Automatic Extraction of Road Intersection Position, Connectivity, and Orientations from Raster Maps

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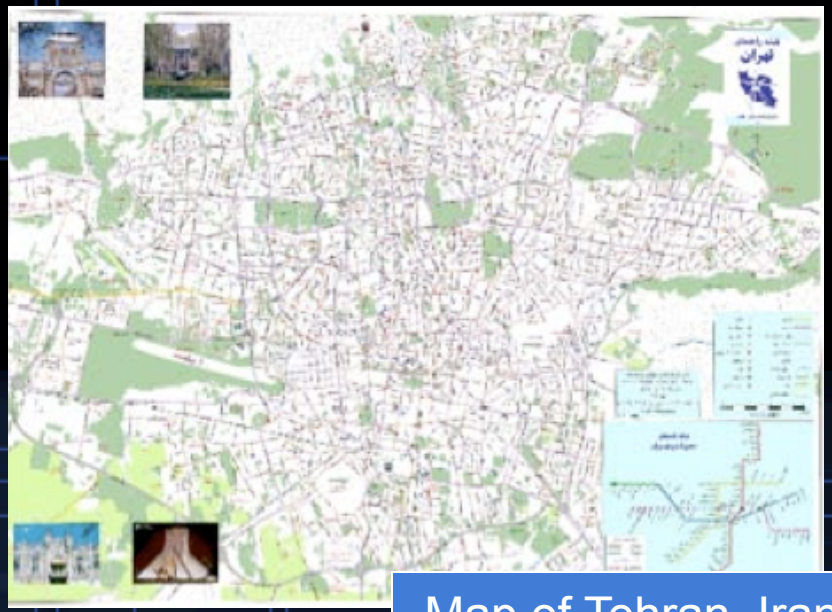
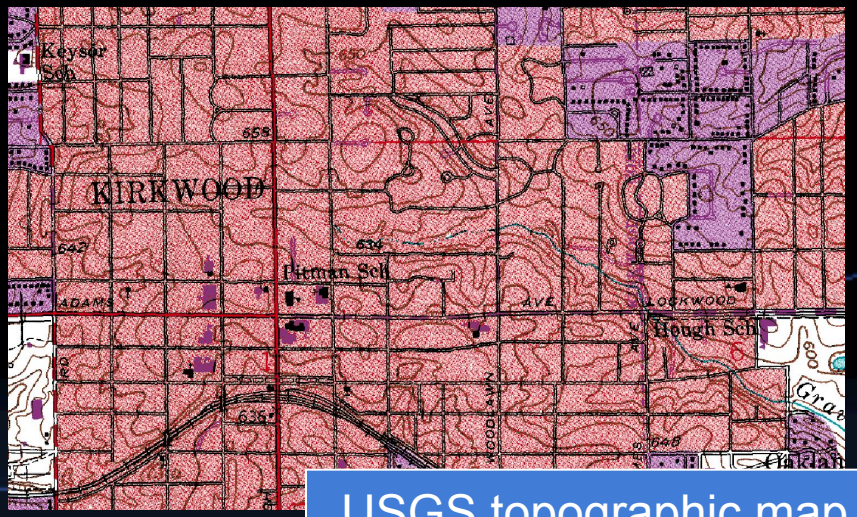
Introduction

- Raster maps are one important source of geospatial data:
  - Contain information that is difficult to find elsewhere
  - Contain the most complete set of data



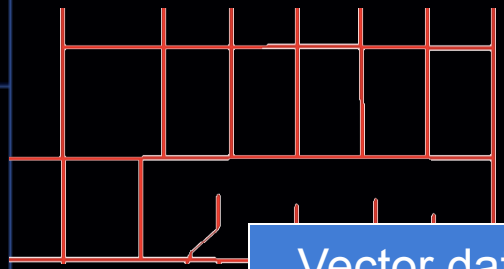
Map of Tehran, Iran



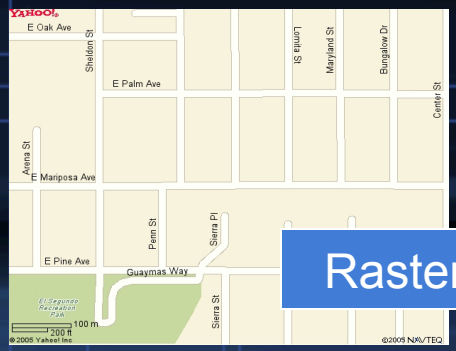
USGS topographic map

Introduction

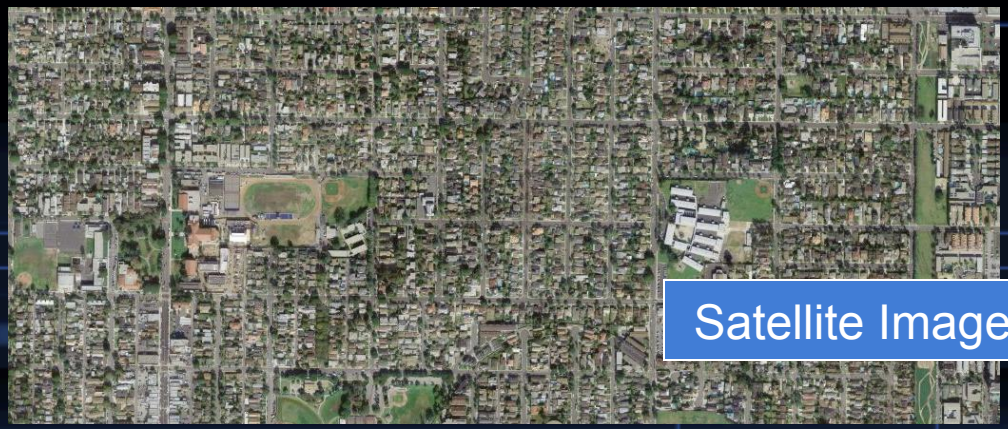
- In [Chen et al. 2008], we utilize the set of road intersection templates as the fingerprint of the raster map to integrate raster maps with other geospatial data
- Road intersection template:
  - Road intersection position, connectivity, and road orientation



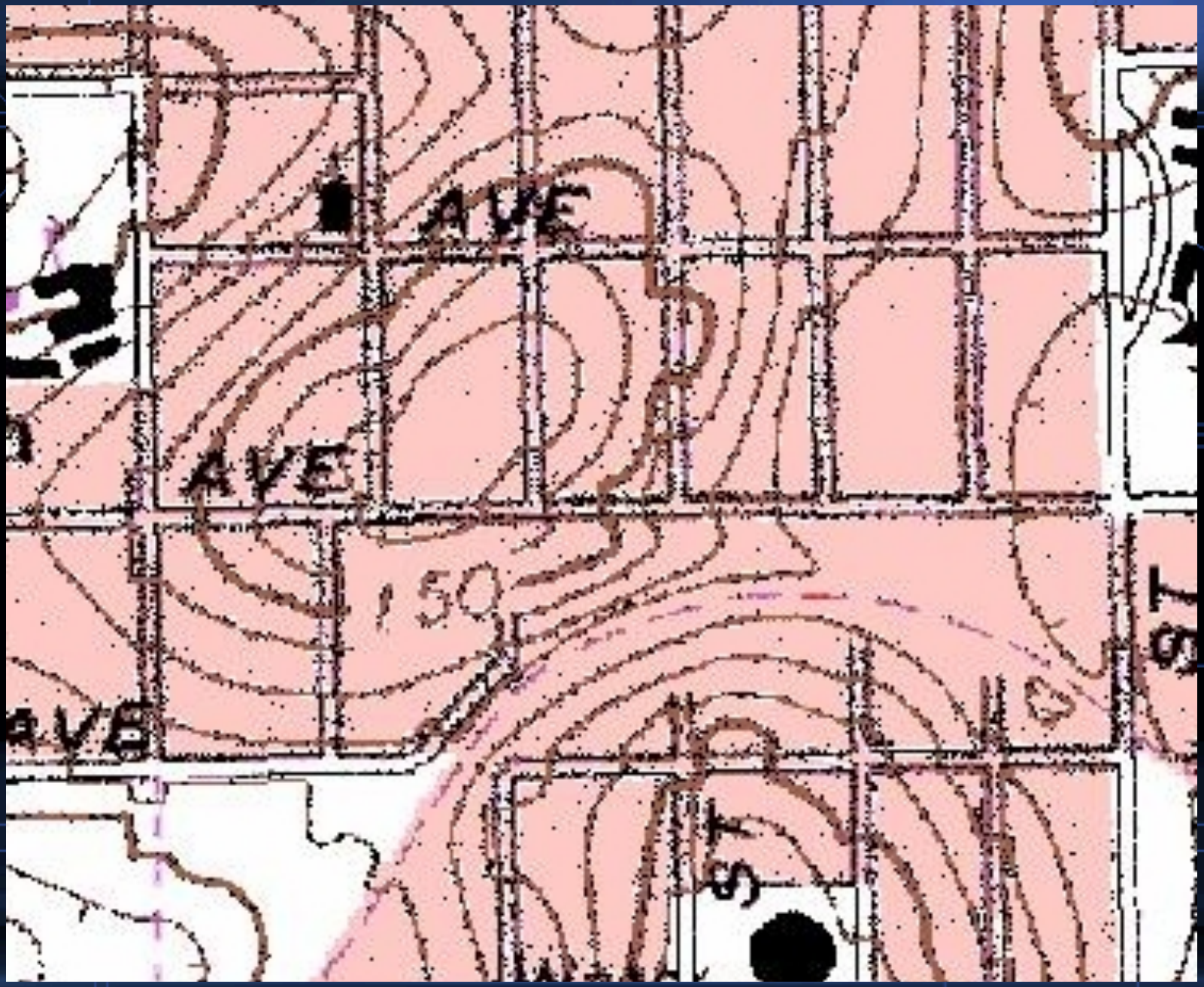
Vector data



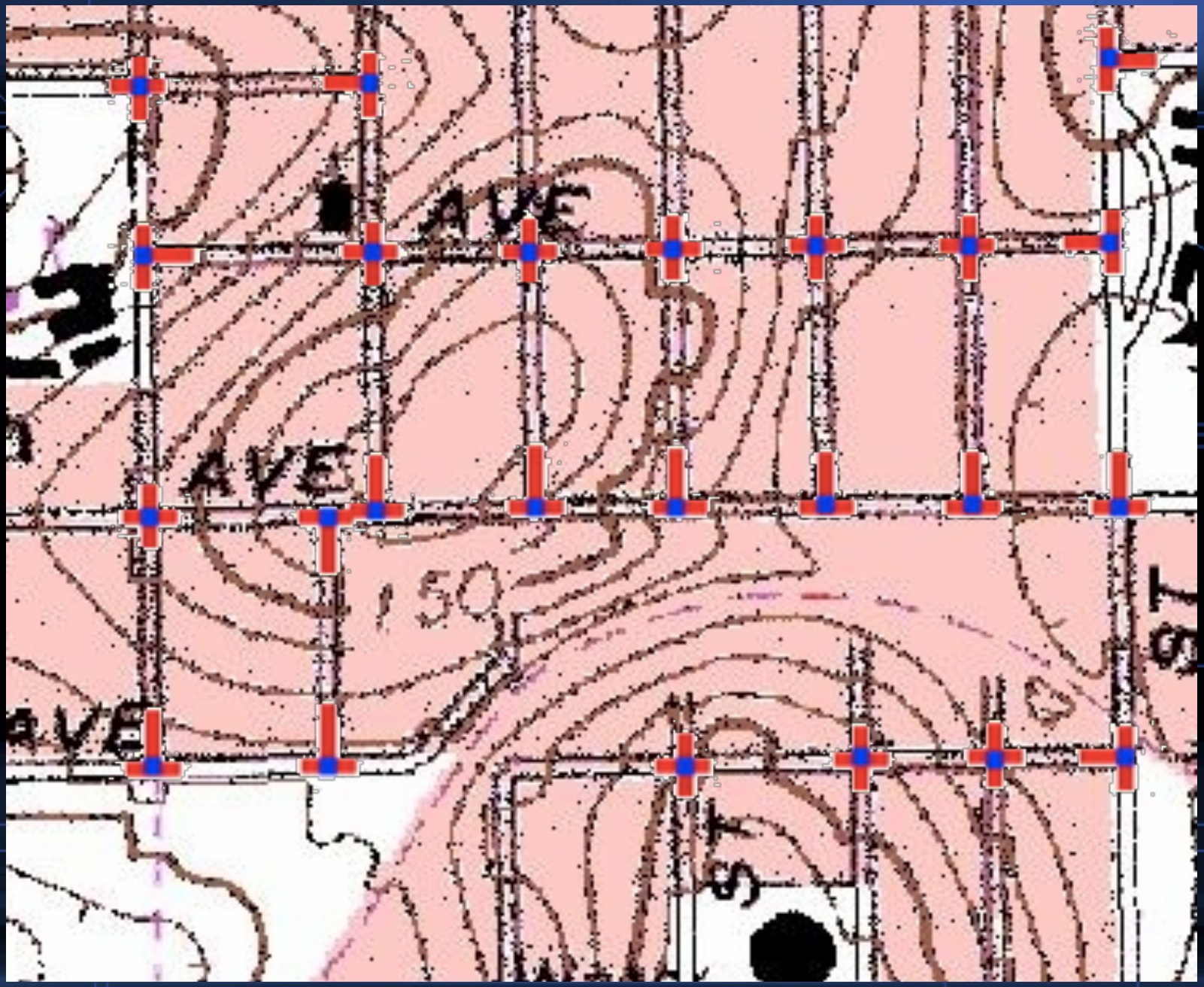
Raster map



Satellite Imagery



USGS Topographic Map, El Segundo, CA USA



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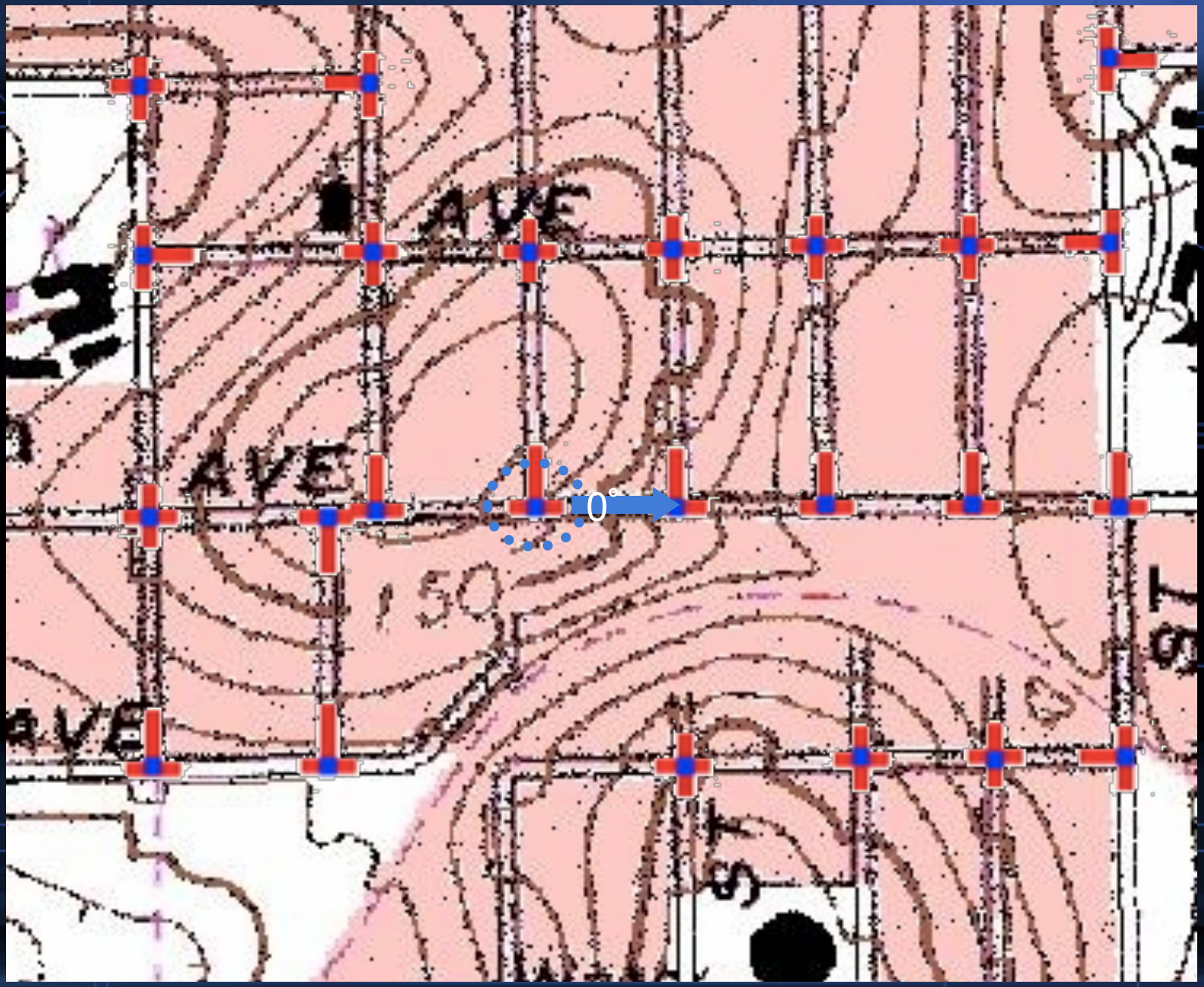

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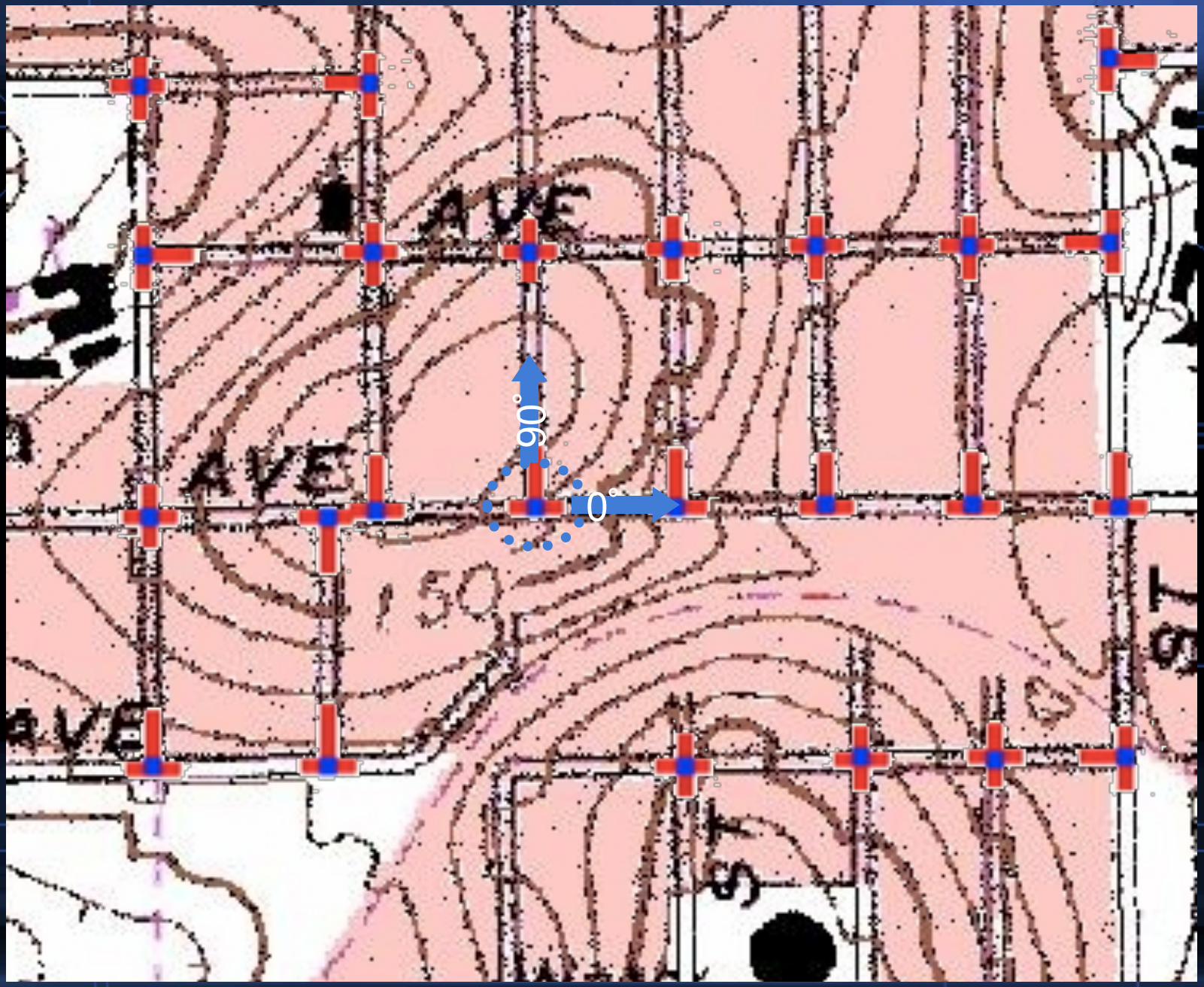

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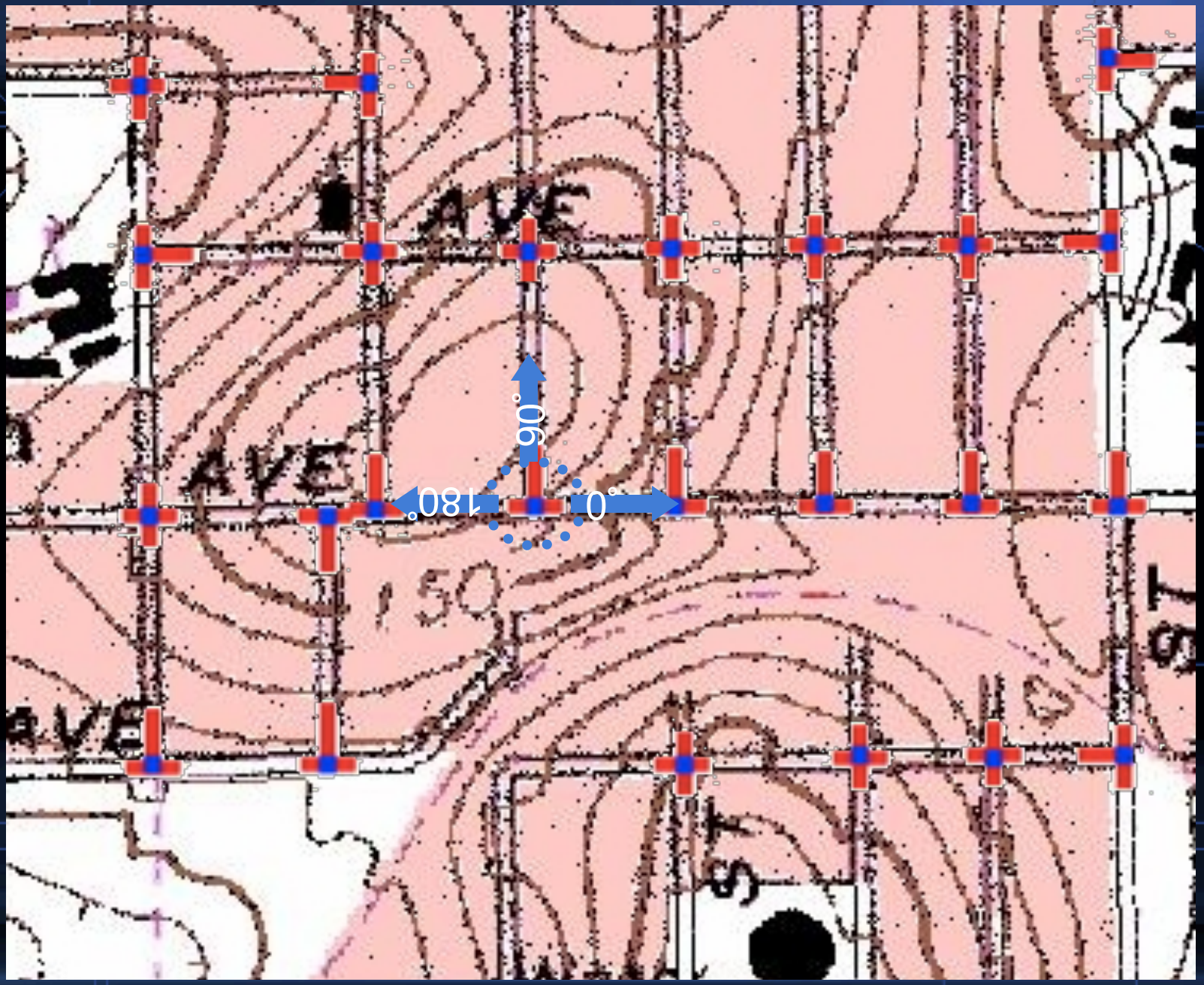

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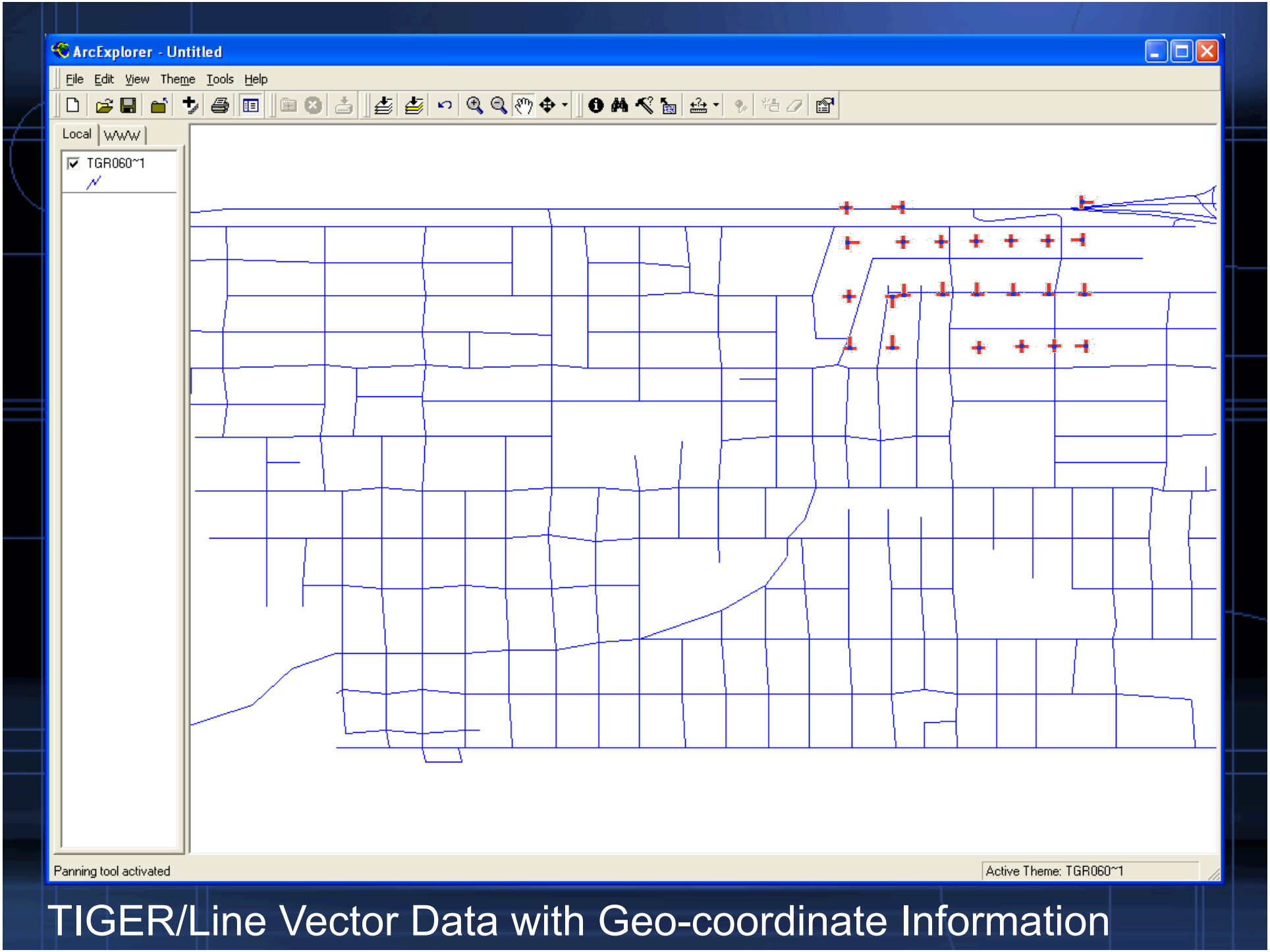
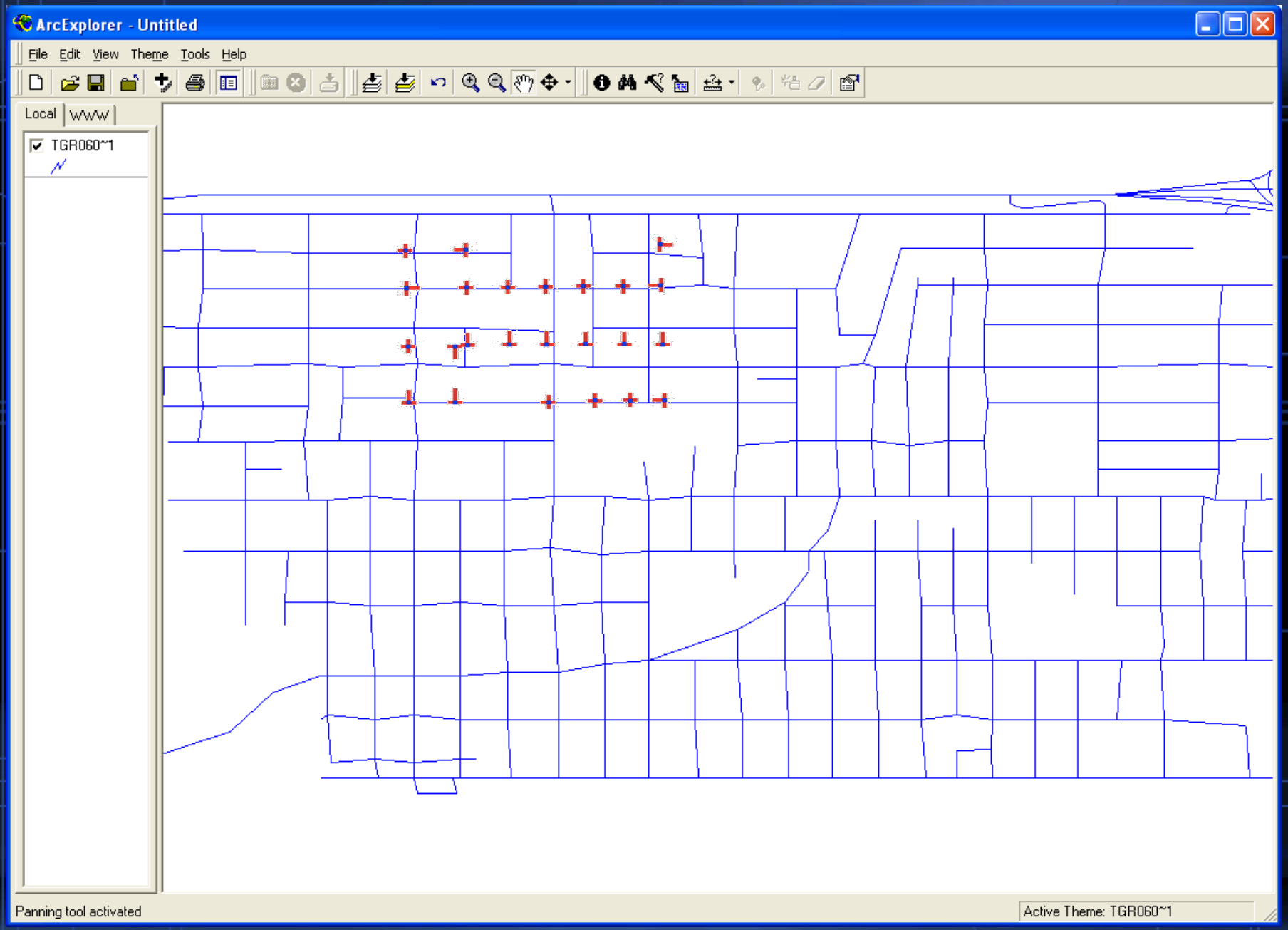


TIGER/Line Vector Data with Geo-coordinate Information



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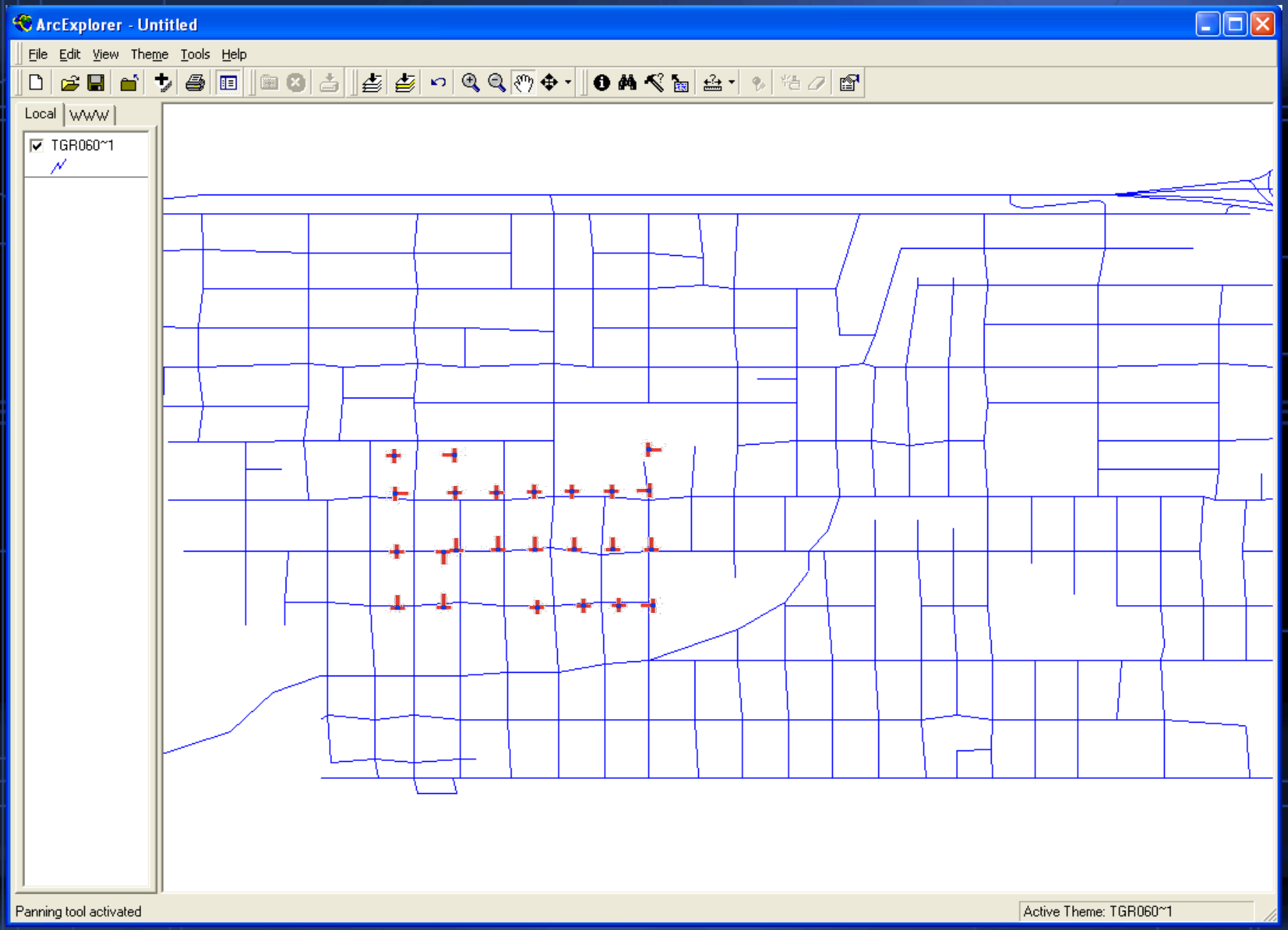

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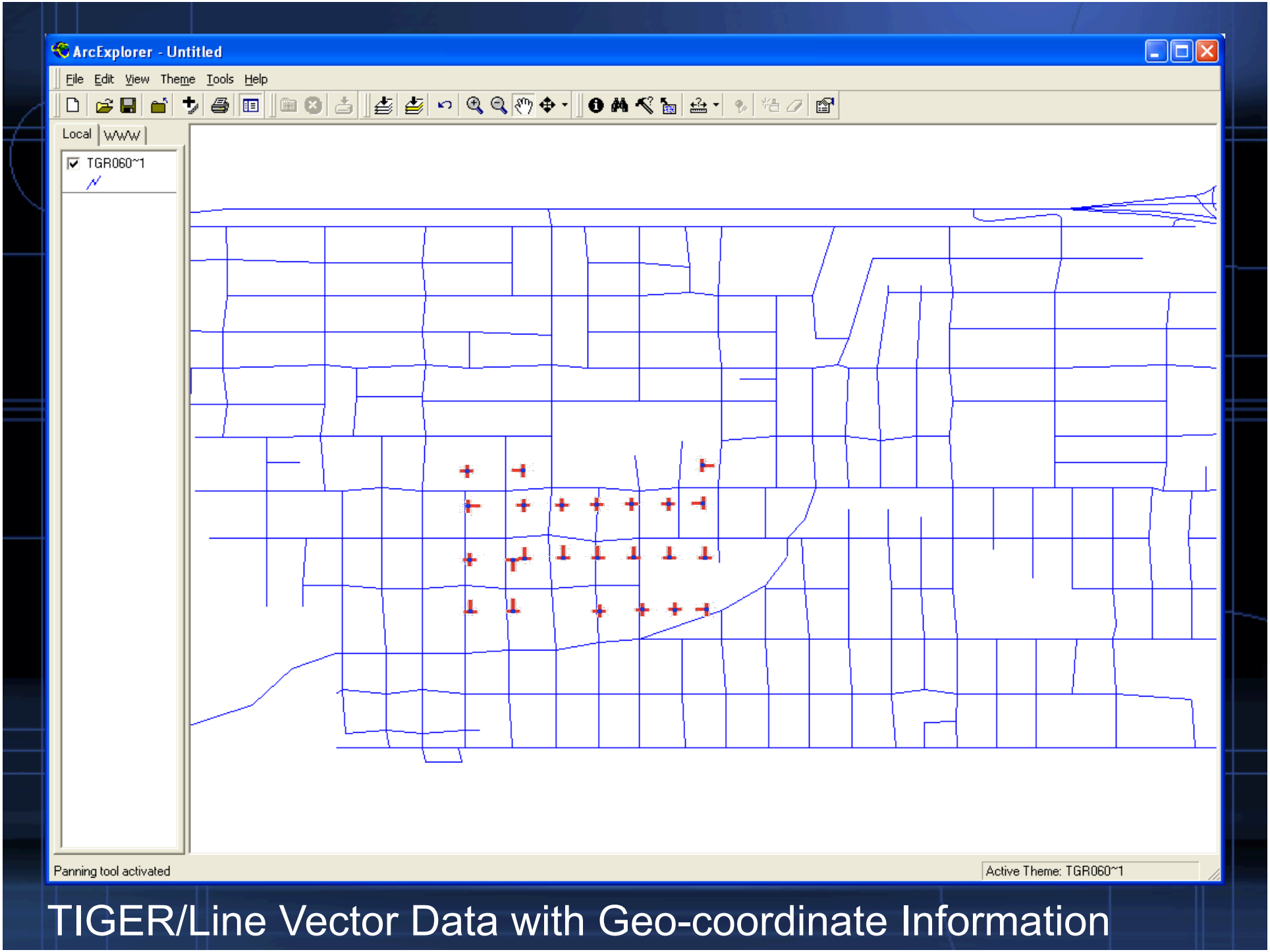

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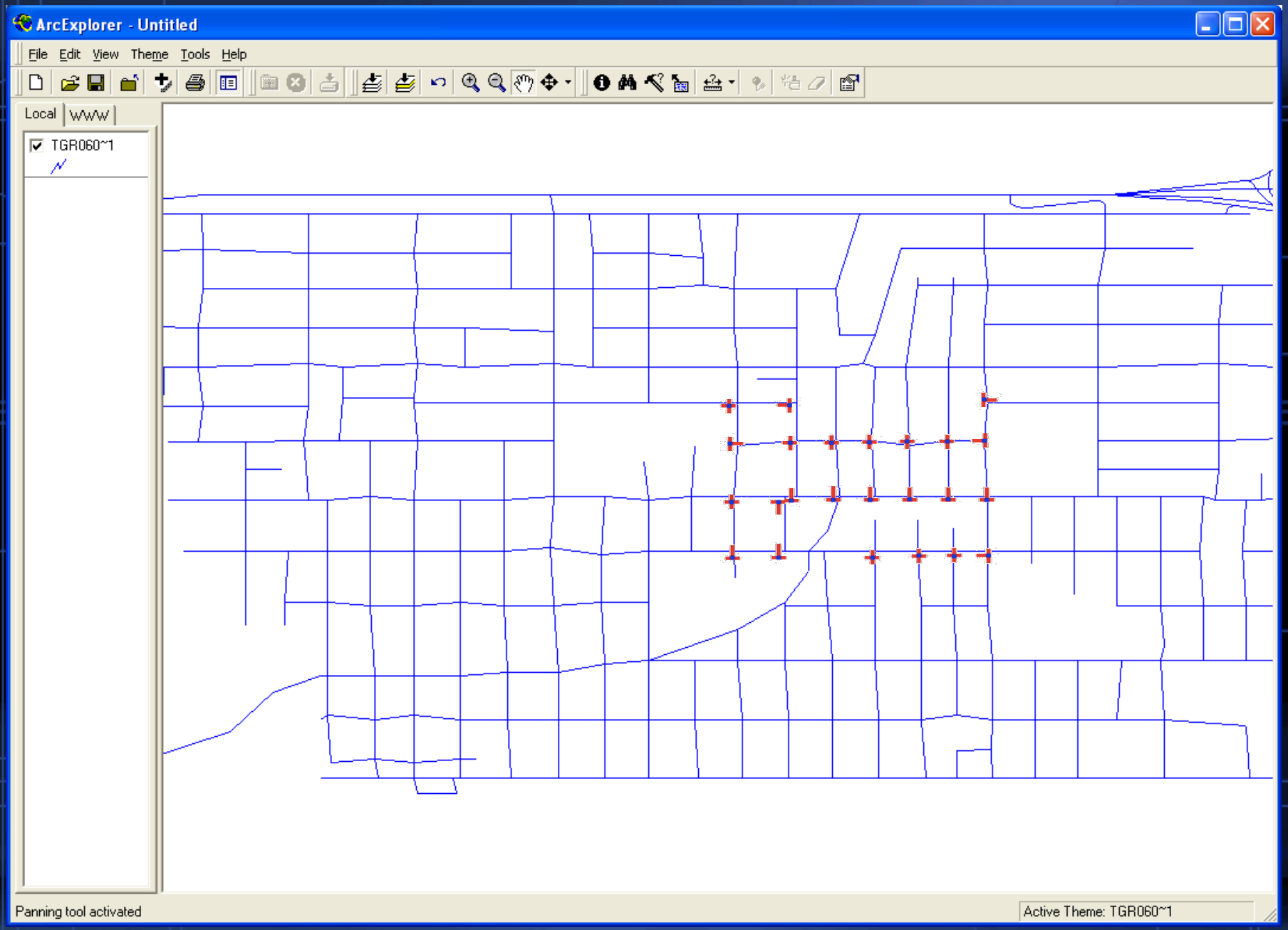

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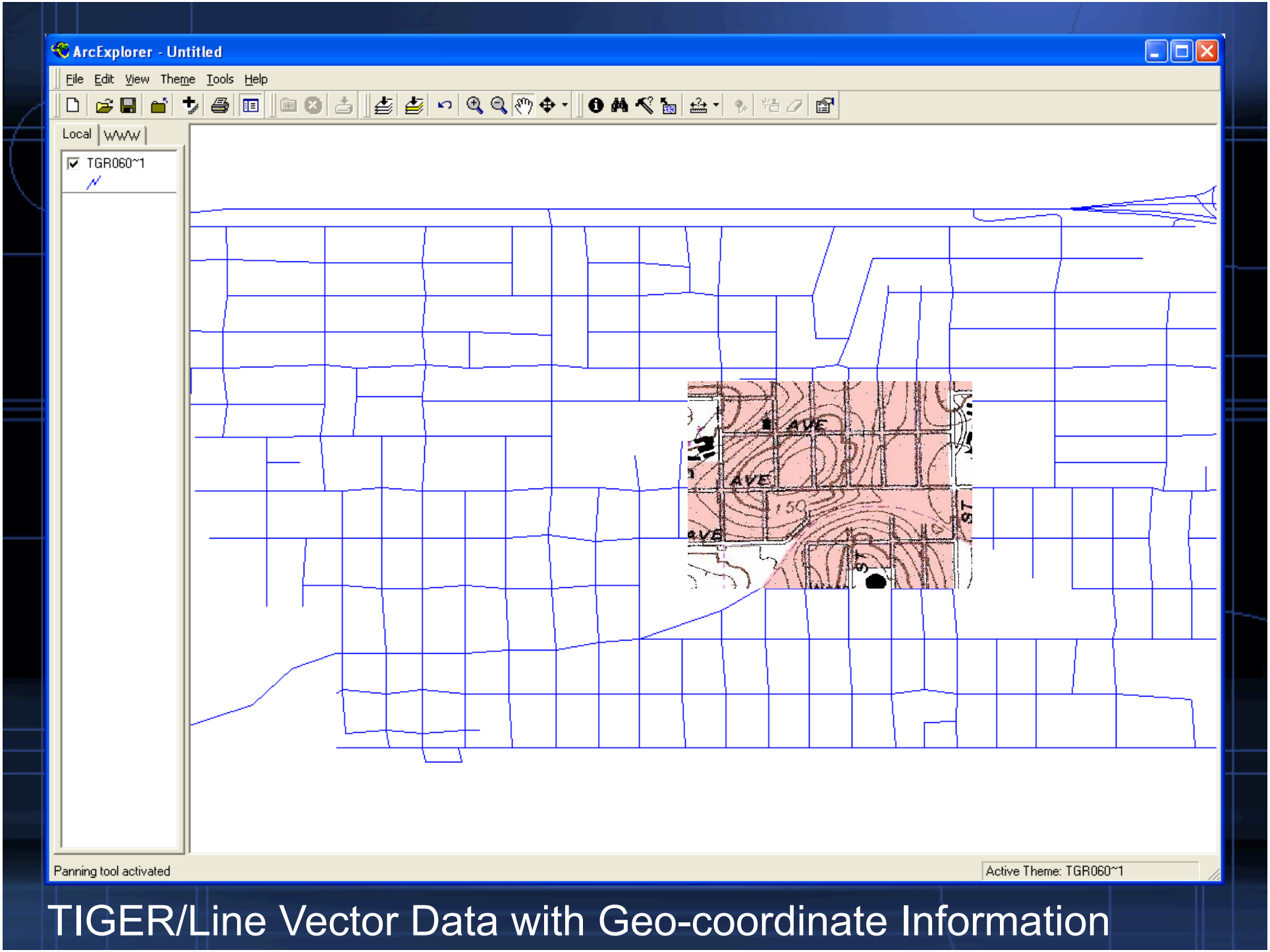

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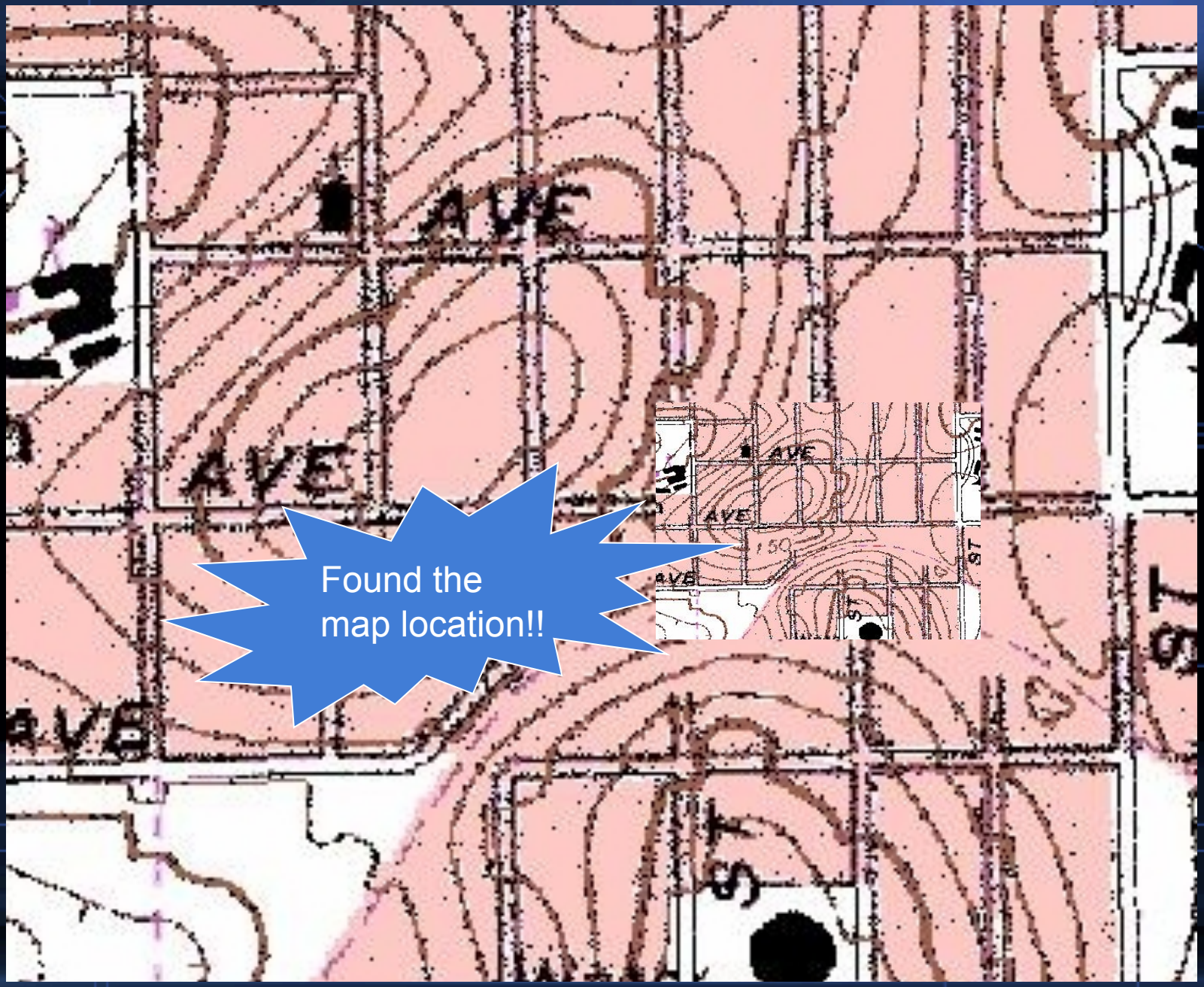
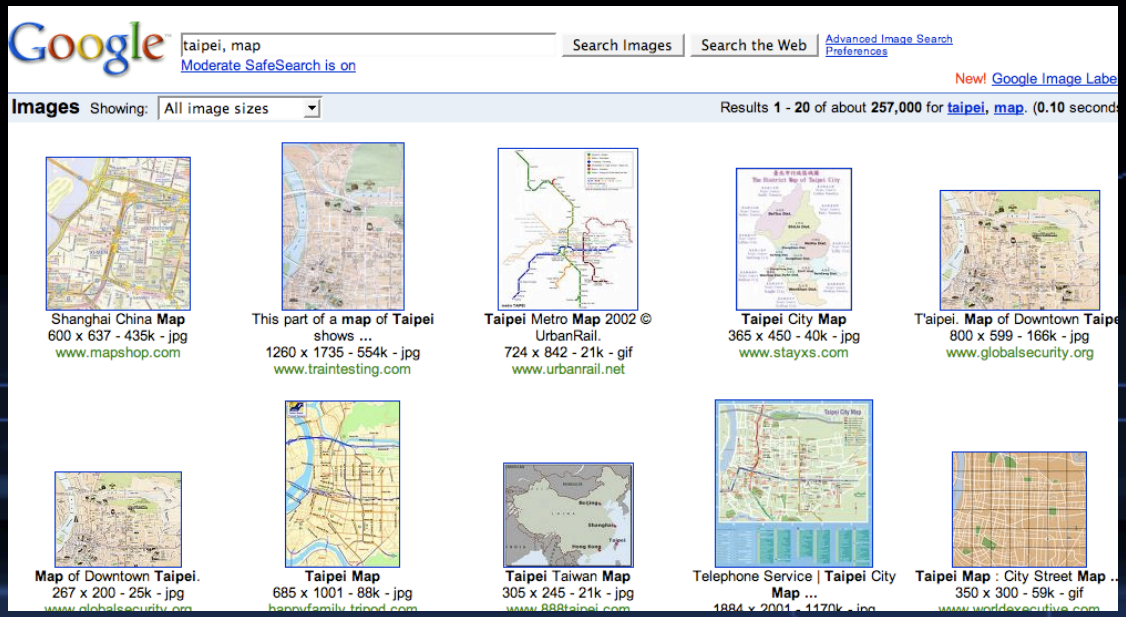


TIGER/Line Vector Data with Geo-coordinate Information

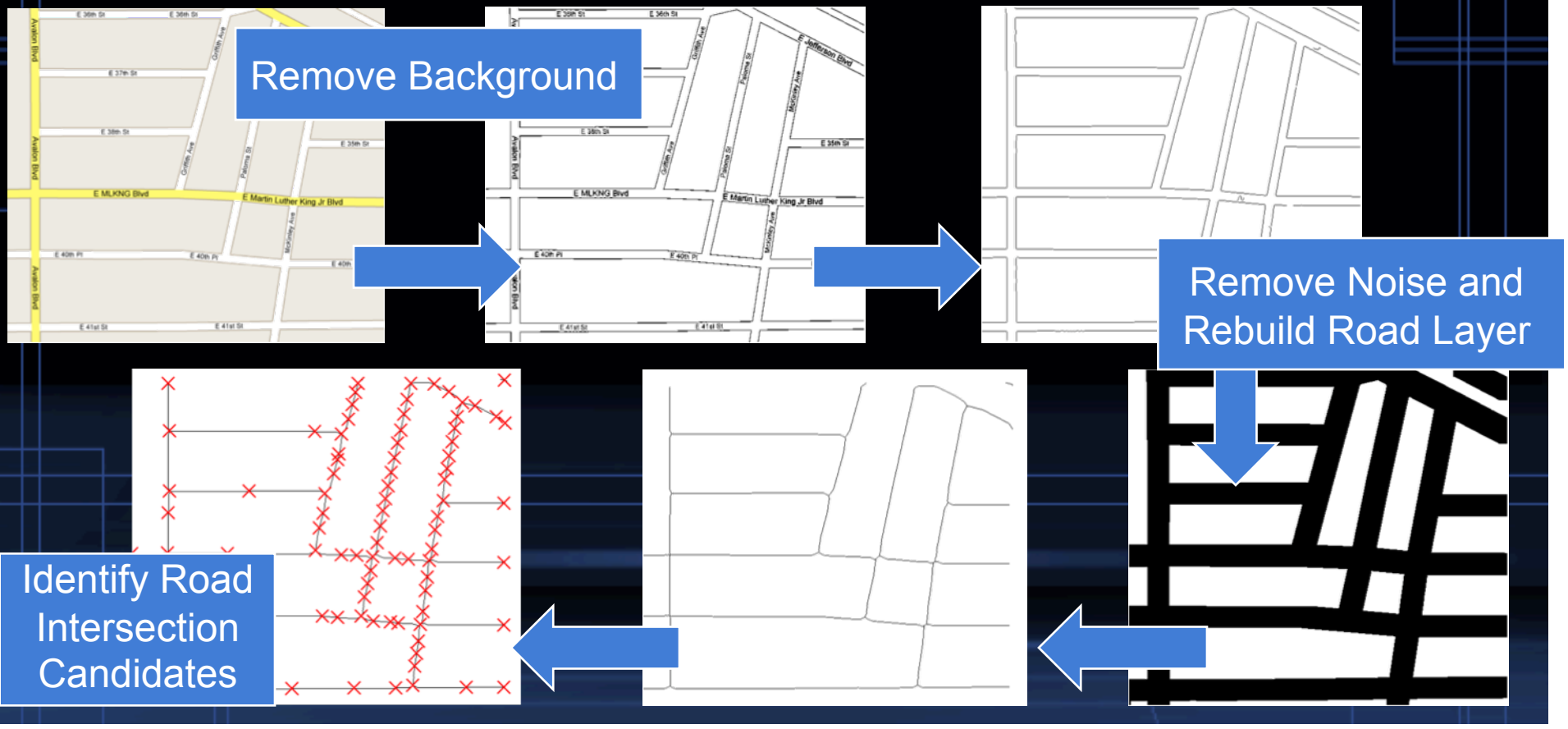
Previous Work

- The accuracy of the road intersection templates is important
  - Help to prune the searching space during the matching
- Challenges for extracting the road intersection templates:
  - Limited access to the metadata of the maps
  - Maps are complex



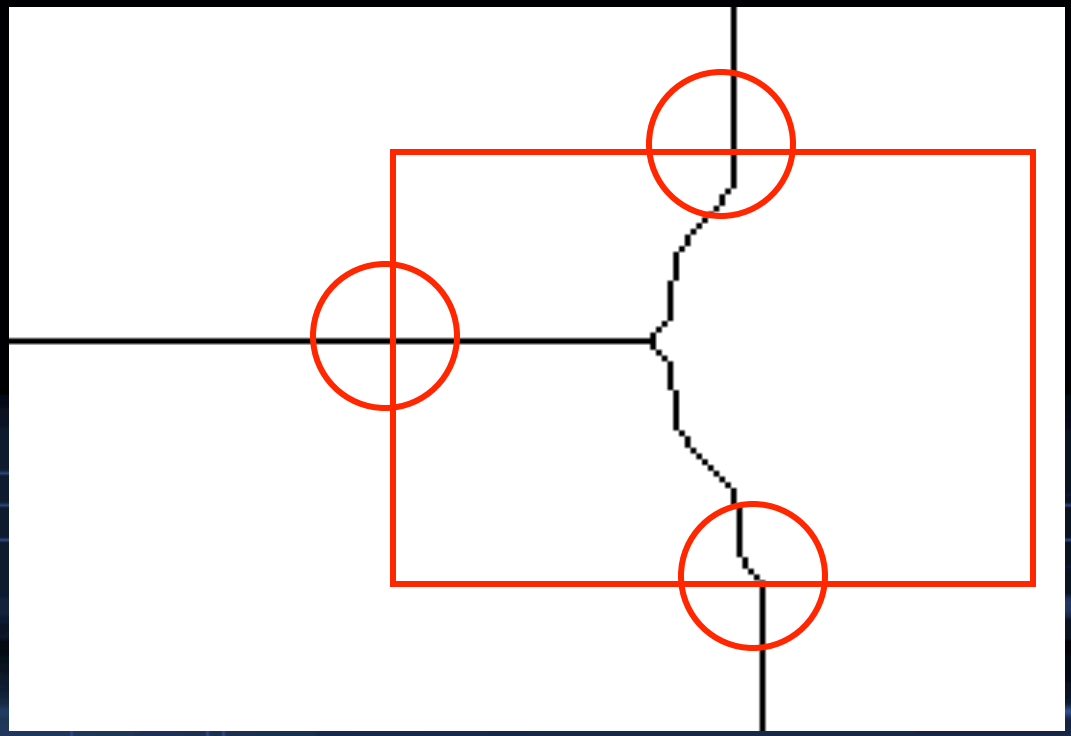
Previous Work

- In [Chiang et al. 2008], we worked on the pixel level to decompose the raster maps and to extract the road intersections automatically



Previous Work

- A simpler method to identify road intersections and extract the road intersection templates
- We also determine the road format (i.e., single or double line) and extract the road width



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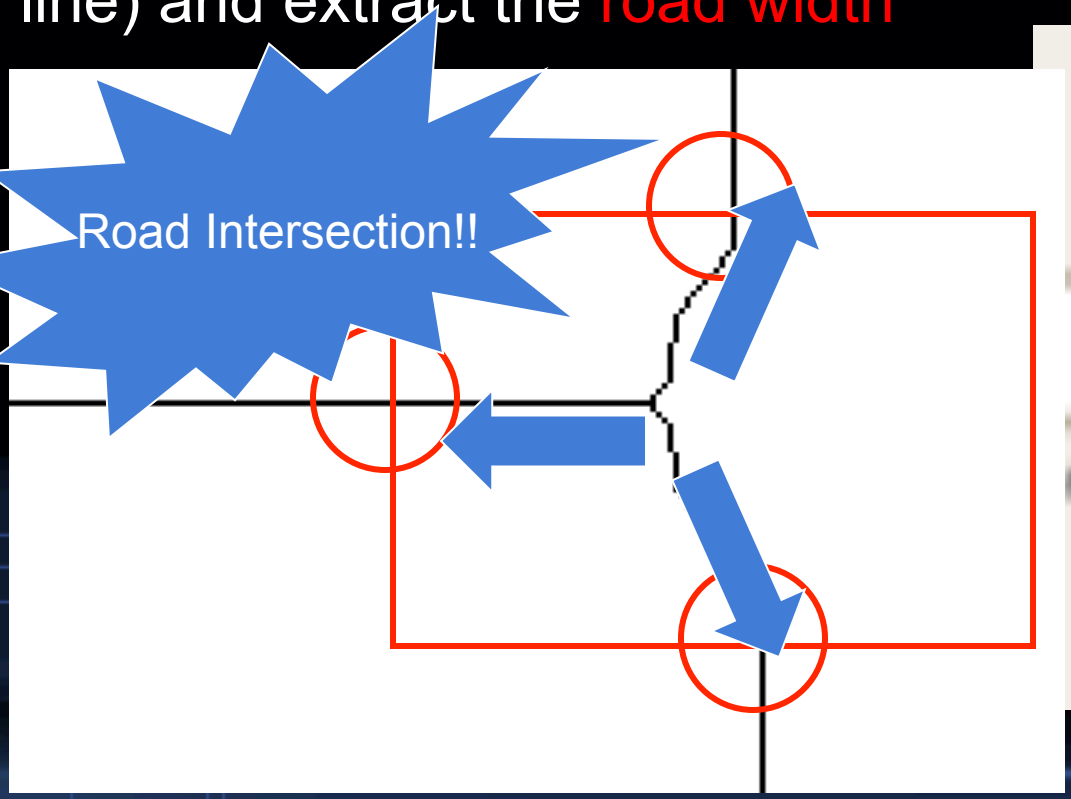
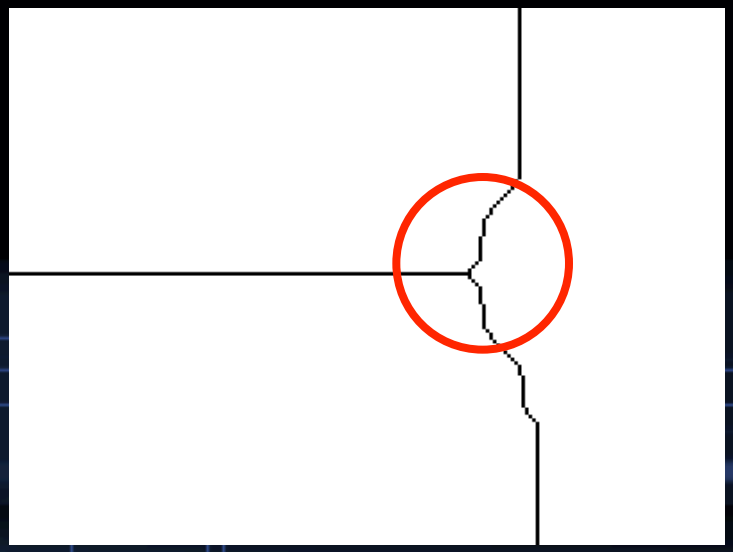
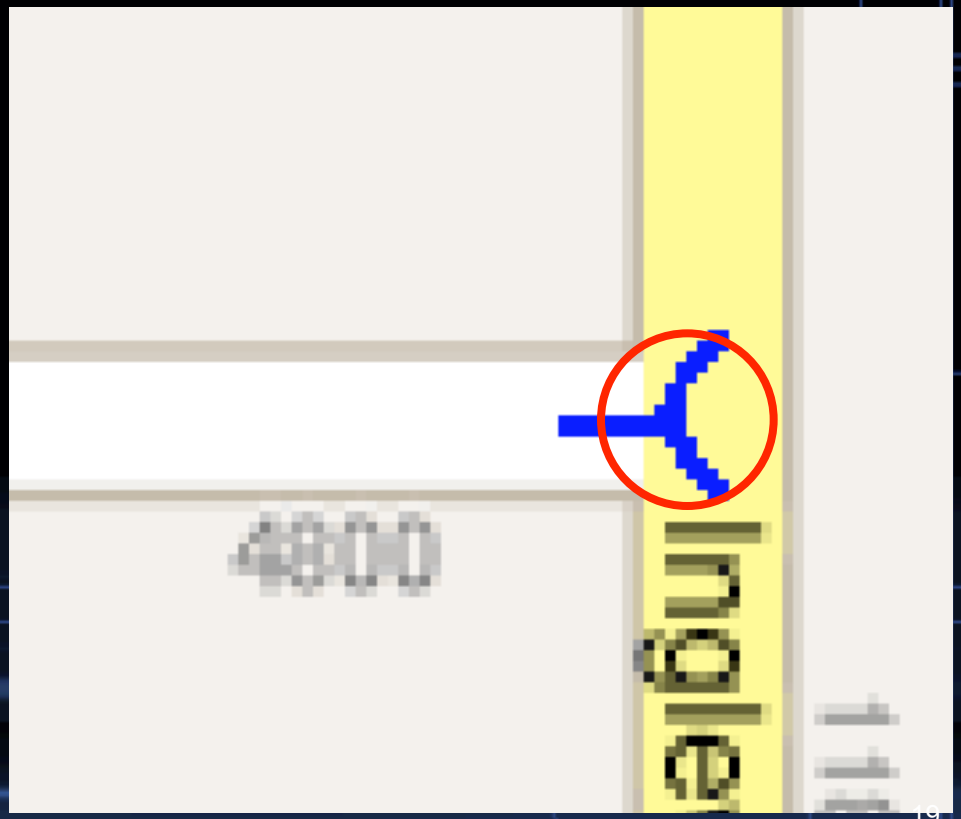


Previous Work

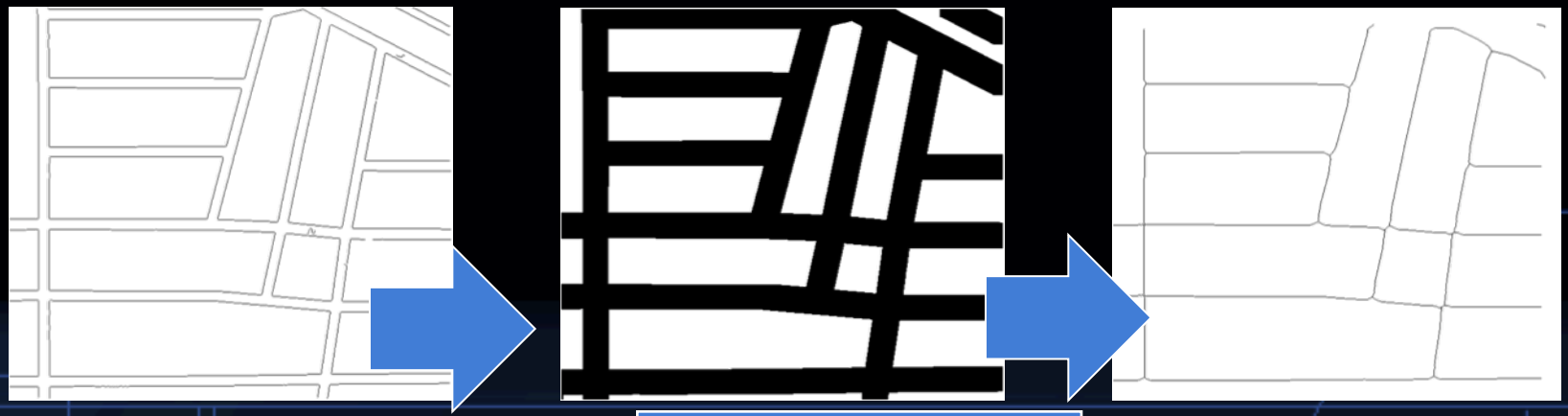
- Lines are distorted by the thinning operator
- The extracted road intersection templates are not accurate





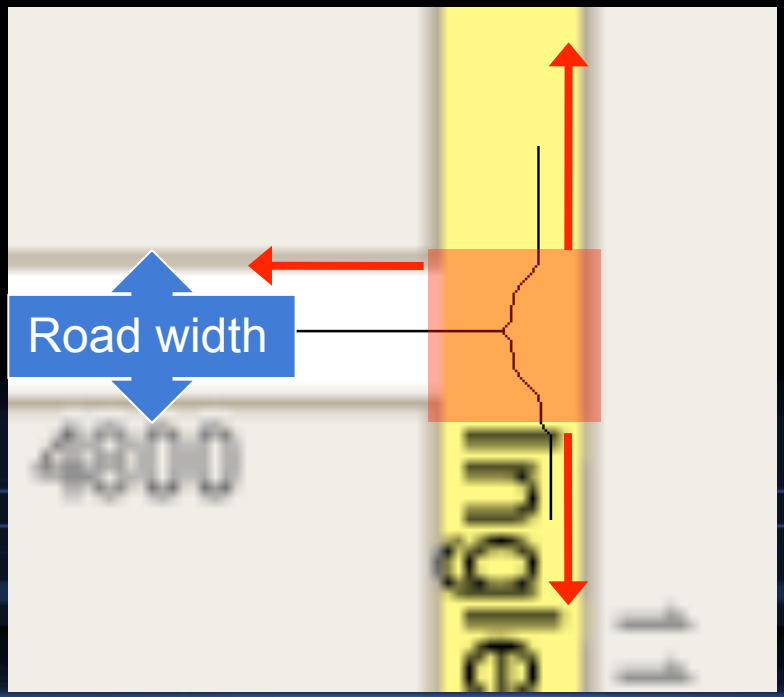
Extract Accurate Road Intersection Templates

- The distortion is caused by using the thinning operator on thick lines
- The extent of the distortion is determined by the road width



Extract Accurate Road Intersection Templates

- In this work, we skip the distorted areas and trace the straight lines to extract accurate road intersection templates



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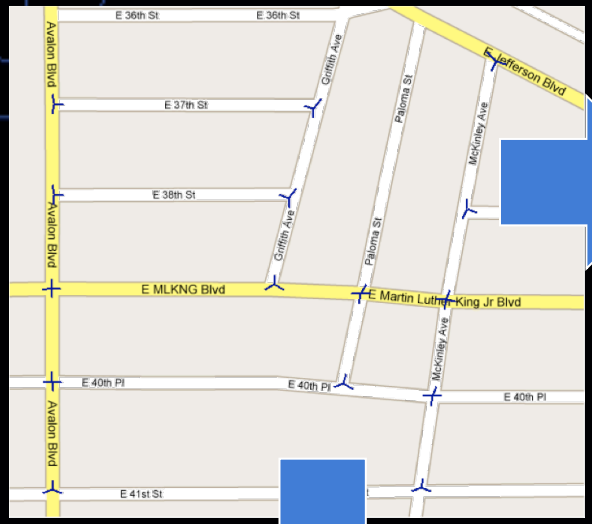
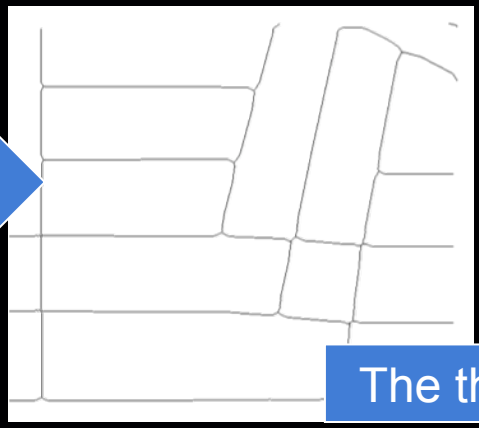
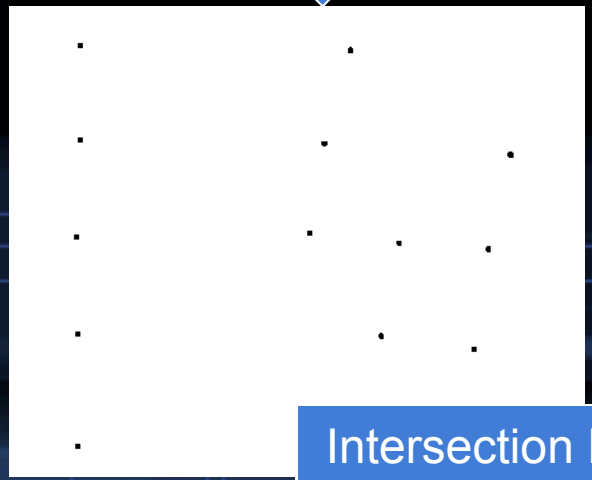


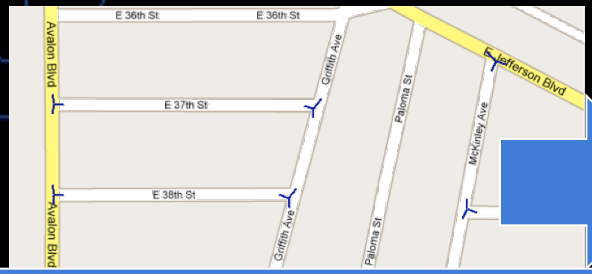


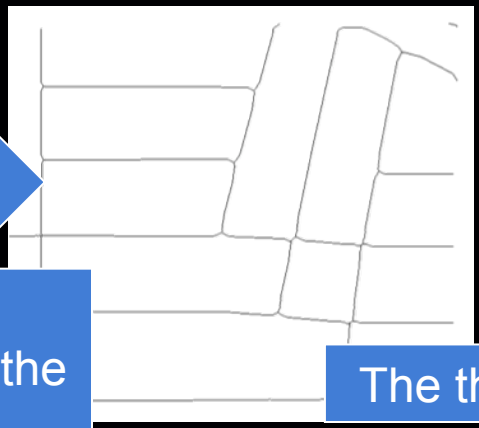
The thinned lines



Intersection Positions

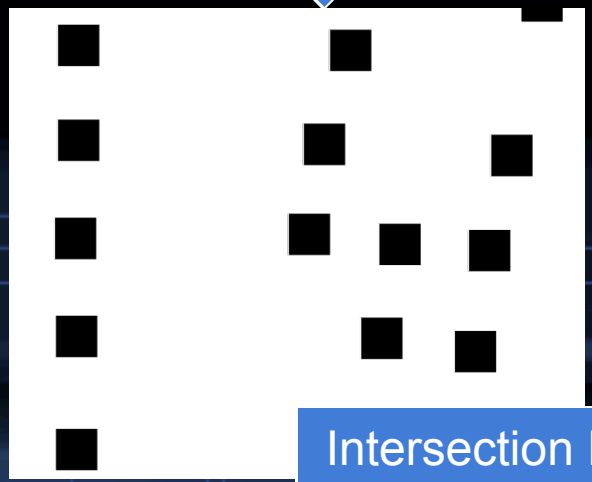
Extract Accurate Road Intersection Templates





The thinned lines

The size of a blob is determined using the road with for covering the distorted lines



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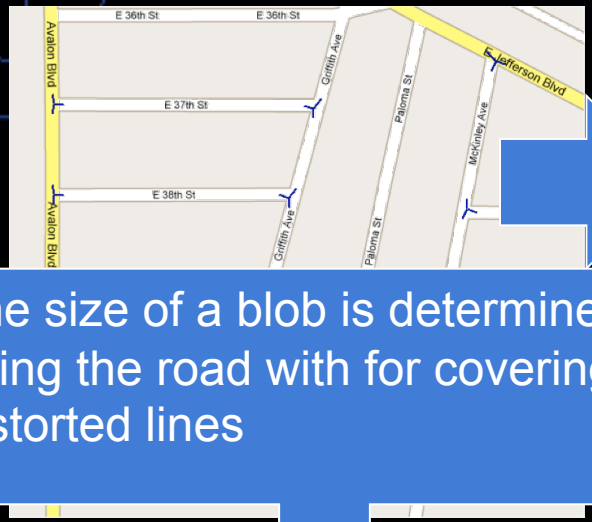

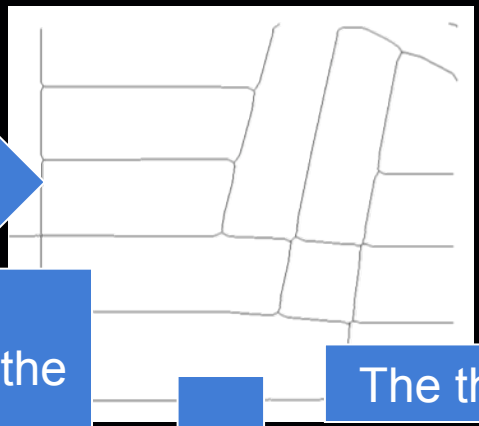

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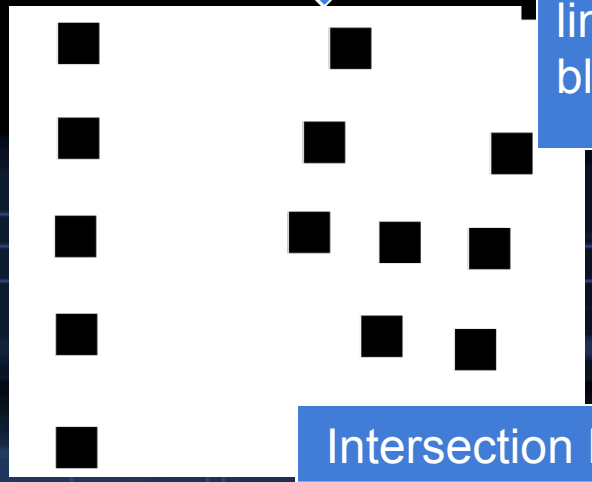
The thinned lines

Intersect the thinned line image with the blob image



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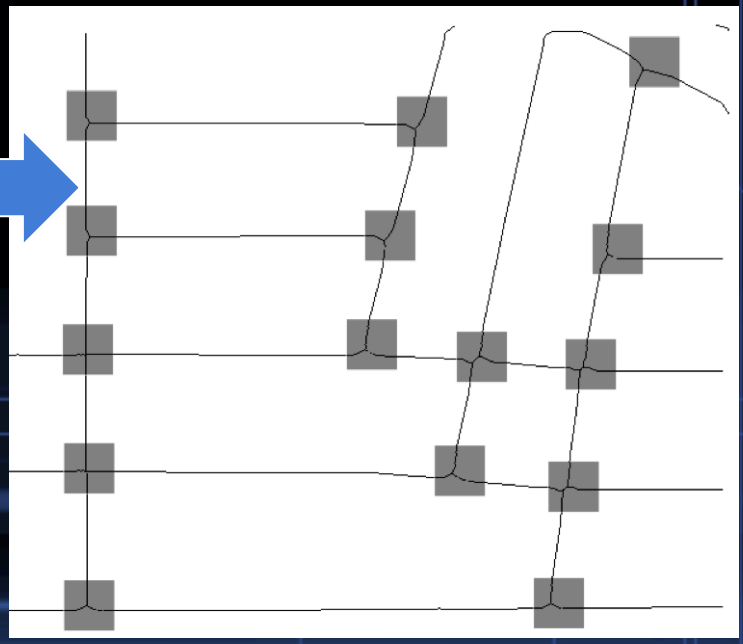
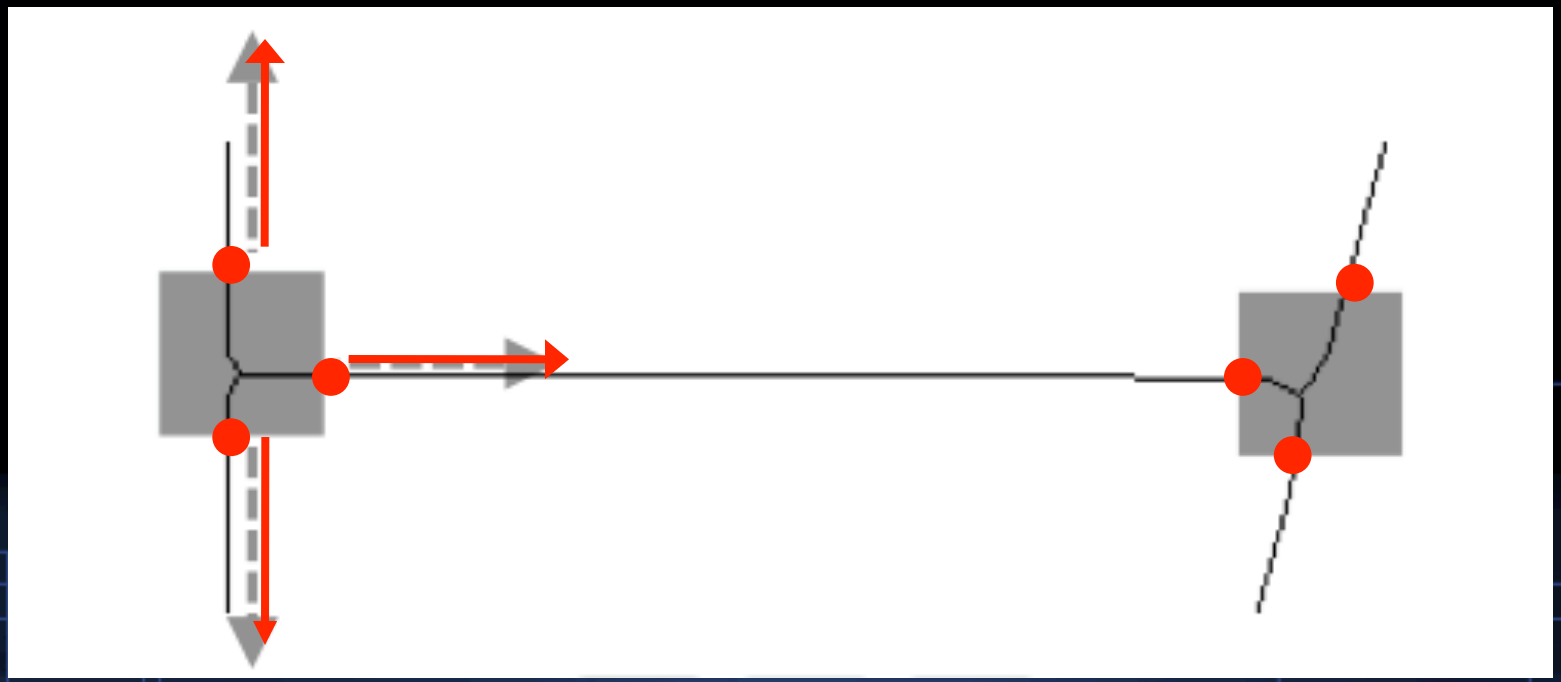


Extract Accurate Road Intersection Templates

- Identify contact points
- Trace road line candidates from contact points



Extract Accurate Road Intersection Templates

- Trace road line candidates from contact points
  - Trace only a certain amount of line pixels to prevent looping
  - Road lines are straight within a small distance (e.g., 5 pixels)
  - Fit a line function (Y= aX+b) to the traced pixels using Least-Squares Fitting algorithm

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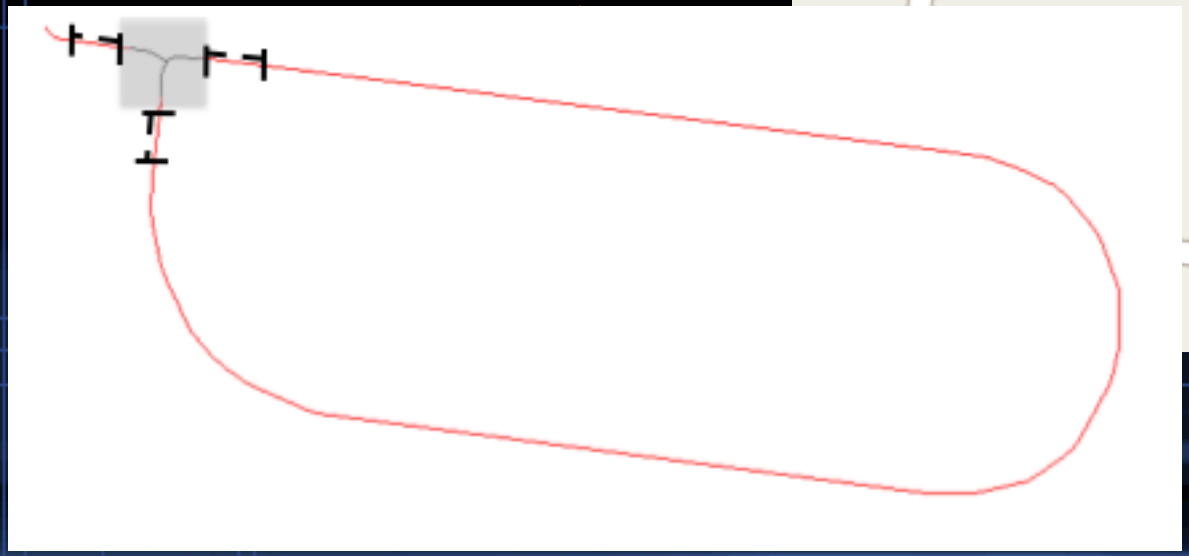

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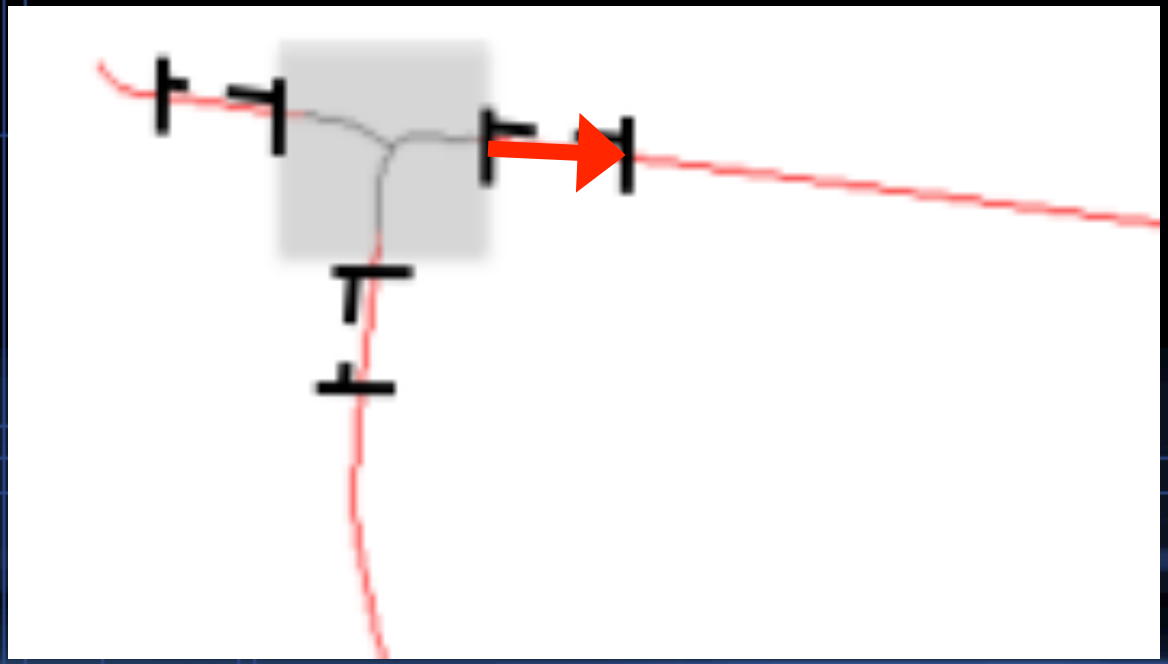
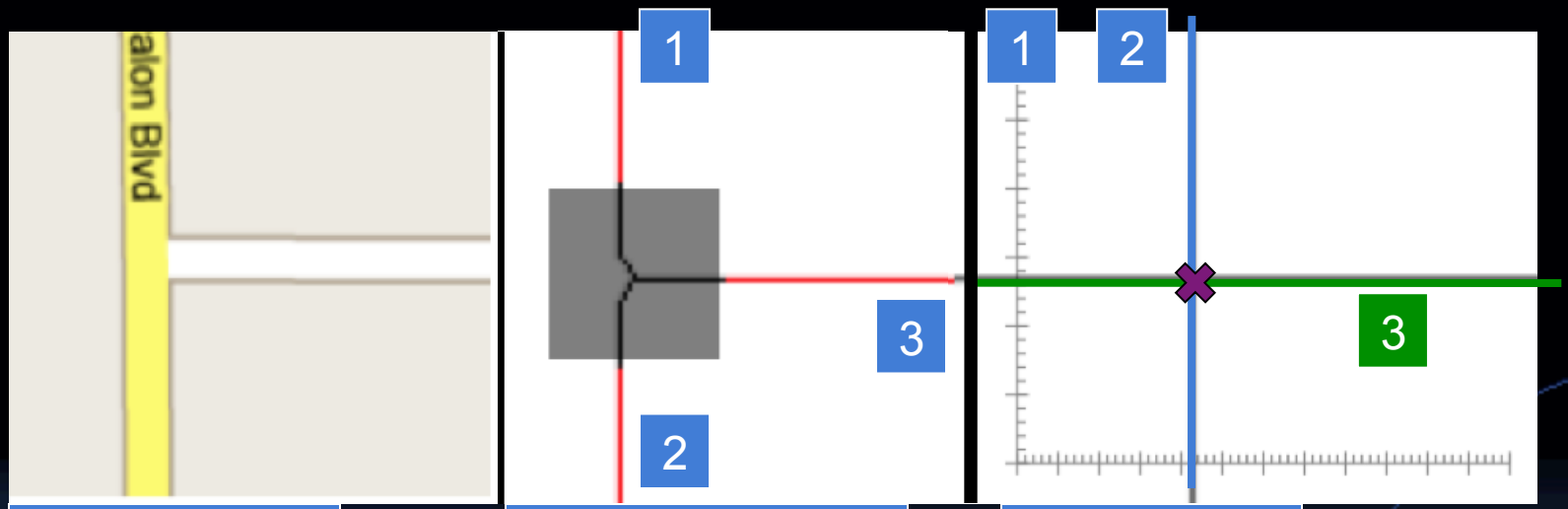


Extract Accurate Road Intersection Templates

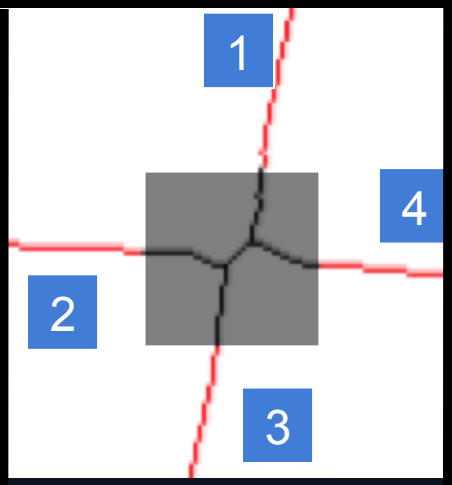
- Update road intersection templates
  - Keep every road line candidate
  - Use the intersection of the line candidates to update the template



Extract Accurate Road Intersection Templates

- Update road intersection templates
  - Keep every road line candidate
  - Use the centroid of the intersections of the line candidates to update the template

Original map



Blob image intersected with thinned lines

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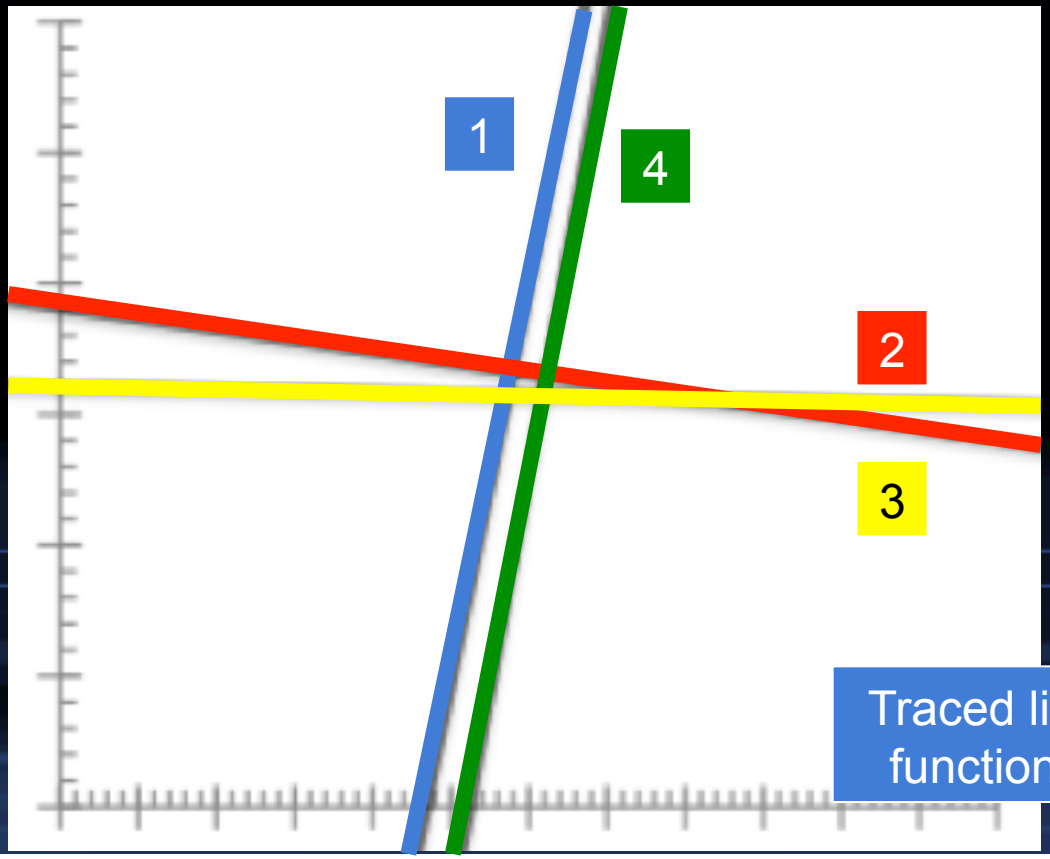

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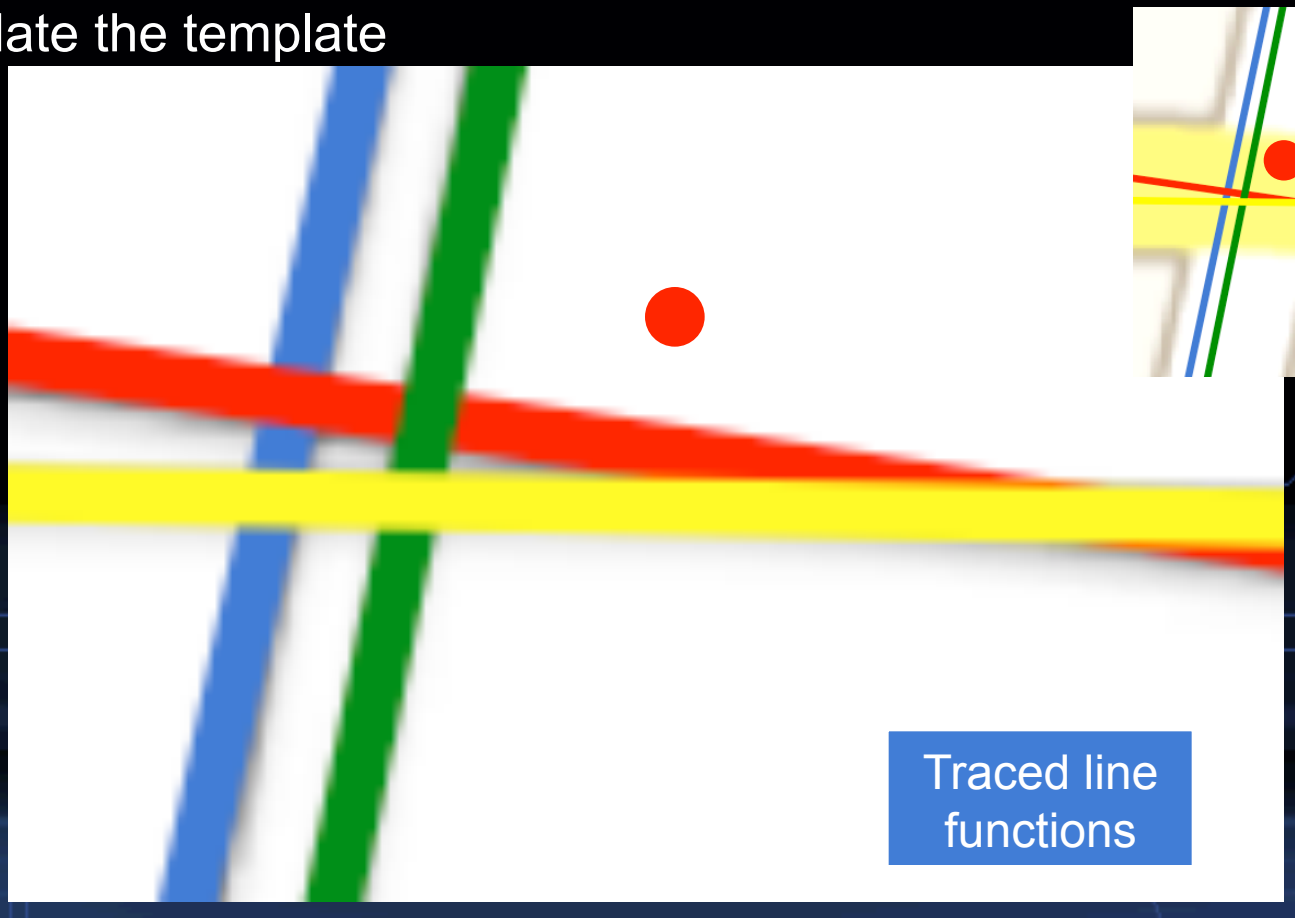

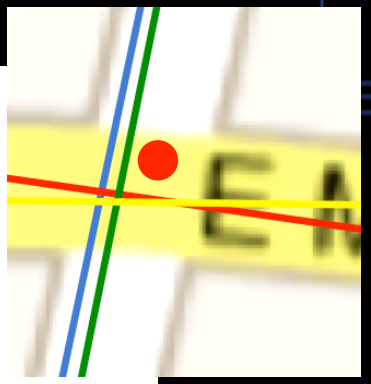

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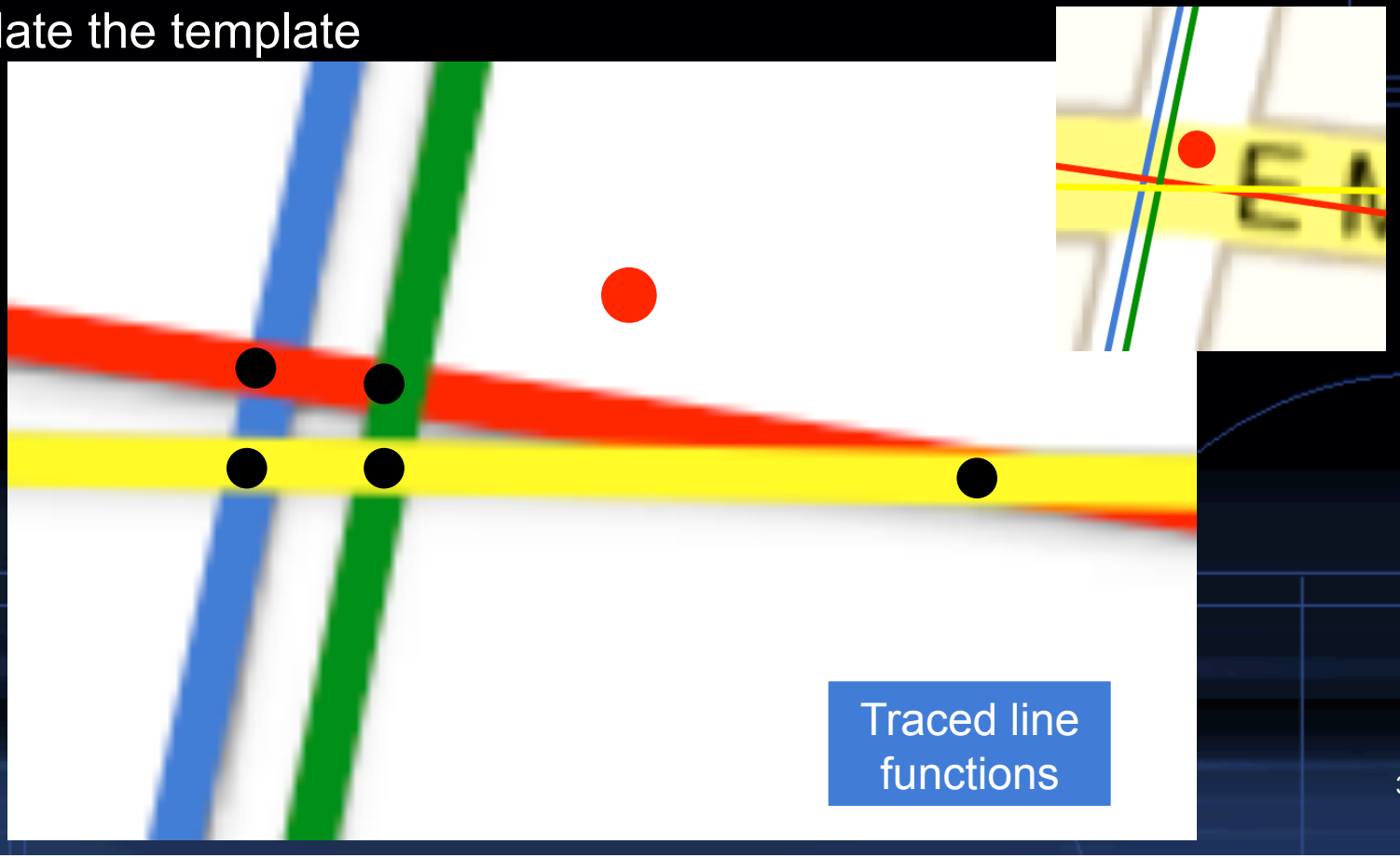

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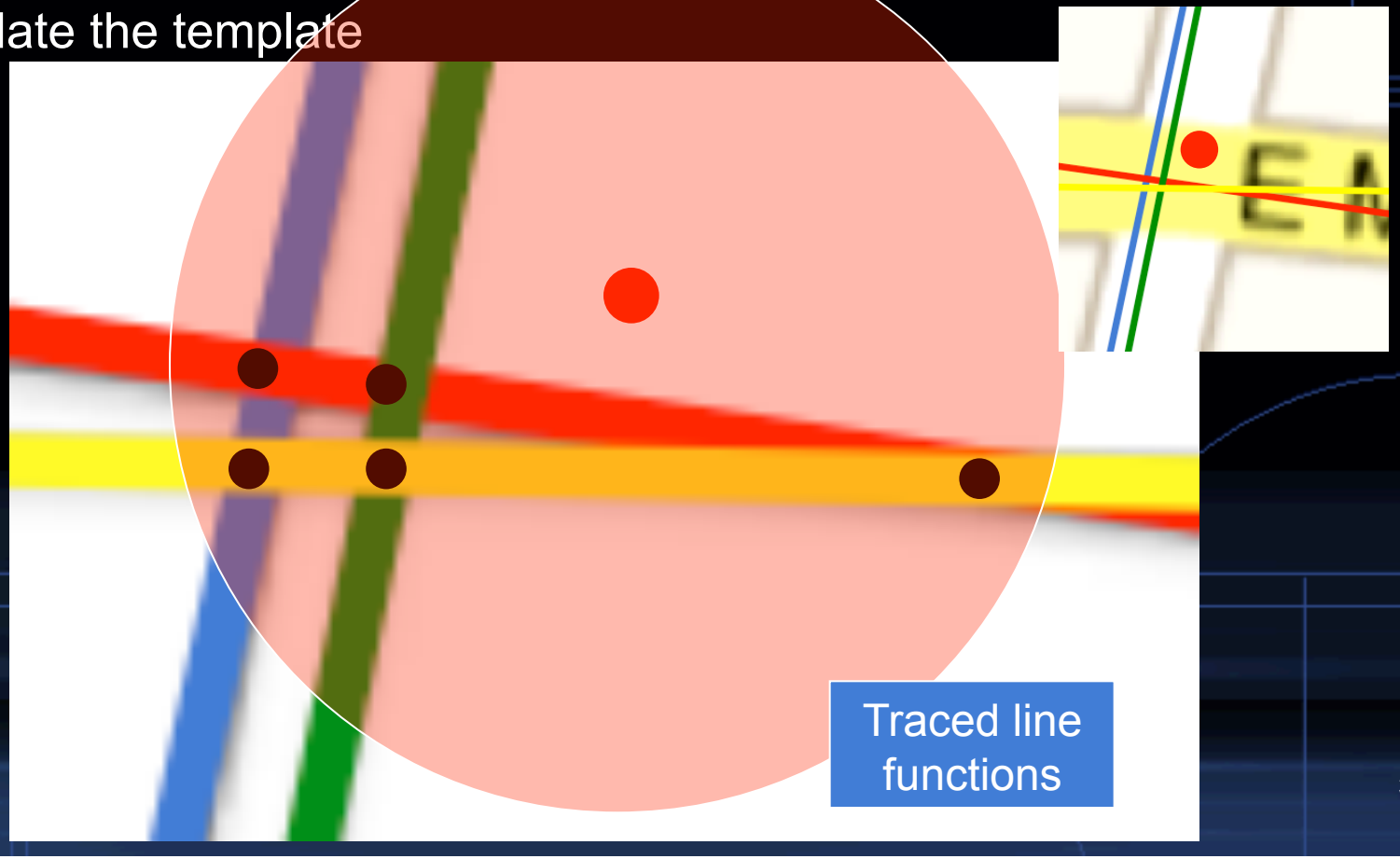

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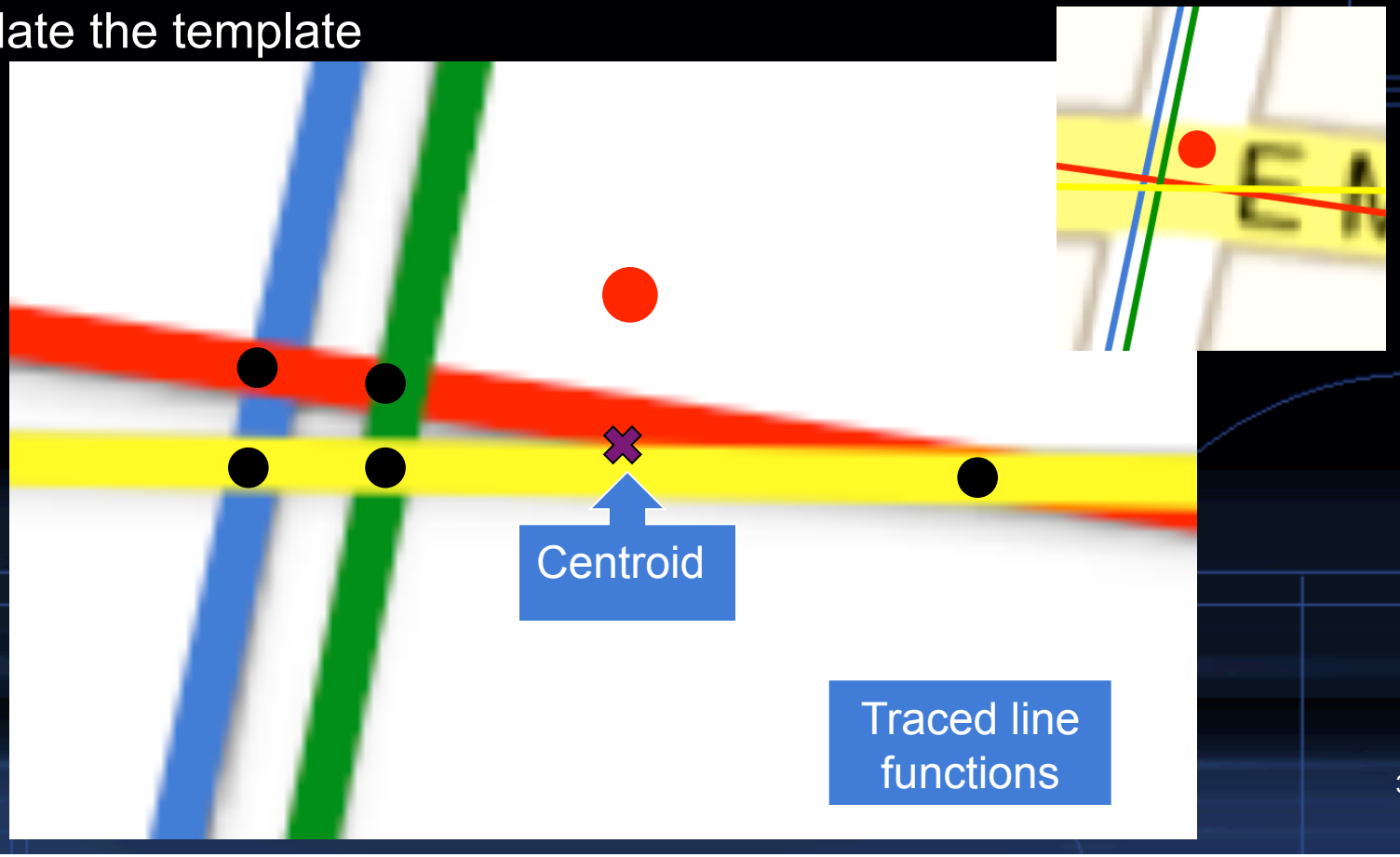
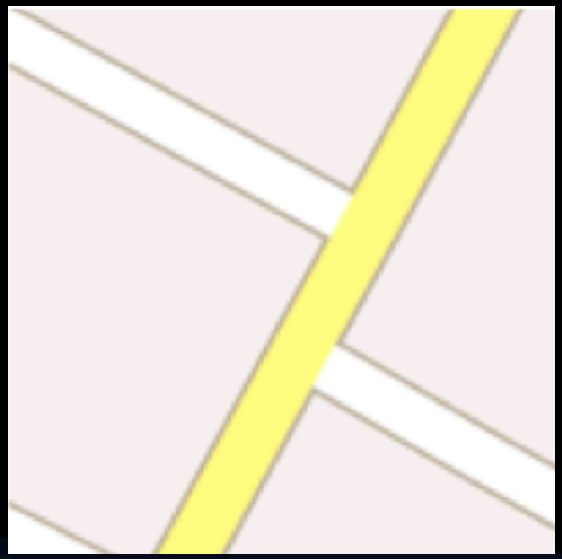
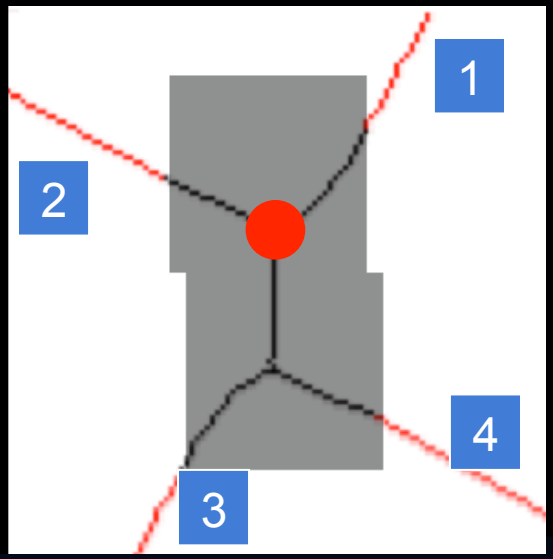


Extract Accurate Road Intersection Templates

- Update road intersection templates
  - Remove outliers and use the centroid of remaining intersections



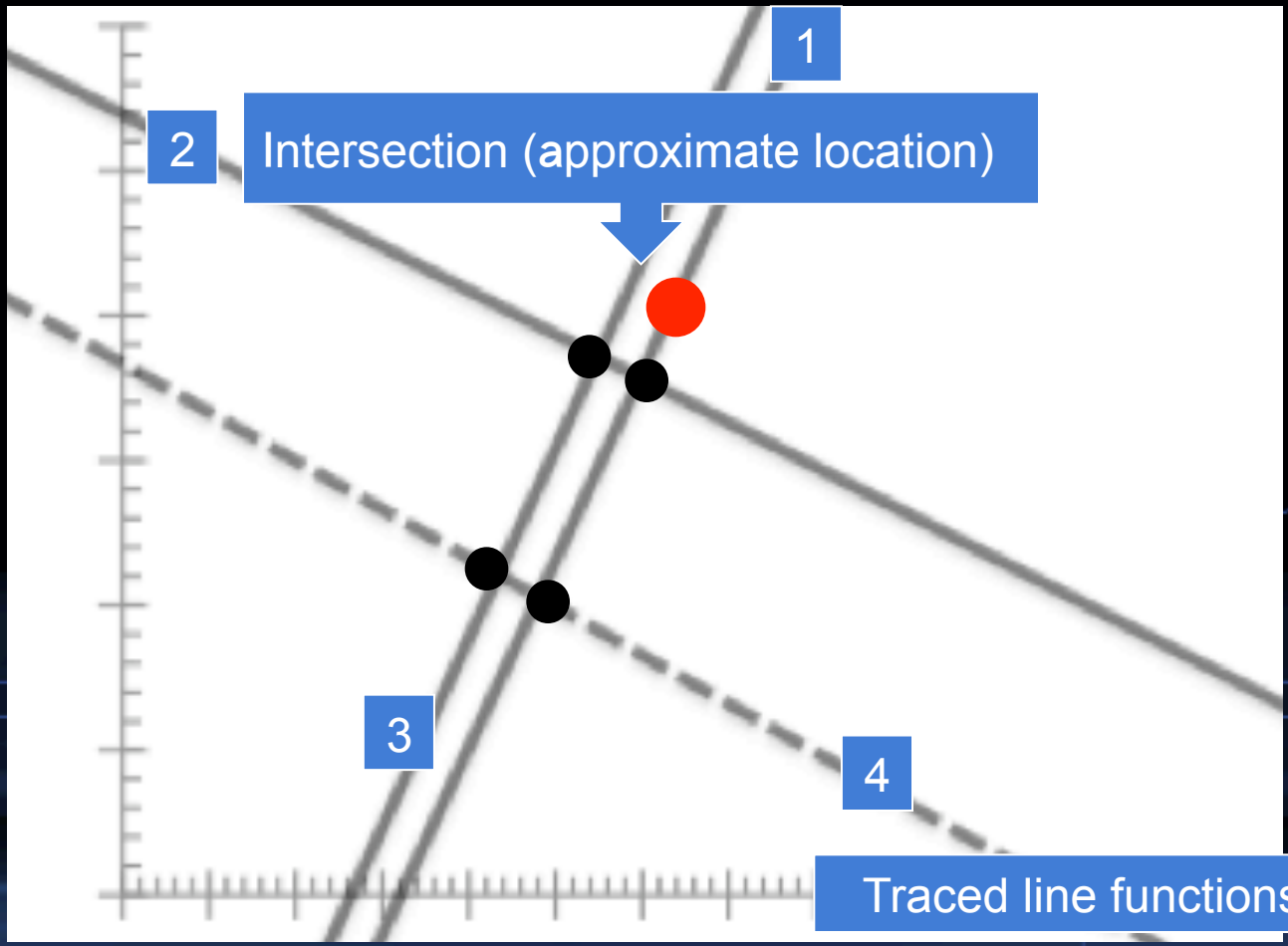
Original map



Blob image intersected with thinned line

Extract Accurate Road Intersection Templates

- Update road intersection templates
  - Remove outliers and use the centroid of remaining intersections



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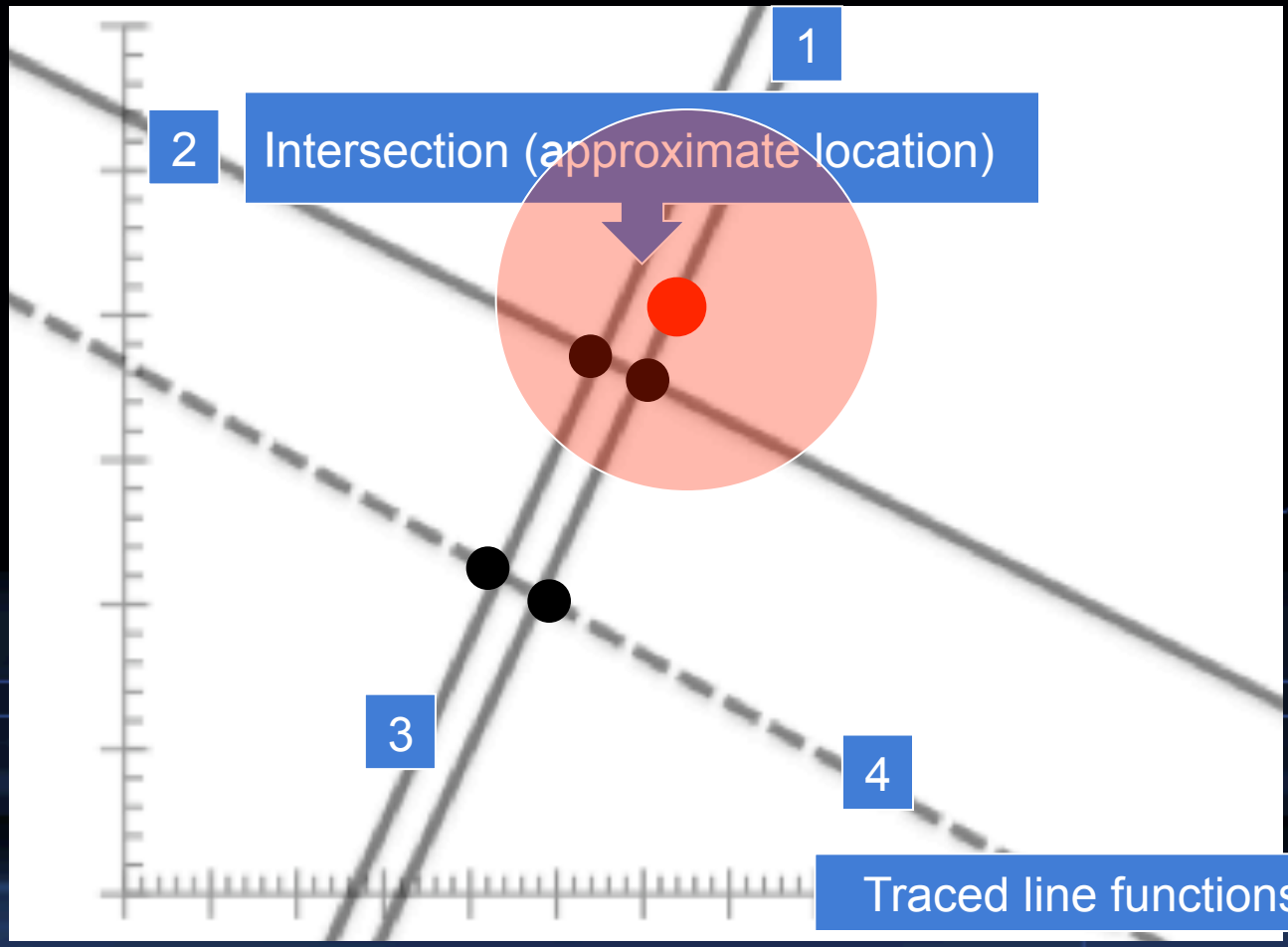

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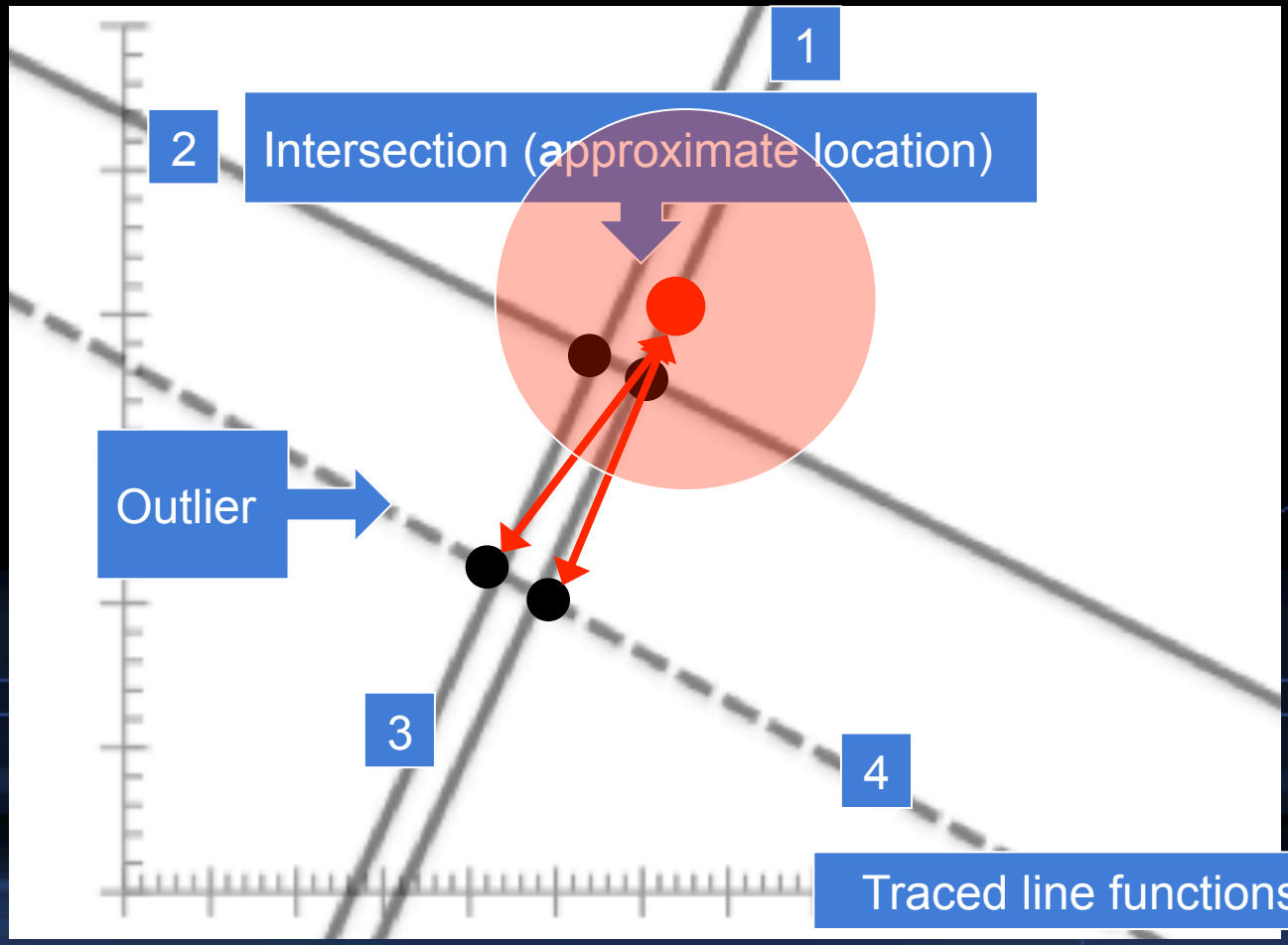

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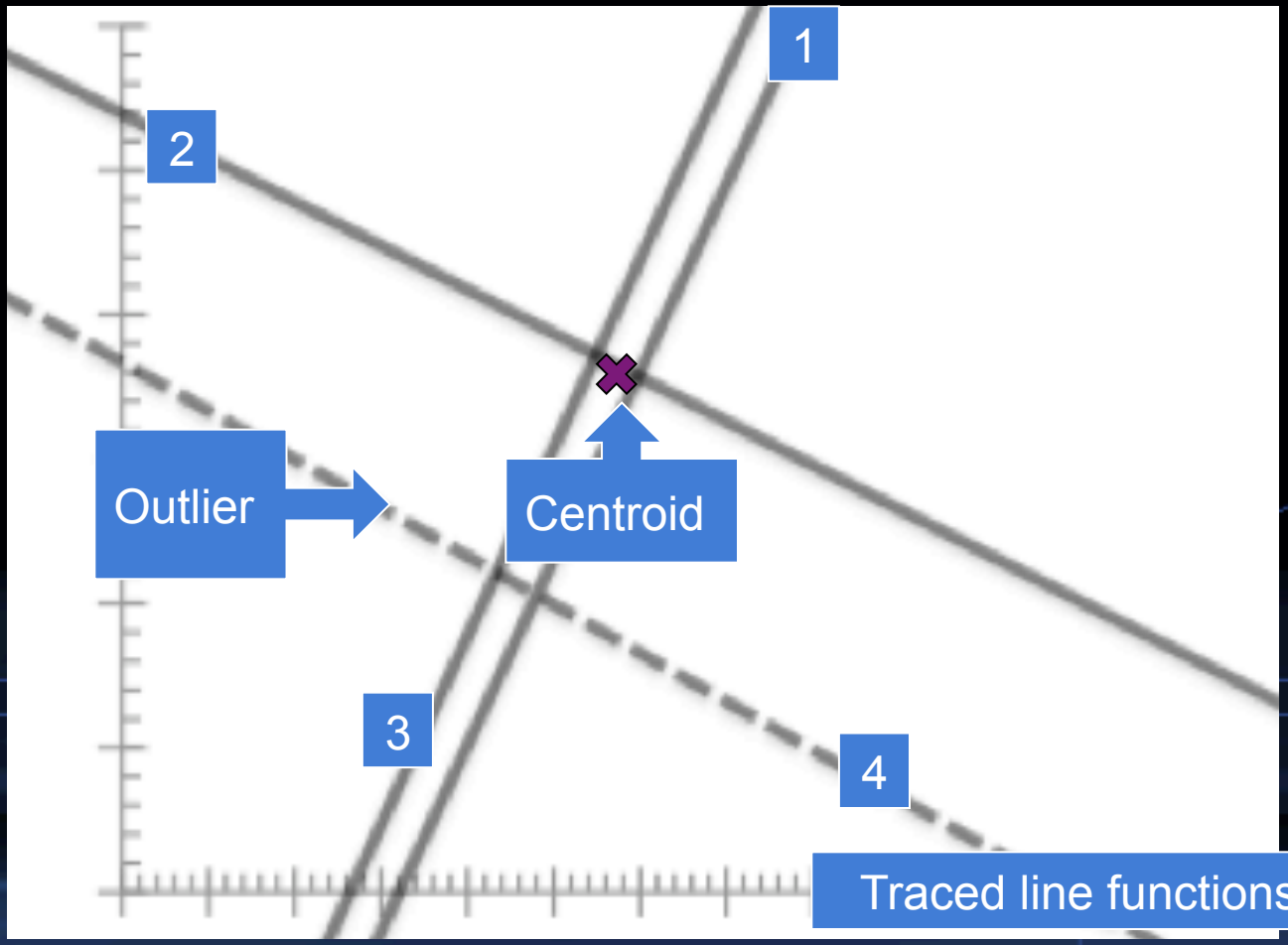
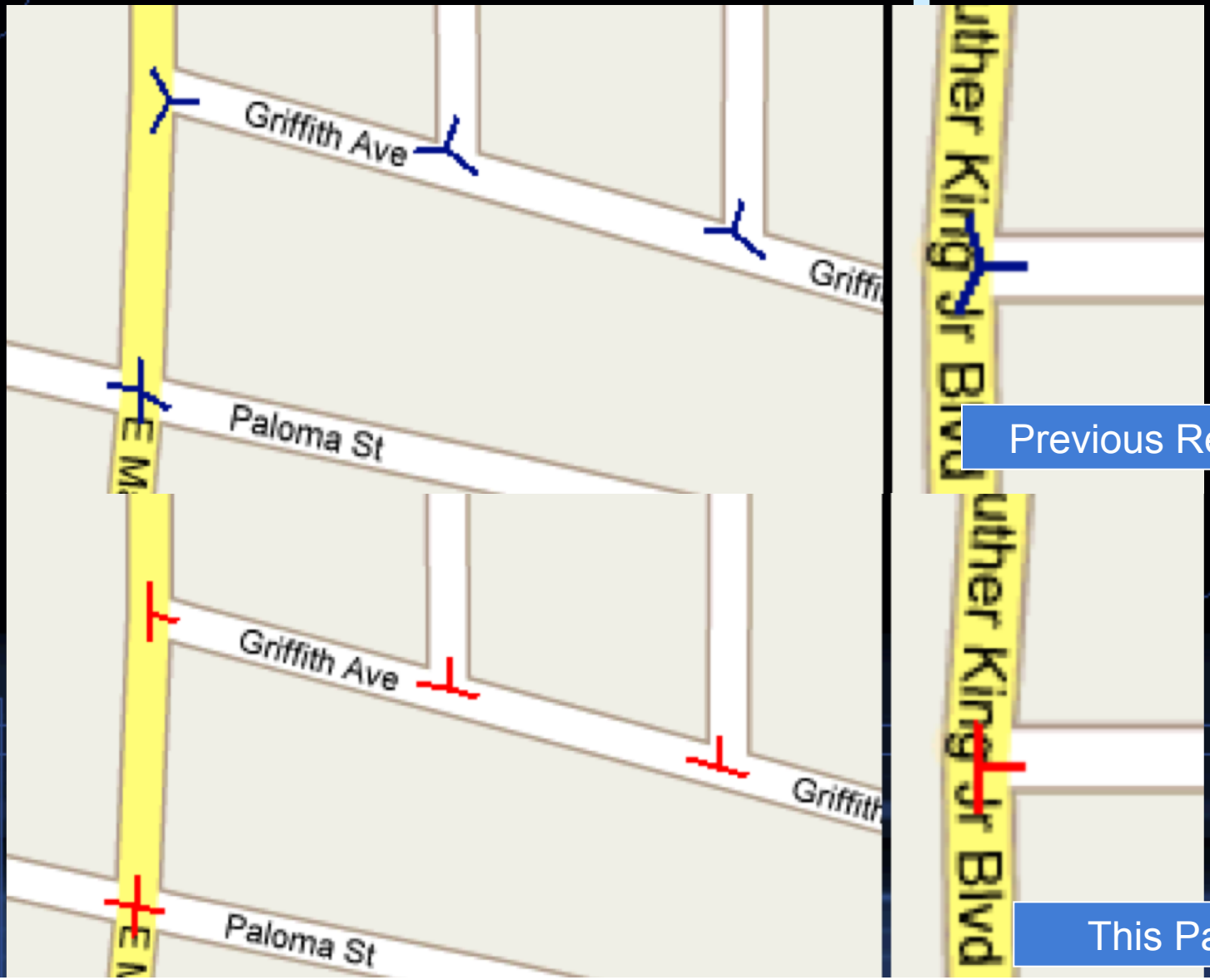


Extract Accurate Road Intersection Templates

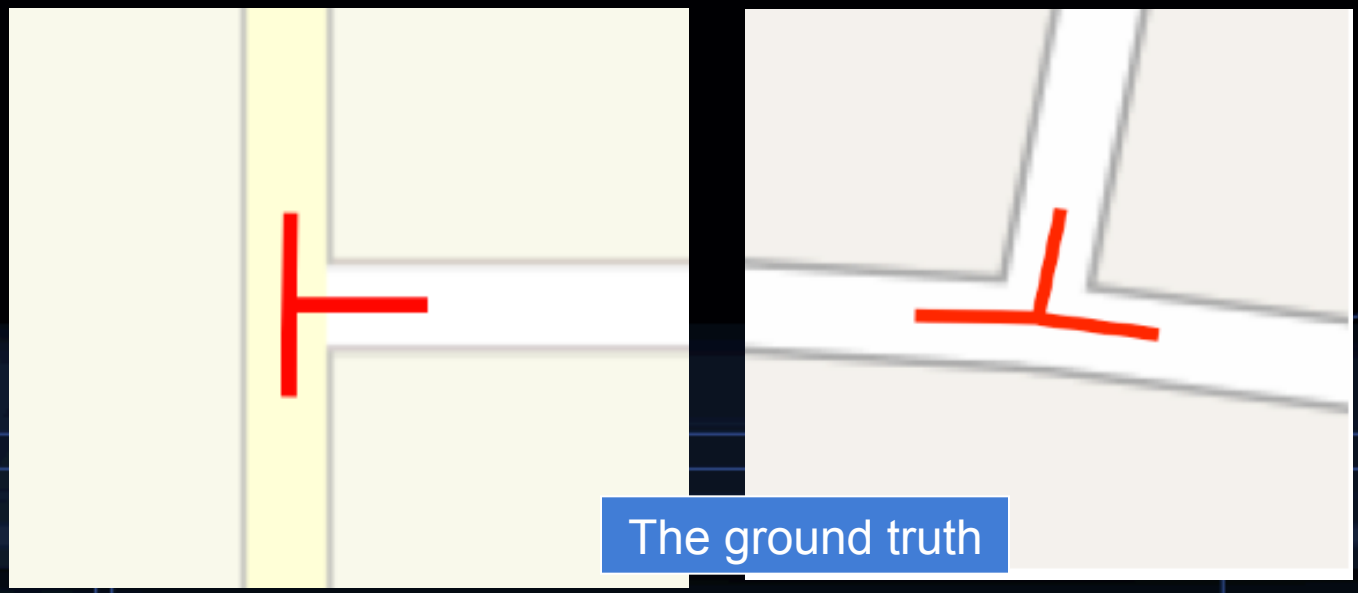


Previous Results

This Paper

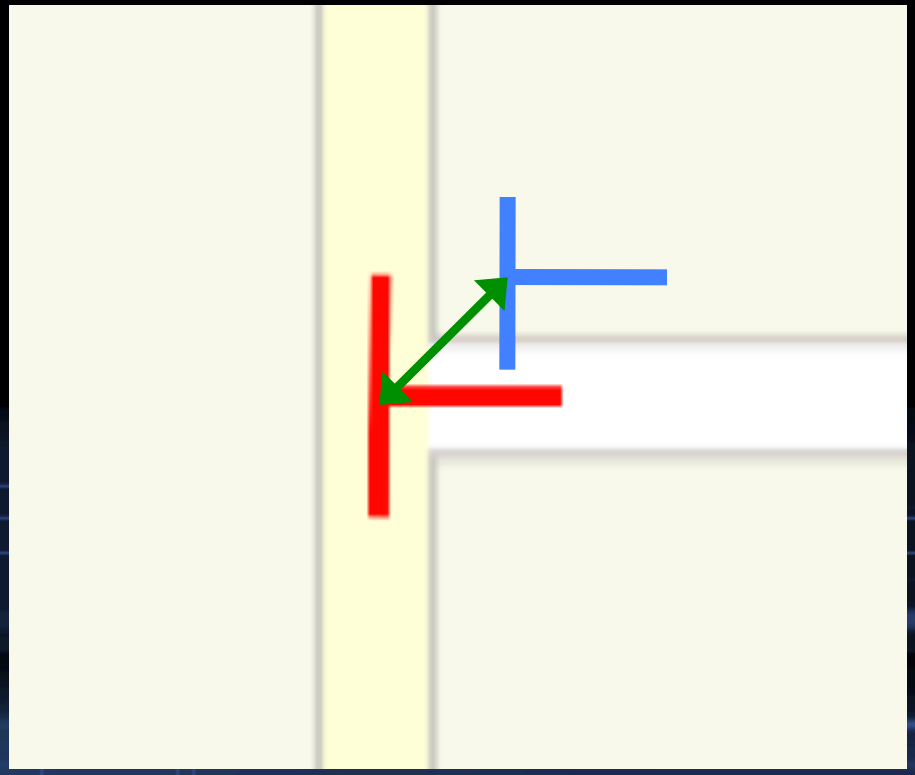
Experiments – Ground truth

- We evaluate 10 raster maps from five different sources
- Manually verify each extracted road intersection templates with the ground truth



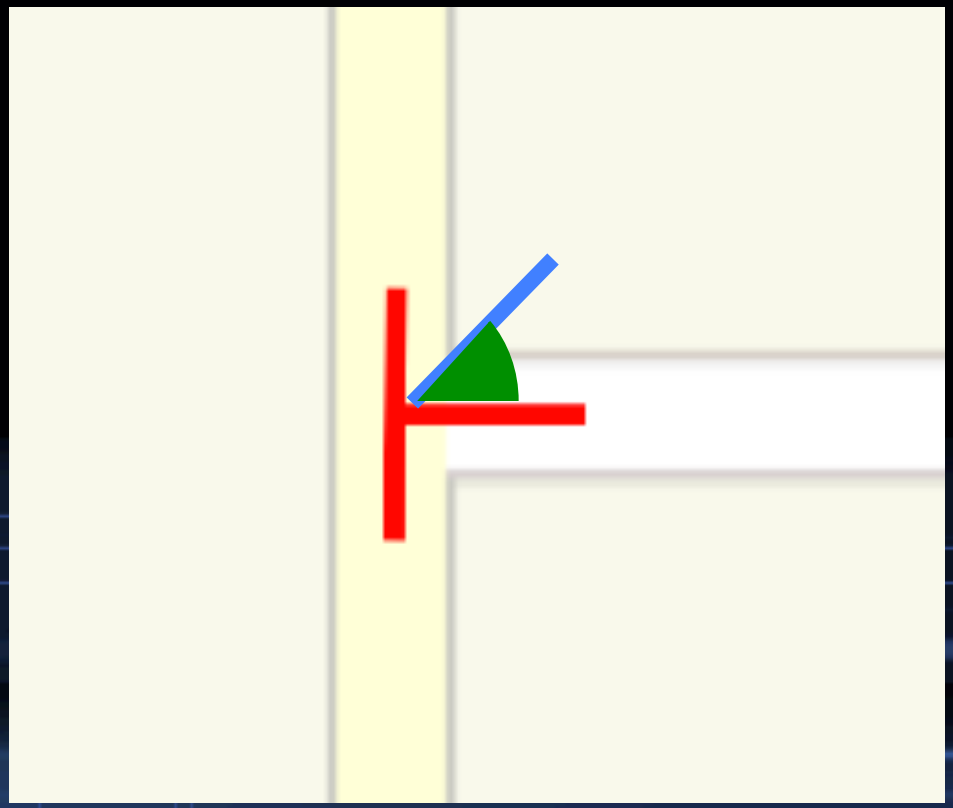
Experiments - Metrics

- Positional offset:
  - The average number of pixels between the extracted road intersection templates and the actual road intersections in the raster maps



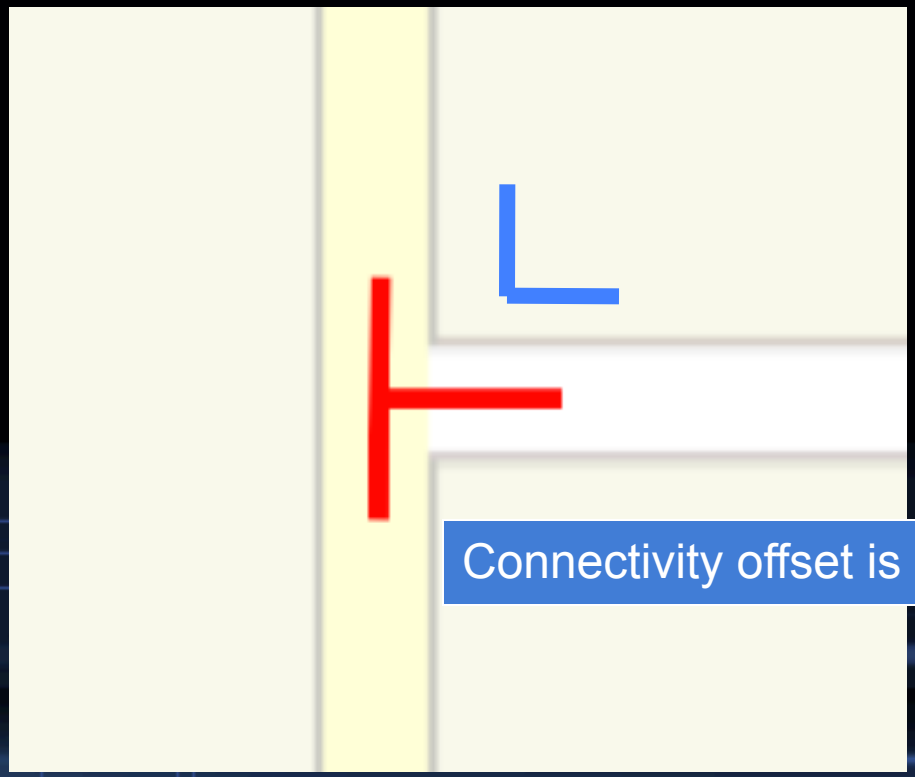
Experiments - Metrics

- Orientation offset:
  - The average number in degrees between the extract road orientations and the actual road orientations.



Experiments - Metrics

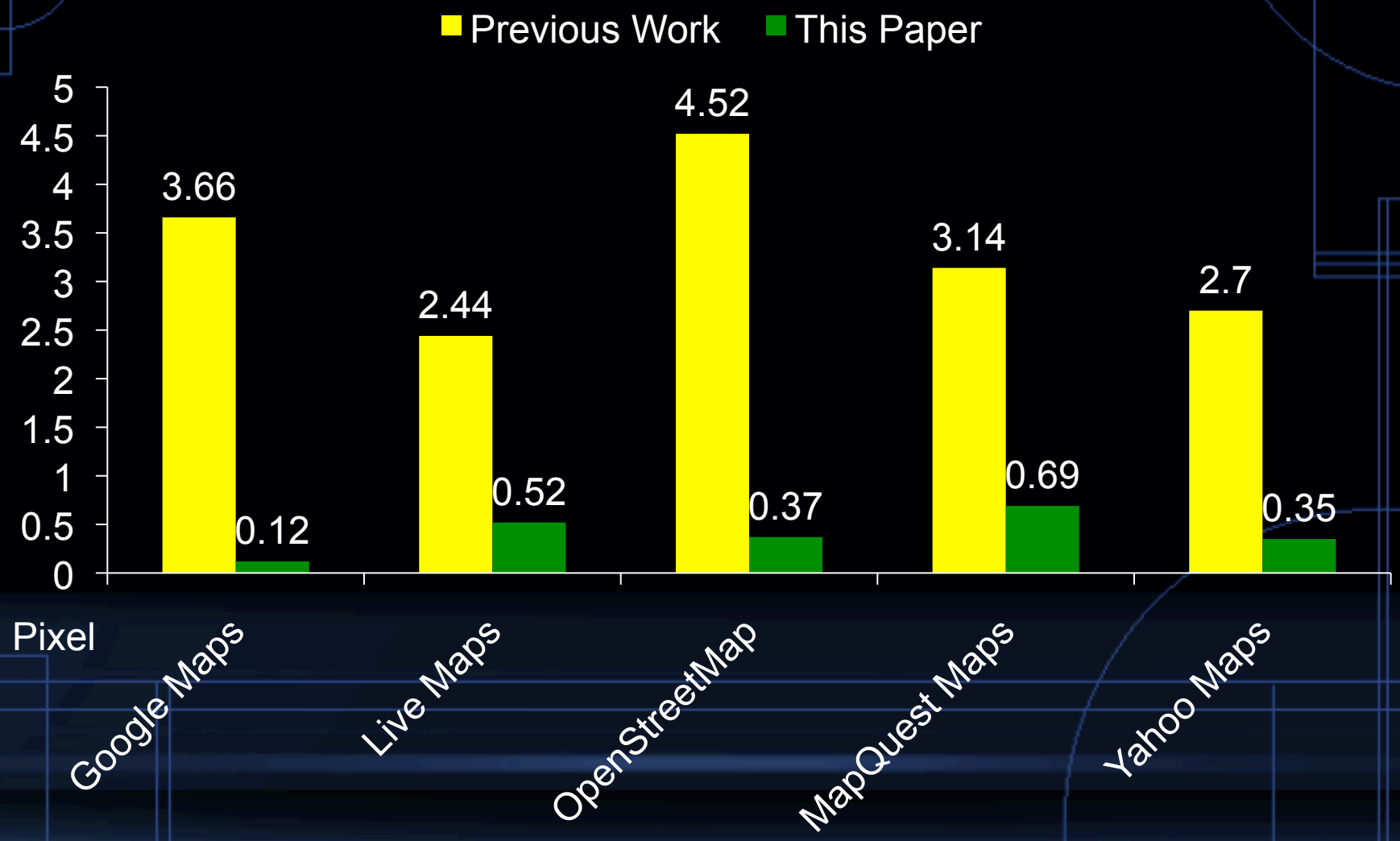
- The connectivity offset:
  - The total number of missed road lines.



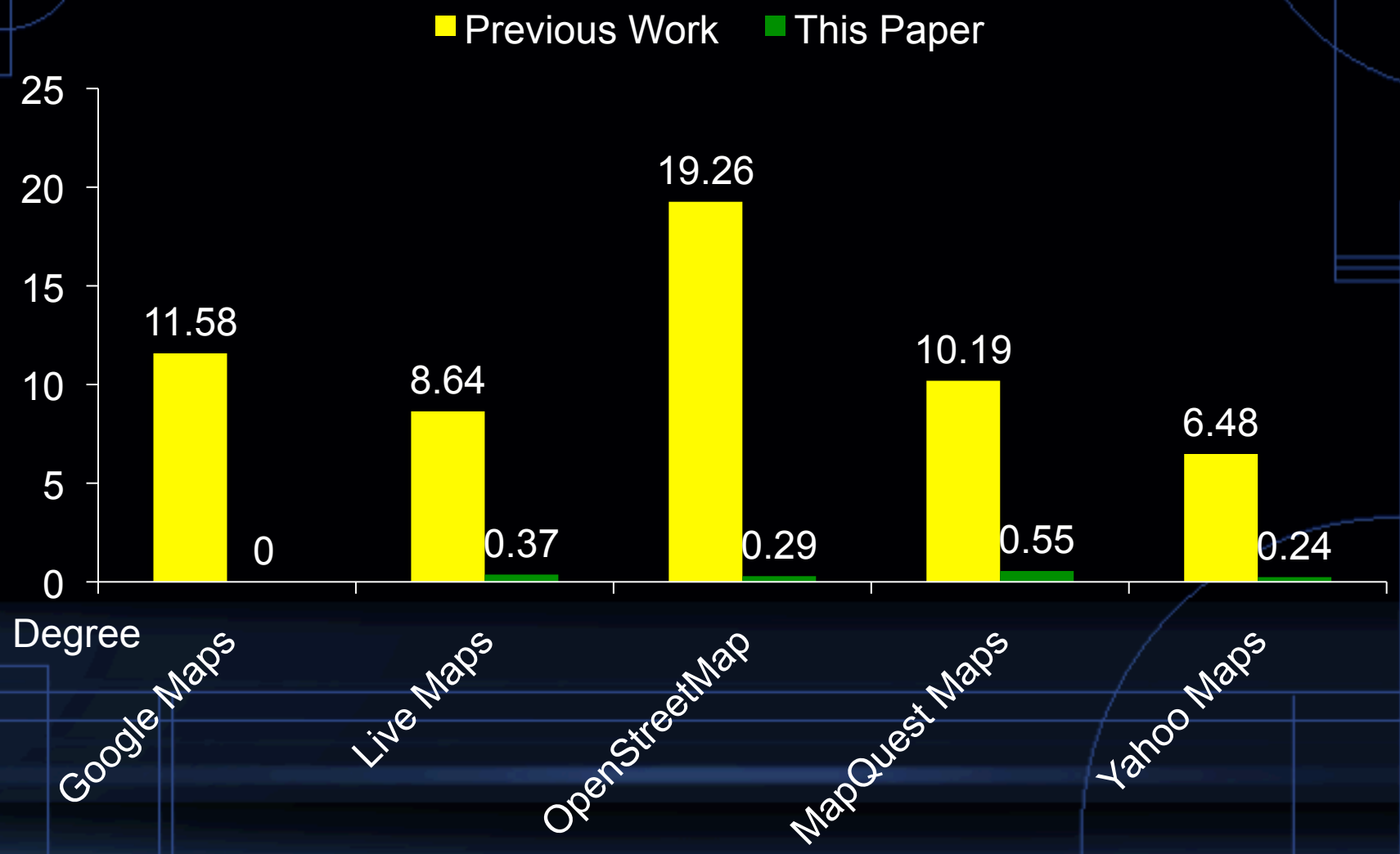
Experimental Results

- Extracted139 road intersection templates with 438 lines from 10 test maps
- The average positional offset:
  - 0.4 pixels
- The average orientation offset:
  - 0.24 degrees
- Extracted road intersection templates are very close to the ground truth
- The connectivity offset:
  - We missed 13 lines from a total of 451 lines – 97% of the lines are extracted
  - Lines that do not have accurate orientations were discarded

Positional Offset Compared to Previous Work



Orientation Offset Compared to Previous Work



Related Work

- Localized Template Matching to improve the positional offset (Chiang et al. 08)
  - The templates used for matching are not accurate
- Cluster corner points to extract road intersections (Habib and Uebbing 99)
  - Cannot extract accurate intersection templates
- Geometrical analyses to extract lines (Cao et al. 02 and Li et al. 00)
  - Do not extract intersection templates
- Color segmentation to extract lines (Khotanzad and Zink 03; Chen et al. 06)
  - Do not extract intersection templates

Discussion

- Our technique automatically extracts accurate road intersection templates from raster maps.
  - Average positional offset: 0.4 pixels
  - Average orientation offset: 0.24 degrees
- Accurate road intersection templates help to:
  - Reduce searching space for map conflation application
  - Use the intersection templates as seed points to extract road from imagery
  - More…

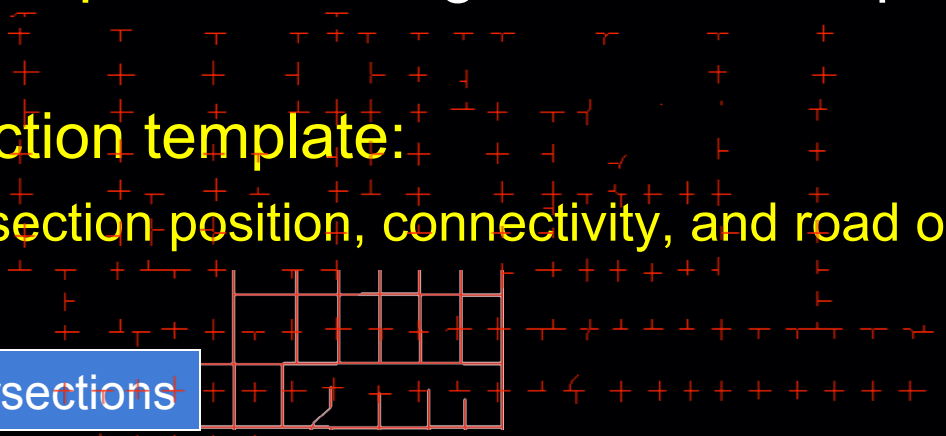
Future Work

- Include manual training to extract more information from raster maps
  - Labels, landmarks
- Include manual training to process more complex maps
  - A metro map with different types of lines
- Identify the training process that minimizes human intervention
- Reuse the training results on similar maps

Thank You

Introduction

- In our previous work [Chen et al. 2008], we extract the road intersection templates to integrate raster maps with imagery
- Road intersection template:
  - Road intersection position, connectivity, and road orientation



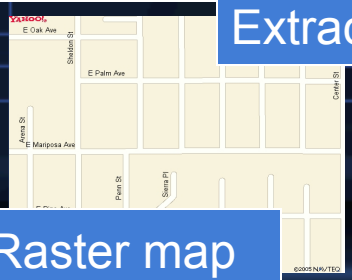
Extract Intersections

Extract Intersections

Satellite Imagery

Vector data

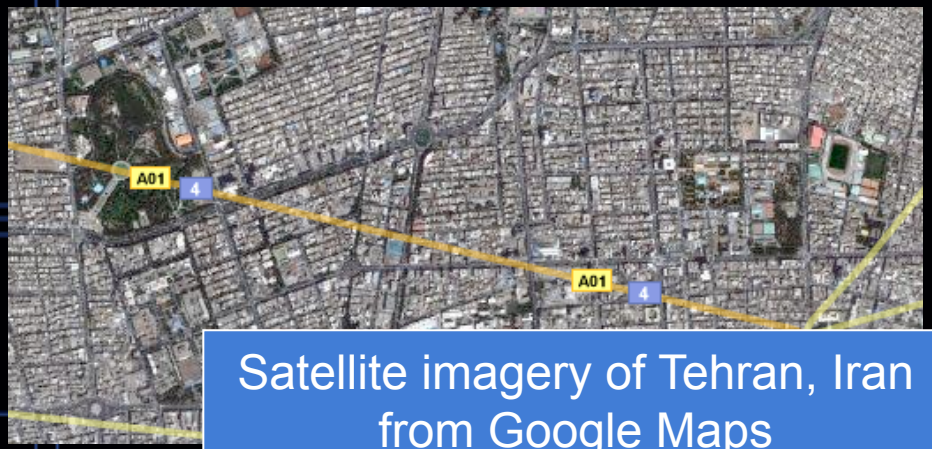
Extract Intersections



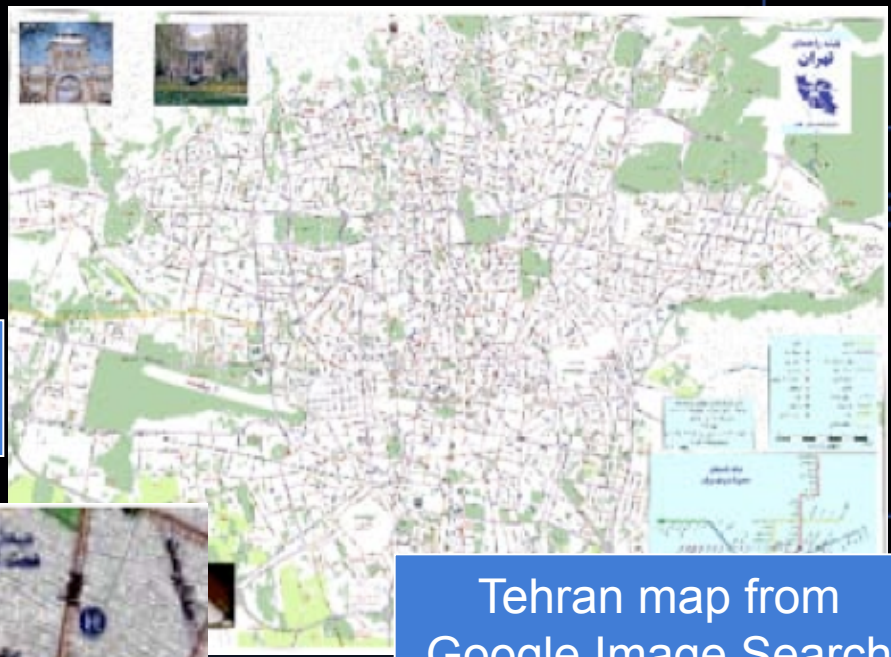
Raster map

Introduction

- Label the imagery with features on the map



Satellite imagery of Tehran, Iran from Google Maps

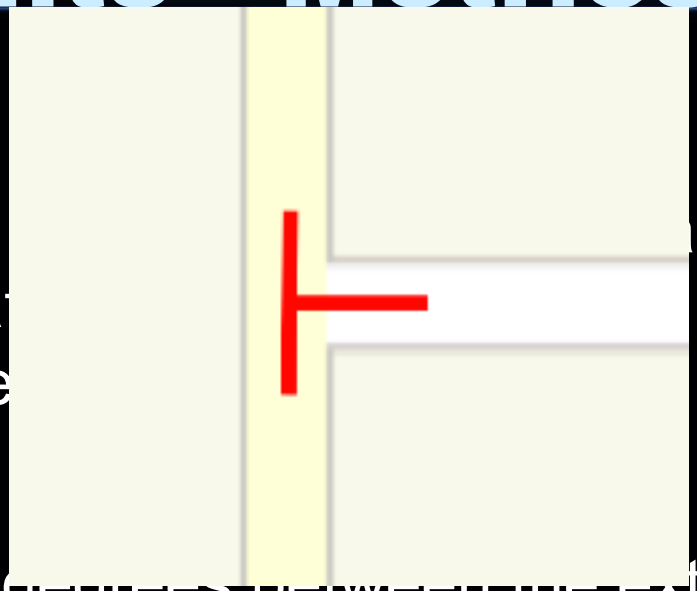


Tehran map from Google Image Search

Align the map with the satellite imagery

Introduction

- Use the intersection templates as seed points to extract road from imagery

Experiments - Metrics

- Positional offset:
  - The average number of …cted road intersection templa… intersections in the raste…
- Orientation offset:
  - The average number in degrees between the extract road orientations and the actual road orientations.
- The connectivity offset:
  - The total number of missed road lines.