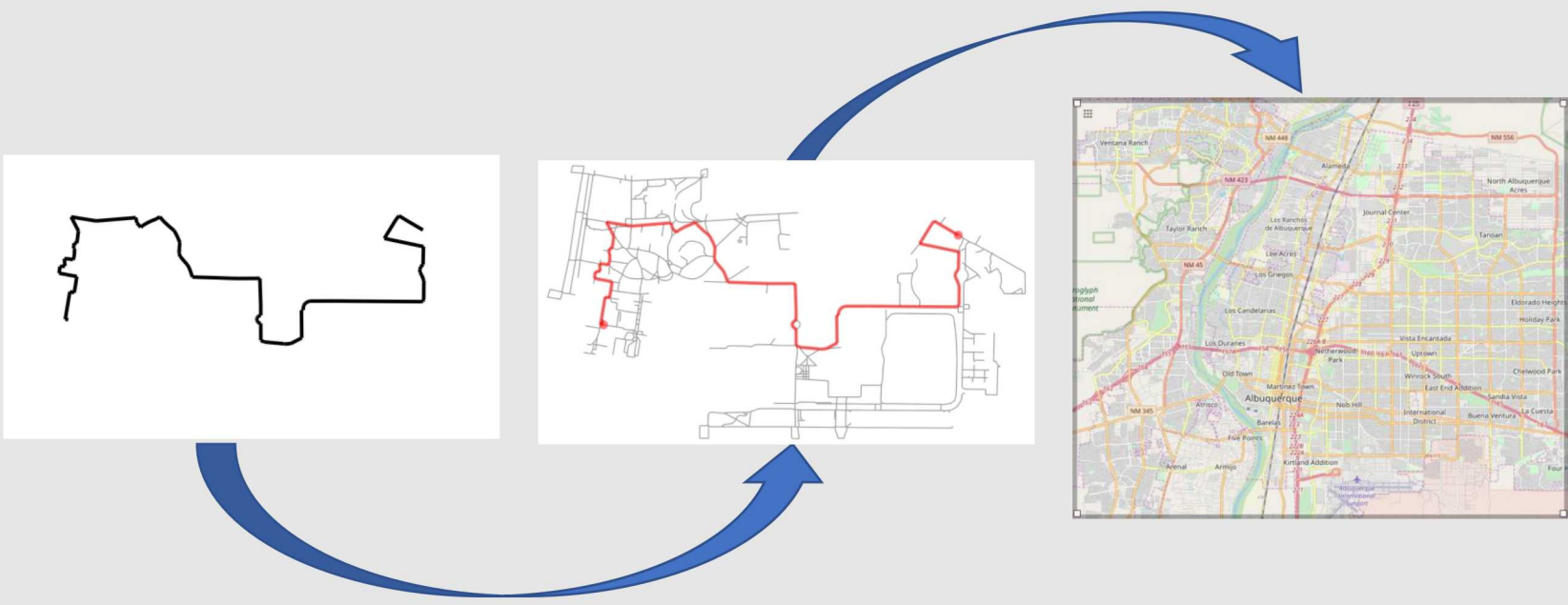




Improved Positioning via Contextual Awareness

Problem Statement

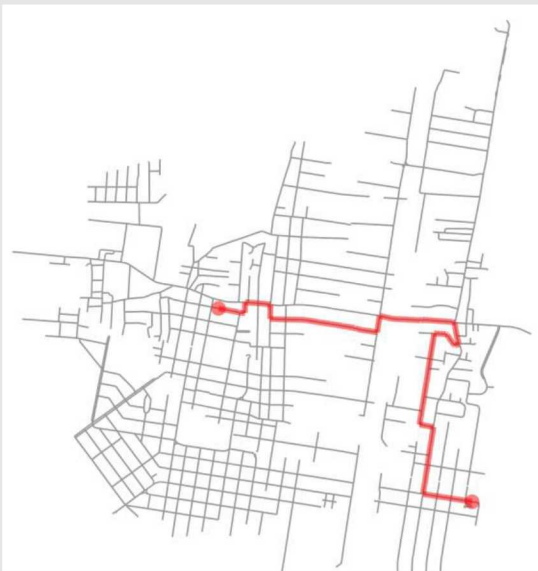
Given a set of (x,y,z) coordinates over a specific geospatial area that represent a path over time, our interest is inferring contextual information from the path which leads to determining the absolute position of the path relative to that geospatial area.



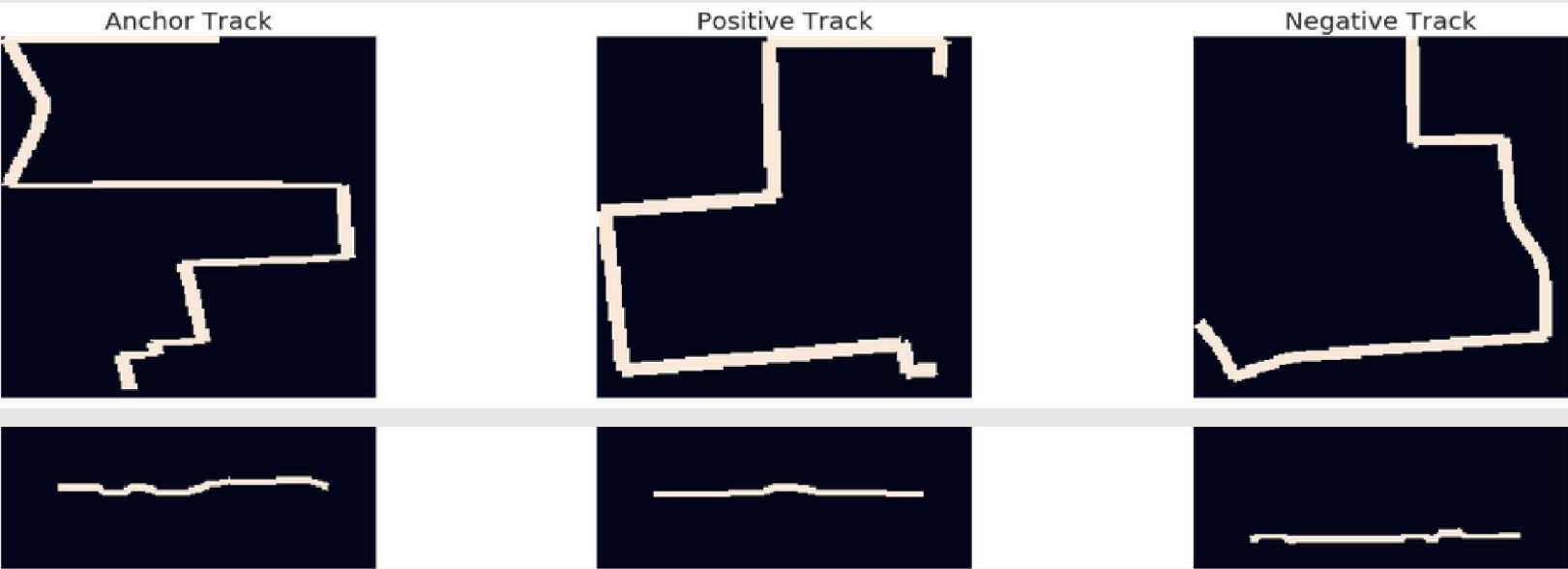
Methods

Data Generation

1. Generate a series of paths relative to specific types of geospatial terrain.
2. Create a series of path triplets which consist of an anchor path (P), a positive path (P_+), and a negative path (P_-)



Example Residential Path



Example triplet of paths with relative elevation

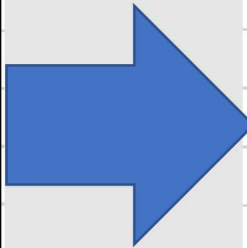
Triplet Loss Function

With these triplet data points, we create a loss function such that:
 $\|f(P) - f(P_+)\|_2 \gg \max(\|f(P) - f(P_-)\|_2, \|f(P_+) - f(P_-)\|_2)$

Deep Learning Architecture

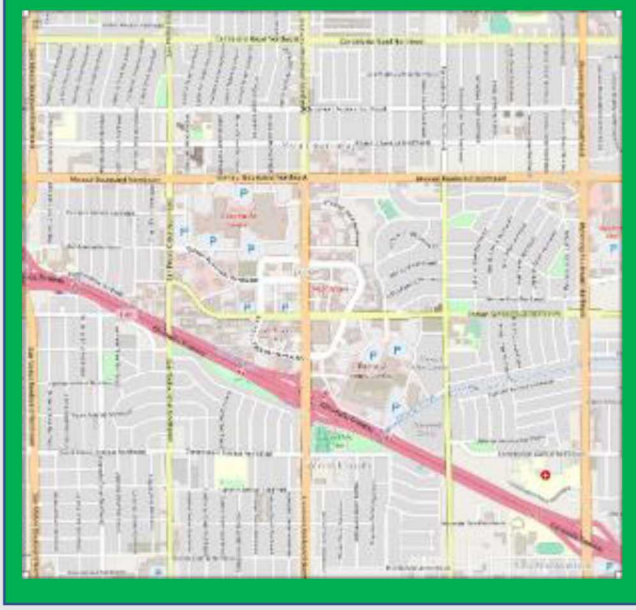
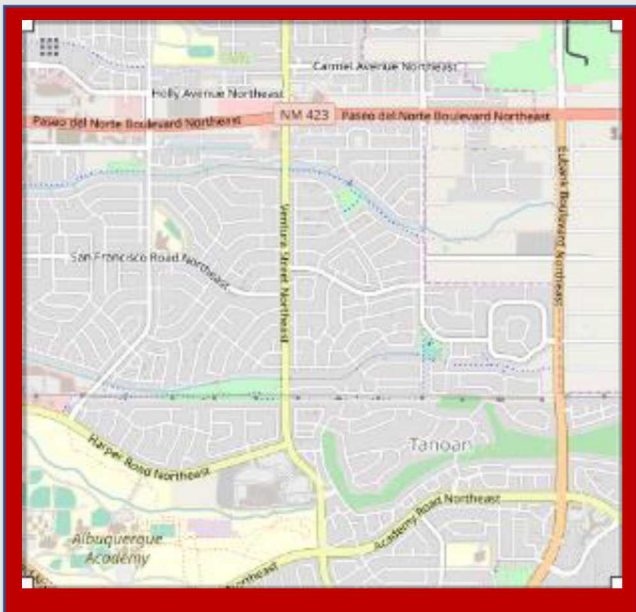
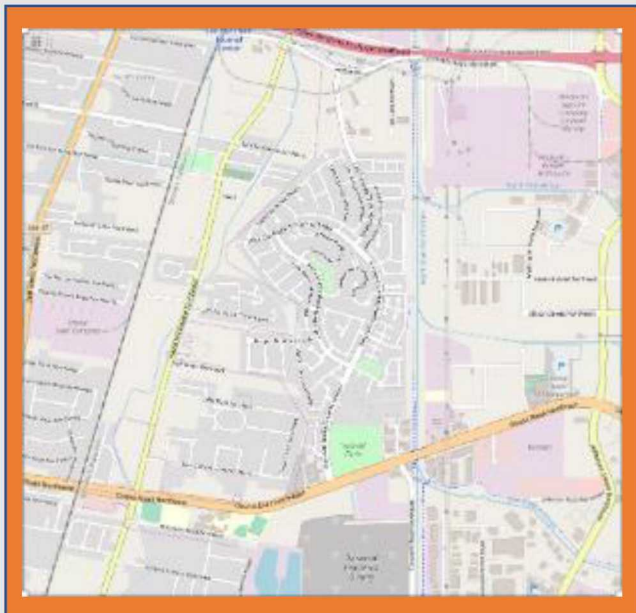
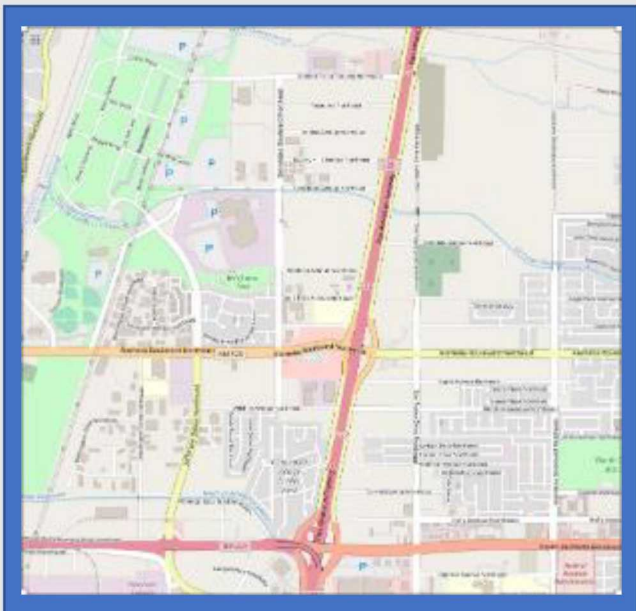
A Convolutional Neural Network based off the Loc2Vec article by sentiance [1] with the architecture listed below that was used to map the paths to a latent space representation obtained by minimizing the triplet loss function shown above.

Layer	Features	Dropout Rate
Convolution	32 Filters	0.1
Pooling	2 Strides	
Convolution	32 Filters	0.1
Pooling	2 Strides	
Convolution	64 Filters	0.1
Pooling	2 Strides	
Convolution	64 Filters	0.2
Pooling	1 Strides	



Layer	Features	Dropout Rate
Convolution	128 Filters	0.2
Pooling	2 Strides	
Convolution	64 Filters	0.1
Pooling	2 Strides	
Convolution	64 Filters	0.1
Pooling	2 Strides	
Dense	64 Units	
Embedding	16 Units	

Results



We achieved promising qualitative results in the preliminary trials of the architecture. Below are example embeddings of multiple tracks in multiple locations using PCA for dimensionality reduction to visualize the embedding space.

2-D Path Embeddings

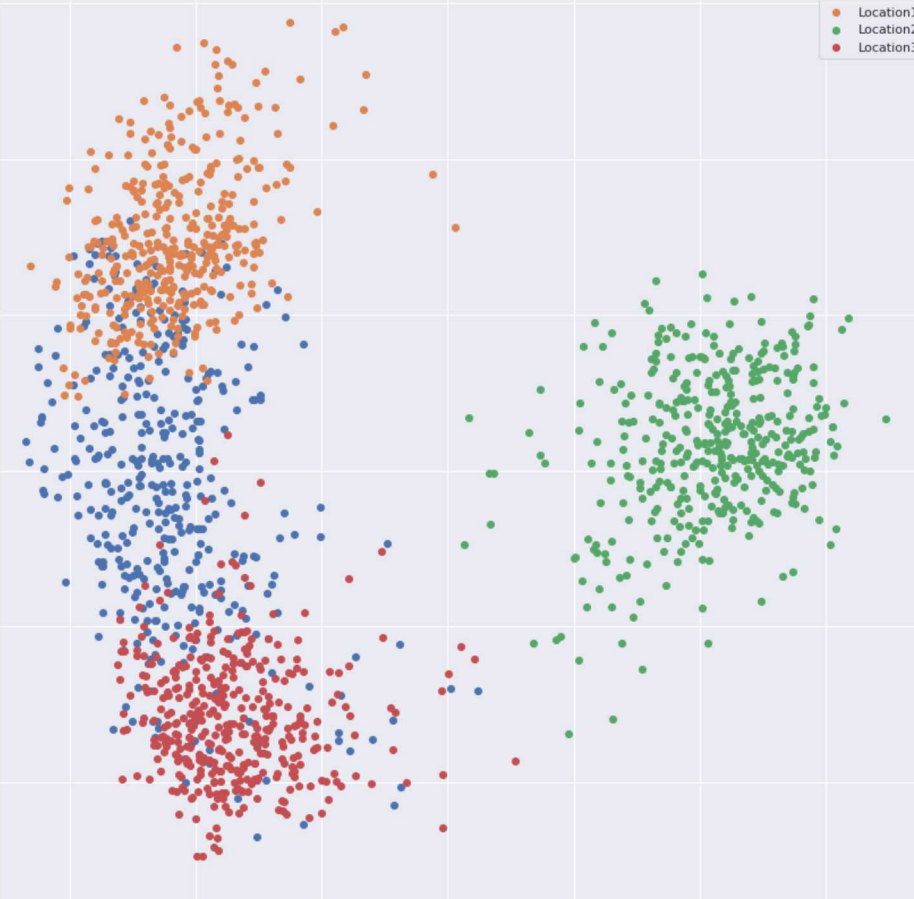


Image Generated by Jacob Hallberg

3-D Path Embeddings



Image Generated by Jacob Hallberg

References

- 1.) Vincent Spruyt (2018, May 3) Loc2Vec: Learning location embeddings with triplet-loss networks <https://www.sentiance.com/2018/05/03/venue-mapping/>
- 2.) arXiv:1810.00319v4 [cs.LG] MODELING UNCERTAINTY WITH HEDGED INSTANCE EMBEDDING

Future Work

The architecture has potential to include Hedged Instance Embeddings, which would allow the architecture to apply a probability distribution to any of the architectures estimations. [2]