Using Genetic Algorithms to solve the Travelling Salesperson Problem

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*Abstract*— In this paper I present a Genetic Algorithm to solve the Travelling Salesperson Problem for two hundred randomly generated cities on a map of the United States of America. I implement a Genetic Algorithm, which goal is to determine the optimal route with the shortest distance for a salesperson to travel. I will also provide an analysis of different Genetic Algorithm parameters such as Selection Method, Scaling Method, Population Size and Max number of generations.

Keywords—component, formatting, style, styling, insert (key words)

# Introduction (*Heading 1*)

The Travelling Salesperson problem is a well-established problem. The problems involves a number of cities with varying distances between each city. The idea behind this problem is to determine the best route for a salesperson to take, assuming the salesperson must visit each city at least once. Although this problem, on the surface, looks simple, it is incredibly difficult to solve and requires intense computational capacity, which twenty years ago would have been almost impossible for a network of two hundred cities.

I will present a genetic algorithm (GA) to solve The Traveling Salesperson problem. A genetic algorithm is a nature inspired algorithm inspired by the process of natural selection. It is mostly used for optimisation and search problems. Each GA initially begins with a population of randomised individuals, each with its own chromosomes, which contains a certain number of parameters. The algorithm simulates biological processes such as mutation and crossover. GA will repeat these processes repeatedly. For each iteration or generation, the algorithm will select the most promising individuals (in accordance to Darwin’s theory of natural selection) to survive and breed for the next generation. It determines the most promising and fittest individuals, by calculating their respective fitness value, and using this value to select the fittest. This simulates Charles Darwin’s theory of Natural Selection and “Survival of the fittest.”

In this paper. I present a specific implementation of The Salesperson Problem with two hundred cities. These cities are randomly generated and randomly located on a map of the United States of America. I use a genetic algorithm to find the shortest route between each city. I also provide an analysis of the different parameters such as varying Scaling and Selection Methods. And the effects of increasing population size and increasing the number of generations that the simulation can run for.

# TRAVELLING SALESPERSON PROBLEM

That Salesperson Problem is a well-known problem. The definitive origin of the problem is unknown, but it is thought to originate from an Austrian mathematician name Karl Menger. The problem was technically first published in the 1948 by Merril Meeks Flood, since than the problem has been widely studied and researched. It is a simple problem to conceptualise and understand, but extremely difficult to solve. Requiring a lot of computational resources to solve. The Salesperson Problem is a situation where there is number of nodes(cities). With varying distances between each node. The goal of The Travelling Salesperson Problem is to find the optimal route between all the cities in the problem, assuming that every single city has to be visited at least once.

# Methodology

A genetic algorithm is used to solve The Salesperson Problem. A GA is inspired from Charles Darwin’s theory of natural selection. So the algorithm’s methodology takes inspiration from this.

### Intialisation of an Intial State

The algorithm initialises a randomised initial state. The initial population’s chromosomes have a random set of parameters. The population size will be set to specified number.

### Evaluation of fitness

A fitness value can be determined by a fitness function. The fitness function will determine a value. This value in The Travelling Salesperson Problem is the total distance travelling on specific route. It is calculated by using the distances between cities. Since the fitness value is the total distance of a route, the individuals with a smaller fitness value, would be considered fitter, meaning they will be more likely to survive and breed.

### Reproduction

In adherence to the theory of Natural Selection the fittest individuals are the most likely to survive and breed to the produce the next generation. for Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used s secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.

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*a**b* 

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* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
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An excellent style manual for science writers is [7].

# implementation

### Program Details

The program is written in MatLab. It is a modified version of a Travelling Salesman Problem provided with MatLab. After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

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##### Acknowledgment *(Heading 5)*

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

##### References

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1. G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

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1. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
2. I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
3. K. Elissa, “Title of paper if known,” unpublished https://pdfs.semanticscholar.org/a5cd/c315936617eb0e41ad54095950dba04b9a84.pdf.
4. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
5. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
6. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.