



An Efficient and Accurate Grid Compression Solution for Point-to-Line Nearest Neighbor Search



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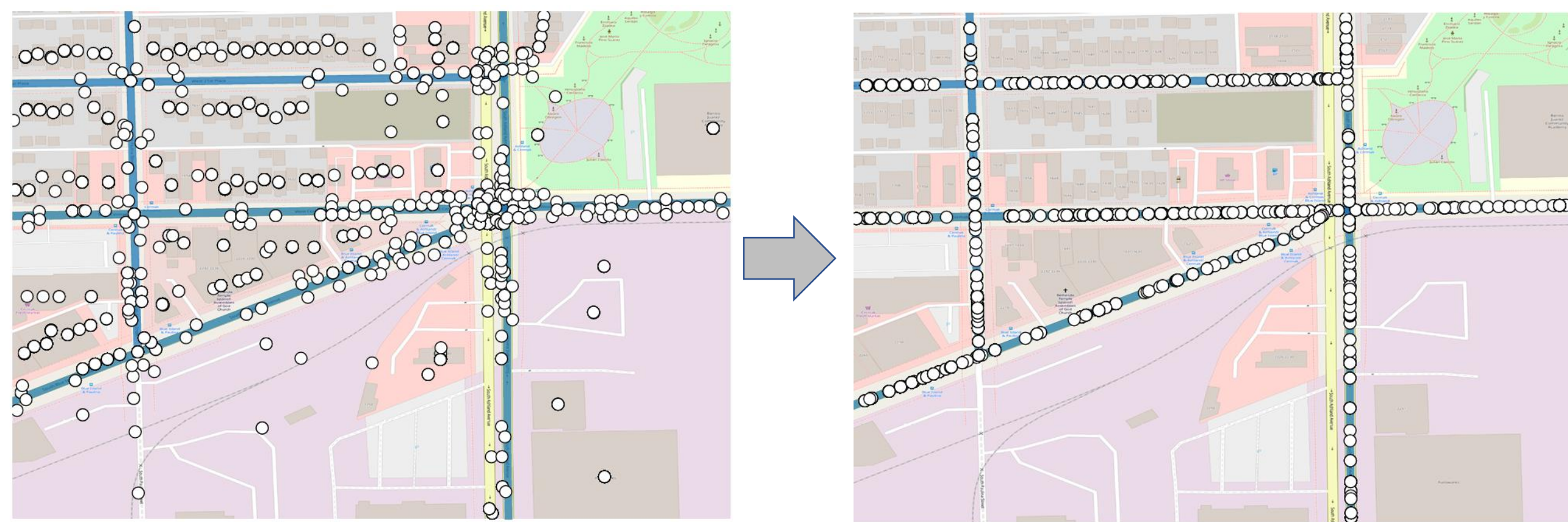
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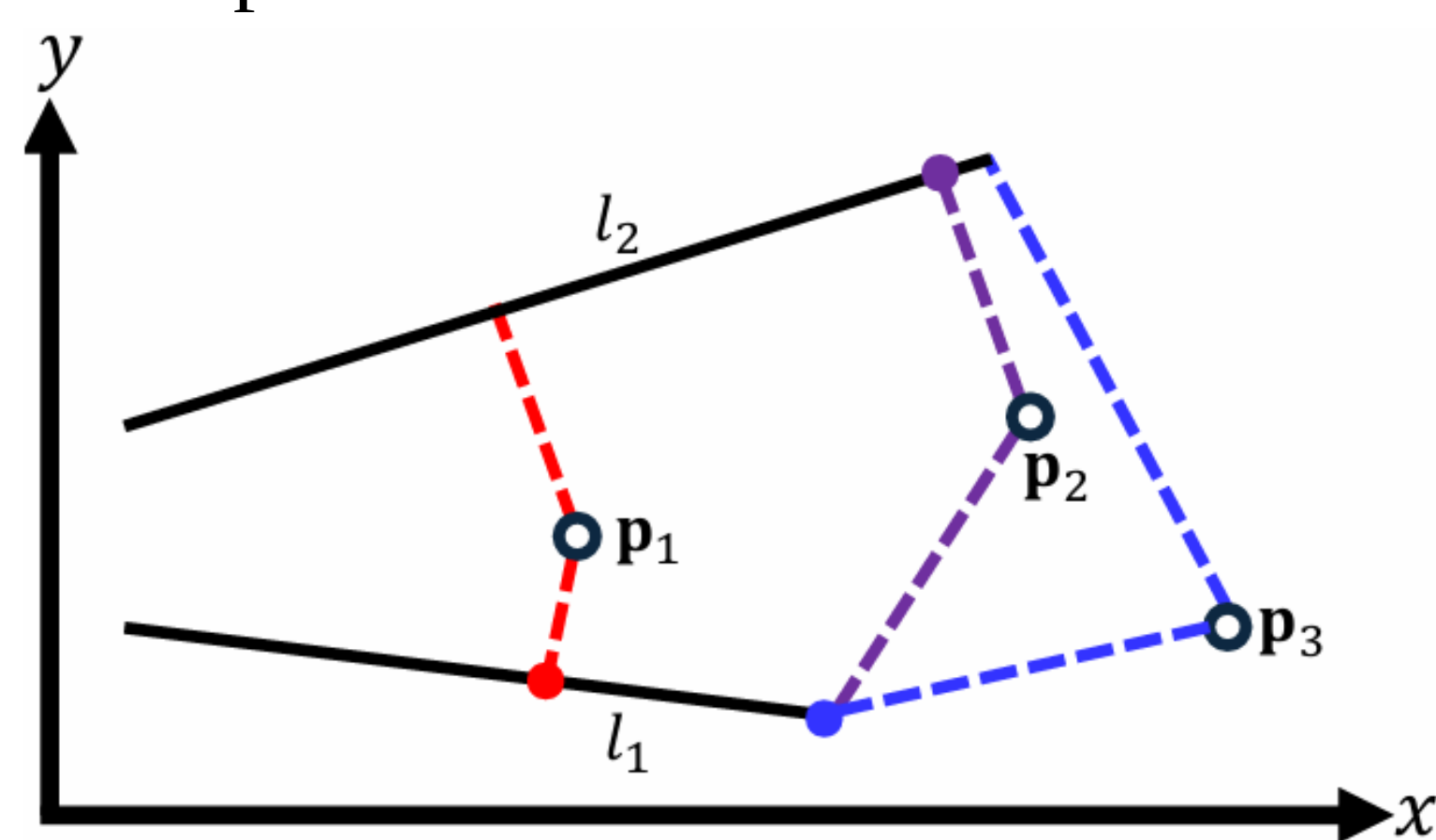
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What is PLNNS ?



Original data points

Projected data points



- **Point-to-Line Nearest Neighbor Search (PLNNS)** finds the nearest line for each spatial point and computes its projection onto the line.
- It is a prerequisite step for many road-network analytics.
 - Network KDE
 - Network K-function
 - Network Histogram
 - ...
- Existing methods process each point independently, leading to high computational costs for large-scale datasets.

$8.2M$ points $\times$ $41K$ road segments
 $\approx 3.4 \times 10^{11}$ distance computations

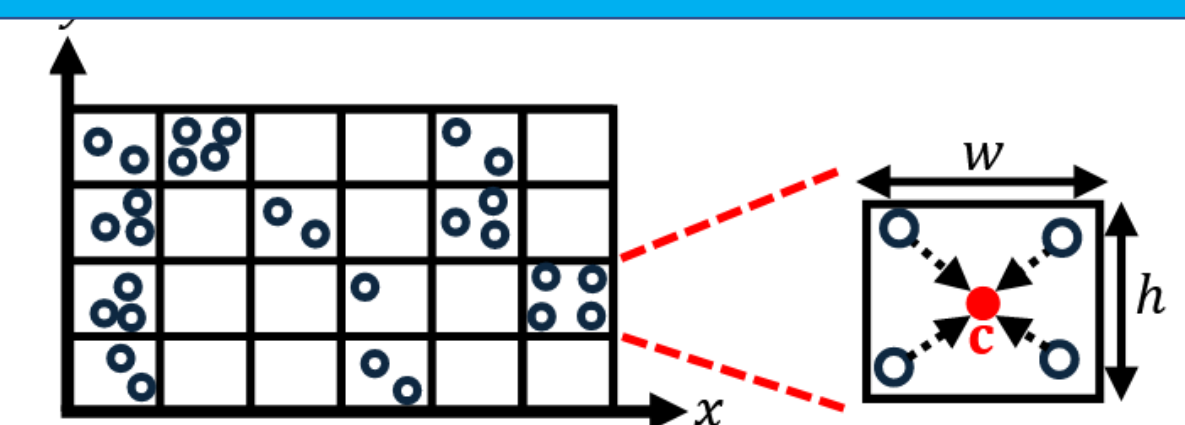
$$O(n|L|)$$

PLNNS is the bottleneck of many road-network analytics.

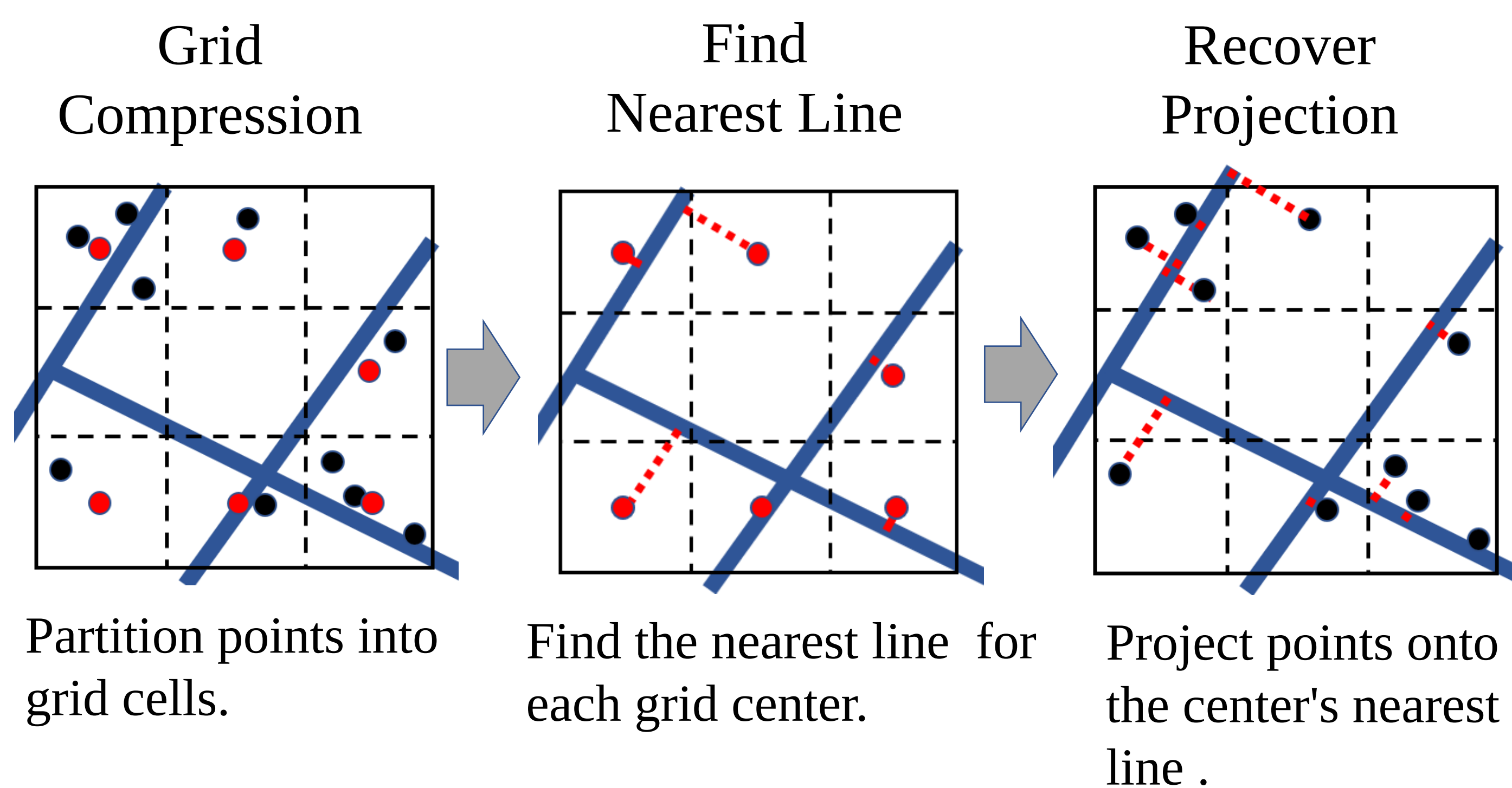
Our Grid Compression Solution

Key Idea: Grid Compression

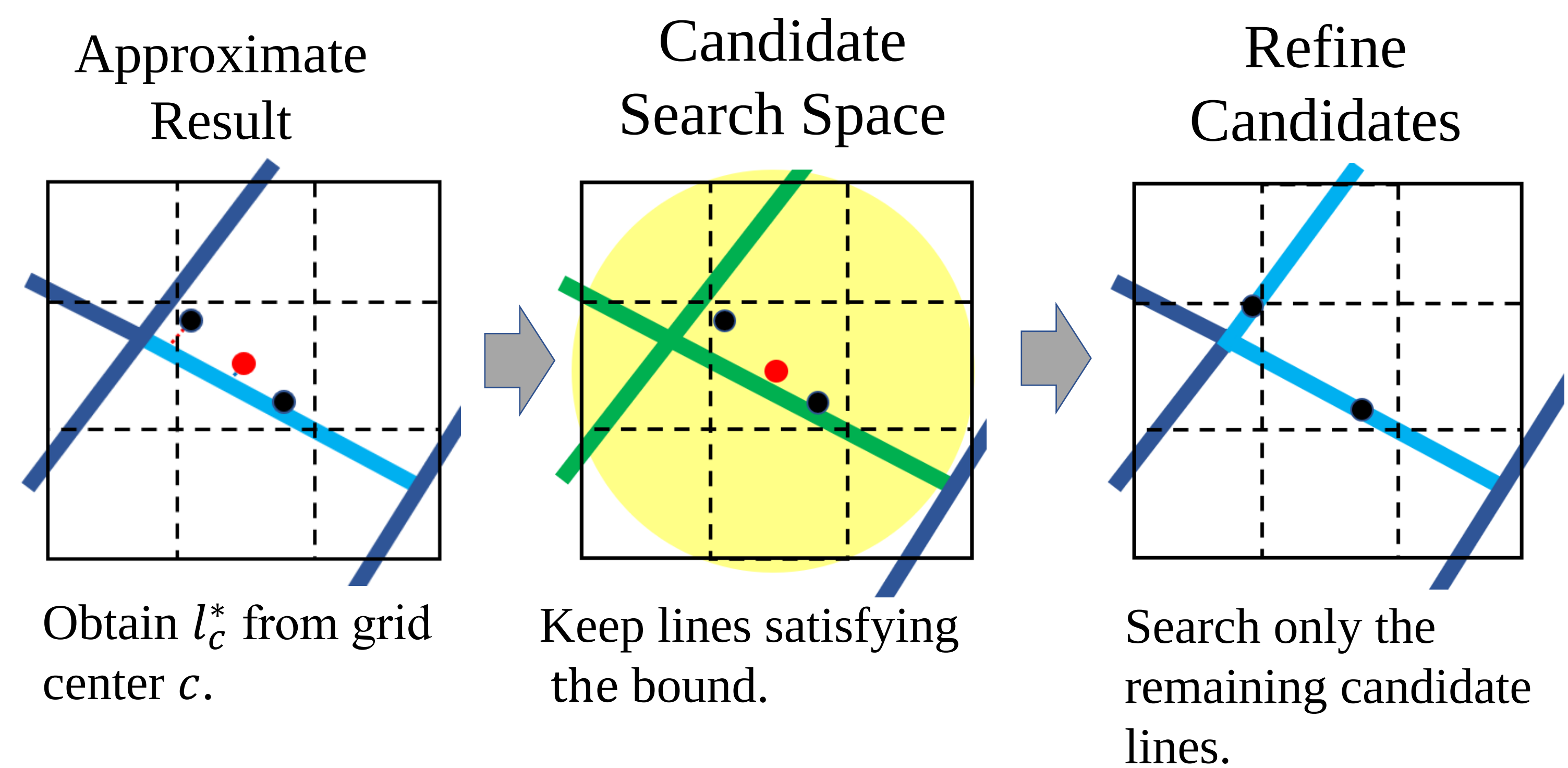
Group nearby points into grid cells and reduce point-wise nearest-neighbor computations through grid-center representation.



Approximation Approach GRID^{APPROX}_{COMP}



Exact Approach GRID^{EXACT}_{COMP}

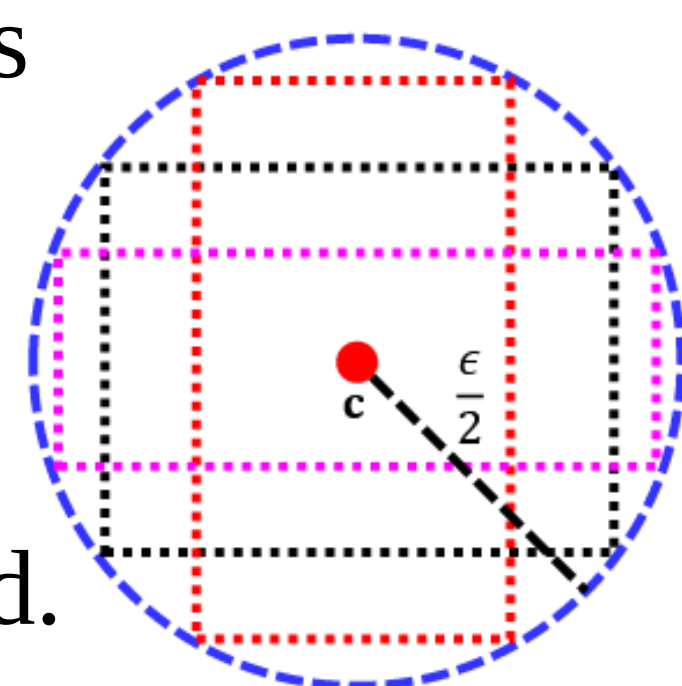


Theoretical Guarantee

For any point p in a grid cell, the nearest line of its grid center provides an ε -bounded approximation.

$$|d(p, l^*) - d(p, l_c^*)| \leq \varepsilon$$

Cell size is determined by the required error bound.



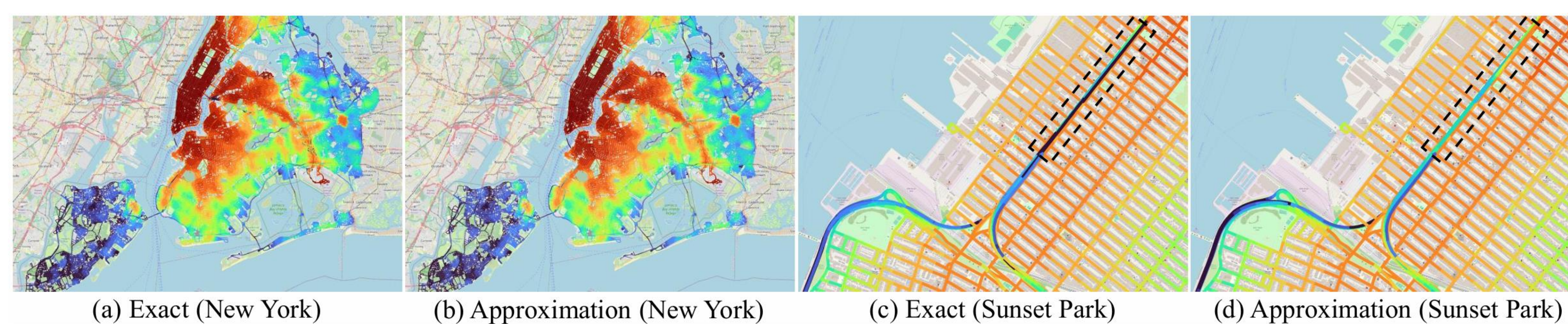
Candidate Search Space

The approximation result defines a bounded search region that contains the true nearest line of every point in the grid cell..

$$d(c, l) \leq d(c, l_c^*) + \varepsilon$$

Only lines satisfying this bound need to be examined for exact search.

Experimental Result



Dataset	HIF _{R-tree}	GRID ^{APPROX} _{COMP}	GRID ^{EXACT} _{COMP}
San Francisco	77.91	1.81	9.15
Chicago	122.83	21.68	23.12
New York _{Taxi}	513.37	30.96	65.86
New York _{Bike}	439.29	17.73	41.42

