Automatic Alignment of Vector Data and Orthoimagery for The National Map

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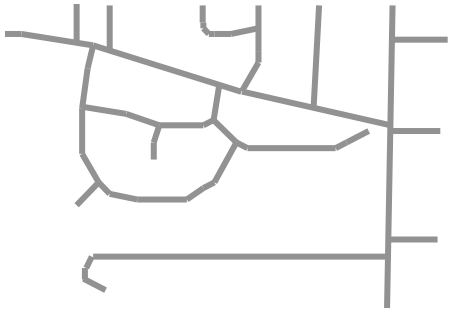
Outline

- Introduction & Motivation
  - The National Map
- Our Approach to align vector and imagery
  - Approach overview
  - Improvements over our previous approach
- Related Work
- Conclusion and Future Work

Introduction

- Geospatial data sources have become widely available
- Automatically and accurately integrating and aligning two spatial datasets is a challenging problem



Road network (in vector format)

Orthoimagery (in raster format)

Street maps (in raster format)

Motivation: Vector and Imagery Integration

- Challenges
  - Different projections, accuracy levels, resolutions result in spatial inconsistencies

Motivation: The National Map

- The National Map is a government effort to make geospatial data available for 133 urban areas of the US for Homeland Security
- Purpose is to make these integrated datasets available to government organizations to support crisis response and emergency planning, etc.
- There are no automated techniques for aligning vector data with orthoimagery and this is a very labor intensive task.

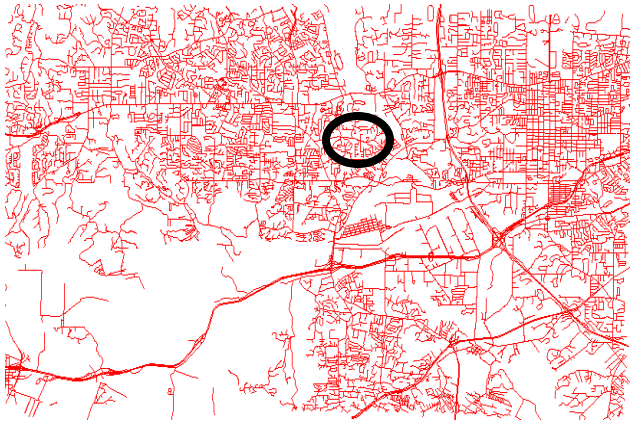
Motivation: The state of the art

- Traditionally, the problems of vector-imagery and map-imagery alignment have been in the domain of GIS and Computer Vision
- In GIS literature
  - The alignments were previously performed manually
    - Commercial products: *ESEA MapMerger* ESRI ArcView; *Able R2V*; *Intergraph I/RASC*
- In Computer Vision literature
  - Alignment was performed automatically based on image processing techniques
    - Often required significant CPU time
    - Accuracy quite poor

The example

- The Data Sets (for the National Map)
  - USGS high resolution color imagery
  - Road vector data from DOT, MO

Road network



USGS 0.3m/p color imagery

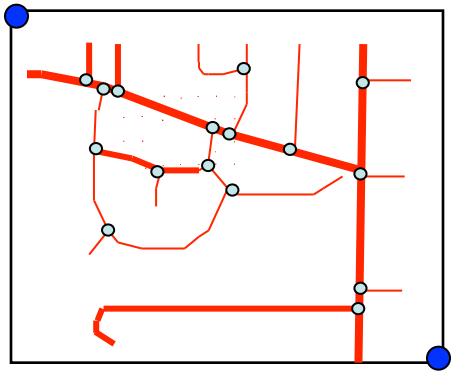
They are misaligned, and there is no global transformation

The Vector-Imagery conflation approach

Lat / Long

Lat / Long

Lat / Long



Lat / Long

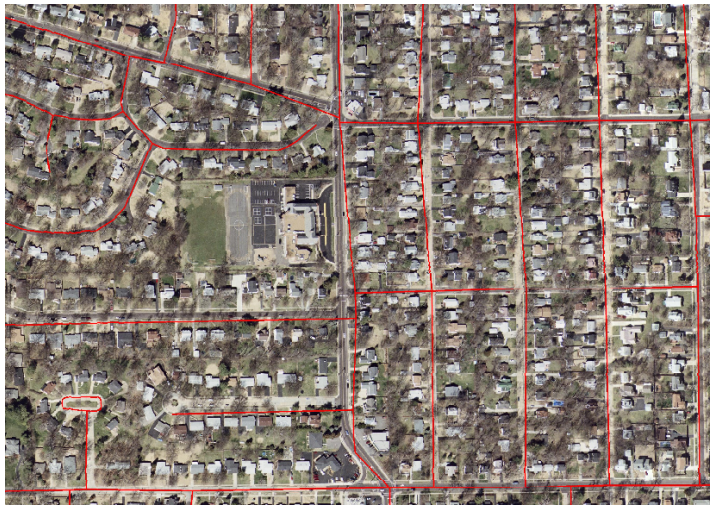
Control Point Detection

Intermediate control points

Filtering Technique

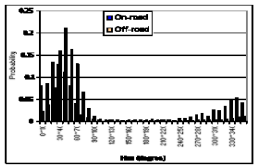
Final control points

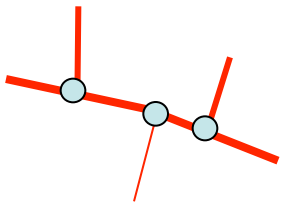
Triangulation and Rubber-Sheeting

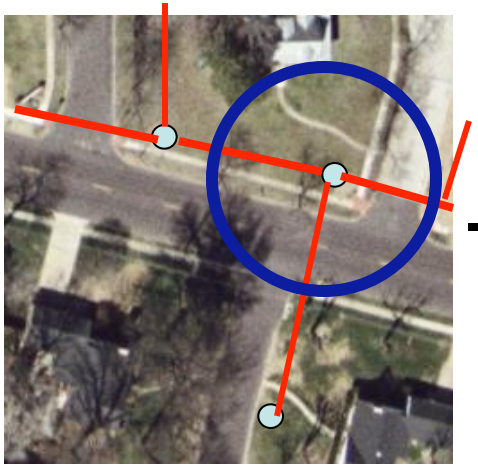


Finding Control Points Using Localized Template Matching

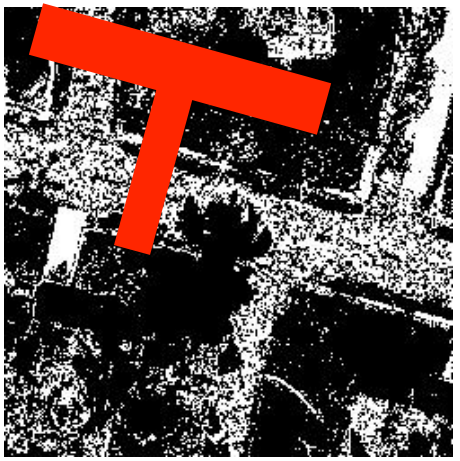
Learned color distribution
for road/off road pixels

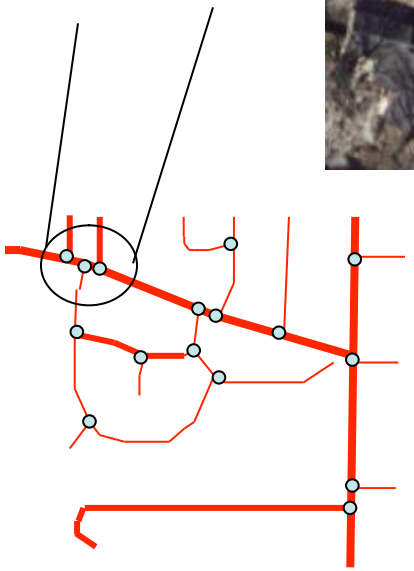






Road classification





road width and road directions

road width and road directions

Matching by Correlation

Finding Control Points Using Localized Template Matching

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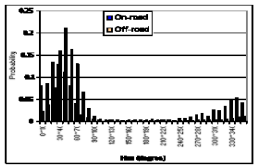

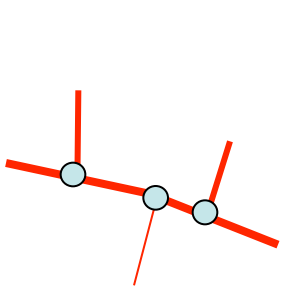

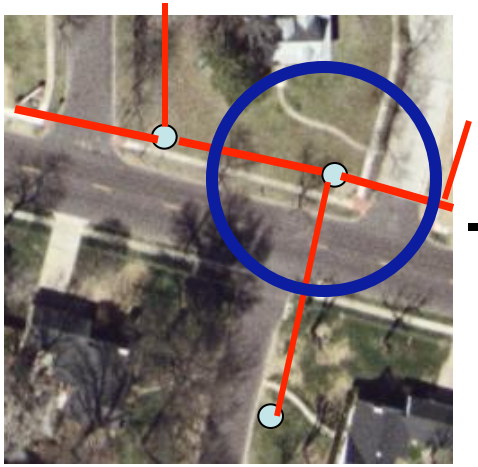

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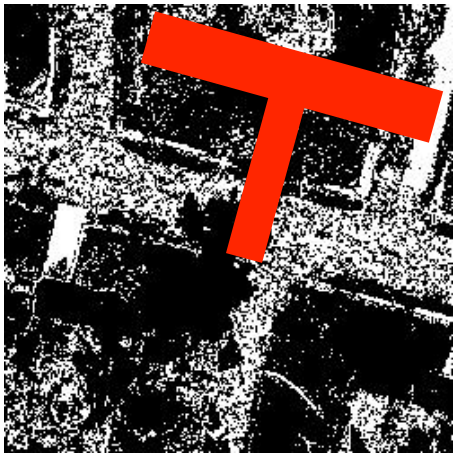

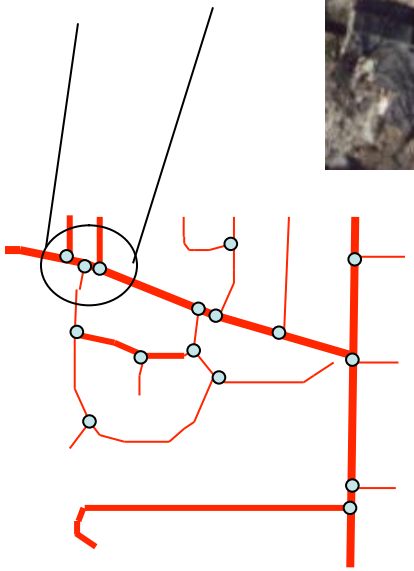

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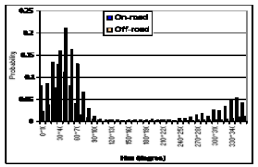

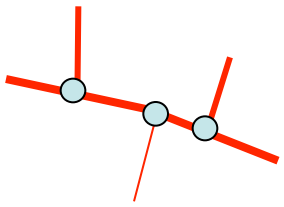

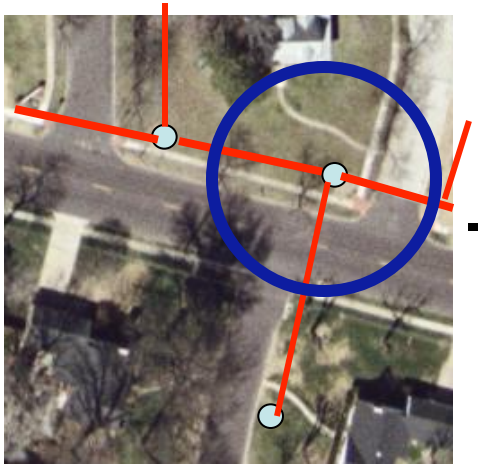

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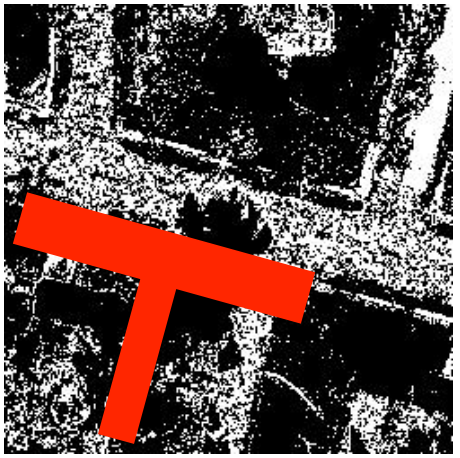

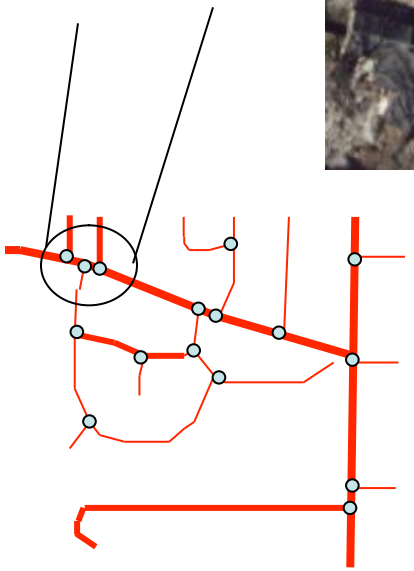

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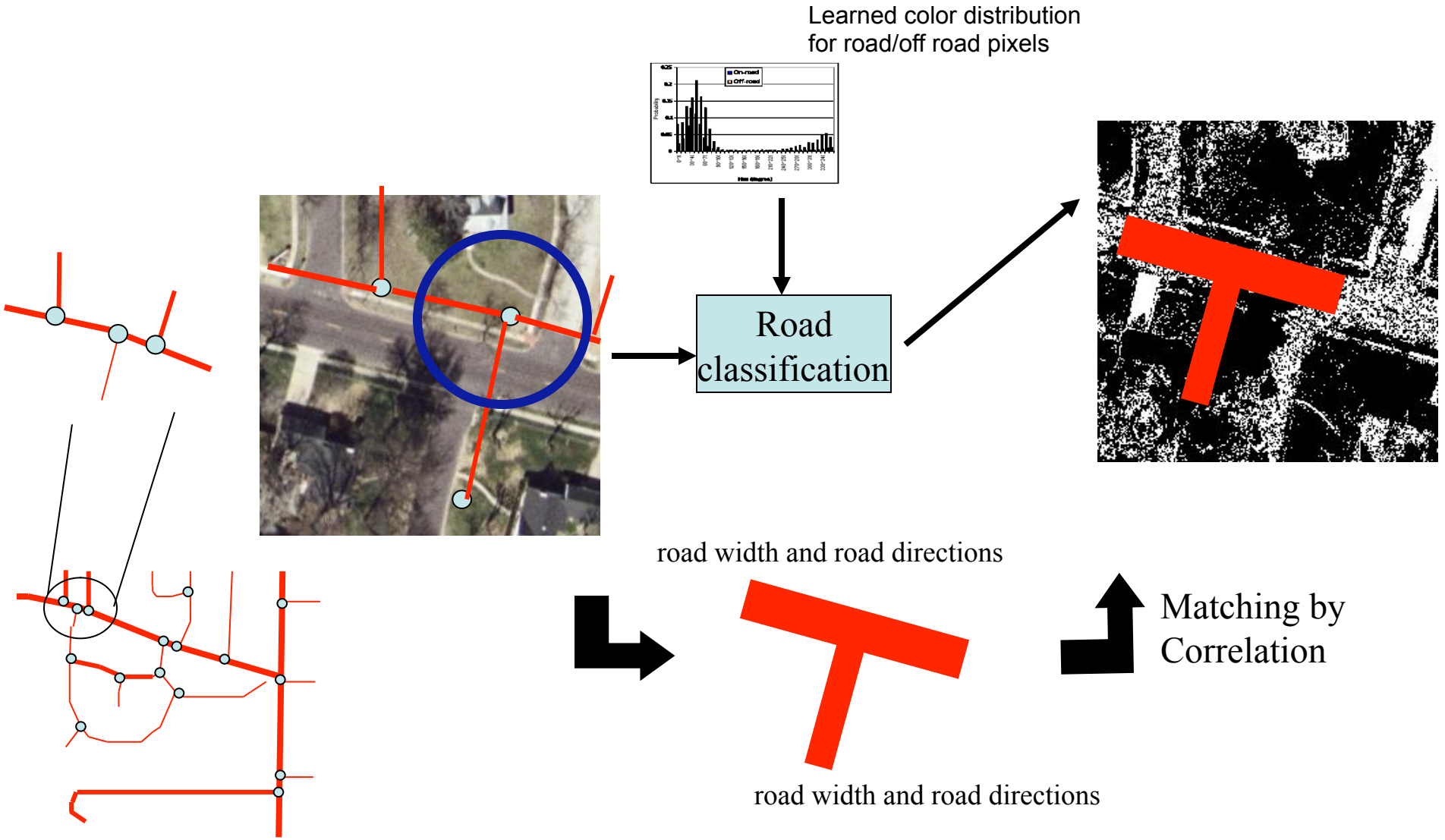

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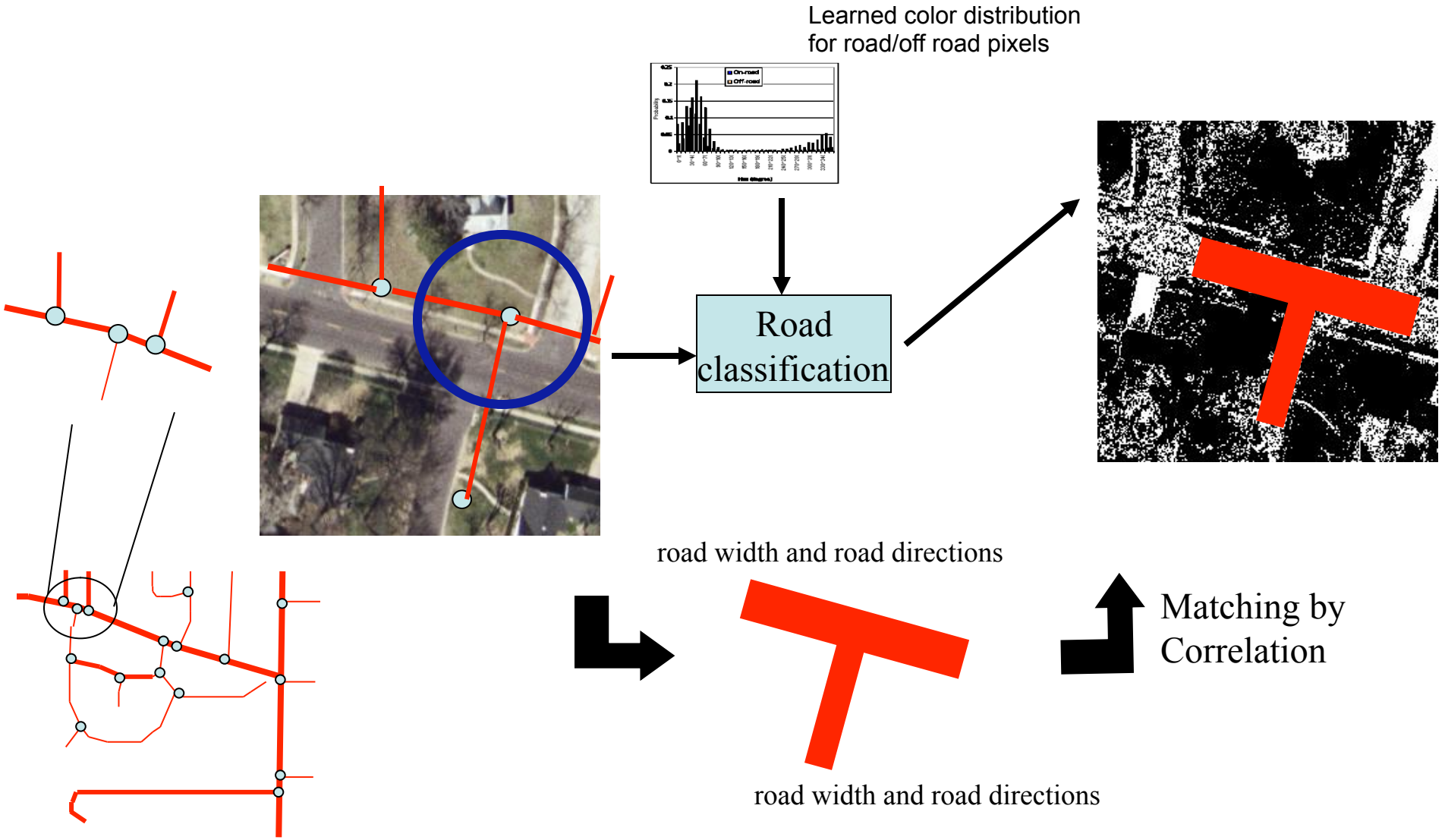
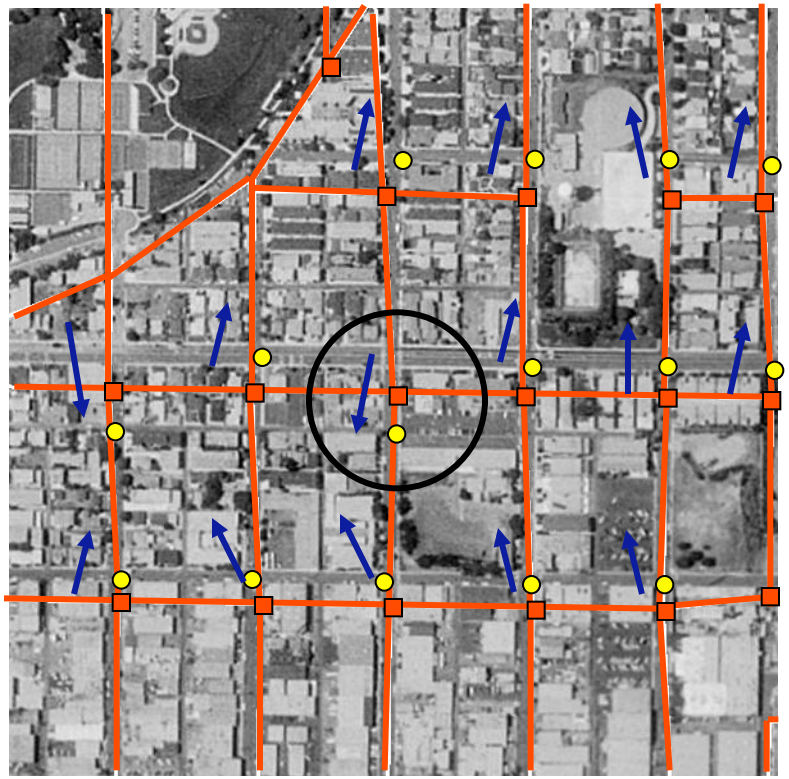
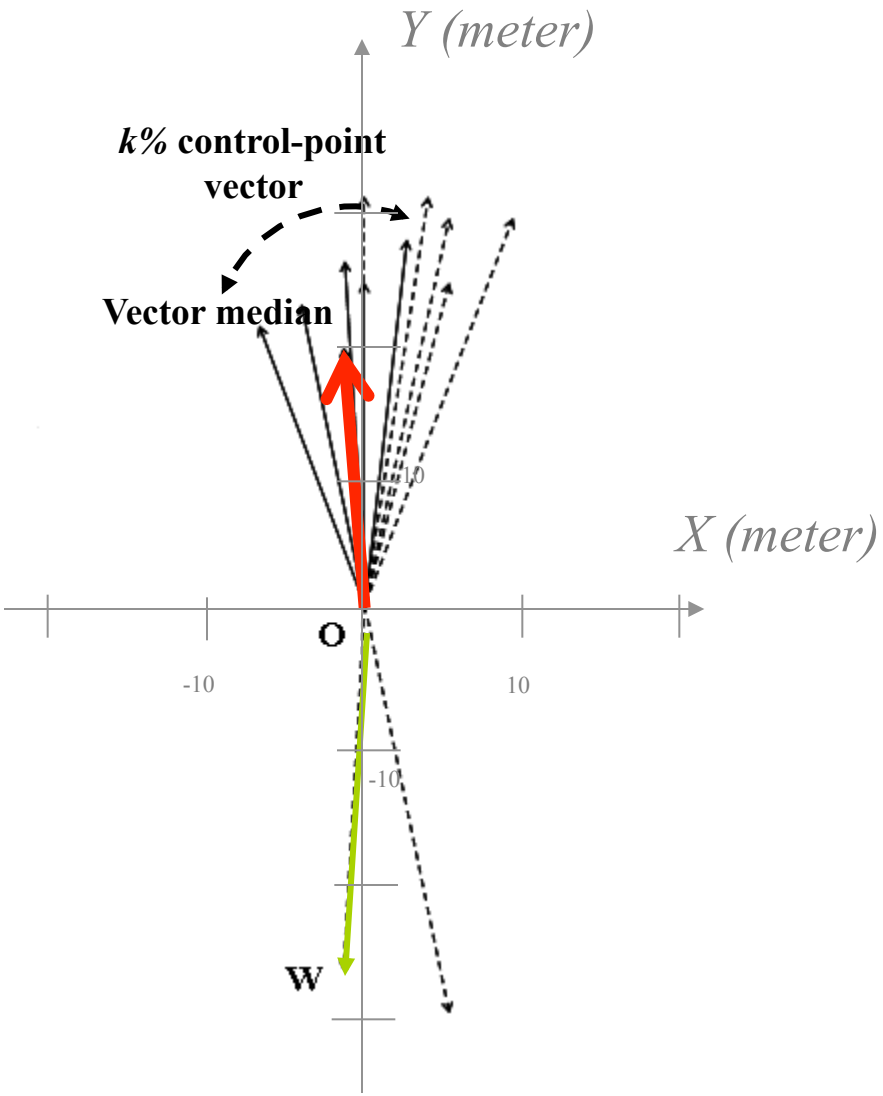


Filtering Control Points Using Vector Median Filter (VMF)

- View the control point pair displacement as vector
- Using a fixed ratio (*k*%) to keep control point pairs that have similar displacement as the median one

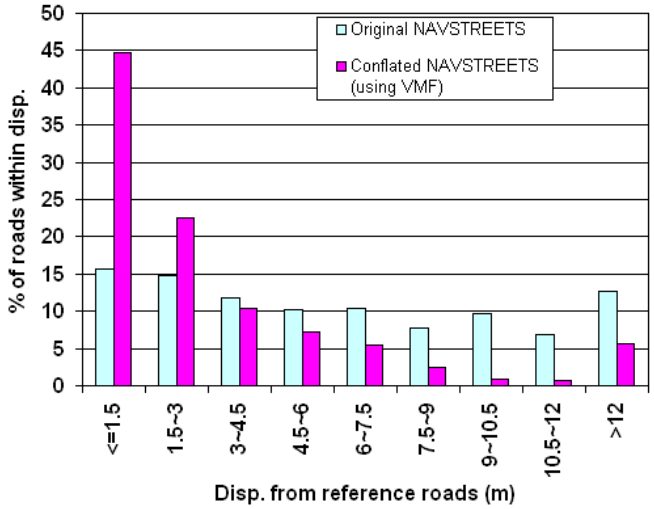




Results: NAVSTREETS + High-res Image

	Original NAVSTREETS	Conflated NAVSTREETS
Completeness	44.9 %	74.4 %
Correctness	47.9 %	85 %

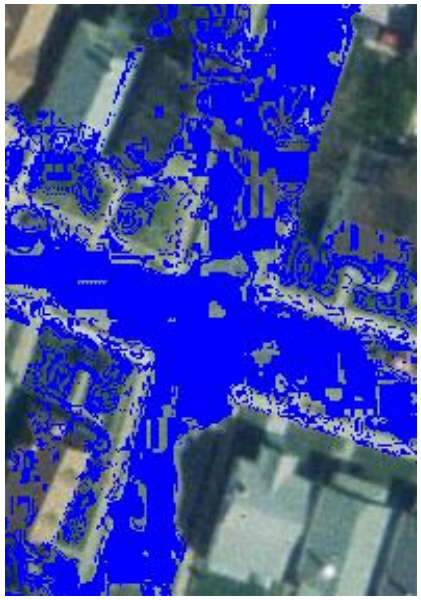
Positional Accuracy



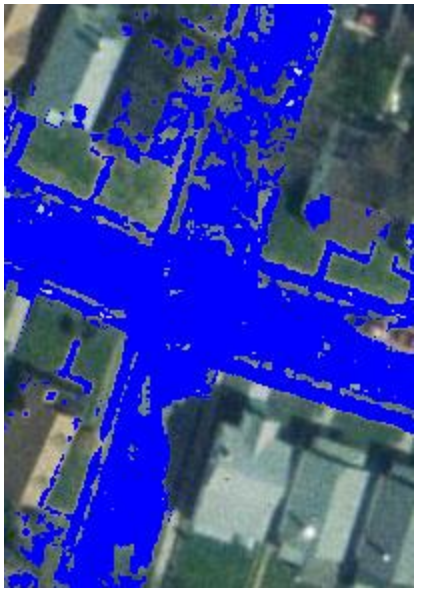
Road Classification Used in Localized Template Matching

- Before: Bayes classifier based on Hue component of learned road/off-road pixels
- Improved: Support Vector Machine (SVM) classifier based on all color channels (R,G,B) of learned road/off-road pixels
  - Much fewer “false positives” and more “true positives”

Original imagery



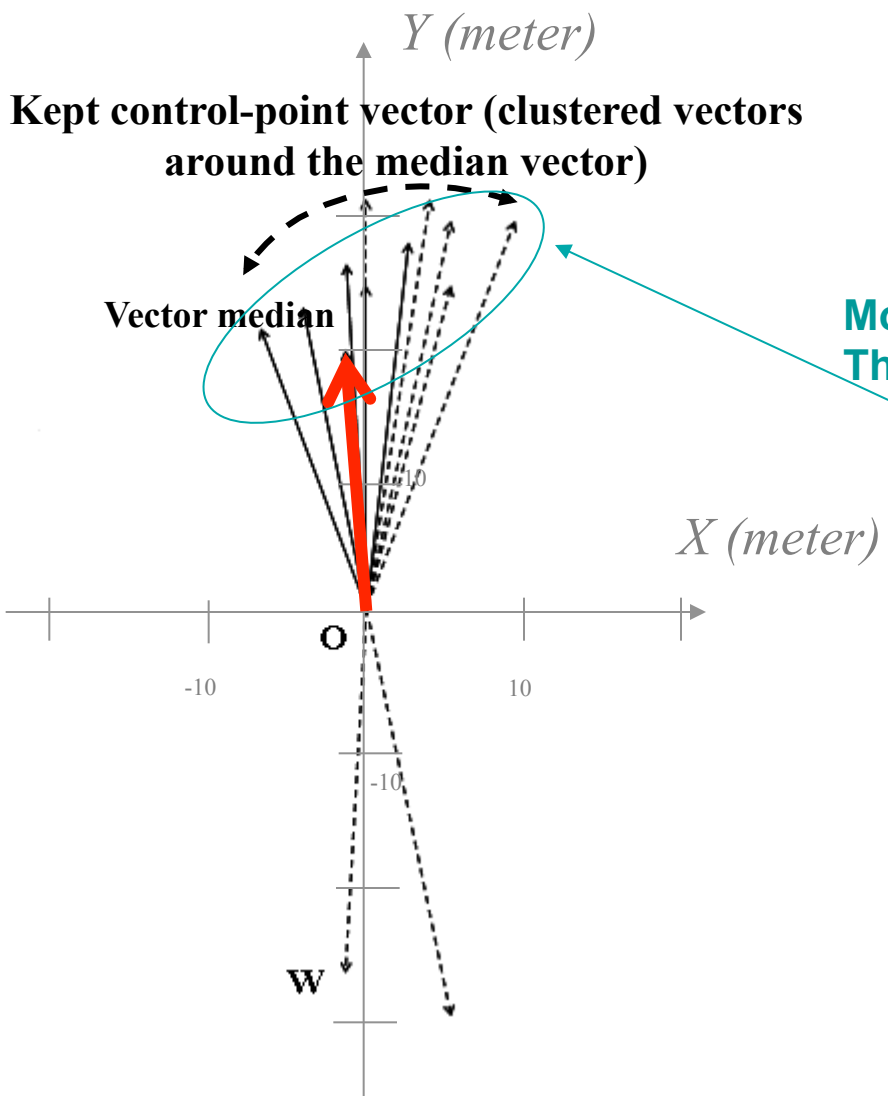
Road-classified pixels based on Bayes classifier



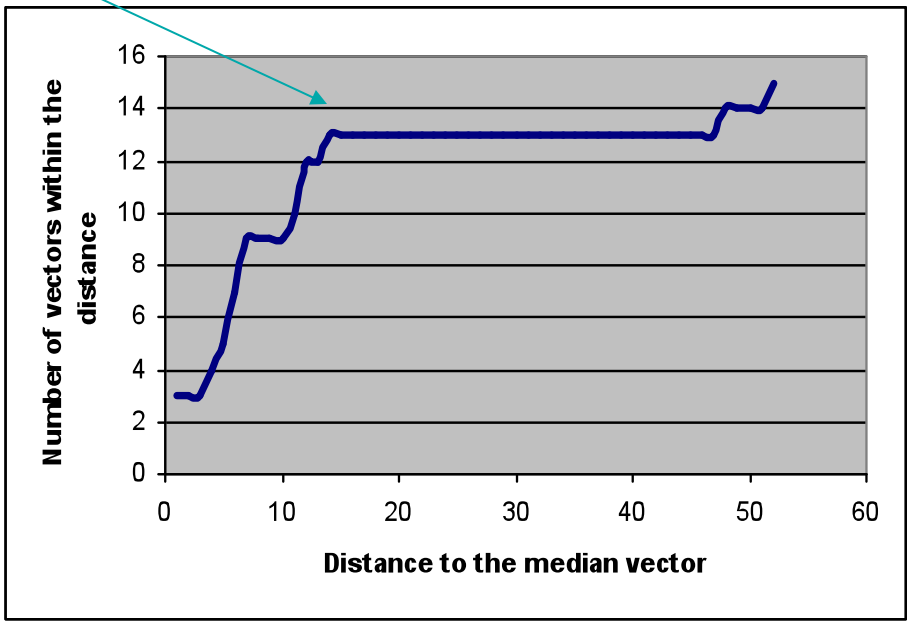
Road-classified pixels based on SVM classifier

Filtering Control Points Using Vector Median Filter (VMF)

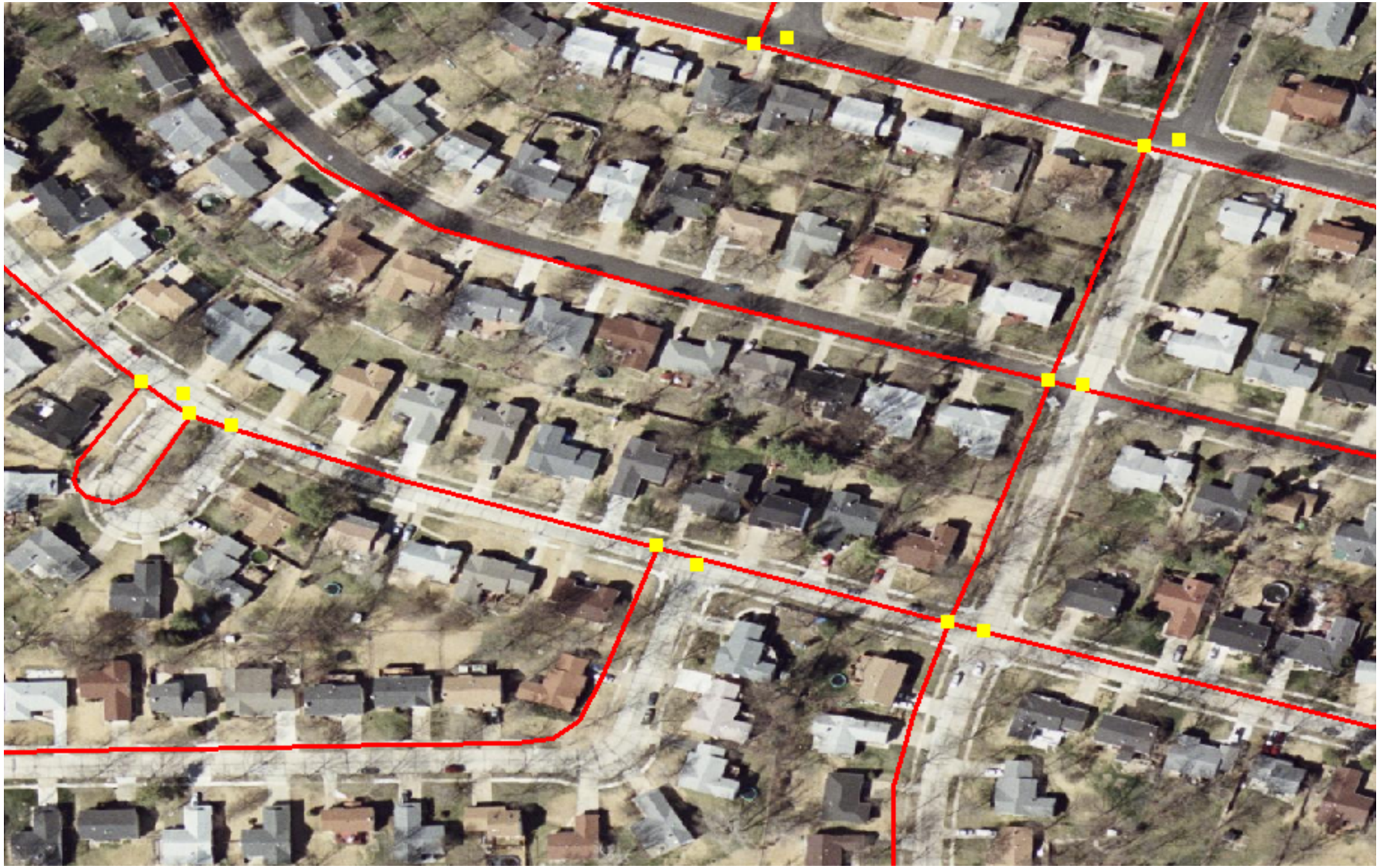
- Improved: Dynamic determine the ratio
  - Investigate the cluster around the median vector
  - Accommodate more control point pairs



Most of the vectors are close to the median vector. This forms a cluster around the median vector



The Vector-Imagery conflation approach: Triangulation and RubberSheeting

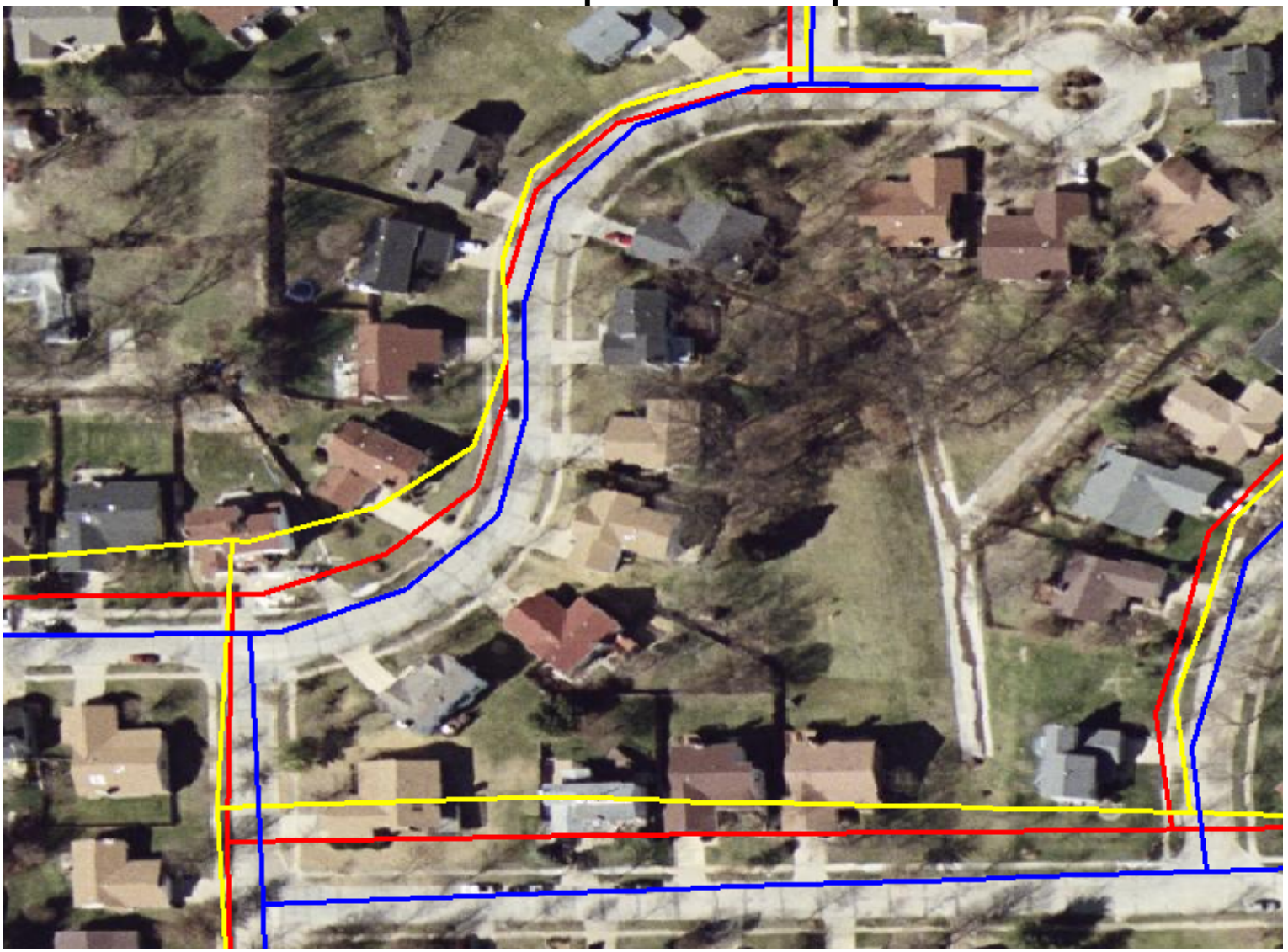


The Vector-Imagery conflation approach: Triangulation and RubberSheeting

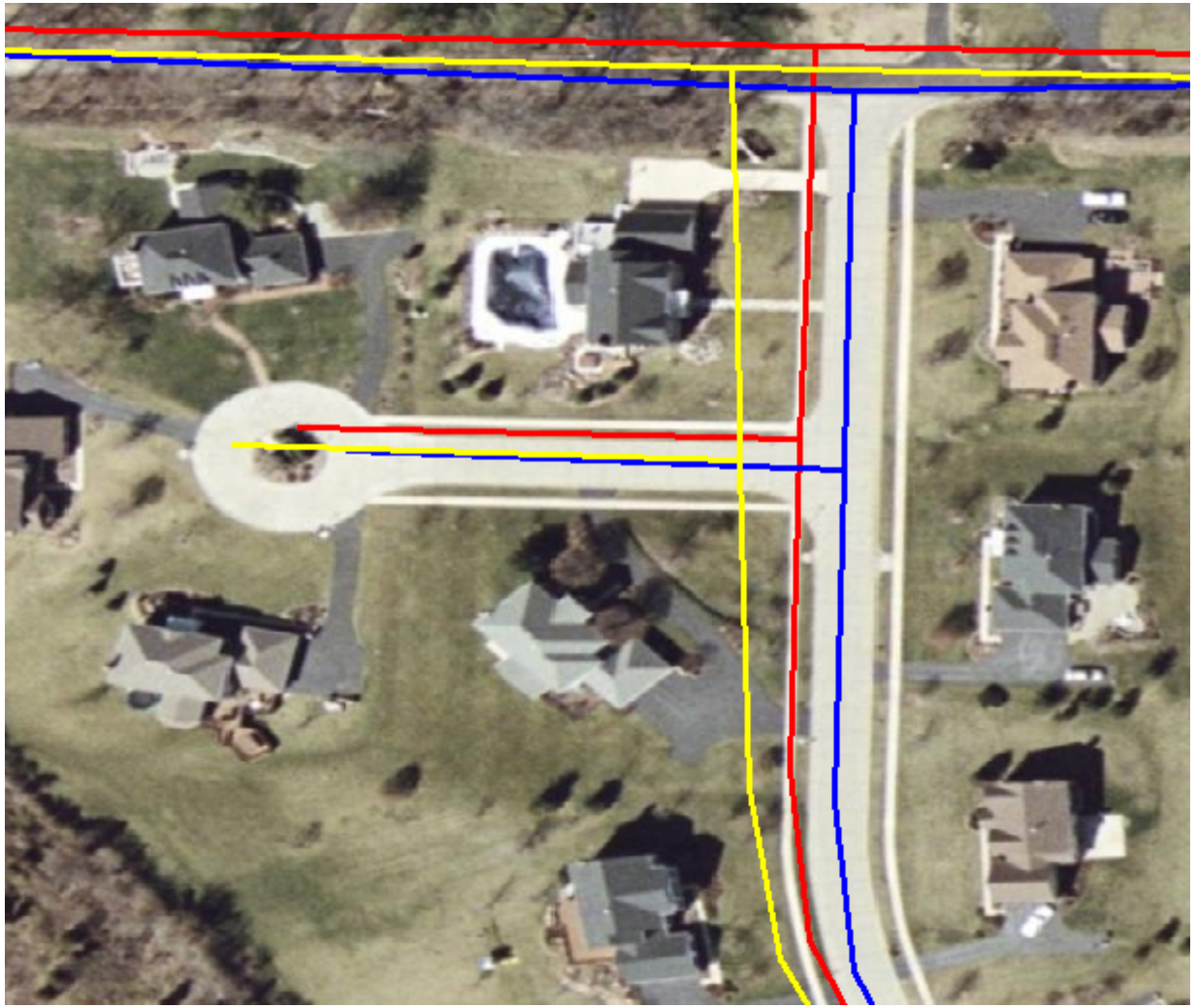
The Vector-Imagery conflation approach: Triangulation and RubberSheeting

Improved results: comparing with results based on previous technique

Red lines: Original roads **Yellow lines: Conflated results based on previous technique**
Blue lines: Conflated results based on improved technique



More improved results: comparing with results based on previous technique



Related Work

- Vector to imagery conflation
  - Utilizing matched polygons [Hild et al. 98]
  - Utilizing matched lines [Filin et al. 00]
  - Utilizing matched junction-points [Flavie et al. 00]
  - All above solutions
    - Require lots of CPU time
    - Utilize vector data only for verifying detected features not for extracting features
  - Commercial products: ESRI AreView
    - Pick control points manually

Conclusion

- Accomplishments
  - ✓ Refinement of pattern recognition procedures for identifying the road intersections in the images
  - ✓ Refinement of the filtering procedures for the ground control points
  - ✓ Development of methods for matching across image panels
  - ✓ Overall improvement of the accuracy of the transformed transportation data to match the images

Future Work

- Address the alignment of road vector data with highways
- Apply the same techniques to automatically align:
  - Vector Parcel Data
  - Hydrographic Data
  - Elevation Data