Evolutionary artificial intelligence and robotics

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November 2024

Abstract

Evolutionary artificial intelligence used to solve search and optimization problems, based on genetic processes of biological organisms. In this report, we have focused in some important algorithms to solve some real problems.

0.1 GitHub Repository

https://github.com/Harithelamin/ACIT4610-24H-G13

1 Traffic Management Optimization Using Multi-Objective Evolutionary Algorithms

In this task, we have applyed a Multi-Objective Evolutionary Algorithm (MOEA) to optimize traffic management strategies for selected New York City (NYC) areas, in order to minimize conflicting objectives, Total Travel Time (TTT) and Fuel Consumption (FC), using real-world traffic data from NYC Open Data.

The traffic management strategy has involved controlling traffic signal timings (green, yellow, and red light durations), and setting speed limits on these segments. We have developed an MOEA that optimized these parameters to achieve the best trade-off between minimizing TTT and FC.

1.1 Data Exploration, and Preprocessing

In addition, we have used two datasets from the NYC Open Data portal: 1. NYC Traffic Volume Counts[1]. 2. Traffic Speed Data[2].

The both datasets were collected from New York City Department of Transportation (NYC DOT). The first dataset uses Automated Traffic Recorders (ATR) to collect traffic sample volume counts at bridge crossings and roadways, and contains 31 columns[1], while the second dataset uses average speed of a vehicle traveled between end points, and contains 13 columns[2].

```
Column names in Traffic_Volume_Count_data:
Index(['id', 'segmentid', 'roadway_name', 'from', 'to', 'direction', 'date',
       '_12_00_1_00_am', '_1_00_2_00am', '_2_00_3_00am', '_3_00_4_00am',
       '_4_00_5_00am', '_5_00_6_00am', '_6_00_7_00am', '_7_00_8_00am',
       '_8_00_9_00am', '_9_00_10_00am', '_10_00_11_00am', '_11_00_12_00pm',
       '_12_00_1_00pm', '_1_00_2_00pm', '_2_00_3_00pm', '_3_00_4_00pm',
       '_4_00_5_00pm', '_5_00_6_00pm', '_6_00_7_00pm', '_7_00_8_00pm',
       '_8_00_9_00pm', '_9_00_10_00pm', '_10_00_11_00pm', '_11_00_12_00am'],
      dtype='object')
```

Figure 1: Trafic Volume Count

```
Column names in Average_Speed dataset:
Index(['id', 'speed', 'travel_time', 'status', 'data_as_of', 'link_id',
       'link_points', 'encoded_poly_line', 'encoded_poly_line_lvls', 'owner',
       'transcom_id', 'borough', 'link_name'],
      dtype='object')
```

Figure 2: Average Speed Of a Vehicle

We have focused on optimizing traffic management for the three road segments in New York City; 1. 5th Ave between 42nd St and 47th St (Manhattan) 2. Atlantic Ave between Flatbush Ave and Bedford Ave (Brooklyn). 3. Queens Blvd between Union Tpke and Yellowstone Blvd (Queens).

	speed	travel_time	borough	roadway_name	date
0	19.26	353	Queens	TRAVIS AVENUE	2012-01-12T00:00:00.000
1	8.07	1440	Queens	LEWIS AVE	2012-01-10T00:00:00.000
2	8.07	1440	Queens	3 AVENUE	2012-10-12T00:00:00.000
3	8.07	1440	Queens	3 AVENUE	2012-10-13T00:00:00.000
4	8.07	1440	Queens	3 AVENUE	2012-10-14T00:00:00.000
5	8.07	1440	Queens	3 AVENUE	2012-10-15T00:00:00.000
6	8.07	1440	Queens	3 AVENUE	2012-10-16T00:00:00.000
7	8.07	1440	Queens	3 AVENUE	2012-10-17T00:00:00.000
8	8.07	1440	Queens	3 AVENUE	2012-10-18T00:00:00.000
9	8.07	1440	Queens	3 AVENUE	2012-10-19T00:00:00.000

Figure 3: Average Speed Of a Vehicle

We have Identified and preprocess relevant data points, such as peak-hour traffic

volumes, average speeds. The peak-hour trafik time has been calculated based on number of travel time in selected hours. The following figure showes the selected hours list.

We have found that the Overall peak hour is between 5.00 Pm, and 6.00 PM,

```
hourly_columns = [
    '_12_00_1_00_am', '_1_00_2_00am', '_2_00_3_00am', '_3_00_4_00am',
    '_4_00_5_00am', '_5_00_6_00am', '_6_00_7_00am', '_7_00_8_00am',
    '_8_00_9_00am', '_9_00_10_00am', '_10_00_11_00am', '_11_00_12_00pm',
    '_12_00_1_00pm', '_1_00_2_00pm', '_2_00_3_00pm', '_3_00_4_00pm',
    '_4_00_5_00pm', '_5_00_6_00pm', '_6_00_7_00pm', '_7_00_8_00pm',
    '_8_00_9_00pm', '_9_00_10_00pm', '_10_00_11_00pm', '_11_00_12_00am'
]
```

Figure 4: Selected Hours List

Overall volume: 14434156.0.

```
       speed travel_time       peak_hour  peak_hour_volume
0      19.26         353    _4_00_5_00pm             717.0
1       8.07        1440    _8_00_9_00am             552.0
2       8.07        1440    _8_00_9_00am            1603.0
3       8.07        1440    _1_00_2_00pm            1872.0
4       8.07        1440  _11_00_12_00pm            1554.0
...      ...         ...             ...               ...
18049  36.66         250    _4_00_5_00pm             920.0
18050  36.66         250    _4_00_5_00pm             910.0
18051  36.66         250    _2_00_3_00pm             879.0
18052  36.66         250    _3_00_4_00pm             825.0
18053  36.66         250    _5_00_6_00pm             643.0

[18054 rows x 4 columns]
Overall peak hour: _5_00_6_00pm, Overall volume: 14434156.0
```

Figure 5: The peak-hour Time

1.2 Fuel Consumption Calculation

Fuel consumption measures the amount of fuel a car consumes to go a specific distance[4]. We used the common fuel Consumption equation, defined as folowing:

Fuel Consumption = a × V + b × 1/v + c
Where:

• V is the average speed (in mph).
• a, b, and c are empirical const, which a indicating an increase in fuel consumption with speed, while b representing a decrease in fuel consumption as speed, and c represents the base fuel consumption, as very low-speed conditions.

Then, we have update the code to use the formula as following: $FuelConsumption = \sum_{i=1}^{n}(volume_i \times (aV_i + b\frac{1}{v} + c) \times segment_Length_i)$

where: n is the number of time intervals. Volumei is the vehicle count in interval i from the Traffic Volume dataset. Vi is the average speed in interval i from the Traffic Speed dataset. Segment Lengthi is the length of the road segment.

1.3 Formulate the Optimization Problem

xxxxxx

1.4 Implement the MOEA

genetic algorithm

1.5 Analysis and Results

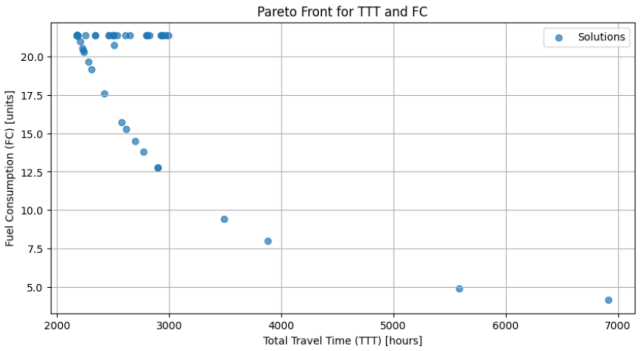

Figure 6: TTT

2 Task 2

This is the introduction of the document. Here we will cite some references, for example, [1].

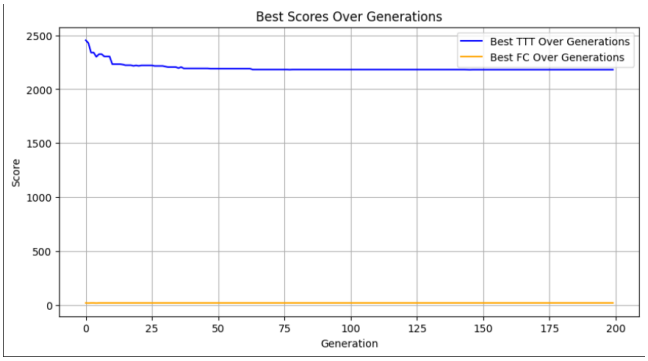

Figure 7: The best score over generation

3 Task 4

This is the introduction of the document. Here we will cite some references, for example, [1].

4 Refrences

[1] NYC Open Data. "Traffic Volume Counts". 2022. Available at: https://data.cityofnewyork.us/Transportation/Automated-Traffic-Volume-Counts/7ym2-wayt (Accessed: 2024-11-04).
[2] NYC Open Data. "DOT Traffic Speeds NBE". 2017. Available at: https://data.cityofnewyork.us/Transportation/DOT-Traffic-Speeds-NBE/i4gi-tjb9 (Accessed: 2024-11-04).
[3]Krivoshapov, S, Nazarov, A , Mysiura, M , Marmut, I , Zuyev, V , Bezridnyi, V , Pavlenko, V. (2020). Calculation methods for determining of fuel consumption per hour by transport vehicles. IOP Conference Series: Materials Science and Engineering. 977. 012004. 10.1088/1757-899X/977/1/012004.
[4] the official page of energy education. https://www.energyeducation.ca/encyclopedia/Fuelconsumption.