AI utilization in route planning for delivery trucks within the supply chain

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Introduction

The supply chain has potential for improvement. Many different parts can be optimized, and every possible improvement has not yet been tested.

The study focused on route optimization with the specific goal of figuring out how machine learning (ML) can be applied to route planning and how key factors that impact travel time for a route could be taken into account for this problem.

To fulfill the goal, several problems were solved such as how route optimization is done today, which key factors that can be applied, collected, and used in ML algorithms, how different ML algorithms can be applied to route planning as well as how load planning can be incorporated.

The thesis work done in cooperation with Capgemini Sverige AB

Explanation of associated words of the thesis work:

Supply chain - Network between companies and suppliers that handles the distribution of wares.

Route optimization - Optimizing the routes delivery trucks have to take either by limiting the total amount of routes or making the routes they take more efficient

Key Factors - Important factors that can be used as input data for route optimization.

Load planning - The planning that goes into loading delivery trucks, such as optimizing storage usage.

Methodology

The thesis work started with an initial study to learn more about machine learning (ML). With this knowledge, algorithms and key factors that were deemed suitable for solving the problem were chosen.

Afterward, specific knowledge was gathered regarding the chosen algorithms and key factors. The gathered knowledge was then put to use and a prototype was created to test the eligibility of the algorithms and key factors that were decided on in the previous phase.

The algorithms traversed a node network, trying to find the cheapest, most efficient, route between the nodes, while incorporating key factors.

Prototype

To fulfill the goal and problems of the thesis, a prototype that allowed for visualization and efficient testing was implemented.

Two different algorithms were tested. This allowed for comparison between them, and increased the possibility of finding a solution to the problems described in the introduction.

NEAT

First the "Neuro Evolution of Augmenting topologies" (NEAT) algorithm was tested to solve "the XOR problem". After seeing promising results, NEAT was implemented to solve route planning cases.

This was done by having truck objects, with a neural network as a brain, traverse the node network. The path each truck took was evaluated, and then the neural network inside each truck was evolved using NEAT.

GA

After testing the NEAT algorithm, a Genetic Algorithm (GA) solution was tested. It worked similarly to the NEAT algorithm, however each truck did not have a neural network to make its decisions.

Instead an initial path was randomly generated, and then evaluated. Then, the process of using crossover and mutation to change the paths, and then evaluate them again, was looped for a desired amount of times.

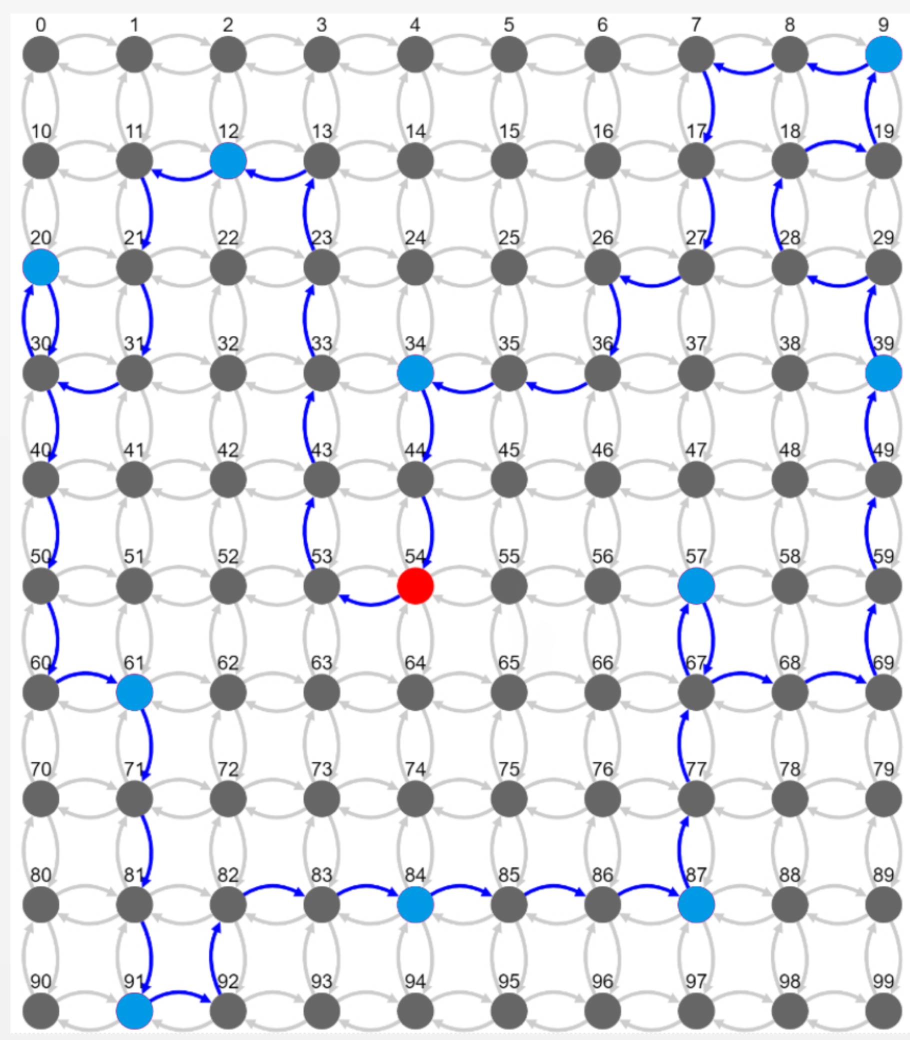
Result

By following the methodology, the problems in the introduction could be answered

It was concluded that route optimization is done in many different ways. Optimizations in the supply chain can have a direct impact on route optimization. However, route planning still has the most direct effect on route optimization, and the primary way route planning is done today is by the use of software such as Google Maps or other route planning software.

Ways to collect key factors are presented in the thesis and their application to NEAT and GA was verified. The key factors can also likely be used in different ML algorithms for other potential ways to optimize routes.

NEAT showed the possibility of using the key factors to plan routes but was later overshadowed by the GA solution that could solve multi-stop route planning problems while also generating paths faster and more efficiently than the NEAT solution. The GA solution also provided ideas on load planning



Multi-stop path generated by the GA algorithm. The start and end node is colored red, and the nodes to be visited are colored blue.

Conclusion

Three main parts were studied during the thesis work.

- ML application in route planning
- Key factor utilization in ML algorithms
- Incorporating load planning in ML route planning

Results relevant to all three parts were presented and all the problems specified in the introduction were answered.

ML algorithms that can be used for route planning were tested and key factors were utilized in the algorithms.

Two algorithms have been tested and had their abilities verified in route planning scenarios. NEAT, as we implemented it, did not show signs of working effectively. However the genetic algorithm solution showed promising results in solving complex route planning problems with efficiency and great potential for improvement.

The implemented solutions cannot be used for real-time route planning and optimization. Instead, the potential of these conclusions lay in their ability to be worked on in the future, given more testing and better implementation.

During the thesis work many conclusions and ideas were devised and documented in the thesis. The one we believe could be the most beneficial is the following:

The most important key factor that can be applied to route planning is the exact amount of time a road takes to travel. With the experience retrieved by studying route planning and machine learning, we believe that by analyzing real data it would be possible to train a neural network with supervised learning and make it create accurate predictions regarding how long time a road takes to travel.