Shannen Daly, Levi Hubbard, Sean Lantto

**Using a Genetic Algorithm to Optimize a Multiple Burn Orbit Transfer**

MAE 565 – Spring 2016

Artificial Intelligence Techniques in Engineering

Department of Mechanical and Aerospace Engineering, West Virginia University, Morgantown, WV 26506/6106

02/15/2017

## Abstract

## Table of Contents

[Abstract i](#_Toc473981178)

[Table of Contents ii](#_Toc473981179)

[Symbols iii](#_Toc473981180)

[Introduction 1](#_Toc473981181)

[Procedure 2](#_Toc473981182)

[Technical Discussion 3](#_Toc473981183)

[Results 4](#_Toc473981184)

[Conclusions and Recommendations 5](#_Toc473981185)

[References 6](#_Toc473981186)

## Symbols

Symbol

Description

Unit

## Introduction

In space travel, the traditional method for performing a transfer between two orbits is the implementation of a two-burn Hohmann transfer. This method is the simplest and most effective way to perform such a maneuver. It may also be used to facilitate a rendezvous between two spacecraft in this new orbit. There may rise an occasion, however, when this two-burn transfer is not available.

To solve this problem, a four-burn transfer may be used. To keep all four burns within the required time window to complete a possible rendezvous and reach the same delta V of the Hohmann transfer, a genetic algorithm will be used. It will be designed to optimize the performance of the four-burn transfer as well as maintain all required parameters while searching through a large field of possibilities.

## Procedure

## Technical Discussion

When considering performance indices for each individual in the population, it is important to think about the different possible solutions that can be created through initialization and application of genetic modifiers. To ensure that all possible individuals are given a chance to potentially reproduce, all possible representations of genes are given positive values. This process is acted out by a series of if statements that are nested within a for loop that runs for every individual in a population. As the four delta-vs work together to reach the desired final delta-v, they are added together and evaluated as a group. The evaluation criterion has six different classifications for the final delta-v value depending upon the range of acceptable delta-v values. The process for evaluating the time of flight of the individual is the same as that for the delta-v, but the time of flight is only one value as opposed the delta-v’s four.

The performance indices for all of the genes are then added together and the overall performance of the individual outputted by the fitness function. These values may then be used to evaluate the individuals within the population and decide what genetic modifiers are to be used to further improve the solutions.

To select which individuals were to be inserted into the group that are to have the genetic modifiers applied to them, a roulette wheel selection approach was used. This selection technique was chosen to ensure that all individuals are given a chance for reproduction. This available chance allows for the situation to potentially occur in which “bad parents make a good offspring”. With such a large search space, keeping all potential options for a good outcome must be maintained as the resulting fitness improves.

This was initialized by each of the individual’s total fitness being divided by the sum of the total fitness of the population to accurately evaluate how much of a chance they had to reproduce.

Once these probabilities were evaluated, a series of random numbers between zero and one were generated with the same number as that of the population being evaluated. The population will remain the same in terms of number of individuals to preserve the balance between exploration and exploitation. To make the selection of individuals, each member of the population’s calculated probability was evaluated against the built vector of random numbers. To preserve the range of these values, both the random value and the individuals’ probability was rounded to the nearest hundredth. This will allow more of a range for the selection criterion and allow more of the population to be chosen. The population of those chosen to be changed by the genetic operators would now be created and the process may move on.

## Results

## Conclusions and Recommendations

## References