介绍

路网嵌入是一种用来计算最短道路距离的方案，通过记录每个节点（道路之间的交叉口）的信息，把常规的道路用多维空间向量表示，使得每个节点之间的距离更能更有效地被计算。

> Road Network Embedding (RNE), proposed by Shahabi et al.* [12], is an approach to compute shortest path distance in road networks, which bases on the LLR embedding techniques [19]. RNE transforms a road network into a higher dimensional space by assigning a sketch (i.e., a vector) to every node such that the distance between any two nodes can be efficiently approximated using only their sketches.

主要步骤

(1) 设G=(V,E)为路网（road network）

V代表道路之间的交叉节点，E（edge）代表道路。

(2) V有n个，把V分成**n个子集**如下

V : R = {V1,1, . . . , V1,α, . . . , Vβ,1, . . . , Vβ,α}

> Let n = |V | be the size of the node set V . Define R as a set of O(log2n) reference sets, which are subsets of V : R = {V1,1, . . . , V1,α, . . . , Vβ,1, . . . , Vβ,α}, where α = O(log n) and β = O(log n).
>
> Each subset Vi,ji is defined as a random subset of V with 2i nodes randomly chosen from V .

(3) 一个节点到一个子集Vij的距离即该节点到这个子集的最近距离所有节点距离的最小值

> The distance between node v and subset Vi,j is defined as dist(v, Vi,j) = minw∈Vi,j dist(v, w)

(4) 对于一个节点，把其到每个子集的最短距离记录下来，构成一个S集，这个S集就是该节点的**路网嵌入向量**，然后我们把所有的向量放在一起，构成路网嵌入数据集。

Based on this, each node $v \in V$ in the road network is mapped to a sketch as follows:

$$S(v) = (S_{V_{1,1}}(v), \ldots, S_{V_{1,\alpha}}(v), \ldots, S_{V_{\beta,1}}(v), \ldots, S_{V_{\beta,\alpha}}(v)),$$

where $S_{V_{i,j}}(v) = dist(v, V_{i,j})$. Note that the sketch $S(v)$ is a $O(\log^2 n)$-dimension vector in the high-dimensional embedding space defined by R. Finally, denote $\Omega = \{S(v)|v \in V\}$ as the embedded road network.

(5) 假设一个点u，处于节点s和t之间，该节点u到某个子集Vij之间的距离可以如下公式计算，

dist(u，s)为点u到节点s的距离,dist(u,t)同理。

$$S_{V_{i,j}}(u) = dist(u, V_{i,j})$$
$$= \min\left\{dist(u,s) + S_{V_{i,j}}(s), dist(u,t) + S_{V_{i,j}}(t)\right\}.$$

(6) 根据上面的分析，对于该点u，我们也可以得到一个**路网嵌入向量**如下

$$S(u) = (S_{V_{1,1}}(u), \ldots, S_{V_{1,\alpha}}(u), \ldots, S_{V_{\beta,1}}(u), \ldots, S_{V_{\beta,\alpha}}(u)).$$

$S(u)$ is a vector in the embedding space. For simplicity, we denote a sketch of a rider or driver u as:

$$S(u) = (S_1(u), \ldots, S_\kappa(u)), \tag{1}$$

(7) 最终，我们可以计算任意两点a,b的最短距离

$$dist(a,b) \approx \delta(a,b) = \max_{1 \leqslant j \leqslant \kappa} \left(|S_j(a) - S_j(b)|\right),$$