Adaptive Multifactor Routing with Constrained Data Sets for Autonomous Vehicle (AV) Applications

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CAT Vehicle 2014

- Research Experience for Undergraduates
- Focus on Vehicle Autonomy
- University of Arizona Dept. of Electrical and Computer Engineering

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- Motivations and Background
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- Simulation Software Design
- Results
- Analysis
- Conclusions
- Supporters

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Motivations and Background

- Autonomous Vehicles can balance multiple factors for holistic routing
- V2V communications offer the ability to provide many routing factors
- Existing literature explores these issues and offers many areas for expansion

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Focus

- Use signal strength and other routing factors to create a route not purely based on distance
- Shortest Path algorithms combined with cost metric allow efficient multifactor routing
- Use limited factor data to simulate potential V2V communication limitations

Signal Strength Factors

- Weighting formula determines holistic "cost" of a route
- Shortest "path" algorithm minimizes these costs to find ideal route
- We focus on distance and cellular signal strength routing factors
- k: Distance Gain
- β: Signal Average Gain

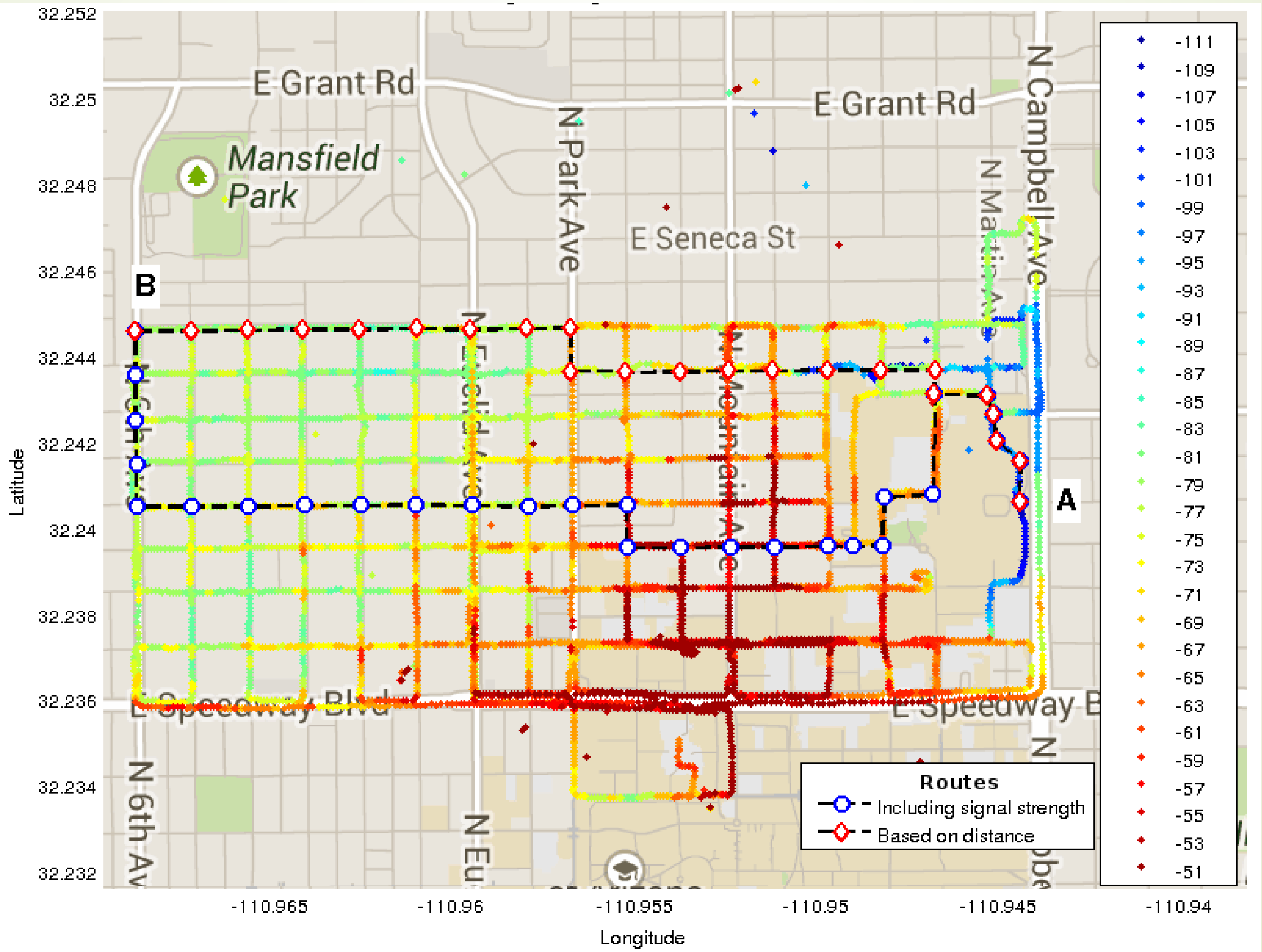
$$EdgeWeight = \frac{k}{k+\beta} \cdot distance + \frac{\beta}{k+\beta} \cdot SignalStrength$$

Shortest Path Algorithms Complexity Trade-Offs

SUMMARY OF SHORTEST PATH ALGORITHMS

Algorithm	Advantage(s)	Disadvantage(s)	Complexity
Dijkstra Link-State Algorithm			
DIKBD[4]	• Handles larger scale graphs (arc length > 1500)	• Time Consuming via Relaxation Principle	$O(m + n(\beta + (\frac{C}{\beta})))$
	• Considers all weights (with loops)	• Considers only Non-Negative Weights	
DIKBA[3]	• Handles smaller scale graphs (arc length < 1500)	• Time Consuming via Relaxation Principle	$O(m\beta + n(\beta + \frac{C}{\beta}))$
	• Considers all weights (with loops)	• Considers only Non-Negative Weights	
	• Terminates un-used routes during iteration process		
Bellman-Ford Distance-Vector Algorithm			
BF[5]	• Considers Positive and Negative Weights (with loops)	• Time Consuming via Relaxtion Principle	O(nm)
		• Does not terminate other iterations when searching for Shortest Possible Route	
Acyclic Topological Ordering			
DAG[6]	• Operates Faster than Bellman-Ford or Dijkstra	• Less Weight Consideration	O(nm)
	• Deletes the ignored arcs	• Considers only Non-Negative weights	
		• Considers out-going weights only (No loops)	

Signal Heat Map with Distance and Multifactor Based Routes



Signal Values in dBm

V2V Factors: Partial Knowledge of the Total Signal Map

- V2V communications may have substantial bandwidth and distance limitations
- V2V based routing factors may be limited by communication constraints
- We evaluate the performance impact of distance constraints

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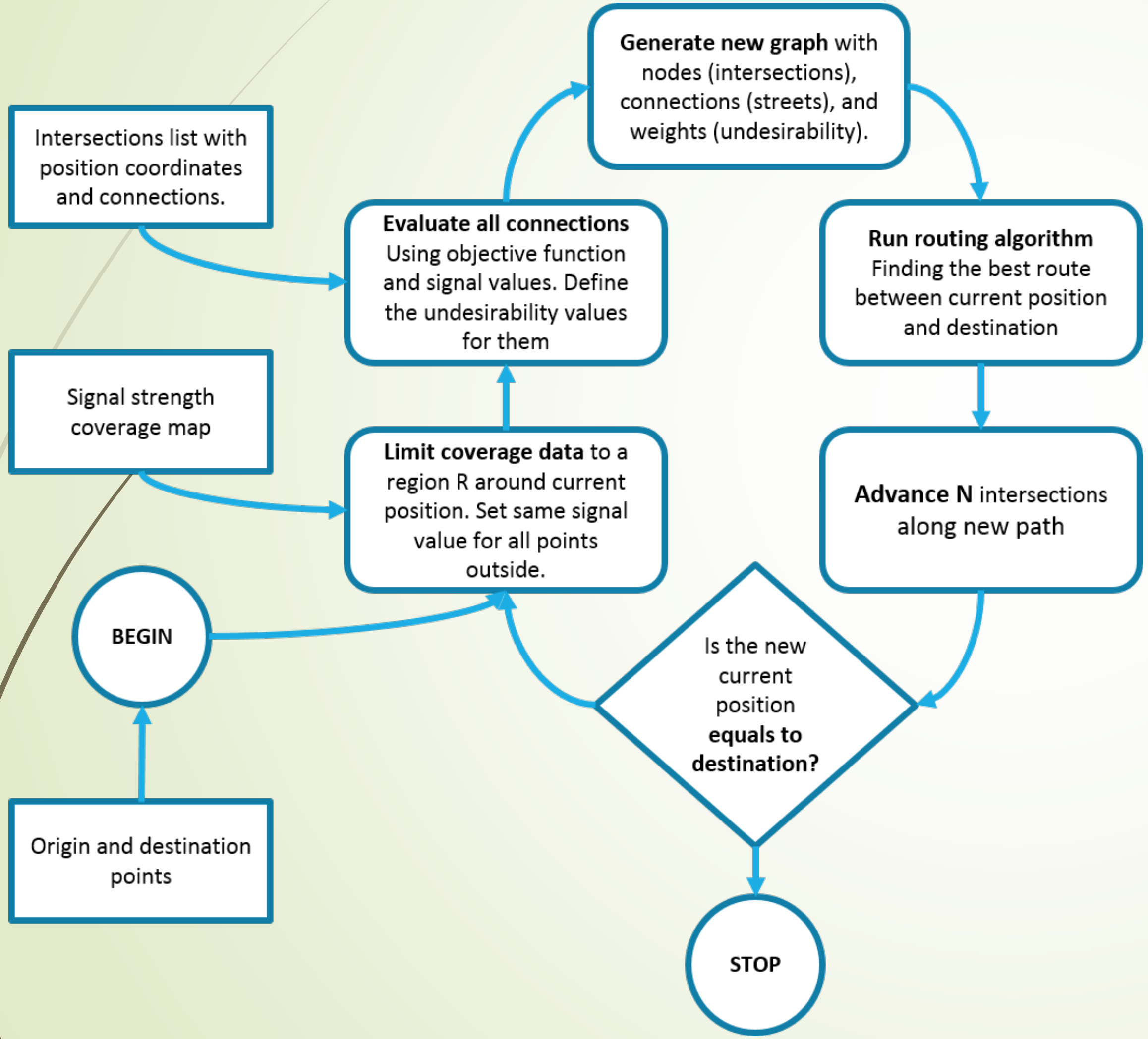
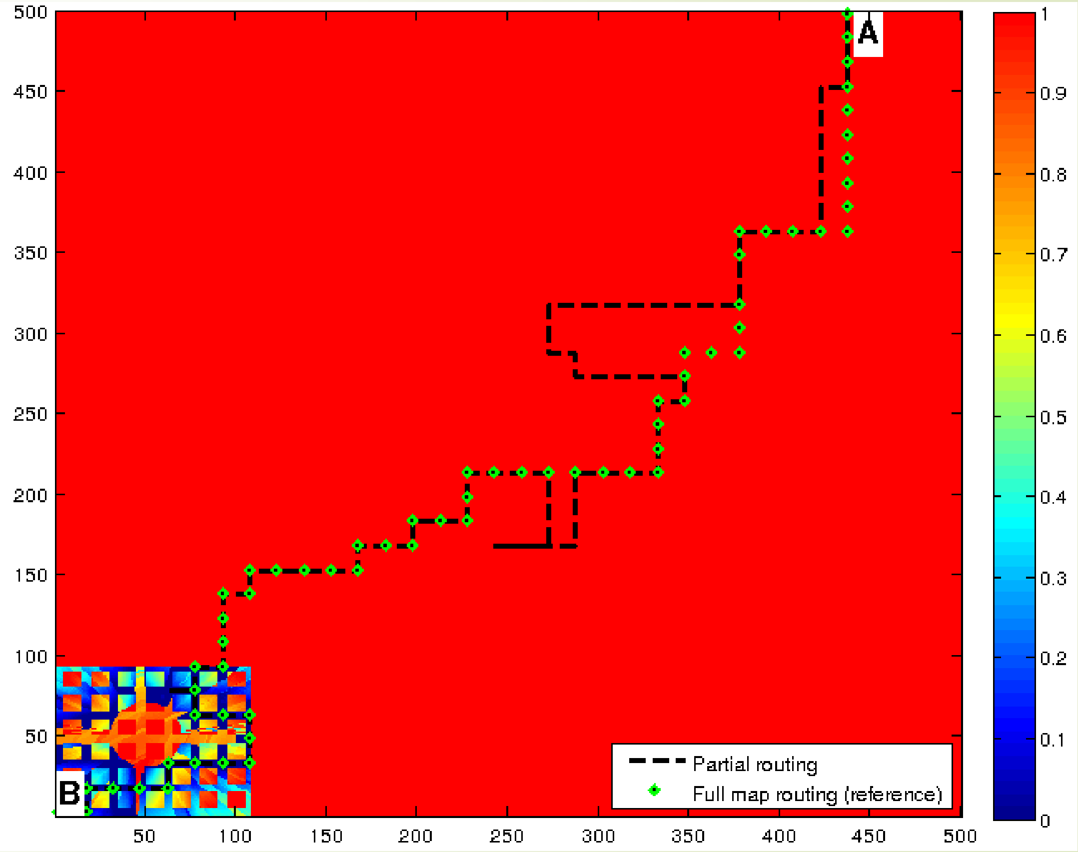
Software Design

- Use simulated signal data combined with shortest path algorithms
- Limit routing algorithm factor knowledge along route to simulate V2V limitations

Software Function:





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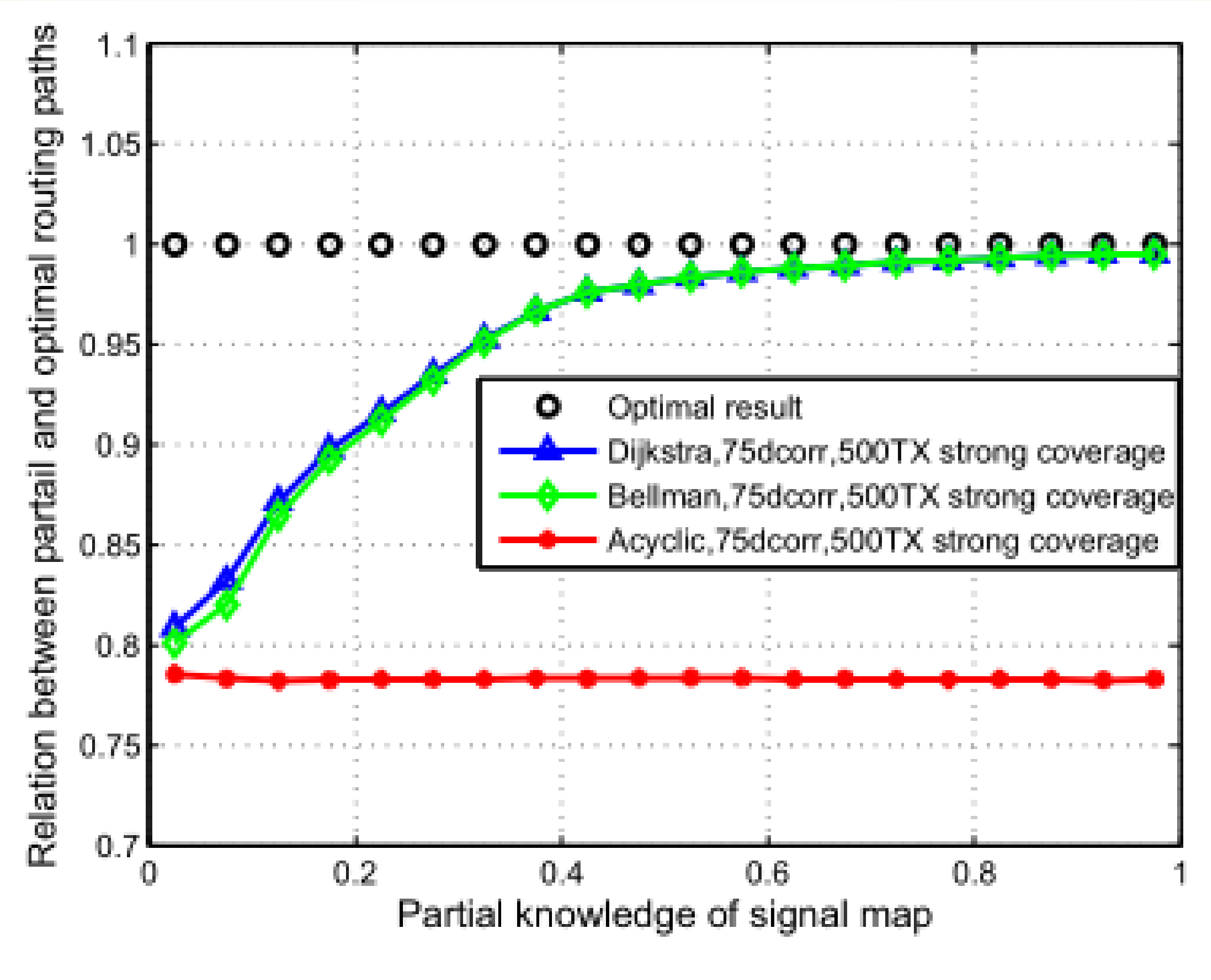
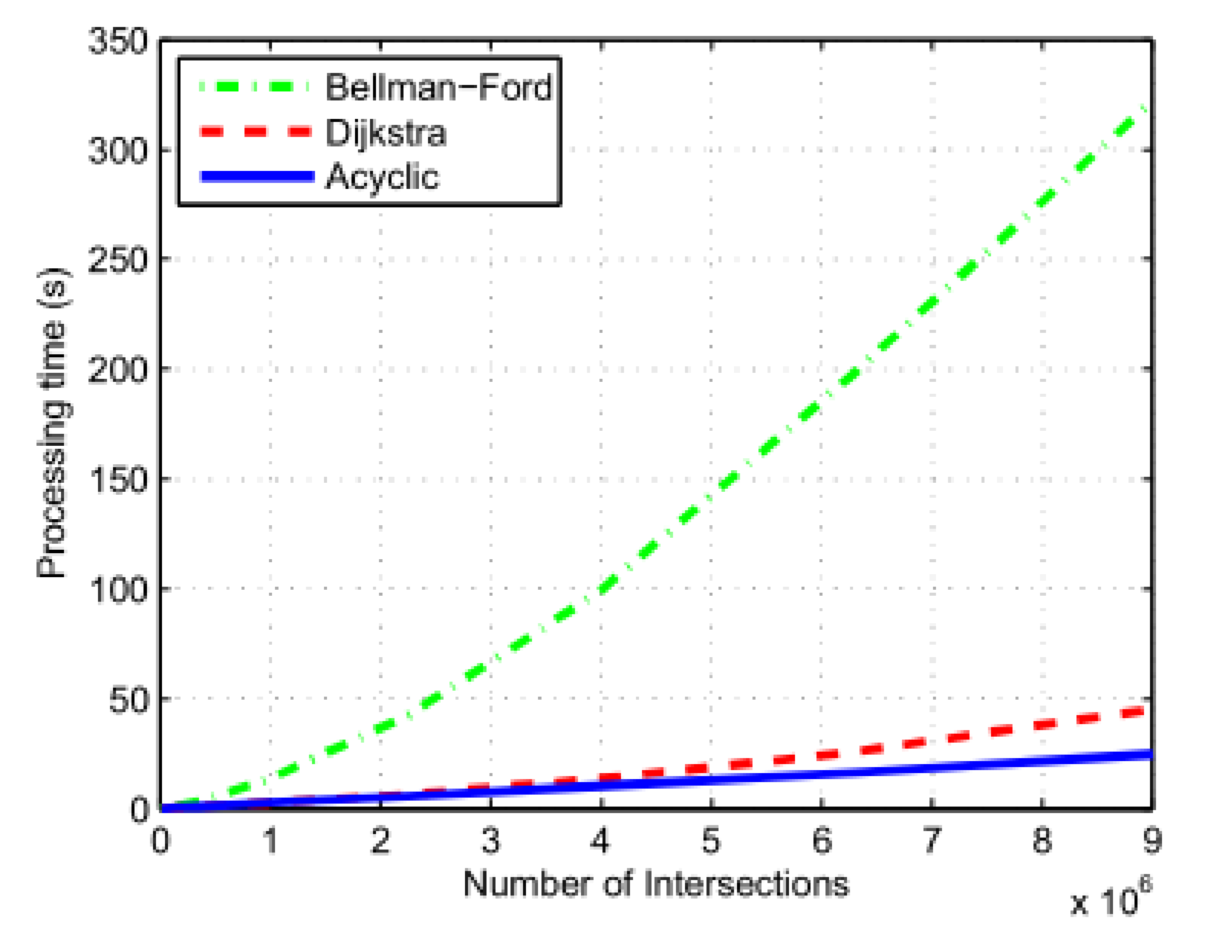
Partial Factor Analysis



Algorithm Speeds



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Analysis

- Analysis limited to routes in dense grid layouts
- Long distance routing over less dense intersections limits locally optimal solution’s performance as compared to global solution

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Conclusions

- In dense grid layouts routing based on local optima allows near global optimal performance
- Globally optimal results are possible with local data (~40% of route size)
- V2V communications can allow excellent routing with constrained factor data in urban areas

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Thank You For Listening

- Research Supported by:
- National Science Foundation
- Air Force Office of Scientific Research
- Award IIS-1262960