

# A Text-to-Image Recommendation System for the Associated Press

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Project TF: Isaac Slavitt





# Project Objective

Create a Text-to-Image Recommendation system that takes the text and headline of an article and recommends a set of best matching photos from AP's archive.



# Agenda

- 1 Motivation
- 2 Data
- 3 Modeling: Tag-to-Tag Recommendation
- 4 Modeling: Text-to-Text Recommendation
- 5 UI Demonstration
- 6 Results and Discussion

# Motivation



# Motivation

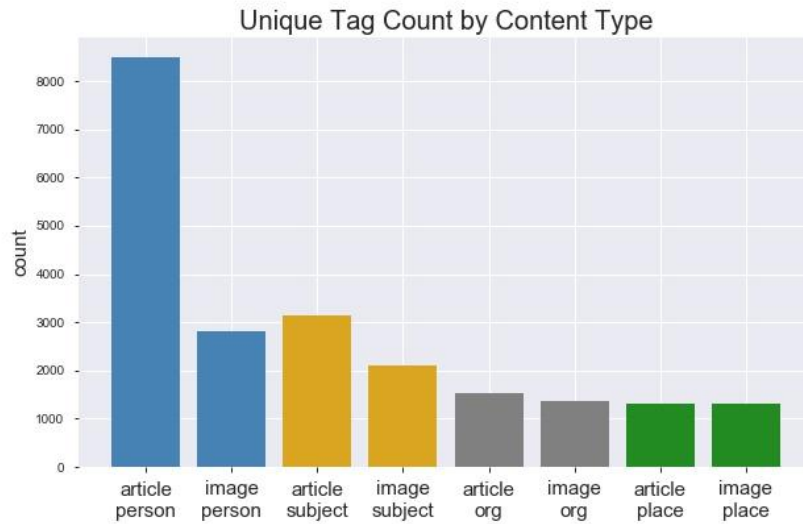
- Currently, clients/editors must manually search through AP images with subjective criteria
  - Use case: Recommendation system would output more relevant images with less effort for the user
- Encompasses wide domain of possible features (computer vision to NLP)
- Evaluation of recommended images is qualitative

The background of the slide is a teal color with a grid of 12 faded, semi-transparent images. These images depict various scenes of people and animals in a natural, possibly coastal or island, environment. The scenes include groups of people standing together, individuals in traditional or outdoor clothing, and animals like birds and possibly marine life. The overall theme suggests a focus on environmental or community data.

# Data

## Data Description

- 22,602 news articles published between Mar-Sep, 2019
- 78,021 images associated with news articles
- AP-generated Tags: Subject, Person, Organization, Place



# Example

## Articles

22,602 news articles published between Feb – Sep 2019

**Headline:** Essence Fest marks 25 years of celebrating black culture

**Tags:** New Orleans, Mary J.Blige, African American, Fourth of July ...

**Summary:** The Essence Festival draws thousands to New Orleans during the fourth of July week and is celebrating 25 years of bringing African American women of all ages together for thought-provoking conversation and performances from top musical acts. ...The festival is July 5-7 and will include a performance by Mary J. Blige.

## Images

78,021 images associated with news articles

**Headline:** Essence Festival 25

**Tags:** United States, Fairs and festivals, Recreation and leisure, Lifestyle

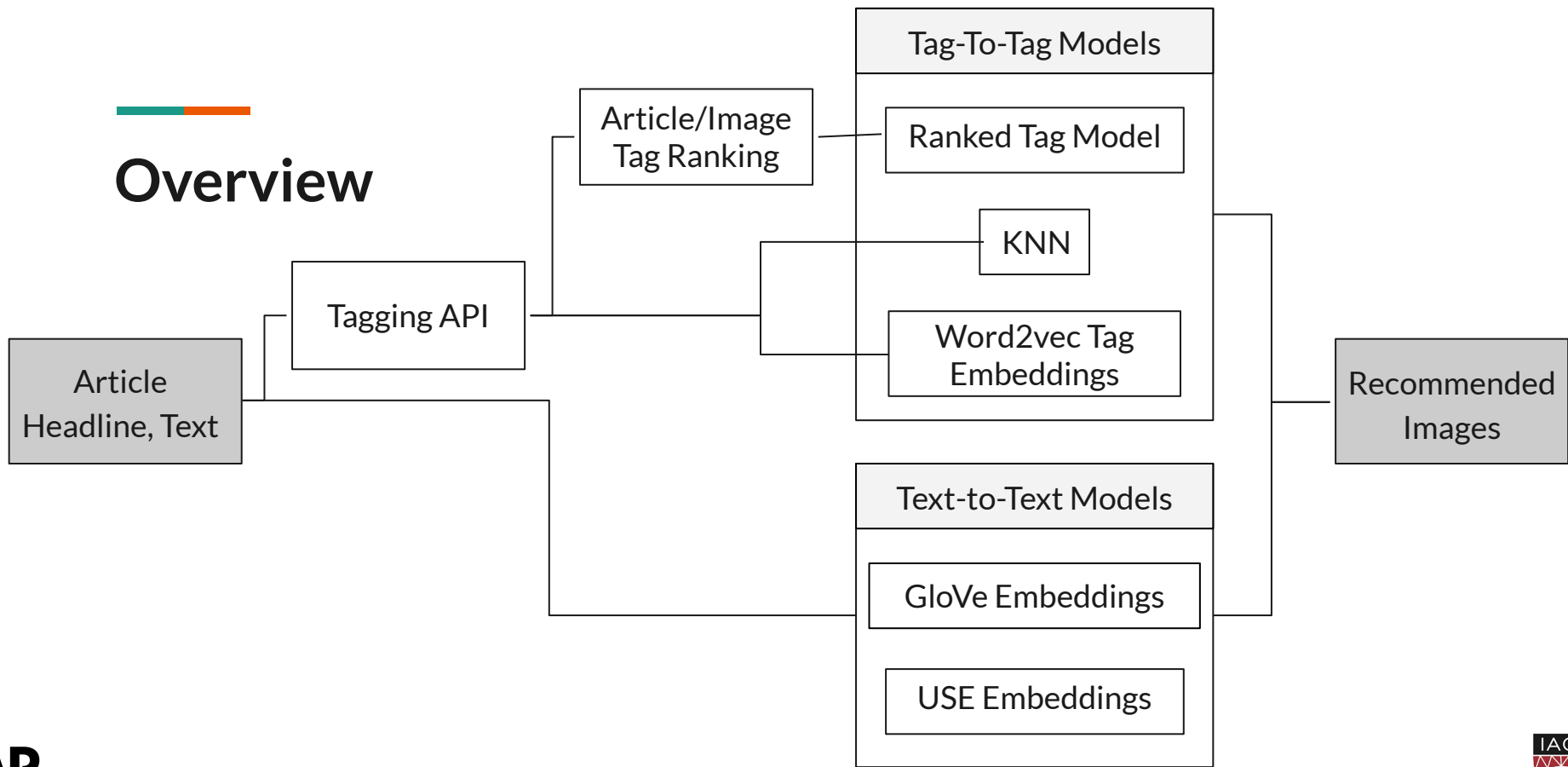
**Caption:** ... H.E.R. performs at the Coachella Music & Arts Festival at the Empire Polo Club in Indio, Calif. ...





# Modeling

# Overview



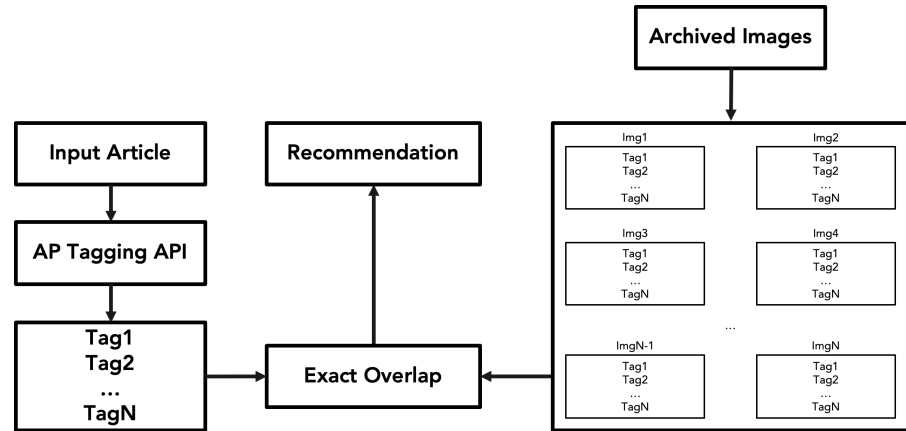
The background of the slide is a teal-colored collage of various nature photographs. The photos are arranged in a grid-like pattern, though some are partially obscured or faded. Visible images include a bird in flight, a close-up of a flower, a landscape with trees, and other natural scenes. The overall aesthetic is clean and modern, with a focus on nature.

# Tag-to-Tag Recommendation

# Tag-to-Tag Recommendation System: kNN [Baseline]

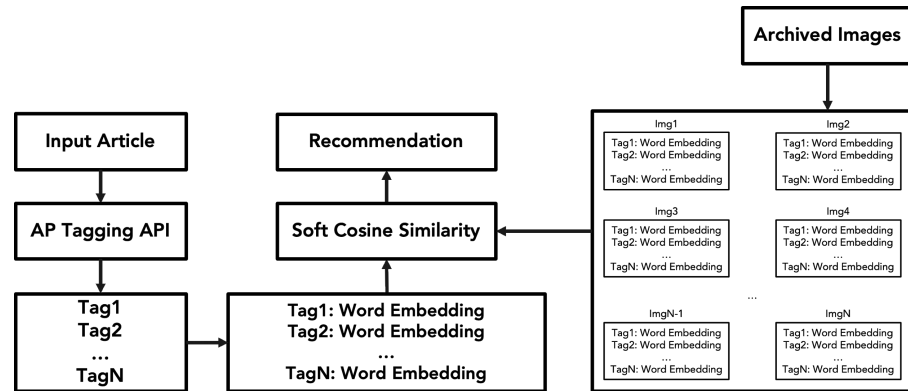
(✓) Exact tag overlap between article and image tags

(✗) All tags weighted equally; rely on quality of tags



# Tag-to-Tag Recommendation System: word2vec

- (✓) Prioritize relevant and semantically related content
- (✗) Rely heavily on tags and description being complete and present



## Article Tag Ranking: TextRank (Mihalcea & Tarau, 2004)

- A graph-based ranking model that ranks tags with “importance”
- Multiplies word co-occurrence matrix with words' weights
- A word's weight increases if it occurs with other important words

TextRank Bags of Words	TextRank Score	Named Entities
organization Nevada Policy Research Ins...	.60	Nevada
Supportive Nevada lawmaker	.54	Nevada
Speaker Barbara Buckley	.30	Barbara Buckley
State Legislatures	.21	Legislature
Carson City	.13	Carson City



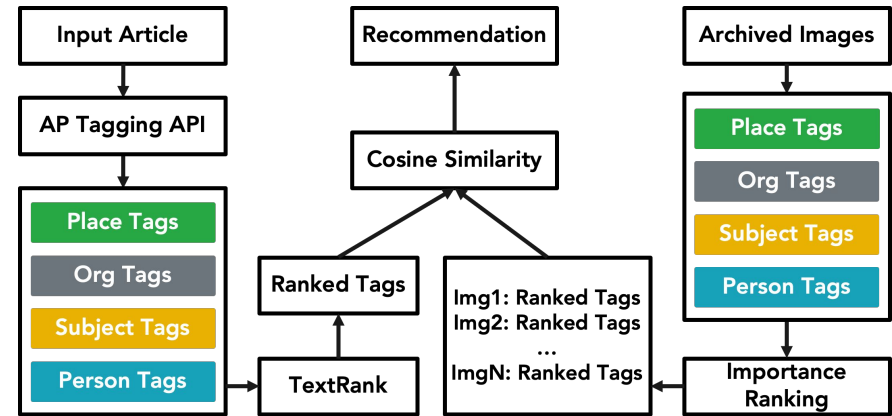
## Image Tag Importance Ranking (Li et al., 2017)

- Discount object tags [**person**] importance by
  - occurrence
  - number of descriptions
- Upvote scene tags [**org**, **place**, **subject**] importance if
  - tag appear in sentence
  - tag is the subject of the sentence

# Ranked Tag-to-Tag Recommendation System

(✓) Prioritize relevant and semantically related content

(✗) Long training time; rely on quality of tags



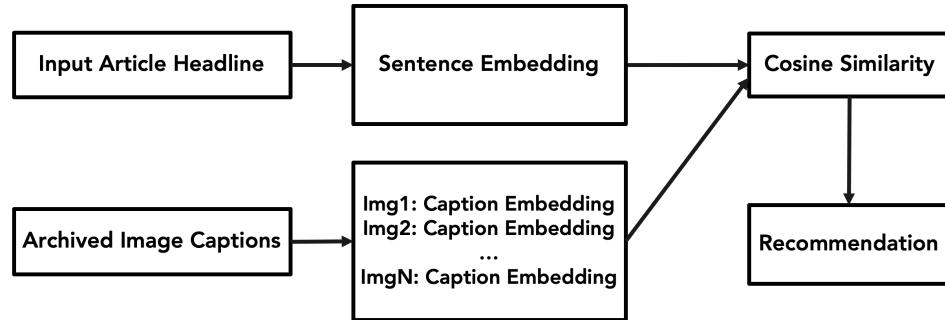


# Text-to-Text Recommendation

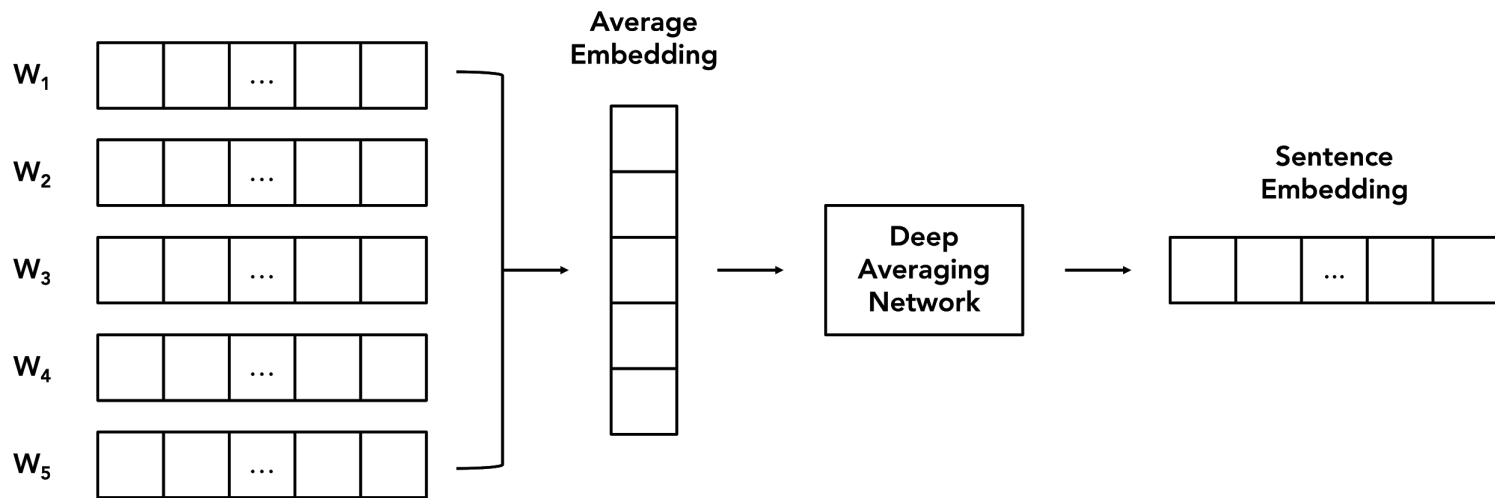
# Text-to-Text Recommendation System: GloVe

(✓) Fast and captures semantic similarity between words

(✗) Does not consider the order of words in headline

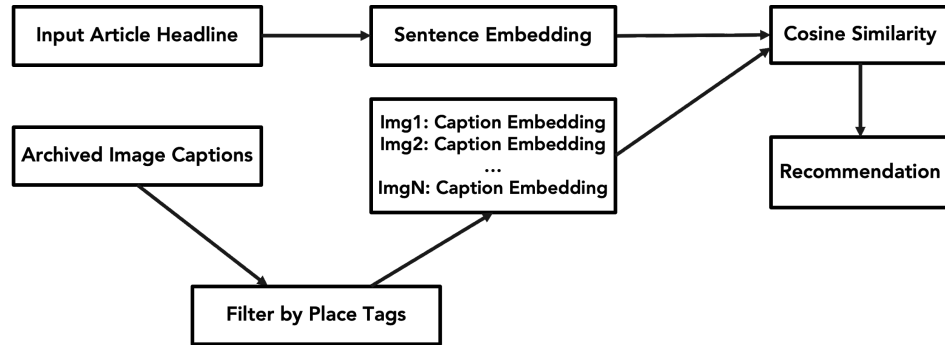


# Universal Sentence Encoder (Iyyer et al., 2015; Cer et al., 2018)



# Text-to-Text Recommendation System: USE

- (✓) Fast, simple and context-aware sentence encoding
- (✗) Lower interpretability compared with other approaches



# User-Interface Demo

# User-Interface Demo

Built using VueJS, Uvicorn and FastAPI



Article Input

As craft beer market grows, so do wild flavors

Anyone for steak and onion Kolsch? Or a macaroni and cheese pale ale? Those were among the flavors at the Strange Brew Festival in Reno, Nevada, this month, where competition for attention has intensified as craft beers have boomed. Brewers have always experimented, from the medieval Belgians who stirred sour cherries into their beer to newer varieties like the white IPA, a marriage of Belgian and American styles that was developed about a decade ago. But today's brewers have kicked it up a notch as they try to distinguish themselves from everyone else trying to distinguish themselves. Visitors at the festival in Reno could sample a peanut butter and pickle pilsner, a tamale lager and a smoked carrot stout. There were concoctions from big

Ensemble Model

Exact Matches Only | Thematically Related Only

Slider to control ensembling

Get 24 Images

Choose a model or an ensemble

Tags 3.52 seconds

Nevada: place: 0.51704 Beer: subject: 0.47829 Reno: place: 0.47584 United States: place: 0.41247 California: place: 0.32766

Recommended Images 5.13 seconds

Weird Beers

Accept Reject

Weird Beers

Accept Reject

Get User Feedback

Similar Article Headlines

New Dyersville brewery could be catalyst to downtown rebirth

Class teaches students to appreciate beer \_ and brew it

Detailed view on click

Weird Beers

Weird Beers



# Results and Discussion

23



# Model Comparison

## Headline

Lyft opens its IPO road show, to offer more than 30M shares

## Tags

Dara Khosrowshahi, Travis Kalanick, Business, General news, Technology, Initial public offerings, Stock offerings, Corporate stock, Corporate news, Stock price movements, Stock performance, Stock prices, Leading economic indicators, Economy

## Full Text

NEW YORK (AP) — Lyft officially kicked off the road show for its initial public offering, saying Monday it plans to put more than 30 million shares up for sale with an anticipated price of between \$62 and \$68 per share...



## Lyft opens its IPO road show, to offer more than 30M shares

NEW YORK (AP) — Lyft officially kicked off the road show for its initial public offering, saying Monday it plans to put more than 30 million shares up for sale with an anticipated price of between \$62 and \$68 per share. That would raise more than \$2 billion for the San Francisco ride-hailing company, pegging its market value at \$20 billion to \$25 billion, even though it hasn't been able to turn a profit yet. It's the first time that Lyft has revealed how much money it hopes to raise in the IPO, and how much it believes it's worth. Those financial targets could still change as Lyft's investment bankers gauge demand for the company's stock leading up to the IPO pricing, which is expected to happen next week. Lyft and Uber have raced to be first with an IPO, and Lyft's rival is expected to offer shares in the coming weeks. Uber is hoping its larger ride-hailing service will justify a market value as high as \$120 billion after its IPO is

k-Nearest Neighbor Model

Get 24 Images

Tags 3.19 seconds

Dara Khosrowshahi: person: 0.72821

Travis Kalanick: person: 0.68535

Recommended Images 2.71 seconds



APTOPIX Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



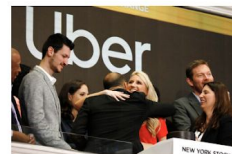
Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



APTOPIX Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Chewy IPO

Accept Reject



Beyond Meat IPO

Accept Reject

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Tag-to-tag Model

Get 24 Images

Tags 3.37 seconds

Dara Khosrowshahi: person: 0.72821

Travis Kalanick: person: 0.68535

Recommended Images 6.18 seconds



Earns Uber

Accept Reject



Uber Layoffs

Accept Reject



Uber Lyft Duopoly

Accept Reject



APTOPIX Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



APTOPIX Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject



Financial Market Uber IPO

Accept Reject

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GloVe Embedding Model

Get 24 Images

Tags 3.37 seconds

Dara Khosrowshahi: person: 0.72821

Travis Kalanick: person: 0.68535

Recommended Images 1.72 seconds



Financial Markets IPOs What to Know

Accept Reject



Sports Betting-New Sportsbooks

Accept Reject



Marriott Home Sharing

Accept Reject



Financial Markets Wall Street Uber IPO

Accept Reject



Uber IPO

Accept Reject



Retail Sportsbooks

Accept Reject



Marriott Home Sharing

Accept Reject



Marriott Home Sharing

Accept Reject





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Soft Cosine Model

Get 24 Images

Tags

3.25 seconds

Dara Khosrowshahi: person: 0.72821

Travis Kalanick: person: 0.68535

Recommended Images

3.26 seconds



China Financial Markets

Accept Reject

Financial Markets Wall Street  
Pinterest IPO

Accept Reject

Financial Markets Wall Street Levi  
Strauss IPO

Accept Reject



Financial Markets RealReal IPO

Accept Reject

Financial Markets Wall Street Slack  
IPO

Accept Reject

Financial Markets Wall Street Slack  
IPO

Accept Reject

Financial Markets Wall Street Slack  
IPO

Accept Reject

Financial Markets Wall Street Levi  
Strauss IPO

Accept Reject

## Article Input

Lyft opens its IPO road show, to offer more than 30M shares

NEW YORK (AP) — Lyft officially kicked off the road show for its initial public offering, saying Monday it plans to put more than 30 million shares up for sale with an anticipated price of between \$62 and \$68 per share. That would raise more than \$2 billion for the San Francisco ride-hailing company, pegging its market value at \$20 billion to \$25 billion, even though it hasn't been able to turn a profit yet. It's the first time that Lyft has revealed how much money it hopes to raise in the IPO, and how much it believes it's worth. Those financial targets could still change as Lyft's investment bankers gauge demand for the company's stock leading up to the IPO pricing, which is expected to happen next week. Lyft and Uber have raced to be first with an IPO, and Lyft's rival is expected to offer shares in the coming weeks. Uber is hoping its larger ride-hailing service will justify a market value as high as \$120 billion after its IPO is

Universal Sentence Embedding Model

Get 24 Images

Tags 3.17 seconds

Dara Khosrowshahi: person: 0.72821

Travis Kalanick: person: 0.68535

Recommended Images 2.08 seconds



Lyft IPO

Accept Reject



Lyft IPO

Accept Reject



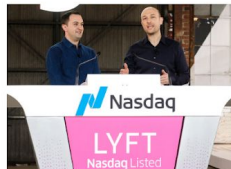
Lyft IPO

Accept Reject



Lyft IPO

Accept Reject



Lyft IPO

Accept Reject



Lyft IPO

Accept Reject



Lyft IPO

Accept Reject



Lyft IPO

Accept Reject



Lyft IPO



Lyft IPO



Uber IPO

# Model Evaluation

1. Recall
2. Precision
3. R-Precision
4. NDCG

$$\text{R-precision} = \frac{|G \cap R_{1:|G|}|}{|G|}$$

$$DCG = rel_1 + \sum_{i=2}^{|R|} \frac{rel_i}{\log_2(i+1)}.$$

$$IDCG = 1 + \sum_{i=2}^{|G|} \frac{1}{\log_2(i+1)}.$$

Used Images (G)	Recommendation (R)
Image A	Image A
Image B	Image B
Image C	Image E
Image D	Image F
	Image D

# Model Evaluation

500 randomly sampled articles and their true images (10 predictions per model)

Model Name	Recall	Precision	R-Precision	NDCG
kNN	.244	.071	.150	.150
Ranked Tags	.115	.037	.071	.073
word2vec Tag Embeddings	.117	.046	.094	.095
GloVe Embeddings	.203	.059	.111	.111
USE Embeddings	.359	.110	.240	.239

# Model Evaluation

500 randomly sampled articles and their true images (60 predictions per model)

Model Name	Recall	Precision	R-Precision	NDCG	Prediction Time (s)
kNN	.418	.024	.155	.155	1.838
Ranked Tags	.297	.017	.074	.075	1.336
word2vec Tag Embeddings	.282	.016	.097	.097	3.876
GloVe Embeddings	.380	.021	.113	.113	0.053
USE Embeddings	.520	.030	.246	.246	0.216





## Discussion

- Impact: Recommend AP to use some combination of models to output images more relevant for clients/editors
  - They showed strong interest in the TextRank implementation
- Evaluation metrics only focus on used images

Nice-to-have:

- Accept & Reject: user-inputs
- TextRank with subject tags

**Thank You!**

**AP**





## References

- Cer, D., Yang, Y., Kong, S. Y., Hua, N., Limtiaco, N., John, R. S., ... & Sung, Y. H. (2018). Universal sentence encoder. *arXiv preprint arXiv:1803.11175*.
- Iyyer, M., Manjunatha, V., Boyd-Graber, J., & Daumé III, H. (2015). Deep unordered composition rivals syntactic methods for text classification. In *Proceedings of the 53rd Annual Meeting of the Association for Computational Linguistics and the 7th International Joint Conference on Natural Language Processing (Volume 1: Long Papers)* (Vol. 1, pp. 1681-1691).
- Li, S., Purushotham, S., Chen, C., Ren, Y., & Kuo, C. C. J. (2017). Measuring and predicting tag importance for image retrieval. *IEEE transactions on pattern analysis and machine intelligence*, 39(12), 2423-2436.
- Mihalcea, R., & Tarau, P. (2004). Textrank: Bringing order into text. In *Proceedings of the 2004 conference on empirical methods in natural language processing* (pp. 404-411).