MDP-based Itinerary Recommendation using Geo-Tagged Social Media

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Motivation

- Planning trips is a complex decision problem
- Many decisions to be made at once: duration, costs, places to visit, food and many more!
- Overload of information on the Web renders task tedious

Markov Decision Process (MDP) Framework

- State: a sequence of at most k places the user visited until now
- Actions: all POI categories present in the city
- Transition & reward function estimate by maximum-likelihood

$$T(s,a,s') = \frac{count(s'|s)}{\sum_{s''} count(s''|s)}, \quad R(s,a) = \frac{count(s,a)}{count(s)}$$

Optimizing the MDP via Value Iteration algorithm:

$$V(s) = \max_a \left(R(s,a) + \gamma \sum_{s'} T(s,a,s') V(s') \right)$$

State-action values, $Q(s,a)$, are obtained from the learned value function which serve as scores for recommendation:

$$Q(s,a) = R(s,a) + \gamma \sum_{s'} T(s,a,s') V^*(s')$$

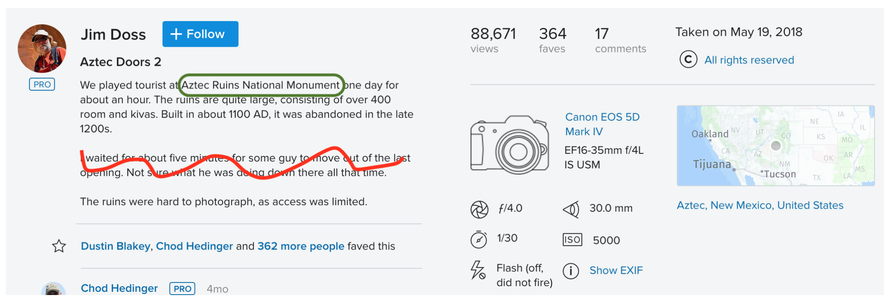
$\Rightarrow$ The goal is to recommend a sequence of POIs given individual user preferences based on previous visited places.

Data Acquisition

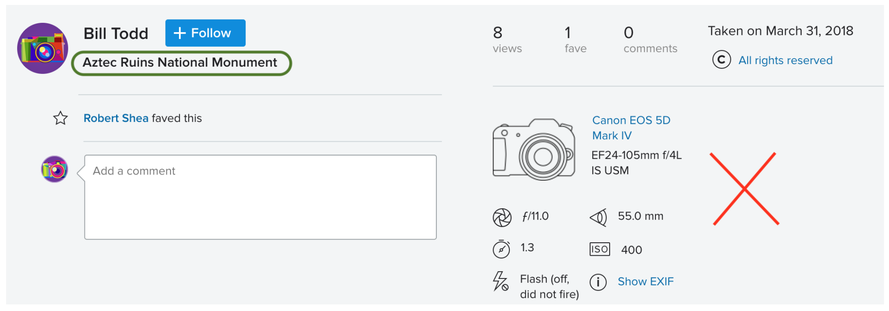
Utilizing photos from *Flickr* for reconstructing user trips:

- Geographical coordinate (small-fraction)
- Timestamp of capturing the photo
- Semantic data; tags and titles

Photos without coordinate information: Using Latent Semantic Analysis (LSA) to compute the semantic similarity between the tags of geo-tagged and non-geotagged photos



An example of non-geotagged photo



An example of geo-tagged photo

Conclusions

- An RL approach to recommend user itinerary
- Utilize freely available data from social media with minimal manual intervention
- Computationally inexpensive
- Outperforms standard path planning methods

Online Personalization

- **Duration-based:** Amount of time a user spends on a category
- **Frequency-based:** Frequency of visiting a certain category

$\Rightarrow$ A POI is recommended from the optimal category:

Weighted(distance + personalized score)

Empirical Study

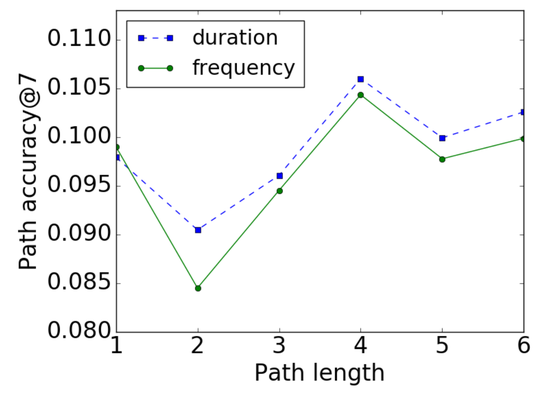
- Leave-one-out cross-validation method
- Baselines: Breadth first search, Dijkstra, Heuristic Search, A*

Partial path accuracy in terms of order of Markov chain:

Path Length	1	2	3	4	5	6
1st order	0.041	0.041	0.042	0.042	0.041	0.034
2nd order	**0.098**	**0.090**	**0.096**	**0.106**	**0.100**	**0.103**
3rd order	0.097	**0.090**	0.093	0.105	0.090	0.087
4th order	0.089	0.084	0.083	0.094	0.077	0.060
5th order	0.074	0.071	0.058	0.072	0.070	0.058

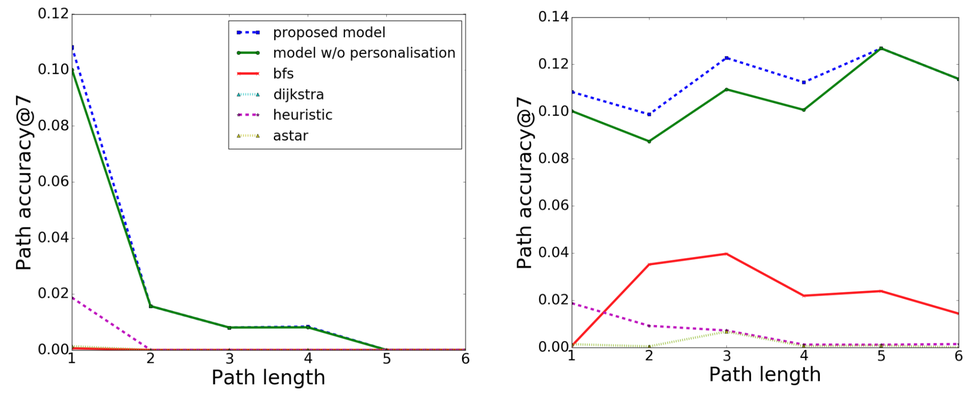
$\Rightarrow$ Encoding more history in the state improves the performance.

Personalization techniques:



$\Rightarrow$ Duration-based outperforms frequency-based.

Exact (left) and partial path accuracy (right) for Paris:



$\Rightarrow$ Our approach outperforms the baselines.