Engineering Route Planning Algorithms in Complex Environments

Delivery Apps' Convenient and Destructive Business Models

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

In software, route planning algorithms serve as a building block to help entities get from point A to point B. After numerous optimizations, route planning algorithms for transportation networks including cars, buses, and trains have gone through rapid development, resulting in methods that are now hundreds of thousands of times faster than their predecessors. The result of these advancements have led to increased safety, reduced transportation expenses, and overall better planning for businesses.

As third-party delivery companies such as Uber Eats, DoorDash, and Grubhub generate hundreds of millions in revenue and continue to fuel their expansion, they advertise their technology as innovation to allow ordering low-cost food. Bolstering this motto to increase usage of their apps, delivery platforms subsidize delivery, minimizing costs and making it cheap for consumers; the delivery apps these companies fund have formed a convenience culture to train consumers to expect what they want and when they want it. However, while making it convenient for consumers, delivery apps have a common practice of charging 20 to 30 percent commission rates for every order, squeezing restaurants with high fees. From the perspective of restaurants, these apps are predatory in that they insist on such a large cut of the order price to the point that the restaurants are left without much profit on the order. These delivery apps have a radically different interpretation based on the social group being considered; in this case, consumers benefiting from a convenience culture compared to workers and restaurants becoming financially pressed.

In real world contexts, route planning algorithms are seen in various applications, including Google maps, autonomous vehicles, and taxis. Most notably, these algorithms are at the core of the operation of the primary services delivery apps offer, from companies mentioned such as DoorDash, Grubhub, and Uber Eats. The exploration of creating better and new methods of route planning is directly related to the underlying technologies used by the products of these companies that are discussed as creating conflicting business models.

Technical Topic

Computing an optimal route in a network between a specified source and target node is a frequent functionality when planning trips with public transportation and cars. There are many applications such as logistic planning that solve a large number of requests to calculate shortest-paths in transportation networks. As mobility is very important in our society, everytime someone travels from one location to another, he or she determines the best route to reach the destination, accounting for random variables such as the day and week, time, congestion patterns, and construction. Car navigation systems are capable of taking over these tasks that are otherwise performed by the driver; using route optimization software leads to increased safety, reduced transportation expenses, and better planning. By having a clear route set out, the driver experiences a significant impact on risk reduction, potentially helping avoid accidents. Transportation expenses such as fuel and maintenance rise quickly from unplanned routes that result in long periods of driving time. For businesses that require scale to reach hundreds of destinations in one day, route planning arranges the destinations in a timely and efficient manner for the perfect solution. Optimal routing drastically cuts fuel costs, guarantees the safest path, and efficiently utilizes vehicles to allow businesses and individuals to achieve more.

Currently, virtually all route planning algorithms use depth-first or breadth-first search as a basis (Mallet 2019). In fact, the most widely used algorithm for route planning is simply BFS weighted, Dijkstra’s algorithm. The algorithm maintains the tentative distances for each node and settles the nodes of the road network in the order of their distance to the source node, until the target node is visited (Kadry 2012). Bidirectional search is another classical route planning algorithm used today, which executes Dijkstra's simultaneously forward from the source and backwards from the destination (Kainz 1997).

As described above, there is a considerable amount of prior art related to the research topic, and one may argue that would leave little room for breakthroughs in the near future. However, most research in route planning algorithms is on *how they work,* not *how they are being used.* In other words, there has been rigorous research and improvements to the functionality of classic route planning algorithms, but they have yet to be placed and examined in more complex settings. In particular, route planning algorithms have only been commonly modeled on the cartesian plane, using euclidean distance. This leads to the objective of this technical research: to adapt existing route planning algorithms to more complex environments and, potentially, further optimize them. This research will initially challenge *how they are being used* by simulating them in more complex environments, specifically polar coordinates, to adapt them to such settings and possibly circle back to insights as to *how they work.*

To carry out the stated objective, the following methodology will be performed by myself: firstly, to build intuition by simulating existing route planning algorithms in said complex environments (i.e. polar coordinates), and secondly to extract observations for potential to optimize, implement discoveries, and re-simulate to analyze performance. A Java applet will be built from scratch for full control over simulation.

So far, a considerable amount of work has been done towards the first step, and is kept in a repository. The Java applet for simulating route planning algorithms on a polar plane has been built, and three algorithms, including BFS, DFS, and Dijkstra's have been implemented. Shown below in Figure 1 is simulating Dijkstra's, where the green node represents the source, the red node represents the destination, black represents obstructions, blue represents nodes traversed, and yellow represents computed shortest-path; see the full gif animation here.

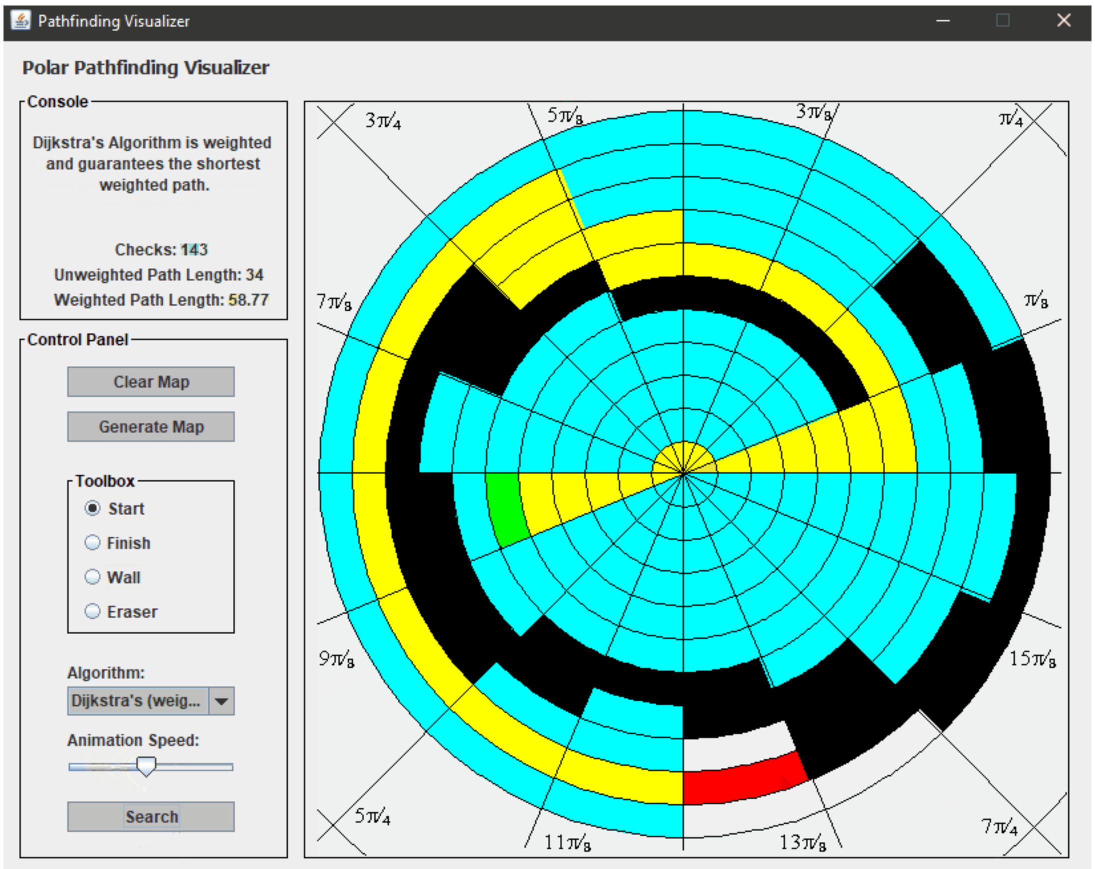

Figure 1 : Dijkstra's as simulated on Polar Coordinates

Placing well-known route-planning algorithms in the simulator has already led to some remarkable observations:

1. BFS does not take into account the arc length weights on the polar grid and can look misleading in the depiction. However, BFS is still able to find the shortest unweighted path represented by the number of edges.
2. DFS' property to go as far down a path before backtracking makes it go in a spiral in a polar grid
3. As a weighted algorithm, watching Dijkstra's on the polar grid was able to find the shortest weighted path by journeying as close to the origin as possible before going left and right, recognizing how arc length is less with smaller radii closer to the origin.

These observations led to the discovery of an intuitive depiction of weighted versus unweighted algorithms using arc length; the visualizer makes it obvious why unweighted algorithms do not work on the weighted polar grid.

Although some progress has been made, going forward, there are more algorithms to be implemented into the simulator, and observations need to be converted into optimizations to actually make the algorithm more efficient and improve route planning in practice.

STS Topic

Delivery services such as Uber Eats, DoorDash, and Grubhub, are constantly expanding to meet high customer demand. Offering low-cost food, these delivery platforms minimize costs for consumers while providing the convenience of having a wide selection of restaurants from anywhere, requiring little physical effort. The delivery apps these companies fund have formed a convenience culture, wiring consumers to commonly have the expectation that takeout is offered, or only ordering from companies that do. However, while popular and convenient for consumers, delivery apps have a common practice of charging a high percentage of commission rates for every order, charging restaurants with high fees. From the perspective of restaurants, these apps take a large cut of the order price leaving little to no profits on orders. These delivery apps are a direct example of the politics of design from sociotechnical systems, by having clear design choices that have political, economic, and societal implications; while there are consumers that benefit from a convenience culture, workers and restaurants are becoming financially pressed. This research paper will detail the convenient business model third-party delivery apps have created for consumers, but the financially destructive business model they have created for workers and restaurants.

Beneath their wonderfully designed location-data driven and route planning technology, delivery platforms leave restaurants with next to nothing, as reported by multiple sources. By an article on smaller food delivery apps seeking out more ethical business models, Gabriela Barkho expresses how although delivery platforms have promised a higher demand from customers to partnered restaurants, top takeout platforms bring on enormous fees and that recently there has even been a pushback against high commission-based delivery apps, “even calling for boycotts”

(Barkho 2021). Voicing how boycotts are taking place and solutions from smaller, ethical, and restaurant friendly apps are being introduced as competitive business models, this article establishes how high commissioned delivery apps have gone too far with the issue at hand. In an article on restaurants trying to ditch delivery apps, Gina Pollack states the numbers by company: UberEats has commission rates that range from 15% to 30%, Grubhub on average, costs restaurants 25% commission on each order, and that DoorDash fees roughly %22 commission (Pollack 2020). This article provides a non-biased, factual, and statistical standpoint on how much restaurants are actually being hit. Analyzing statistics based on these commission percentages, it is easily understood that these delivery apps are taking advantage of and causing restaurants to lose the majority of their hard-earned revenue.

Analyzing this complex sociotechnical system under the lens of the politics of design is the most suitable, as it relates to the design choices of delivery apps and their political, economic, and societal implications. As evidenced before, the negative impacts of delivery apps on the financial well-being of restaurants is rampant, and will continue to occur unless there is some structural change. For example, in *Regulating Uber: The politics of the Platform Economy* Kathleen Thelen analyzes Uber's reception and responses as a disruptive actor, detailing how the pressure on restaurants will continue because from the perspective of the companies in charge of the delivery platforms, the consumer's knowledge is deemed more important and credible than that of the restaurant's (Thelen 2018); this is established by how they create a convenience culture for consumers at the expense of high commission fees for restaurants, to maximize profit. The construction of the technology was made for the customers, and leaves out restaurants. As far as delivery apps are concerned, they understand that restaurants have little to no choice to use their services to compete during COVID-19 lockdown and take advantage of it, while prioritizing efforts to make the consumer revisit the app.

Next Steps

Completion of both the technical Capstone project and STS project will occur in May 2022. In regards to the future of the technical project, additional route planning algorithms such as A* and bidirectional search is to be implemented into the simulator, and more observations from the complex environment need to be made to lead into optimizations that actually would improve route planning in practice. To perform a more in-depth analysis for the STS project, research as to how the government and legislation is involved, how restaurants are responding, the effect of COVID-19, and possible solutions to help restaurants still need to be investigated. The strategy to complete this work over this and next semester is to work on both projects in parallel, but specifically for the technical research to follow the 2-step process previously detailed and for the STS research to begin by collecting and analyzing more evidence in the form of books, articles, and statistics related to the areas stated to go into more detail about.

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