Road Network Matching: An Iterative Hierarchical Approach

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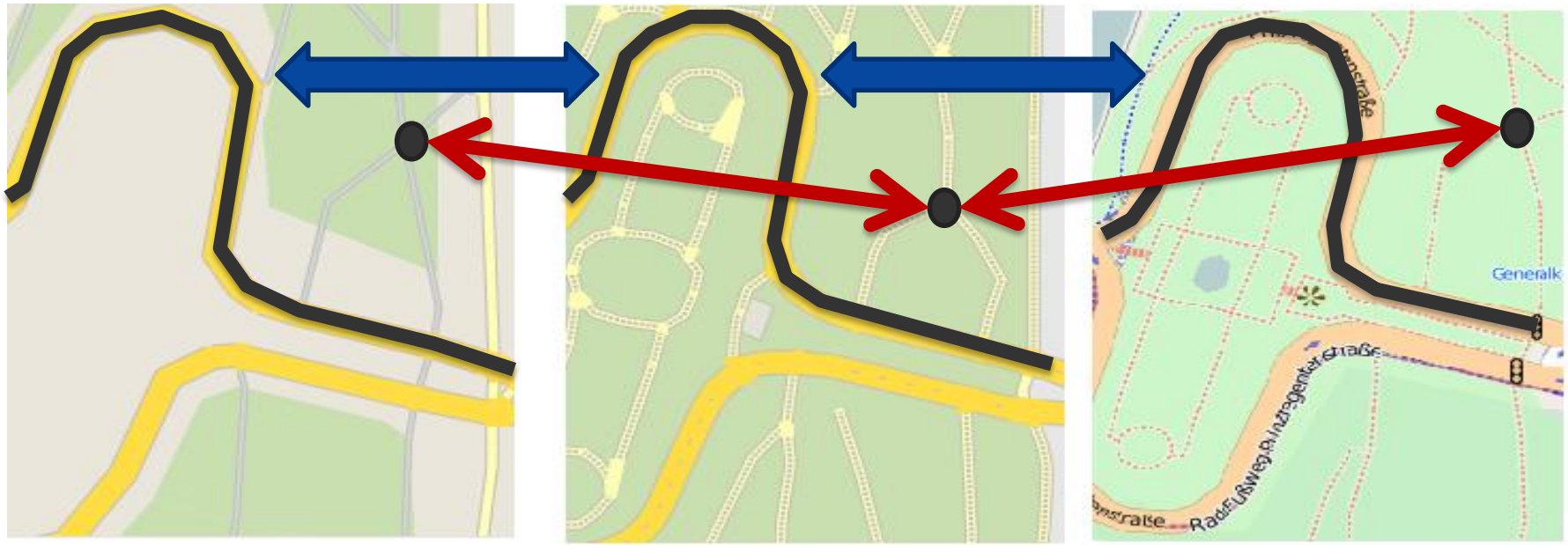
Why do we need Road Network Matching?

This is the same crossing (Munich, Reichenbachplatz)!

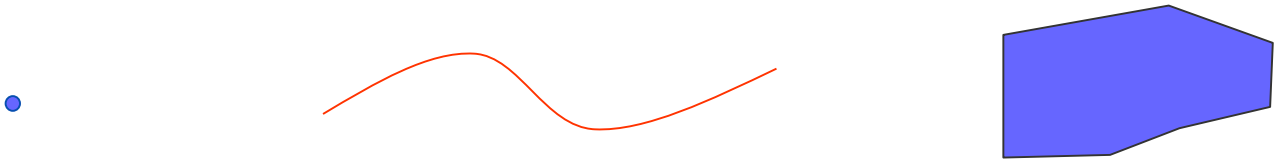
Vendor A

Vendor B

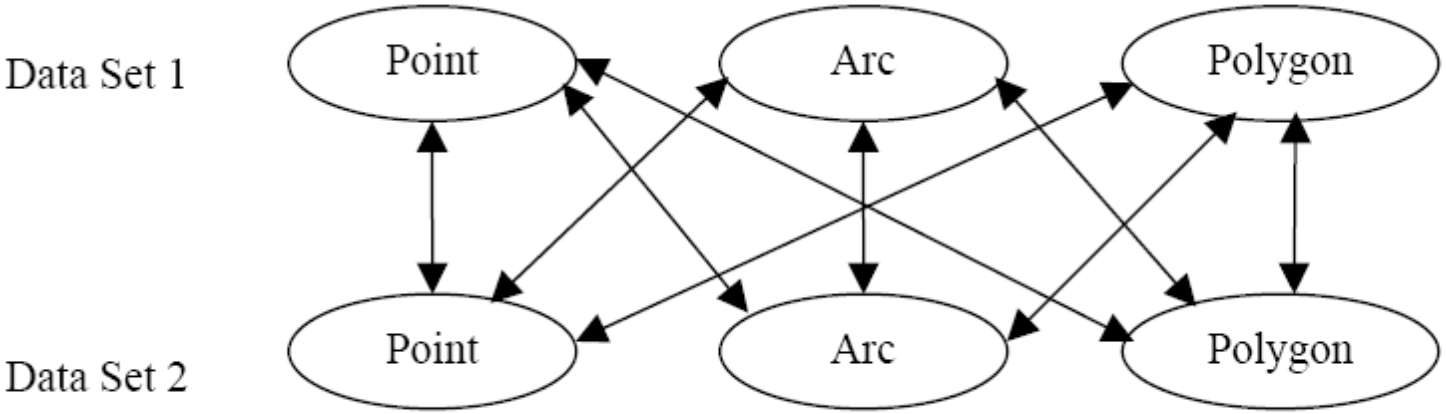
What's what?



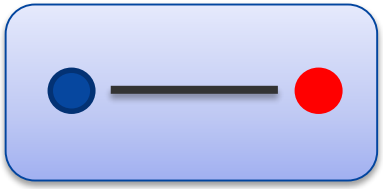
Different types of Data Matching



Point Arc Polygon

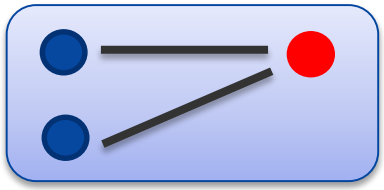


Types of Assignments



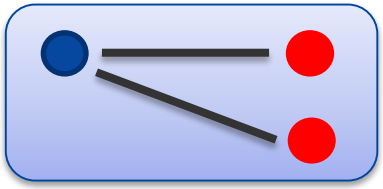
1:1

Bijective relation



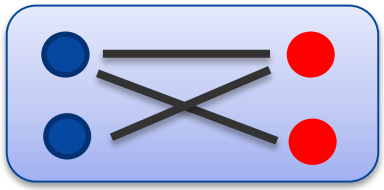
N:1

Functional (right-unique) relation



1:N

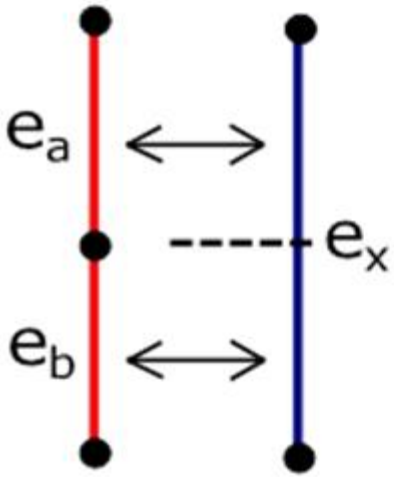
Injective (left-unique) relation



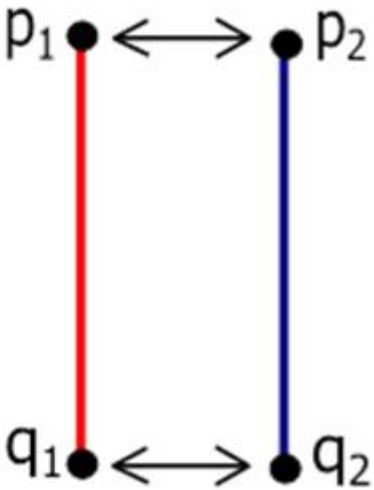
N:M

Neither left- nor right-unique relation

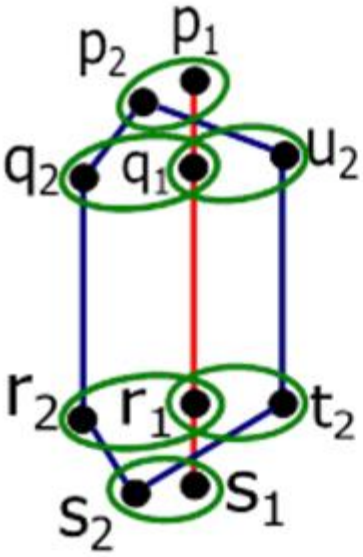
Concepts for dealing with ambiguity



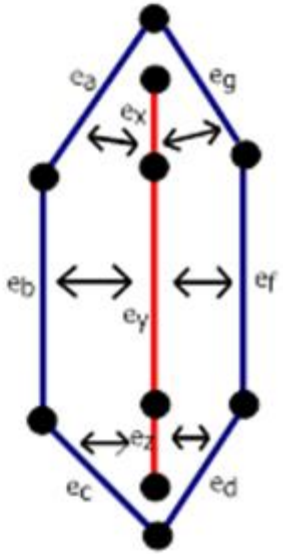
Partial correspondence



1:1 correspondence

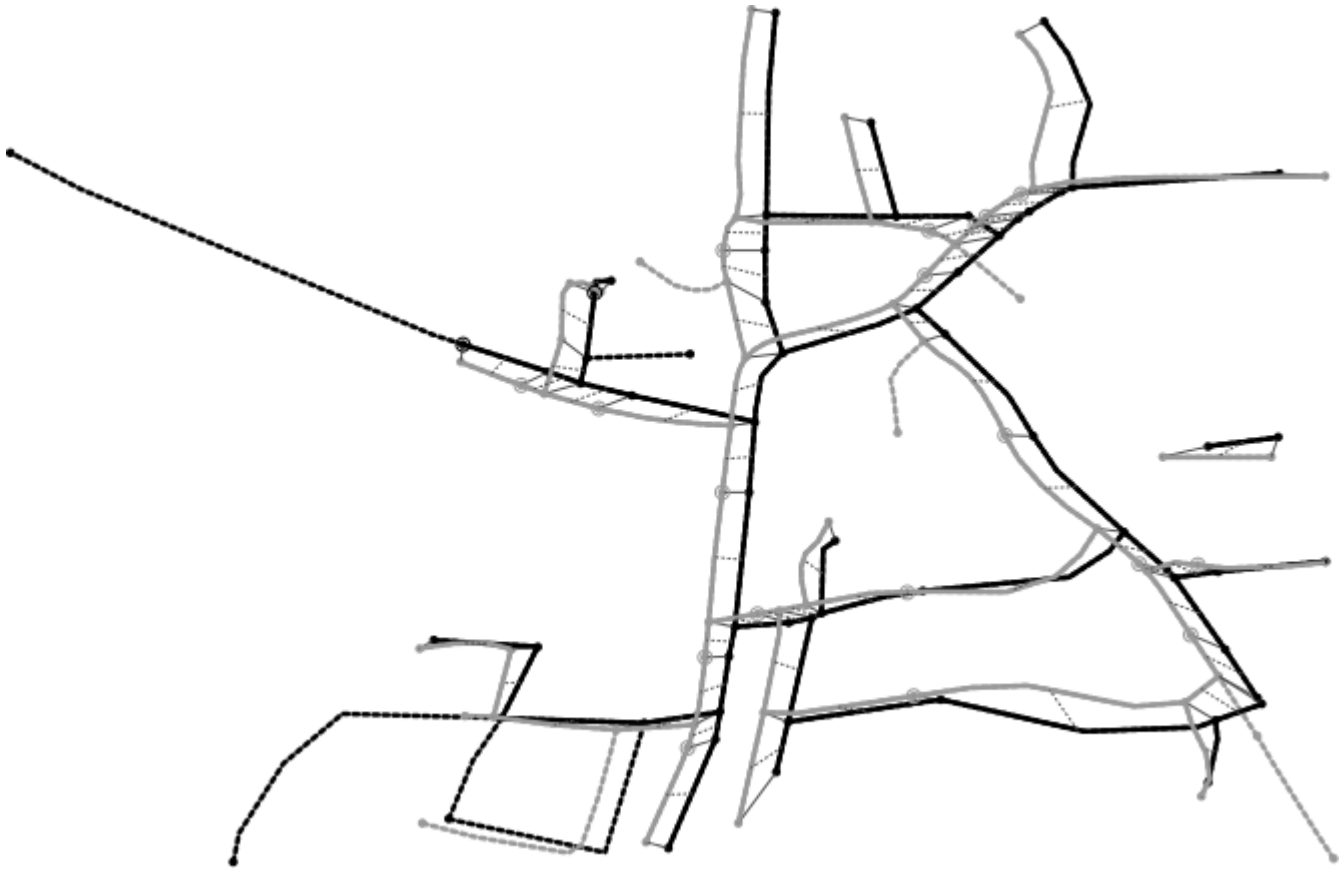


1:N node correspondences

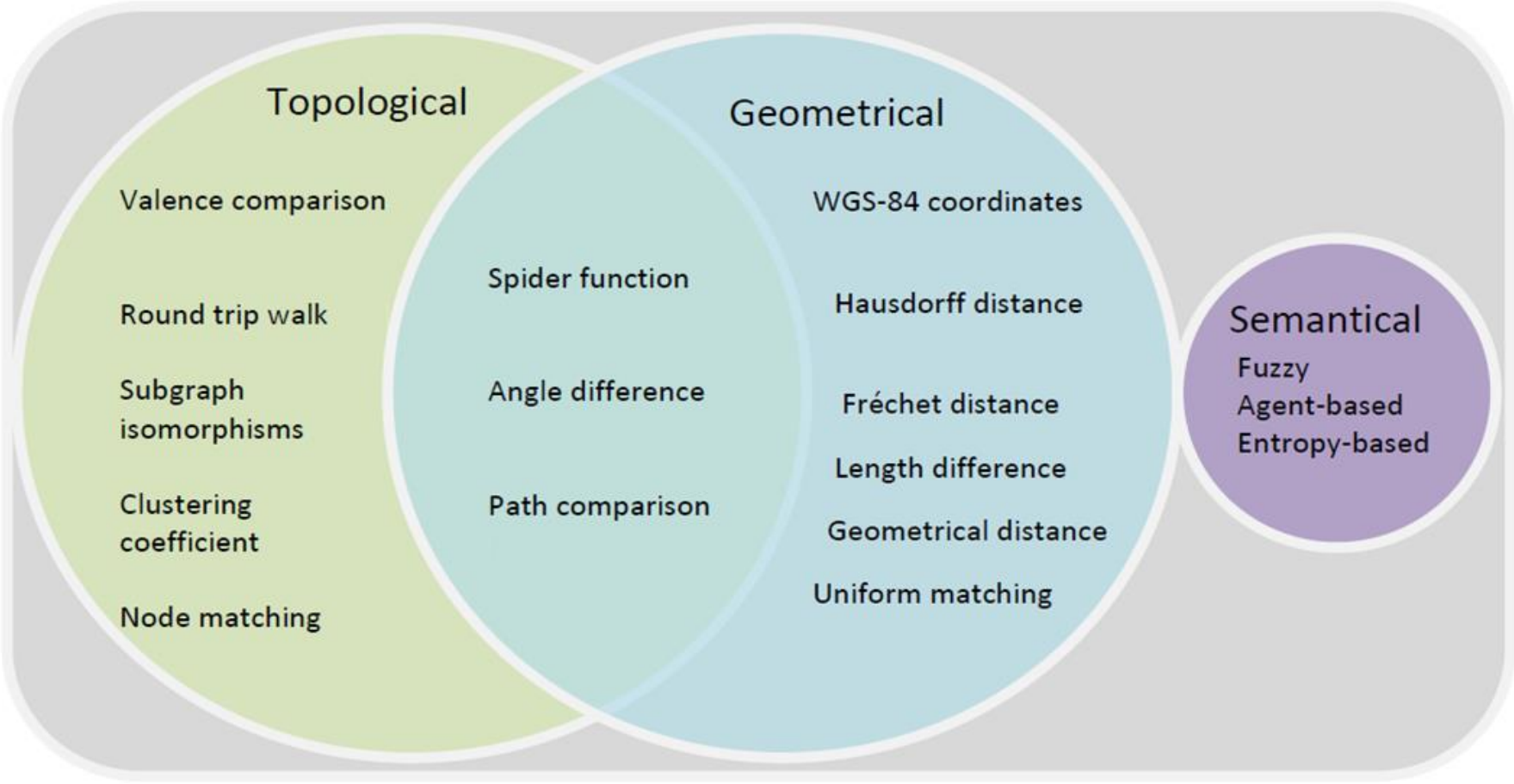


1:N edge correspondences

Example of Road Network Matching



Means of Identification



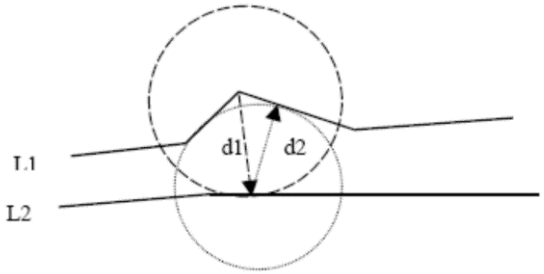
[Hackeloeer et al. 2014]

Comparing geometry

- **Distance:**
  - ***Euclidean distance:*** for point-to-point matchings

$$\mathrm{dist}(p,q) = \sqrt{(p_x - q_x)^2 + (p_y - q_y)^2}.$$

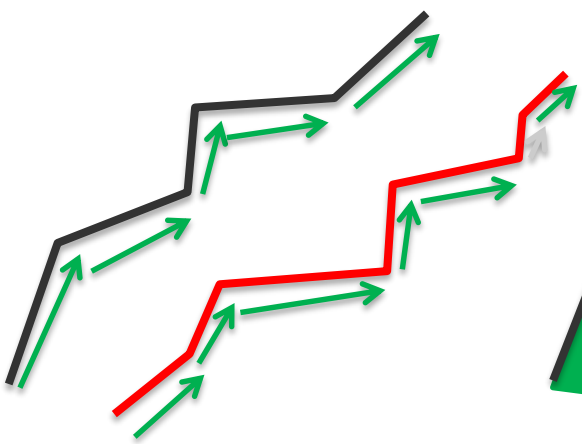
  - ***Hausdorff distance*****:** for line-to-line matchings



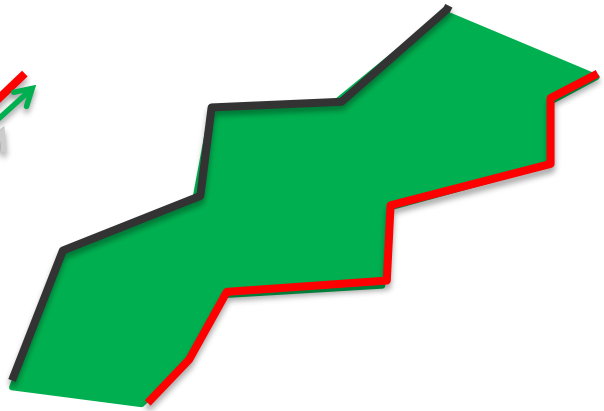
$$D_H = \max(d_1, d_2)$$

[Yuan & Tao 1999]

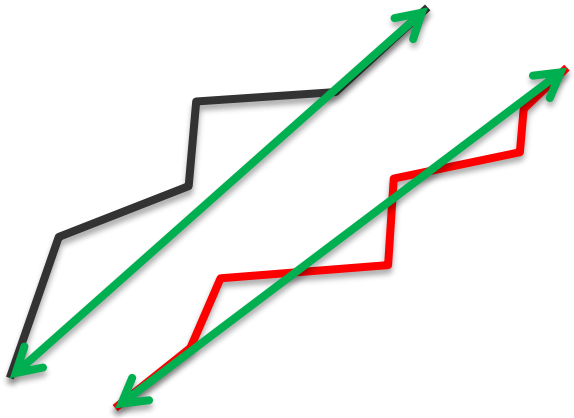
Some polyline distance metrics



Length ratio

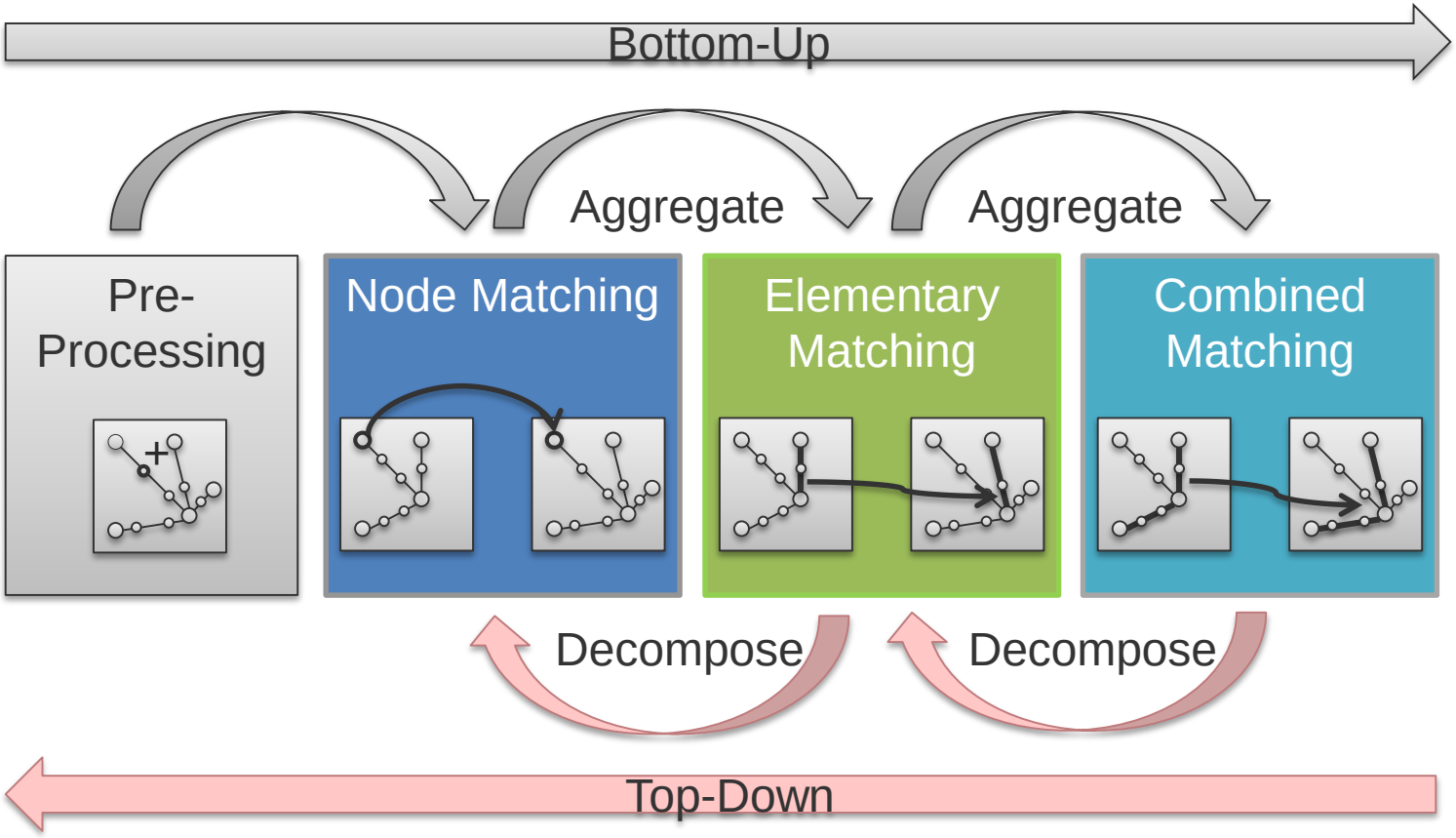


Enclosed area



Curviness

Iterative Hierarchical Conflation

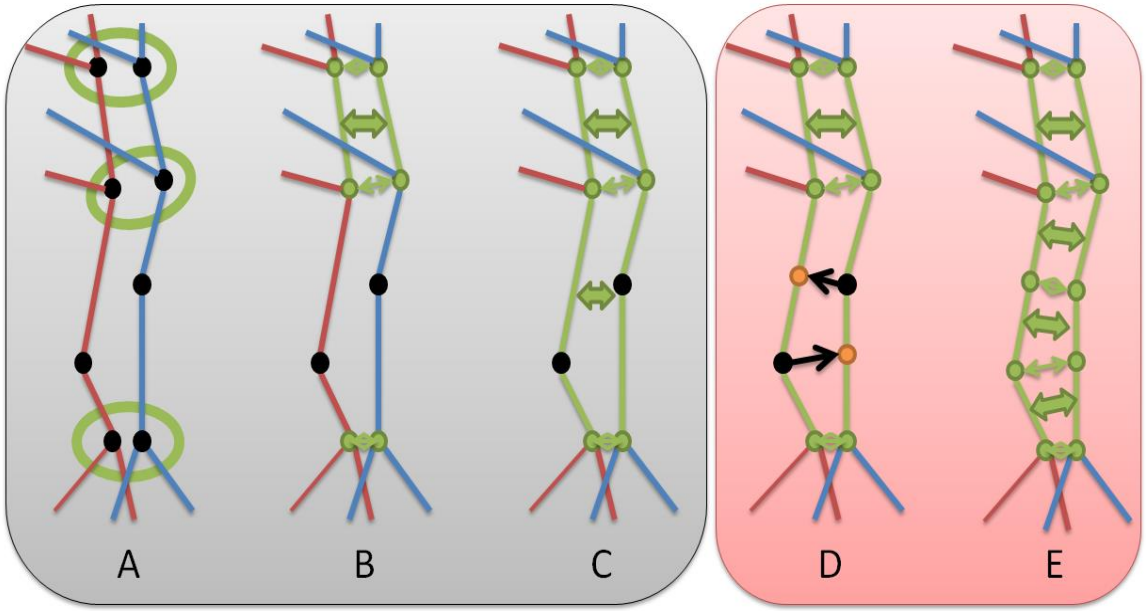


The Matching Pipeline

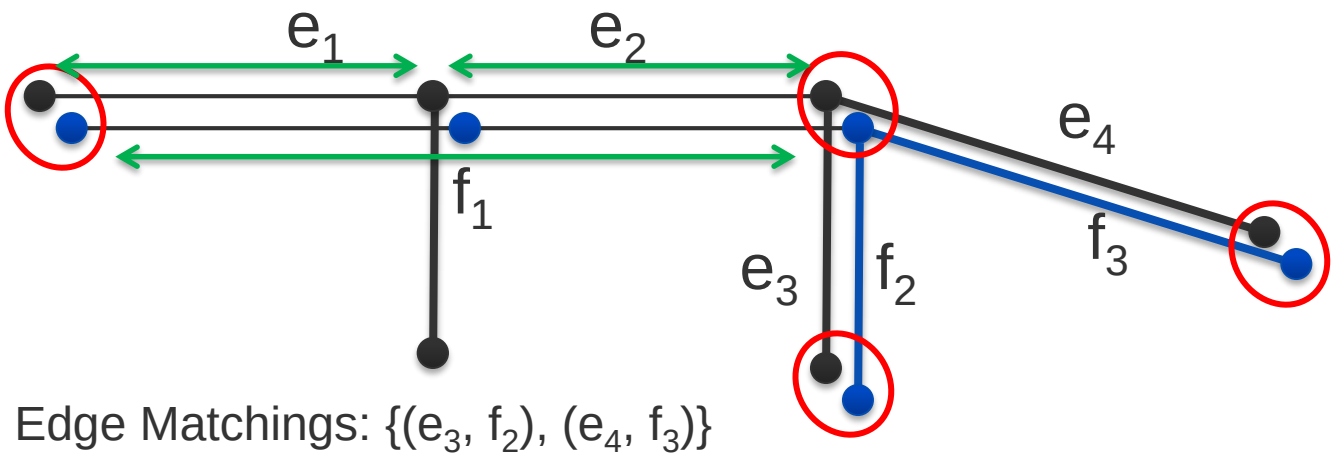
Iterative Hierarchical Conflation

4 Stages:
- Preprocessing
- Node Matching (A/E)
- Elementary Matching (B)
- Combined Matching (C/D)

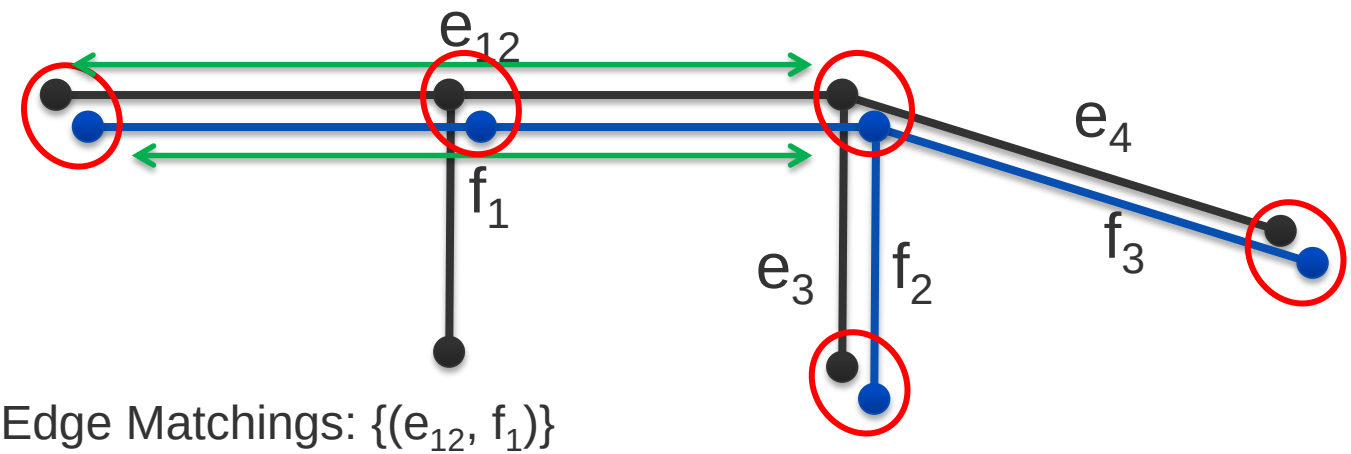
2 Phases:
- Bottom-Up-Phase (A-C)
- Top-Down-Phase (D-E)



IHC Algorithm: Combined Matching

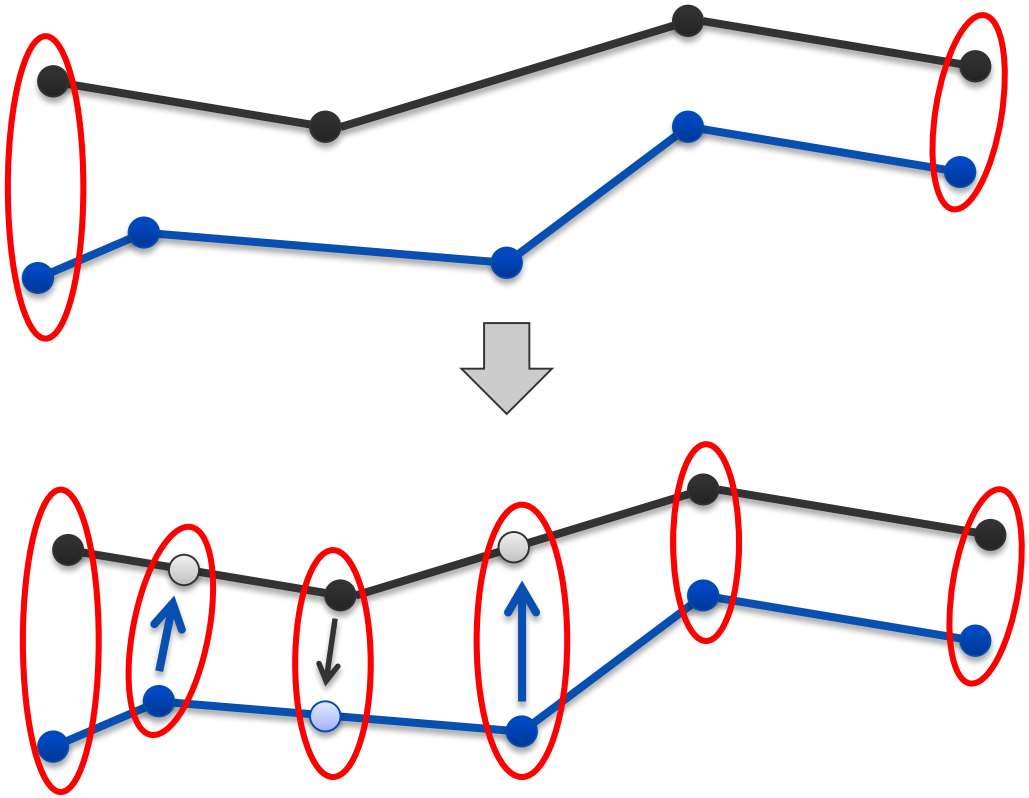


Step 1 Edge Matchings: {(e_3, f_2), (e_4, f_3)}



Step 2 Edge Matchings: {(e_{12}, f_1)}

IHC Algorithm: Assignment of Bivalent Nodes

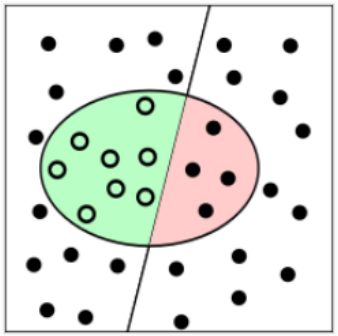


Evaluation Methodology

Algorithm Decision / Reality	True	False
Positive	Correctly identified matching pairs	Pairs incorrectly identified as being a match
Negative	Pairs correctly identified as being no match	Pairs incorrectly identified as being no match

Precision:

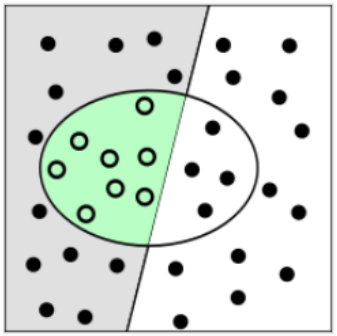
$$\frac{TP}{TP + FP}$$



For evaluating **Correctness**

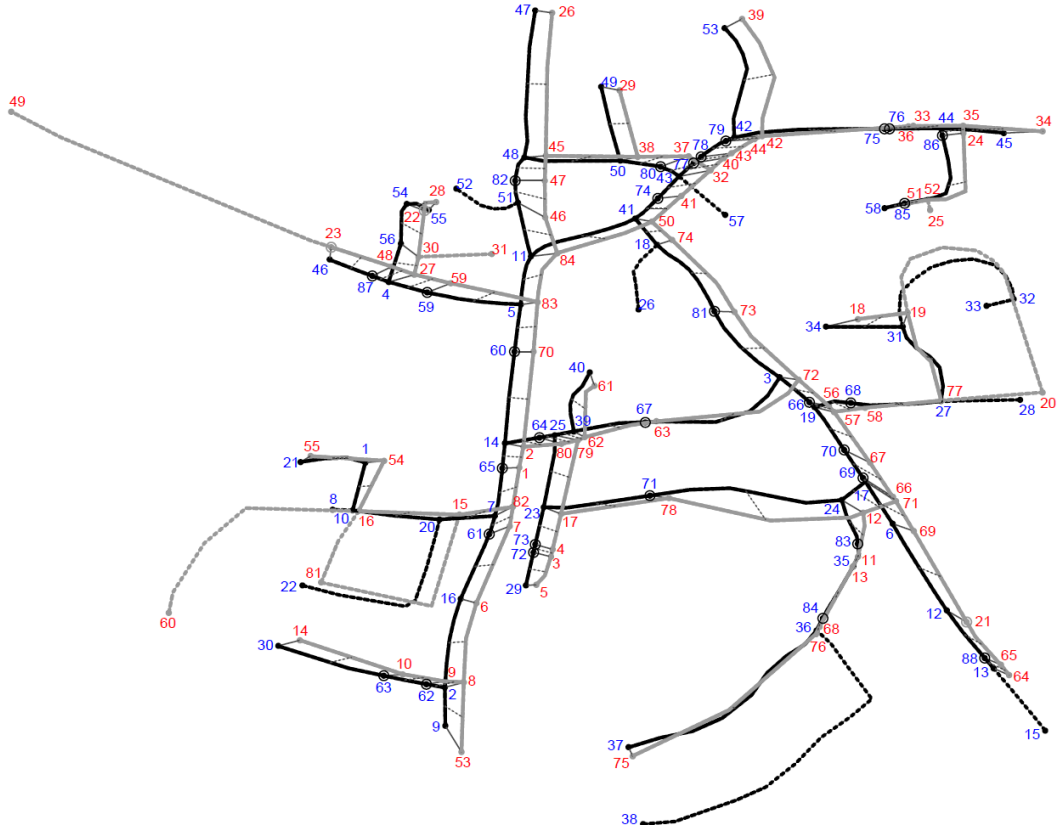
Recall:

$$\frac{TP}{TP + FN}$$



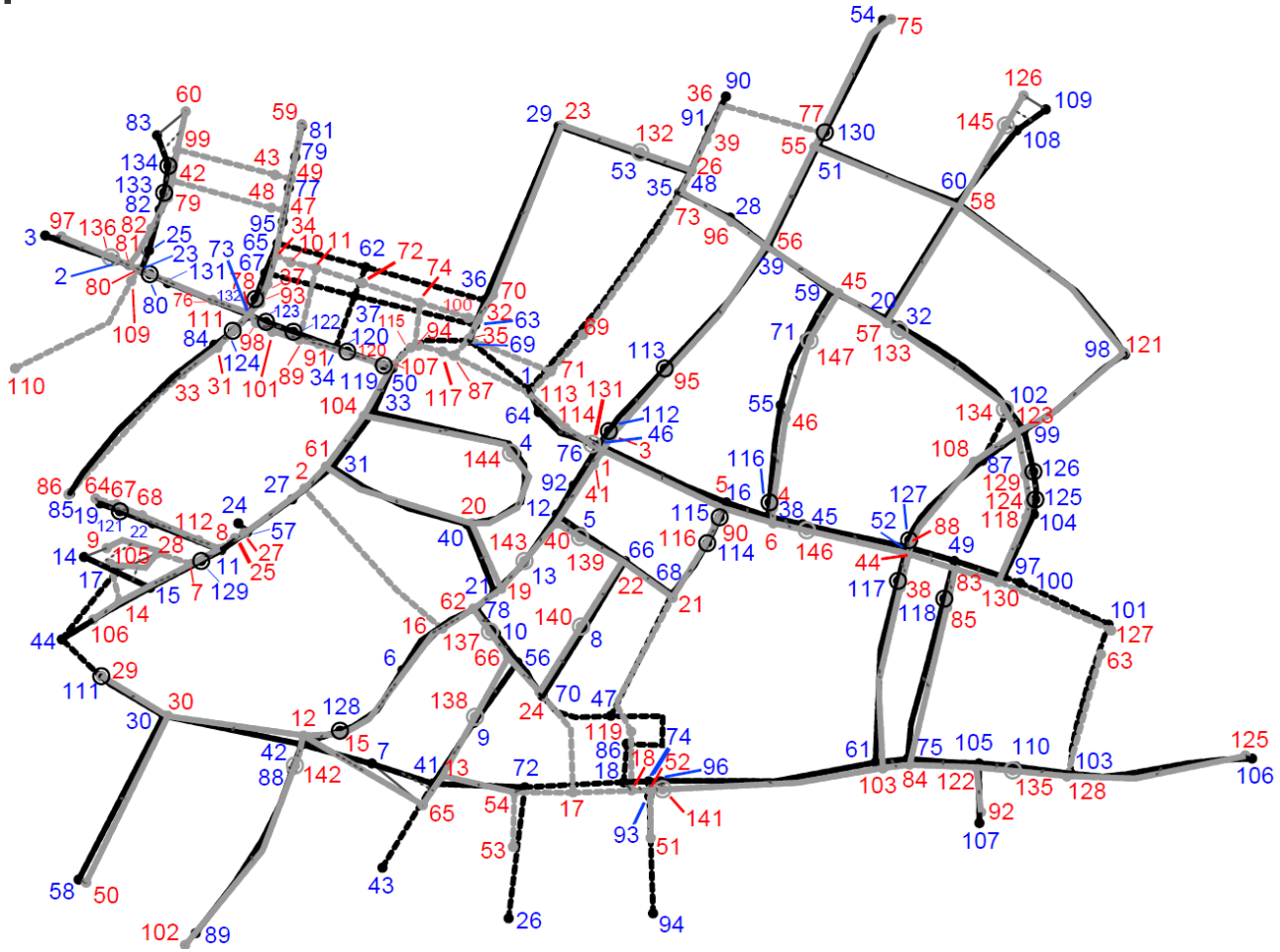
For evaluating **Completeness**

Evaluation against Ground Truth Definition



Map A	Map B	Errors	TP	FP	TN	FN
1	54		1			
2	8		1			
3	72		1			
4	27		1			
5	83		1			
6	69		1			
7	82		1			
8	x	Missing virtual node				1
9	53		1			
10	16		1			
11	84		1			
12	21		1			
13	64		1			
14	2		1			
15	x				1	
16	6		1			
17	71		1			
18	74		1			
19	57		1			
20	15		1			
21	55		1			
22	81	Missing match				1

Example: Munich Old Town Evaluation Index



Evaluation Results

	Urban (Munich)	Urban (Boston)	Rural (Moosach)	Rural (Sullivan)
Found associations	121 / 134	121 / 140	78 / 82	53 / 55
False negatives	23	19	4	2
False positives	1	0	0	0
True negatives	10	28	10	4
Precision	99%	100%	100%	100%
Specificity	91%	100%	100%	100%
Recall	84%	90%	95%	96%
Nodes in Network A	149	139	92	59
Nodes in Network B	150	157	86	55
Network A Coverage	81%	87%	85%	90%
Network B Coverage	81%	77%	91%	96%

Conclusion

- The IHC algorithm works very well in terms of both correctness and completeness in the rural sample regions
- IHC provides a very high correctness while maintaining considerable, but not perfect completeness in the urban sample regions
- Further advancements of the IHC approach are necessary with special attention to the proper resolution of ambiguous correspondences to tackle hard matching cases

Thank you for your attention!

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