Visualizing Low-Dimensional Word Embeddings with Emoji Annotations

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Abstract

Word embeddings are quite a buzz in today's time in the lingusitics community, mainly because of their excellent performance in NLP applications like machine translation, topic modelling, question answering, etc. But when we try to look at the visualizations of these embeddings, we don't seem to get any sort of take-home knowledge from that. We propose 2D visualizations of these embeddings by using a clustering algorithm, and to have these clusters express their semantic information in a more understandable way, we annotate these clusters with emojis.

1 Introduction

Word embeddings [11] has been successful in multiple NLP applications such as machine translation [2, 9] and cross-lingual document classification [8]. The core idea of word embeddings is that assuming a distributional hypothesis [7] i.e., words that have similar context has similar meanings, it maps each word into a vector with dimensions typically ranging from 50 to 300. But one area where there has not been very specific research is directly extracting useful information from the embeddings themselves.

One way to efficiently convey this semantic information about embeddings is to enable an interaction between humans and the visualizations of these embeddings. However, there are problems of visualizing embeddings such as

- Overlap of words when there are lots of data points (Figure 1).
- It takes time for users to understand and analyze embedding space solely from words and its gemometric arrangements.

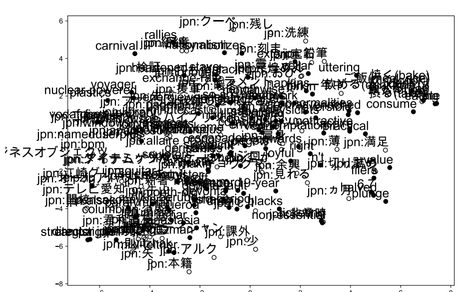

Figure 1: An example of a visualizaiton of word embeddings using t-SNE. Visualization of around 200 words causes clutter and makes humans hard to extract useful information.

The ultimate goal of any good visualization is to convey the user about everything the data represents, and not what the data is like. Therefore, we think that semantics is a crucial aspect of any good

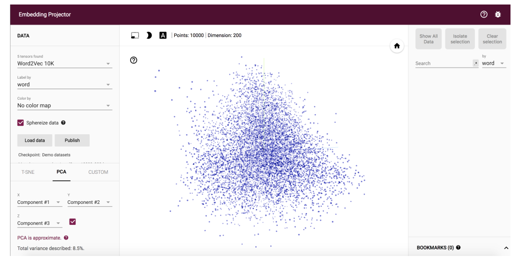

Figure 2: The visualizaiton of word embeddings using Tensorboard.

visualization. So when we decided to carry on this project, the key question we asked ourselves was - How can we represent word embeddings interactively in a 2D design space by keeping the clutter on the design space as minimum as possible?

Therefore using this motivation, we carry forward this project, and accomplished the following:

- Used a 2D design space to visualize the entire word2vec embedding space.
- Kept the clutter minimized by having an efficient k-means clustering algorithm implemented on the cosine similarities of these word vectors.
- Convey the semantic information of every single cluster by annotating them with Emojis, because of their excellent way of conveying semantic information with just a single character.

2 Related Work

The most widely-used way of visualizing word embeddings is conduct dimensitionality reuduction and project onto 2D space using t-SNE [12]. However, the problem of using solely t-SNE to visualize word embedding is that when the number of data points become large, the visualization gets largely cluttered as shown in Figure 1. Furthermore, t-SNE is known to have a counter-intuitive feature such as "cluster sizes mean nothing"[1]). One solution to avoid the visual cluttering is to enable user interaction and move around the words.

One notable work on adding interaction on top of dimensionality reduction methods to avoid the visualization cluttering is Tensorboard (Figure 2) [1]. Tensorboard has multiple user-friendly features to enable exploratory analysis on word embeddings by (1) searching for words, and (2) clickabble and draggable 3D space. However, one downside of Tensorboard-based visualization is the lack of summarizing and collapsing data points. In our project, we focus on adding data collapsing and data summarization feature for word embedding visualization.

3 Description of the Project

Our goal for this project is to visualize word embeddings by avoiding the clutters caused by too many data points. Our core idea for the approach is to collapse the data points into clusters and annotate with emoji to summarize the cluster. Figure 3 shows the example output of our visualization.

Our approach for constructing the visualization is as follows:

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[1]https://distill.pub/2016/misread-tsne/

Figure 3: The visualization of word embeddings using clustered network and emojis.

Figure 4: An example of expanding clusters after clicking on emojis.

1. Train a word embedding using a raw corpus.
2. Run k-means [10] on the word embedding space and obtain clusters
3. Assign an emoji to each cluster
4. Visualize using D3.js

For the number of clusters k, we empirically set $k = \{40, 50\}$. We only show the top 10 nearest neighboring words to the centroid to avoid the visualization clutter. This issue is further discussed in Section 4.

3.1 Annotation of Clusters with Emojis

Searching for a right word to represent the cluster requires external linguistic resources e.g., WordNet and a sophisticated method e.g., hypernym prediction. However, humans are good at associating multiple words and capture the abstract meaning form a picture. For example, when one looks at the tomato emoji (🍅), the possible association of this words are "tomato", "vegetable", "food", or even "object". Therefore, we decide to use emojis to represent the clusters.

Another motivation of using emojis instead of words is the "Picture superiority effect" (e.g., [3]) i.e., humans are better remembering pictures than words. Assuming that the annotation of clusters is the most crucial component to summarize word embeddings, we use emojis to represent the clusters.

To assign an optimal emoji e_c to each cluster c with centroid vector v_c, assume we have a set of emoji and its text description t. We compute the mean word vector v_t of each word w_i in a given emoji description $t = \{w_1, w_2, ..., w_n\}$ with length n out of all set of emoji descriptions T, i.e.,

$$e_c = \text{argmax}_{t \in T} \text{cos\_sim}(v_c, v_t) \tag{1}$$

where

$$v_t = \frac{\sum_{i=1}^{n} w_i}{n}. \tag{2}$$

Word vectors are trained by Skip-gram with negative sampling [11] using 1 million sentences of English news articles from Leipzig corpora collection [6]. We set the word vector dimension as 100. Emojis are obtained from dataset built by [4].

3.2 Interaction

To let the users dive deeper into further details of clusters, users can click on emojis to "drill-down" [5] the cluster and look into the nearest neighboring words in terms of the centroid in the cluster. However, even when we collapse words into each cluster, there are still overlapping words as shown in Figure 4. To solve this issue, we further made each cluster draggable and used forced layout to let users resolve the overlapping words.

4 Discussion

Outliers

Emojis are diverse

Emojis Captures Approximate Meaning One of the successful cases of our visualization is a cluster with the spacecraft emoji 🚀 annotated. This cluster contains transportation-related words such as "c-130" and "refueling".

On the other hand, some emojis (e.g., Leo emoji) are harder to interpret what does a cluster mean. Furthermore, one emoji could have multiple descriptions (e.g., the descriptions for the leo emoji are "greek", "sign", "zodiac", "stars", "constellation", "astrology", "lion") which further requires sophisticated processing when we want to improve the quality of the visualization.

We cannot avoid clutters when data points become large ($>$ 5000) The problem of visual cluttering is still unresolved when the number of data points we want to visualize become large. Since we only made the drill available by one level,even assigning 100 words per cluster would cause visualization clutter.

5 Conclusion

In this project, we used the combination of clustering and annotating those with emojis to relax the problem of visual cluttering and summarizing the visualization. The future work is to further use hierarchical clustering to enable multiple levels of drill down to resolve visual clutters when the number of data points become larger.

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