Empowering A * Search Algorithms with Neural Networks for Personalized Route Recommendation

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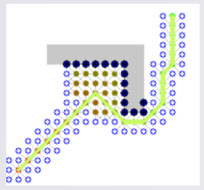
Motivation

- Heuristic Search: a basic recommendation method
  - Design cost function manually, and search an optimal path according to it.
  - Difficult to utilize various kinds of context information in the search process.
- Neural Network: a rising recommendation method
  - Focus on one-step or short-term location prediction.
  - Sequential neural models have been widely used for modeling sequential trajectory data.

Neural network is a promising way to capture complex pattern in auxiliary data.



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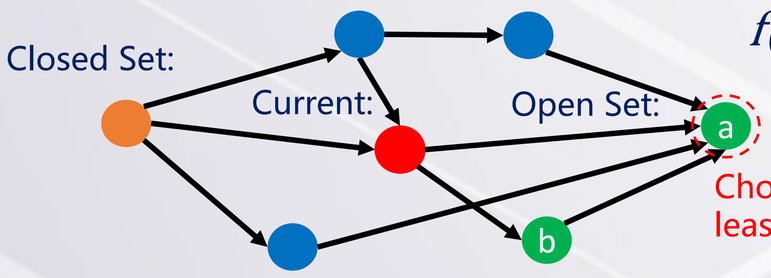
= OUR IDEA

Neuralized A-Star based personalized Route recommendation

A Review of A* Search Algorithm

- **A* Search Algorithm**
- Find the path with least cost.
- Cost function consists of two part: observable cost g() and estimated cost h()



$$f(a) = g(a) + h(a)$$

Choose location in Open Set with least cost

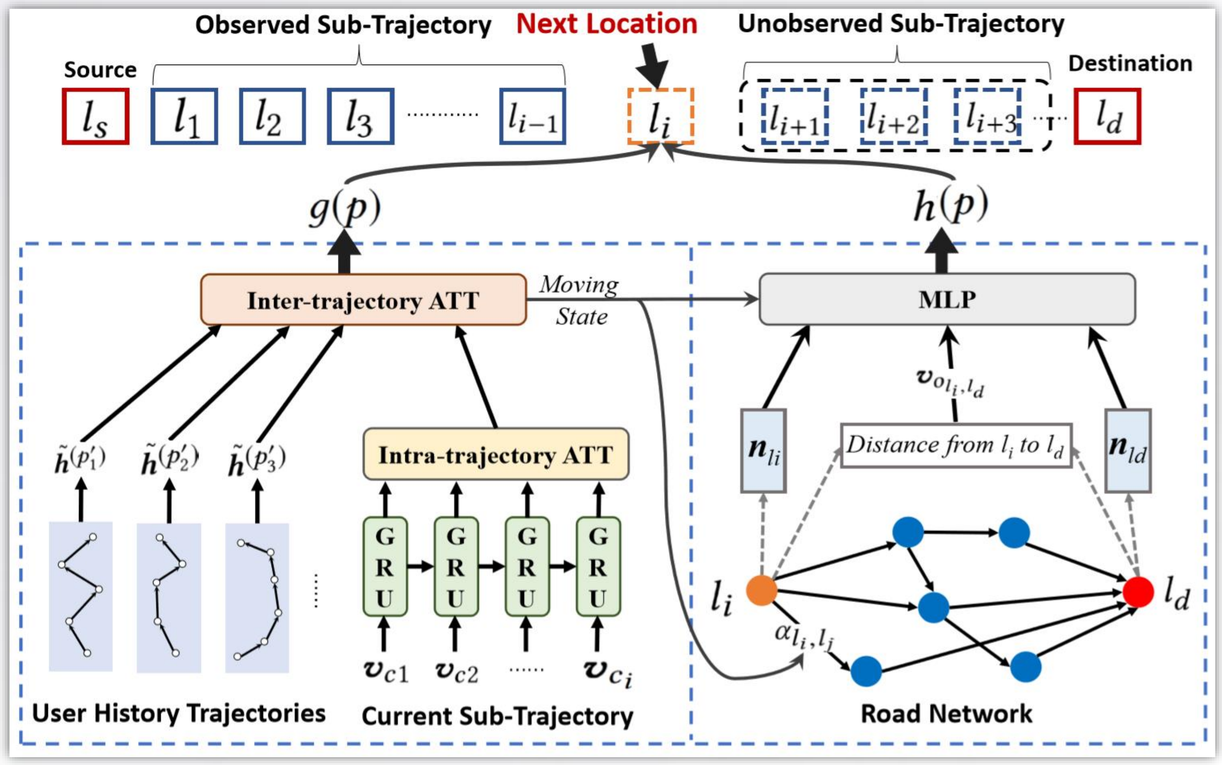
$$f(a) < f(b)$$

In Previous Setting:

$$g(l_s \rightarrow l_i) = -\sum_{i=0}^{m} log\, Pr\,(l_{i+1} | l_s \rightarrow l_i, q, u)$$

$$h(l_i \rightarrow l_d) = Euclid(l_i, l_d)$$

NASR Model Architecture



The overall architecture of the NASR model.

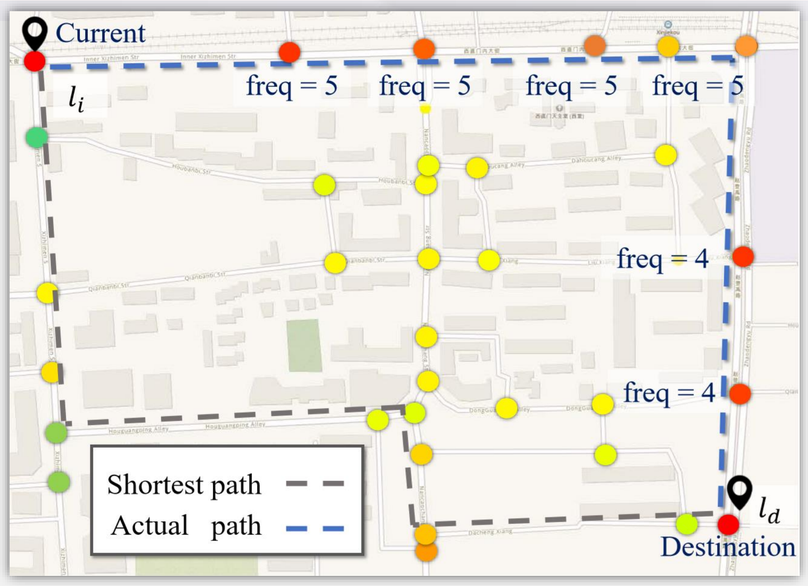
Performance

Performance Comparison using Four Metrics on Three Datasets

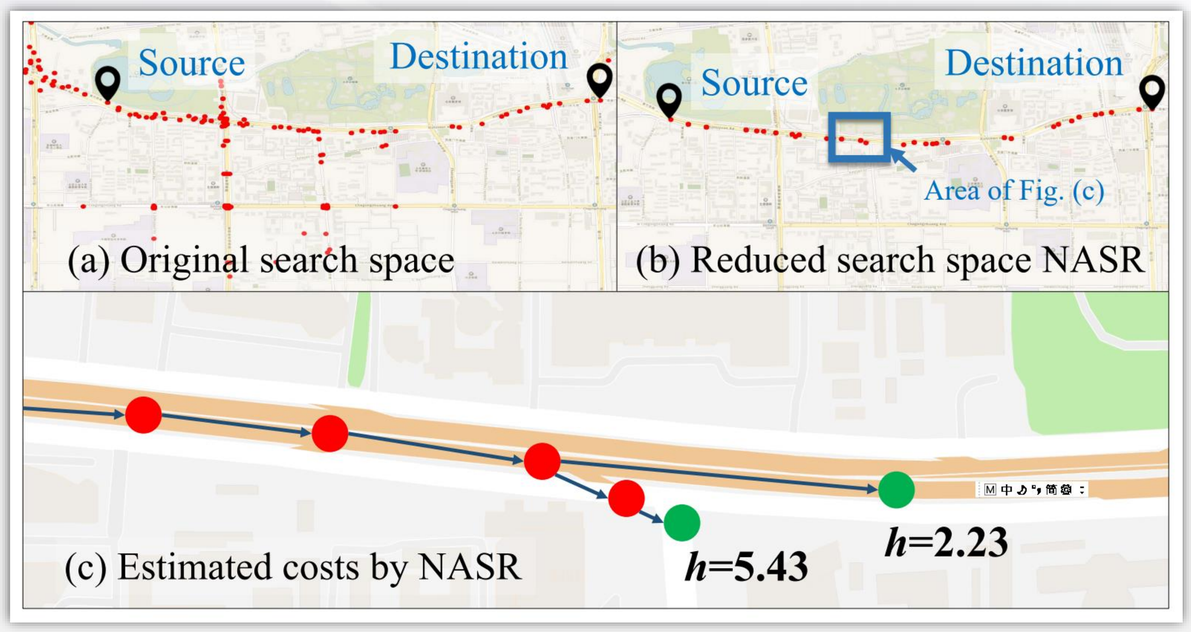
Datasets	Metric	Precision						Recall					
	Length	RICK	MPR	CTRR	STRNN	DeepMove	NASR	RICK	MPR	CTRR	STRNN	DeepMove	NASR
Beijing Taxi	Short	0.712	0.347	0.558	0.491	0.742	**0.821**	0.723	0.372	0.164	0.384	0.756	**0.848**
	Medium	0.638	0.253	0.276	0.446	0.642	**0.757**	0.651	0.261	0.067	0.350	0.654	**0.773**
	Long	0.586	0.169	0.194	0.359	0.562	**0.684**	0.589	0.173	0.045	0.214	0.575	**0.709**
Porto Taxi	Short	0.697	0.359	0.701	0.442	0.721	**0.804**	0.705	0.381	0.358	0.372	0.726	**0.832**
	Medium	0.622	0.271	0.416	0.403	0.619	**0.729**	0.634	0.293	0.106	0.326	0.628	**0.754**
	Long	0.565	0.184	0.305	0.340	0.547	**0.657**	0.578	0.198	0.036	0.218	0.568	**0.671**
Beijing Bicycle	Short	0.652	0.303	0.587	0.559	0.673	**0.788**	0.670	0.313	0.272	0.330	0.685	**0.802**
	Medium	0.568	0.217	0.603	0.461	0.582	**0.715**	0.574	0.226	0.142	0.304	0.589	**0.724**
	Long	0.503	0.129	0.613	0.297	0.487	**0.641**	0.519	0.139	0.045	0.206	0.492	**0.663**
Datasets	Metric	F1-score						EDT					
	Length	RICK	MPR	CTRR	STRNN	DeepMove	NASR	RICK	MPR	CTRR	STRNN	DeepMove	NASR
Beijing Taxi	Short	0.717	0.359	0.253	0.431	0.749	**0.834**	4.594	8.287	9.082	7.551	4.362	**3.376**
	Medium	0.644	0.257	0.108	0.392	0.648	**0.765**	8.273	16.321	23.110	14.725	8.730	**5.728**
	Long	0.587	0.171	0.073	0.268	0.568	**0.703**	11.283	25.873	27.493	22.705	12.059	**8.314**
Porto Taxi	Short	0.701	0.370	0.474	0.404	0.723	**0.818**	4.801	8.104	6.935	8.790	4.496	**3.563**
	Medium	0.628	0.282	0.169	0.360	0.623	**0.741**	8.619	15.032	18.294	13.368	8.020	**5.949**
	Long	0.571	0.191	0.065	0.266	0.557	**0.687**	11.379	21.349	31.745	19.603	12.297	**8.572**
Beijing Bicycle	Short	0.661	0.308	0.372	0.414	0.679	**0.795**	5.183	8.924	7.784	7.092	4.629	**3.719**
	Medium	0.571	0.221	0.229	0.367	0.585	**0.720**	8.972	17.497	20.966	14.503	9.039	**6.253**
	Long	0.511	0.134	0.084	0.243	0.489	**0.671**	11.891	22.028	57.997	21.324	12.692	**8.794**

Our proposed model NASR is able to combine both the benefits of heuristic search and neural networks, and hence it performs best among the comparison methods.

Qualitative Analysis



Visualization of the learned association scores using improved graph attention networks. The colored circles denote locations in the road network. A darker color indicates a larger importance degree w.r.t. current location l_i and destination l_d. freq denotes the visit frequency by the user in historical trajectories.



Visualization of the search procedure with the estimated costs by the NASR model. In (c), red points have been already explored and green points are candidate locations to extend in A * search algorithm.