Fastest Route to eat Honey Fruit!

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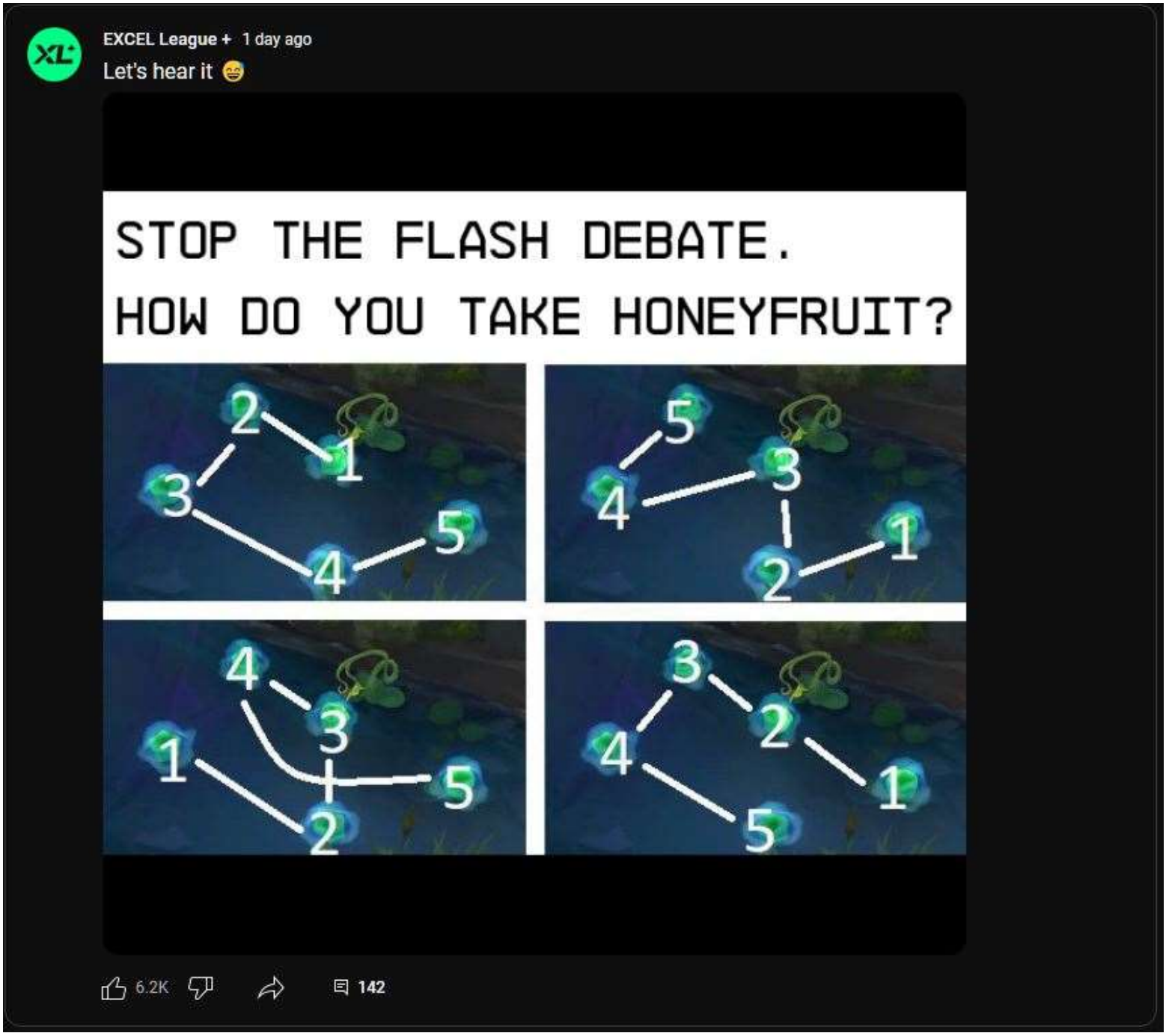


Problem

For those who don't know, the numbered goops in the picture are called Honey Fruits from the game League of Legends. Whenever your character walks over a Honey Fruit, they regain some Health and Mana. I thought it was a pretty funny joke, but I thought knowing the fastest way could one day come in handy. This looks like a **Travelling Salesman Problem (TSP)**, where a salesman wants to find the most efficient route between the cities Albany, Buffalo, Chicago, Denver, and Erie, and wants to visit each city only once. This problem is notorious for being the class NP-hard. This makes it one of the problems that is easy for a computer to verify a solution to but very difficult to find the solution in the first place. It's like finding a needle in a haystack. It's easy to tell once the needle is in your hand, but it's hard to find it. There is currently a one-million-dollar bounty for anyone that can make a magnet to find the needle in the haystack. This is because solving this problem lights the path to the solution to many other NP-hard problems.

I first got L1 pixel measurements of the straight lines between each one of the fruits by using the ruler tool in Photoshop (original photo 300x191px).

AB	80
AC	75
AD	130
BC	120
BD	125
BE	205
CD	75
CE	95
DE	95

*Measured using L1 distance pixel measurement, not in-game units

Results

Assuming that Top laners will be starting at **A** and Mid laners will be starting at **E**:

From Midlane: **E D C A B = 325**

From Toplane: **A B C D E = 290**

Luckily since this is a small TSP, it can be done by hand without too much of a hassle (Though a Java solution is in GitHub). This 5 fruited plant has 25 possible routes. To explain, there are 5 fruits to start from. From there, 4 more fruits can be chosen from, then 3, then 2, and then only 1. By finding all combinations of paths to take this way, there are 5! = 25 routes. If there's a 14 fruited plant in Season 14, we would need a computer's help to solve this problem: 14! = 87,178,291,200. If there's a 20 fruited plant in Season 20, we are past the point of computers being able to help us: 20! = 2.43×10^{18}.

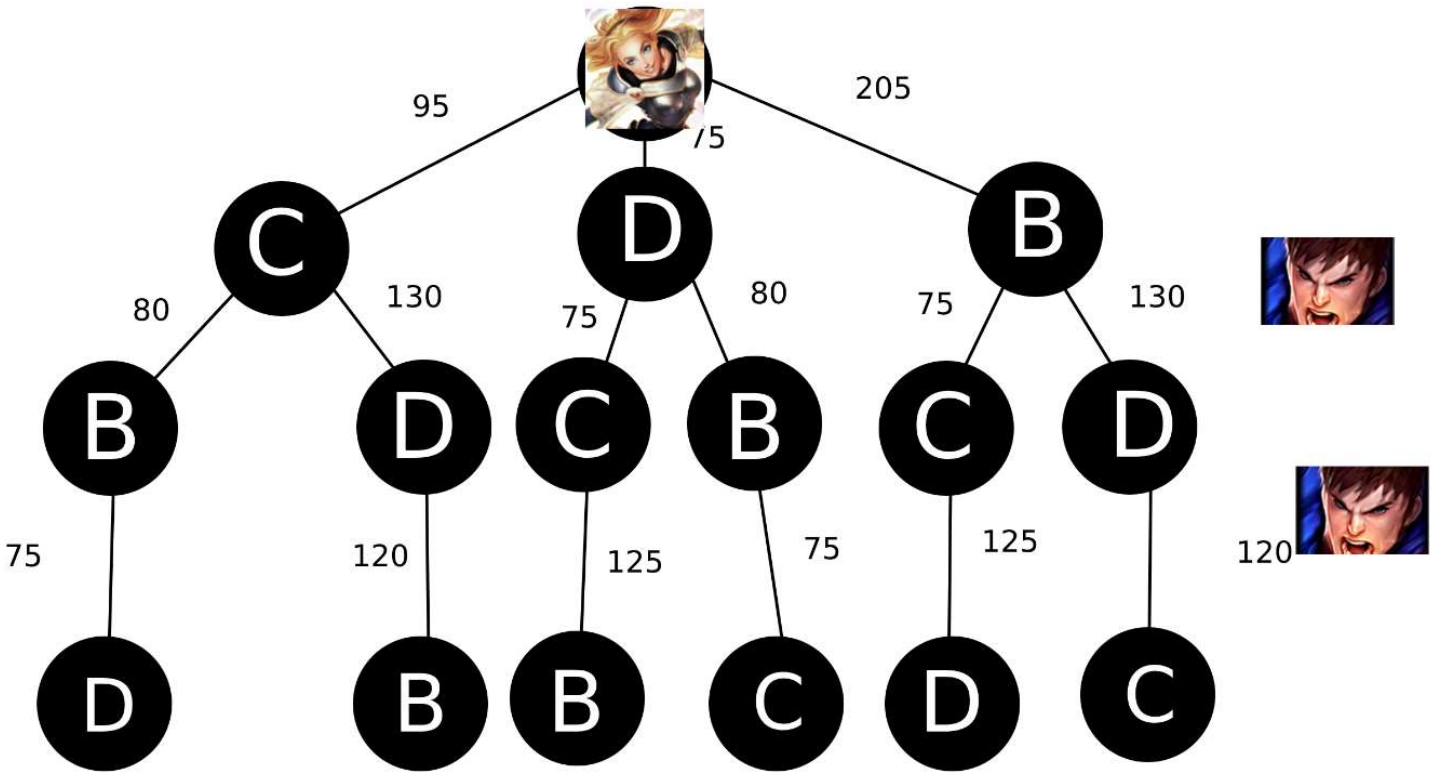
For a smarter approach, the algorithm is given some intuition by ignoring some of the long stretches, such as BE. For larger TSPs this is necessary, with 60 cities, the amount of atoms in the universe couldn't hold that amount of data. However, this approach is greedy as since all paths aren't explored, there isn't a way to know if it's the best. Until it can be proved one path is the best without comparing it to the rest, this problem is NP-hard.

Fight for Fruit!

In this game, Lux wants to eat the fruit for Mana, and Garen wants to eat the fruit for Health. Lux starts on E, she can choose any fruit adjacent to herself to start walking towards. Garen starts on A and can choose any fruit adjacent to himself. Once a fruit has been eaten, it cannot be targeted, but if it is eaten by the other while in transit, the player must keep going until he reaches the location where the fruit was. The game ends once all fruits are eaten, whoever eats more fruits wins.

Problem

This game changes the problem from a TSP to an adversarial search algorithm, in this case, Minimax algorithm. The Minimax algorithm works with a weighted graph and two "agents" (Lux and Garen). The first agent, Lux, looks to take the maximum amount of value (in this case minimum distance). Garen then looks to see what he can do to minimize the other's potential (force the other to take fruits farther away). The hopes for both agents are to have more value (fruits/minimum distance) by the end.



Best case for Lux: **Lux D-C-B = 290, 4 fruits**

Garen D-C-B = 325, 1 fruit

Best case for Garen: **Lux C-D-B = 295, 1 fruit**

Garen C-D-B = 275, 4 fruits

Minimax match: **Lux D-B = 215, 2 fruit**

Garen C-B = 275, 3 fruit

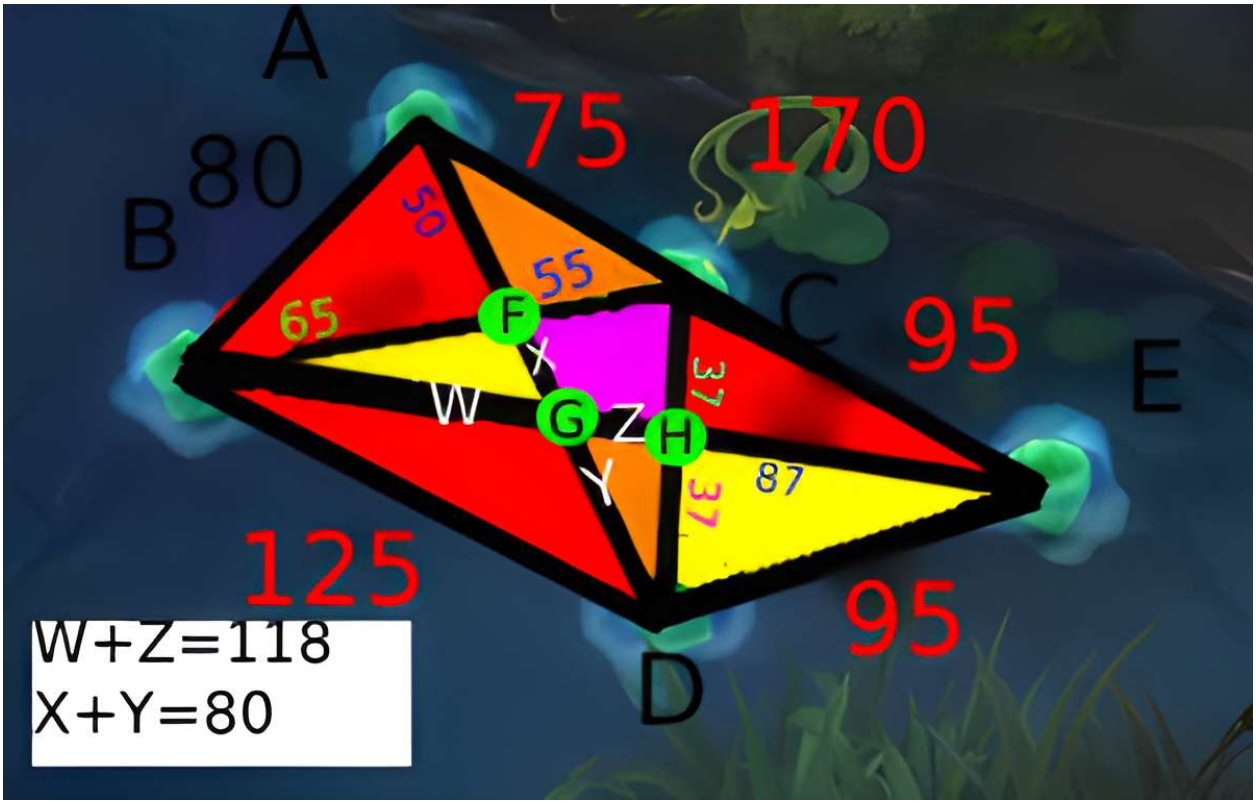
The best and worst cases are kind of trivial. Following your opponent won't get you any fruits, that's a bad strategy.

In the Minimax match, Lux starts by taking the closest fruit **D** (most value, and uncontested), then Garen responds by going to **C** (removing value). This forces Lux to go to the final fruit, which Garen set up to be able to beat her to.

From these results, the Honey Fruits are weighted towards the topside. Top Laners get the fruits faster by themselves and can secure more fruits in a fight, given they know how. Top laners that go A-C-B will always secure the 3 fruits before their opponents, since they are given the shortest path to a fruit to start, and that fruit leads to the next shortest path to a fruit.

Geometric Approach

While geometry is one of my weaker sides, I'd still like to consider what I can. The Honey Fruits make a pretty interesting shape. It's a trapezoid where the parallels are at 170px and 125px length, and two other straight sides of 80px and 95px.



After doing as many triangle rules as I could remember, I am currently looking into how to find WXYZ, to see if having fruitless 'junctions' FGH can swing things in the favor of Lux.