Faster, Faster! Touring Disney

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Background

We visit amusement parks like Walt Disney World to have fun, not to wait in lines or walk between attractions, which motivates us to study how to visit park attractions in as little time as possible. The problem of trying to find an optimal tour of attractions is known as the Traveling Salesman Problem (TSP), and it belongs to a class of problems called NP (nondeterministic polynomial), which are notoriously difficult to solve optimally. In fact many mathematicians suspect that no quick solution to these problems exists. So rather than try to find the *optimal* tour of attractions, many researchers attempt to find *good* tours that approximate optimality.

In the TSP, walk, wait, and ride times are considered fixed constants. At Disney, however, the amount of time a customer spends in line at an attraction depends upon the time of day the customer arrives at the attraction. The problem of finding an optimal tour with time-variable waits is known as the Time Dependent Traveling Salesman Problem (TDTSP). Further, Disney patrons can use special reservations called FastPasses to bypass the regular attraction line to enter a separate line with a much reduced wait time. Each FastPass is valid for only one attraction and it must be used during a specified time. This addition creates a problem known as the TDTSP with Time Windows (TDTSPTW).

Image Credit: themeparkuniversity.com/wp-content/uploads/2014/02/fastpassplus.jpg

FastPass Selection

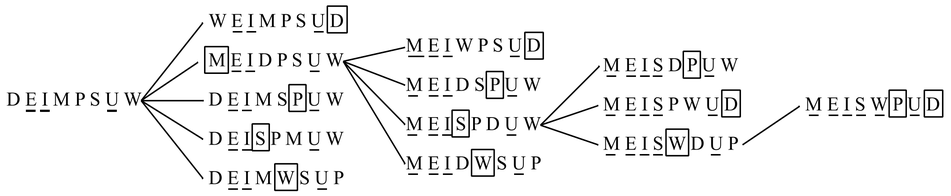
FastPasses can be selected in a variety of ways before optimizing a tour.

- You may have already selected FastPasses on Disney's App
- Disney may offer FastPass suggestions sets
- You may be able to pick any 3 FastPasses
- You may want a FastPass for a particular ride

Method: Genetic Algorithm

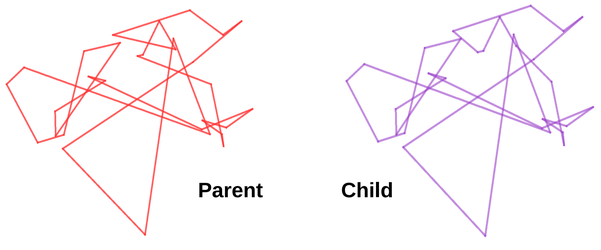
The TDTSPTW is too computationally complex to find an exact solution for even 20 attractions. Thus we use a heuristic approach in the form of genetic algorithms to produce an approximate solution. For a given set of rides, we generate a number of possible tours of a park. To search for better tours, we use the mechanics of natural selection to create new tours. Each tour in the population is given a fitness score. For us, this score is the time it takes to complete the tour. Then we randomly select tours from the population to either undergo a mutation or a crossover.

In mutation, we might swap the position of two attractions in a single tour. In a crossover operation, we combine two tours, taking parts of each parent to produce a child tour. An example of a crossover operator, known as the Path Relink Operator, is seen below. It seeks to find a path of tours between the two parent tours and return the most fit tour along the path as the new (child) tour. Tours with a poor fitness value are discarded and good tours continue to evolve with crossovers and mutations. Over time, this leads to better tours being selected for inclusion in the population.



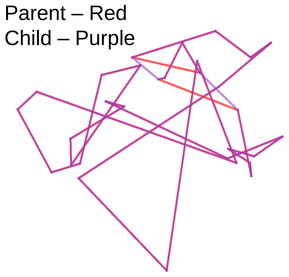
Mutations

LKTD First Mutation



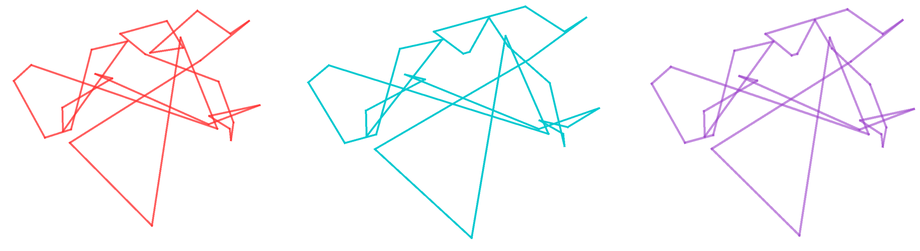
Overlay on map

Overlay
Parent – Red
Child – Purple



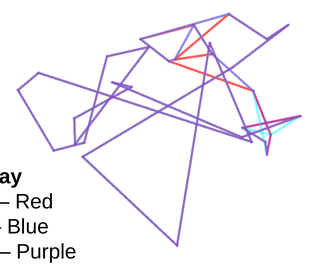
Crossovers

Path Relink Crossover



Overlay on map
Mom – Red
Dad – Blue
Child – Purple

Overlay
Mom – Red
Dad – Blue
Child – Purple



Results

We used the genetic algorithm to compare finish times between tours without FastPasses and tours with FastPasses. In the Magic Kingdom, none of our tours without FastPasses finished in less than 720 min, while the best tour with FastPasses finished in less than 670 min. This tour uses fast passes for Seven Dwarfs, Space Mountain, and Peter Pan.

To test which rides should be given FastPasses, we gave FastPasses to each combination of three particular rides in Magic Kingdom. Each combination ran for 6000 generations and the 14 overall most fit tours were collected. The chart to the right shows the number of times a ride was given a FastPass in these 14 tours.

Ride	FP count
Seven Dwarfs	13
Peter Pan	8
Space Mountain	5
Enchanted Tales with Belle	4
Winnie the Pooh	4
Jungle Cruise	3
Haunted Mansion	2
Under the Sea	1
Big Thunder	1
Magic Carpets	1

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