distance (FID) (Heusel et al. 2017; Seitzer 2020) using the pool 3 activations from an Inception network (Szegedy et al. 2015) between generated album covers and the real album dataset.

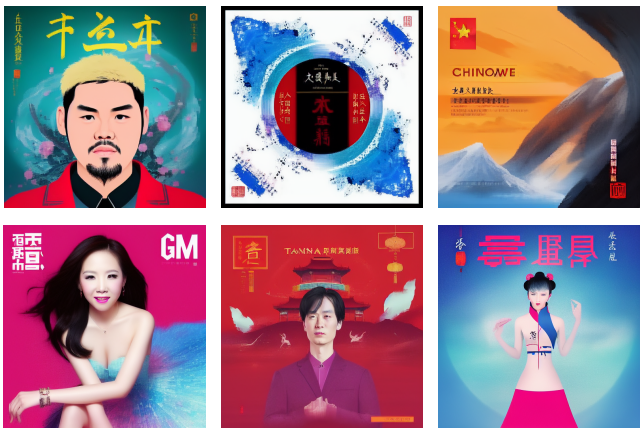

Figure 2: Album covers generated by Taiyi diffusion model in the style of popular Chinese artists

Experimental Setup

Inference on BLOOM-176B was performed via the Huggingface Inference API. All other calculations (stable diffusion, MAUVE, FID) were performed on a machine with an Intel i7-6800K 12-core CPU, 32GB RAM, and a 24GB VRAM RTX 3090 GPU. Seeds starting at 0 are used throughout our experiments for reproducibility.

BLOOM

In order to use BLOOM to generate lyrics in a zero-shot setting, we provide the following prompt:

下面是一首歌的中文歌词。\n歌词：\n

Translation: Below are a song's Chinese lyrics. \n Lyrics: \n

This prompt was chosen based on the observed result of Chinese language song lyrics. Shorter prompts such as simply the words for "lyrics" in Chinese more often resulted in non-song lyrics such as interviews with musicians, and more specific prompts that mentioned specific artists or too closely resembled formatting from specific lyric websites had a higher incidence of generating lyric sequences from real songs. Memorization in large language models is well-documented and is a significant problem undergoing research (Carlini et al. 2021). The selected prompt appears to minimize this behaviour, though future analysis on memorization would be valuable.

Source	rep-2 ↓	rep-3 ↓	rep-4 ↓	diversity ↑	distinct-2 ↑	MAUVE ↑
Human	**0.021**	**0.013**	**0.012**	**0.954**	**0.870**	-
$LLM_{p=0.80}$	0.120	0.090	0.072	0.743	0.650	0.139
$LLM_{p=0.85}$	0.095	0.073	0.063	0.786	0.689	0.162
$LLM_{p=0.90}$	0.072	0.055	0.047	0.835	0.722	0.207
$LLM_{p=0.95}$	0.054	0.044	0.039	0.868	0.760	0.269
$LLM_{p=0.99}$	**0.040**	**0.034**	**0.032**	**0.897**	**0.783**	**0.293**

Table 2: Quantitative degeneration metrics and MAUVE divergence-based quality results for BLOOM-176B generated text at varying sampling probability mass p

Amazon Mechanical Turk

Using Amazon Mechanical Turk to evaluate open-ended text generation is challenging and requires care to perform effectively (Karpinska, Akoury, and Iyyer 2021), however, such platforms remain useful for their ability to provide real human feedback, A selection of 60 samples were taken from the BLOOM generated lyric corpora at each value for $top-p$ nucleus sampling, as well as lyrics from the MojimLyrics dataset. For each of these 60 samples, 3 different reviewers were assigned to score the lyrics for coherence, creativity, affinity (how much the reviewer likes the lyrics), and recognition (whether they believe they may have seen the lyrics before). Answers for each question are converted into normalized scores between 0 and 10.

Instructions were provided in Simplified Chinese. To encourage close reading, a starting question requests a short summary of the lyrics, and a final multiple-choice question tests the reviewer's basic fluency in Chinese by placing the option "I can read Chinese" among various other negative options. Participant responses were removed if they failed to provide a summary or respond correctly to the literacy-testing question.

The projected task duration was 120 seconds, with payment of $0.44 CAD for a projected hourly wage of $13.20 CAD. Actual mean task duration was confirmed to be within the projected task duration. The survey questions are provided in the GitHub repository.

MAUVE Calculation

For calculating MAUVE, we featurize p with a random sample of 3000 real lyrics from the MojimLyrics dataset, and featurize q with 3000 generated lyrics from BLOOM-176B at each probability mass from our nucleus sampling $p \in [0.80, 0.85, 0.90, 0.95, 0.99]$. We set a maximum text length

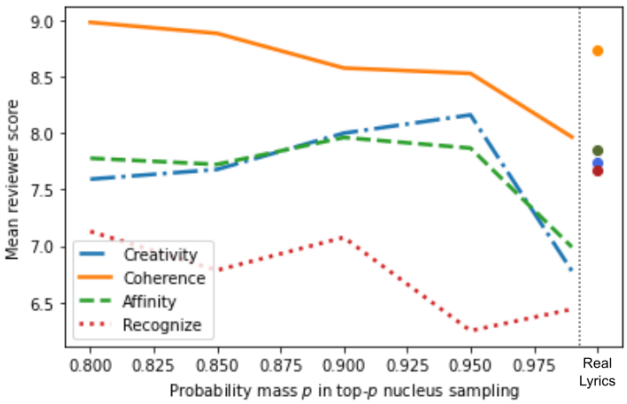

Figure 3: Mean human scores for subjective attributes of generated text at varying sampling probability mass p. Included to the right are reviewer scores for real lyrics.

	CFG@4.0	CFG@7.0	CFG@10.0
FID↓	90.21	93.84	95.91

Table 3: FID with real album dataset of Taiyi stable diffusion generated album art at varying CFG

of 128 and set a batch size of 32 based on the GPU memory available. The seed for the MAUVE calculation is set to 0.

Results

Results for language model evaluation with MAUVE scores and degeneration metrics can be found in Table 2, while results of stable diffusion CFG variation on FID can be found in Table 3. The complete dataset of generated BLOOM lyrics are provided in the GitHub repository. Human assessment of lyrics can be found in Figure 3.

A sample of generated lyrics and the resulting stable diffusion art can be found in Figure 1. A wider range of stable diffusion images using the album art prompt can be found in Figure 2, demonstrating the variety of generations the model can produce. FID scores calculated between outputs of the diffusion model and real album art can be found in Table 3.

On the 10 point normalized scale, mean standard deviation among multiple responses for the same input sample were observed to be 1.29, 1.68, 1.95, and 2.67 for coherence, affinity, creativity, and recognition respectively. However, despite the relatively low variance in response scores, measures of inter-annotator agreement (IAA) are consistently low (i.e., negative Krippendorff ordinal alpha). Survey responses were highly skewed towards positive answers. When a reviewer gave a particular sample a low score, often it was only one reviewer did so. This implies that while reviewers largely agreed on ratings, there was not a consistent criterion across reviewers for giving low scores. Obtaining high IAA scores on concepts such as creativity and personal preference will likely require a larger study with a greater number of trained reviewers.

Discussion

Sampling BLOOM for lyrics from a greater portion of the probability mass tends to improve quantitative metrics of generated lyric quality, as shown in Table 2. As expected, token diversity, distinct-n, and rep-n all improve at increasing p portion of the probability mass. That MAUVE score also continues improving implies a low incidence of Type I errors where the model output distribution Q places high probability mass on text which is unlikely under P. Notably, even at very high p-values, BLOOM-176B generated lyrics are still more repetitive and less diverse than human lyrics.

Human assessment of lyrics at varying p is charted in Figure 3. Coherence is highest at low-p, where common words are frequently sampled, but with a low accompanying creativity score. Subjective quality measurements of creativity and affinity peak around $p = 0.9$, and trend downwards as the model selected less common words and became less coherent. This implies that for a human to recognize work as "creative", it must be coherent enough to be understood, but distinctive enough to be interesting. While MAUVE correlates with creativity as it increases from $p = 0.80$ to $p = 0.95$, this inverts at higher p sampling.

Finally, it is notable that real popular lyrics uploaded to Mojim.com are at points deemed less creative, coherent, and likable than BLOOM-176B generations. Resemblance to a human dataset does not inherently bestow positive perceived qualities to generated art. While the best-scoring CFG setting in Table 3 appears to be at CFG=4.0, this measurement alone is not indicative of subjective human quality.

Conclusion

In conclusion, we have demonstrated the limits of current computational techniques for assessing subjective qualities of song lyrics. Based on human reviewers, we find that large language models such as BLOOM-176B can be used to produce zero-shot song lyrics that are evaluated favourably in comparison to real song lyrics. Inpsired by AI-driven creativity, we provide an approach for generating album art based on lyrics using diffusion. Finally, we provide a novel dataset of in-the-wild popular Chinese song lyrics, and the code for repeating our experiments.

Future Work

We identify the following open problems for future research.

- Quantification or representation of abstract concepts such as creativity, and shaping generative models to produce outputs that manifest such attributes, across modalities.
- Analysis of sampling parameters and prompts on characteristics of LLM text generation, incorporating both MAUVE and subjective human assessment (including a more comprehensive subjective study).
- Deeper study of large multilingual language models such as BLOOM-176B, on topics such as training data memorization, overparameterization, and fairness.

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