

Group 9 Proposal

(Shortest Path Algorithms in Weighted Graphs: Comparative analysis of Bellman-Ford and Dijkstra's Algorithm), (Study of AI-Based Heuristics in Algorithm Design: Application in Autonomous Systems), (Genetic Algorithms for Optimization Problems: Case Study Traveling Salesman Problem)



September 18, 2025

Group 9

CS 4306 Section W02

[Kevin Gomes](https://kennesawedu-my.sharepoint.com/personal/jjncharl_students_kennesaw_edu/Documents/Documents/Shared%20Projects/CS%204306%20Group%209%20Project%20Docs/0%20-%20Auxiliary%20Files/SWE_Intern_Resume_91125.pdf) | [kgomes5@students.kennesaw.edu](mailto:kgomes5@students.kennesaw.edu)

[Kevin Hu](https://kennesawedu-my.sharepoint.com/:b:/r/personal/jjncharl_students_kennesaw_edu/Documents/Documents/Shared%20Projects/CS%204306%20Group%209%20Project%20Docs/0%20-%20Auxiliary%20Files/Kevin-resume%20Jack.pdf?csf=1&web=1&e=r2Z0B1) | [zhu2@students.kennesaw.edu](mailto:zhu2@students.kennesaw.edu)

[J’adore Jn-Charles](mailto:J’adore%20Jn-Charles) | [jjncharl@students.kennesaw.edu](mailto:jjncharl@students.kennesaw.edu)

[Konrad Wilson](../0%20-%20Auxiliary%20Files/Konrad_Wilson_Resume.pdf) | [kwils313@students.kennesaw.edu](mailto:kwils313@students.kennesaw.edu)

# Executive Summary

*We have compiled research, methodologies, and project planning information for each of three topics that pique our interests for the semester-long research project. Detailed are three of the choices, in order of preference:*

1. *Shortest Path Algorithms in Weighted Graphs: Comparative analysis of Bellman-Ford and Dijkstra's Algorithm*
2. *Study of AI-Based Heuristics in Algorithm Design: Application in Autonomous Systems*
3. *Genetic Algorithms for Optimization Problems: Case Study Traveling Salesman Problem*

# Our Problem

*(Outline sections 2 & 3)*

## *Choice 1: Shortest Path Algorithms in Weighted Graphs: Comparative analysis of Bellman-Ford and Dijkstra's Algorithm*

Problem/Research Question:

With the rise of alternative methods of transportation, E-bikes have quickly become a staple in large cities, the battery life on these E-bikes is heavily dependent on the changes in elevation along the chosen route. We think this would be an excellent place to benchmark the two famous shortest path algorithms: Bellman-Ford and Dijkstra’s Algorithm.

Guiding our research, we ask: How do Bellman-Ford and Dijkstra’s algorithms in terms of performance, resource usage, and robustness when applied to E-bike route planning, where route elevation impacts battery consumption?

### Relevant Readings

1. Lin, J. C.-C. (2024). Shortest paths: Dijkstra’s algorithm & Bellman-Ford algorithm. National Taiwan Ocean University. https://josephcclin.github.io/courses/data\_structures/slides/ds\_shortest\_paths.pdf
2. Panigrahi, D., Kell, N., Song, T., & Wang, T. (2017). Shortest path: Dijkstra’s and Bellman-Ford. Duke University, COMPSCI 330: Design and Analysis of Algorithms. https://courses.cs.duke.edu/spring18/compsci330/Notes/shortestpath.pdfSlides
3. Noto, M., & Sato, H. (2000). A method for the shortest path search by extended Dijkstra algorithm. In *2000 IEEE International Conference on Systems, Man, and Cybernetics: ‘Cybernetics evolving to systems, humans, organizations, and their complex interactions’ (Vol. 3, pp. 2316–2320)*. IEEE. https://doi.org/10.1109/ICSMC.2000.88646

## *Choice 2: Study of AI-Based Heuristics in Algorithm Design: Application in Autonomous Systems*

Problem/Research Question:

Artificial Intelligence based heuristics has become a major tool in algorithm design. When it comes to solving complex optimization and decision-making problems it does really well. We see it in autonomous systems like self-driving cars, drones, and robots. These machines rely on efficient decision-making under realistic time constraints with limited computation and uncertainty.

Guiding our research, we ask: How do AI-based heuristics methods compare to traditional approaches for autonomous system design in terms of decision-making, adaptability, and reliability within the scopes of constraints such as real-time, uncertainty-prone, and dynamic environments, such as those within self-driving cars?

### Relevant Readings

1. Russell, S. J., & Norvig, P. (2021). *Artificial intelligence: A modern approach* (4th ed.). Pearson.
2. Koenig, S., & Likhachev, M. (2002). D\* Lite. In *Proceedings of the AAAI Conference on Artificial Intelligence* (pp. 476–483). AAAI Press. https://www.aaai.org/Papers/AAAI/2002/AAAI02-072.pdf
3. Sutton, R. S., & Barto, A. G. (2018). *Reinforcement learning: An introduction* (2nd ed.). MIT Press. http://incompleteideas.net/book/the-book-2nd.html

## *Choice 3: Genetic Algorithms for Optimization Problems: Case Study Traveling Salesman Problem*

Problem/Research Question:

The Traveling Salesman Problem is a famous NP-hard optimization problem, which is a problem to find the shortest path from point A to point B. In this problem, traditional methods can be too time-consuming and are not always the most suitable solution for this problem. To resolve such a discrepancy, we will study Genetic Algorithms (GAs), which are heuristic optimization methods inspired by natural selection. Rather than performing an exhaustive search, GAs combine different randomly generated solutions into a population and generate “offspring” solutions by combining the fittest parent solutions.

Guiding our research, we ask: How effectively can genetic algorithms (GAs) produce near-optimal solutions for, specifically, the Traveling Salesman Problem (TSP) with a focus on the principles of selection, crossover, and mutation and their effectiveness in finding said near-optimal solutions. To reach an even further level of scrutiny, we will also consider which selection, crossover, and mutation combinations yield the most desirable tradeoff between solution quality and convergence time.

### Relevant Readings

1. Nojoumian, M., & Nair, D. K. (2009). Comparing genetic algorithm and guided local search methods by symmetric-TSP instances. *2009 Canadian Conference on Electrical and Computer Engineering (CCECE)*, IEEE. https://doi.org/10.1109/CCECE.2009.5090228
2. Zheng, J., Wang, X., & Li, Y. (2021). Reinforced hybrid genetic algorithm for the traveling salesman problem (RHGA). *arXiv*. https://doi.org/10.48550/arXiv.2107.06870
3. MATLAB Help Center. (2025). *How the genetic algorithm works - matlab & simulink*. MathWorks. https://www.mathworks.com/help/gads/how-the-genetic-algorithm-works.html

# Our Approach

*(Outline sections 4 & 5)*

## *Choice 1: Shortest Path Algorithms in Weighted Graphs: Comparative analysis of Bellman-Ford and Dijkstra's Algorithm*

### Methodology/Algorithm to be Applied

To find the answer for our research question, we will create a set of implementations of the Bellman-Ford Algorithm and Dijkstra’s Algorithm, as well as a sample set of data to perform benchmarks on. The benchmarks will allow us to develop a deeper understanding of each algorithm’s performance in this context, and how they handle different edge cases. We will then research why each algorithm performed the way it did determine under what conditions each algorithm should be used. An additional point we would like to document is the difficulty in implementing each algorithm.

### Evaluation Approach

We will compare the Time complexity, Space Complexity, Difficulty to implement, and the following data from the benchmarks:

* Time to execute
* Memory Usage
* CPU Usage
* Error Rates
* Edge Case handling

## *Choice 2: Study of AI-Based Heuristics in Algorithm Design: Application in Autonomous Systems*

### Methodology/Algorithm to be Applied

To answer our research question, we intend to apply a classic implementation of the **Learned Heuristic A\* (LHA\*) algorithm**. This algorithm will be used to compare AI-based heuristic methods to traditional heuristics methods, demonstrating how AI-based heuristic methods can improve classic real-time decision-making, adaptability, and reliability approaches. We will simulate an environment with dynamic elements like those commonly faced by self-driving cars, such as moving obstacles.

The implemented AI-driven heuristic will evaluate that AI-based heuristics can:

* Adapt in real time in the case of dynamic obstacle handling
* Improve decision-making speed without sacrificing a major portion of reliability.

### Evaluation Approach

Via the methods discussed above, we will evaluate whether AI-based heuristics improve decision-speed, adaptability, and reliability compared to traditional approaches.

To approach this, we will compare metrics such as decision latency, path optimality, adaptability under dynamic changes, and collision/failure rates.

## *Choice 3: Genetic Algorithms for Optimization Problems: Case Study Traveling Salesman Problem*

### Methodology/Algorithm to be Applied

To approach our research question, we intend to implement a GA to solve the TSP. We will then test via solutions represented as permutations of cities and evaluate the route fitness in via tour length. The implemented algorithm will first randomly generate a population of solutions and then evolve said solutions via selection, crossover, and mutation operators. We will utilize standard TSP datasets for our experimentation.

### Evaluation Approach

Result evaluation will include metrics such as solution quality, convergence behavior, and computational efficiency. These results will be compared with traditional heuristic approaches to assess the overall effectiveness of GA in producing near-optimal solutions.

# Project Timeline

*(Outline section 6)*

*This will be the projected timeline that we intend to utilize for any of the three topics. Some dates may be subject to change at our discretion.*

Please click through to here to see our [formatted project Gantt chart](https://kennesawedu-my.sharepoint.com/:x:/g/personal/jjncharl_students_kennesaw_edu/ES3esYjTX21Lg_Kv9bfTN-IBoUHNYGRI2B_GsxNeB09PxQ?e=qoQeHg).