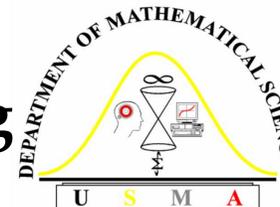




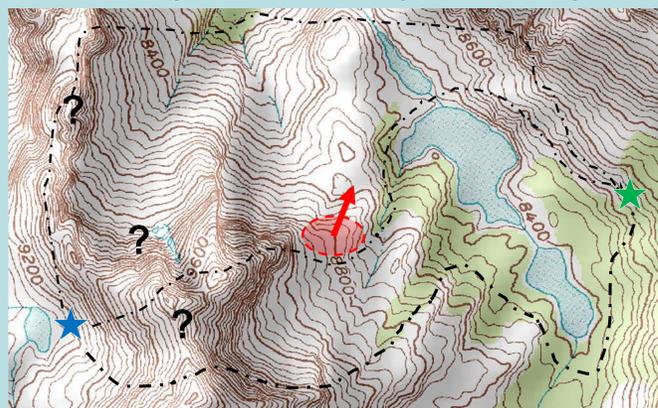
Tactical Route Optimization: A Data Driven Method for Military Route Planning



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Introduction

Can we apply probability models and pathfinding algorithms to satellite imagery data to generate viable routes that minimize the probability of detection from the enemy with minimal input from the planner?



Model: Detection Field

Detection can occur in one of two ways: (1) through visual detection or (2) through audio detection. The probability of detection along an arc then is between 0 and 1 and is a function of both visual and audio detection. We assume the probability of detection is the maximum probability of visual and audio detection, since detection by one form causes the focus of attention of the other form to shift to the target (if you hear something, you look at it and vice versa). This formulation is demonstrated in **Figure 2**.

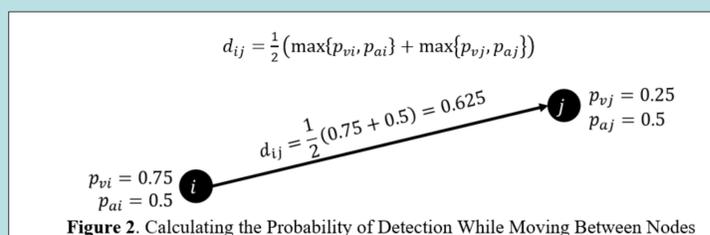


Figure 2. Calculating the Probability of Detection While Moving Between Nodes

Additionally, our model accommodates three methods of movement: walking, crouching, and crawling. Crouching and crawling have the benefits of lower detection at the trade off slower movement speeds. This tradeoff can be visualized in **Figure 1**.

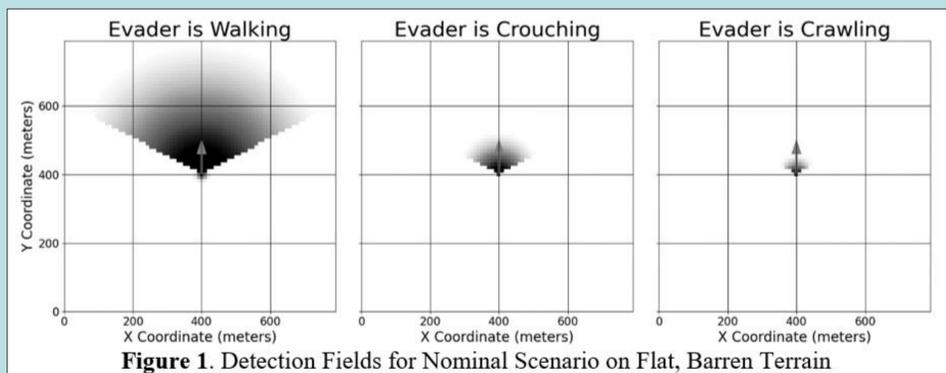
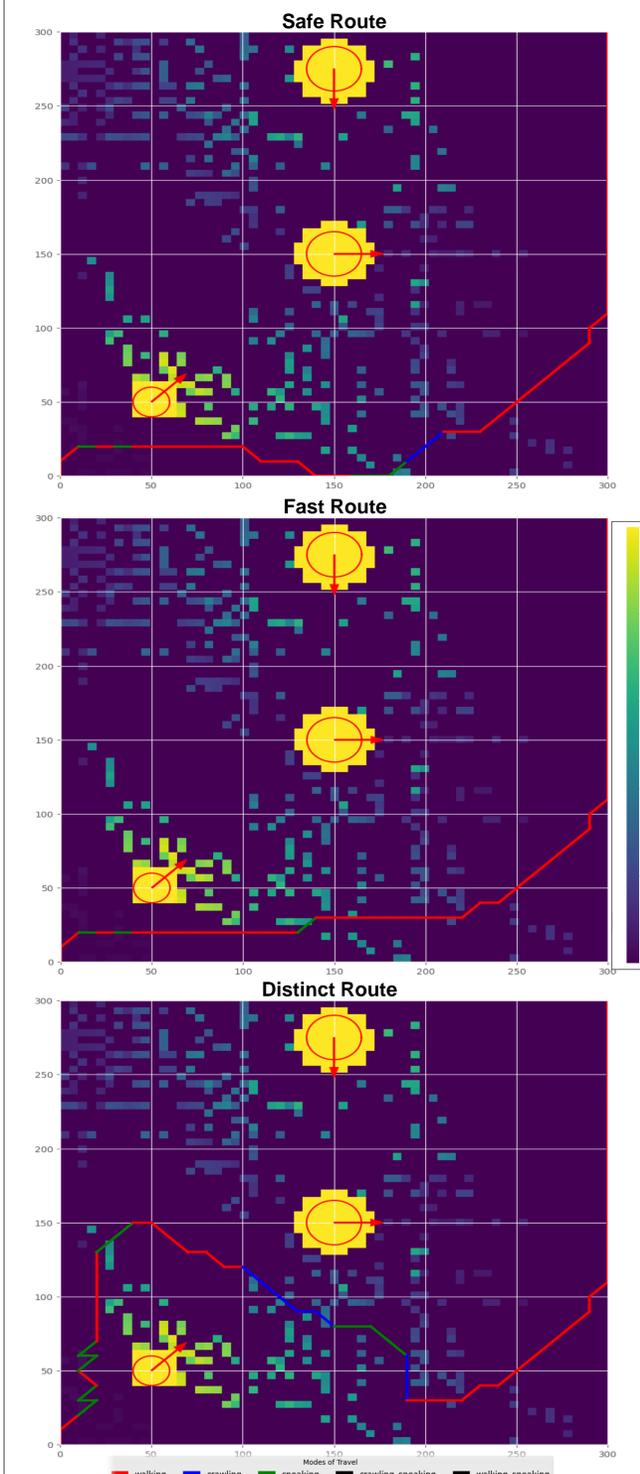


Figure 1. Detection Fields for Nominal Scenario on Flat, Barren Terrain

Results: Avenues of Approach



Route Type	Detection Prob (%)	Time of Travel (seconds)
Safe Route	0.27	1036.5
Fast Route	8.89	638.15
Distinct Route	6.37	2531.36

Table 2 Comparison of Route Metrics

Pathfinding Algorithms: A* and Dijkstra

- Dijkstra is a breadth first search, expanding from the start node in all directions until a feasible route is found. Is more robust but can be expensive in a large node field.
- A* is an informed search, expanding from the start node in the direction of the goal node using a heuristic until a feasible route is found. Less robust but less expensive.

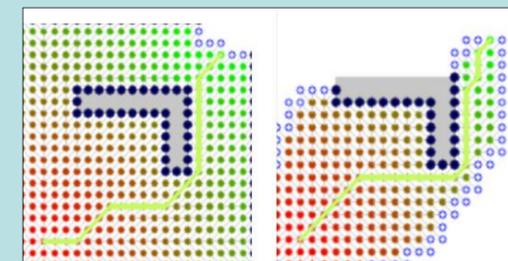


Figure 3: Visualization of Dijkstra (Left) vs. A* (Right)

Our Search Method

- Given the user inputs of the start node, goal node, location and type of the enemies, we apply A* or Dijkstra's to generate three feasible solutions for the user to choose from.
- Safe Route:** The route that minimizes the probability of detection from the start to the goal node.
- Fast Route:** The user provides their risk tolerance (ex. Willing to accept 10% probability of detection). We then find the route that minimizes the probability of detection using the probability
- Distinct Route:** A third unique route is determined by iteratively identifying a path that shares less than a predetermined variation threshold (e.g., 33%) of nodes with the two initial routes, thereby ensuring a set variation in the path composition.
- An example of our results can be seen to the left, and in **Table 2**.

Conclusion

We believe this method has potential to modernize the way route planning is done in the army. Future work includes the development of a user interface so that the untechnical soldier can leverage this technology with minimal friction. There is also potential for the application of machine learning for enemies in a dynamic environment

References

- Kendall, Thomas P., Daniel T. Killian, and Matthew J. Koch. "Optimized Tactical Route Planning." *Military Operations Research Journal* 28, no. 4 (2023): 5-21.