

Traffic Flow Optimization with PSO

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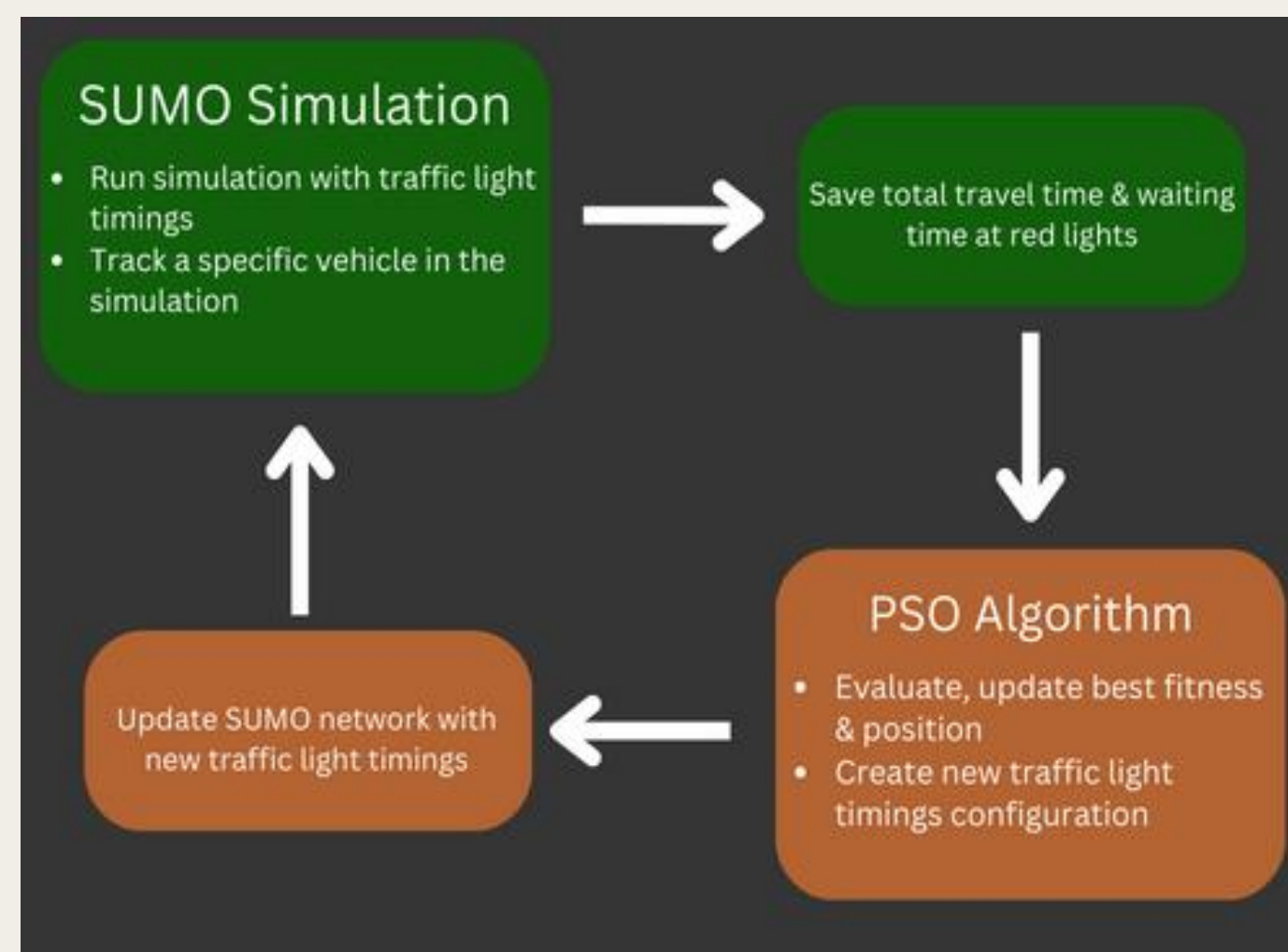
Introduction & Motivation

- Urban areas worldwide face persistent challenges of congestion and inefficient traffic flow, leading to wasted time, energy, and environmental impact.
- Traditional traffic control methods often fall short in dynamically adapting to changing traffic patterns and optimizing signal timings to alleviate congestion effectively.
- Our research aims to address these issues by leveraging Particle Swarm Optimization (PSO) to dynamically optimize traffic signal timings, ultimately minimizing congestion and enhancing the efficiency of traffic flow in urban environments, with a focus on Cumberland Ave in Knoxville, TN.

Methods & Approach

SUMO Traffic Simulator

- Define a network with various traffic lights**
 - Cumberland Ave with 5 intersections
- Ability to define vehicle “trips” and track them through the simulation**
 - A car going from one end of Cumberland to the other
- Track the trip information**
 - View the total travel time and time spent waiting at red lights
- Specify traffic light configurations**
 - Example: `<phase duration="10" state="GGgGGgrr"/>`

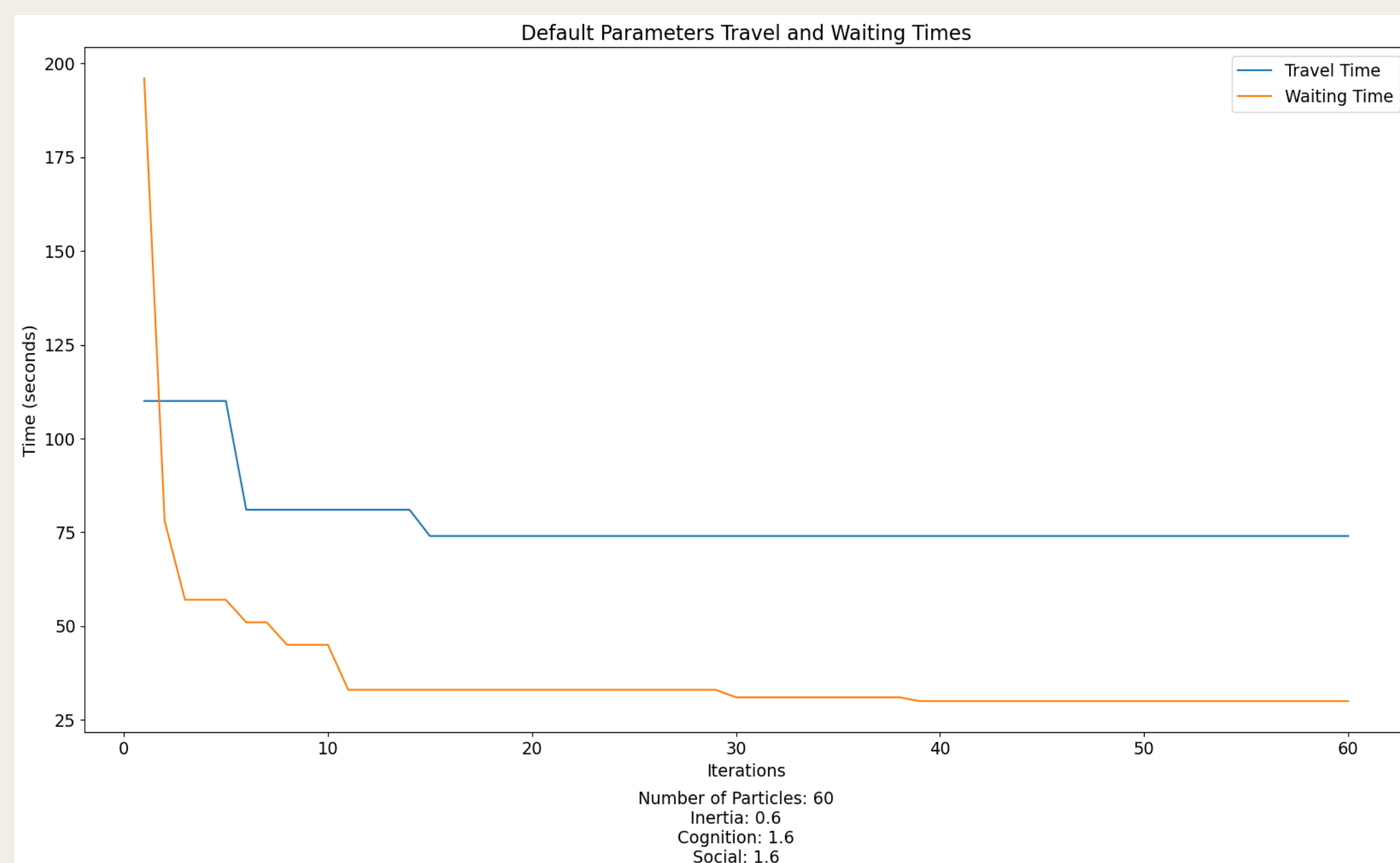


PSO Algorithm

- Used to generate new traffic light timings**
 - Green and Yellow light times
 - Red Light times = Green + Yellow
 - Values must be between 5 & 30 seconds
- Minimize the fitness values**
 - Total Travel Time (seconds)
 - Total Waiting Time at Red Lights (seconds)
- Hyperparameters**
 - Num Particles: [20, 40, 60, 80, 100]
 - Inertia: [0.2, 0.4, 0.6, 0.8, 1.0]
 - Cognition: [0.8, 1.6, 2.4, 3.2, 4.0]
 - Social: [0.8, 1.6, 2.4, 3.2, 4.0]

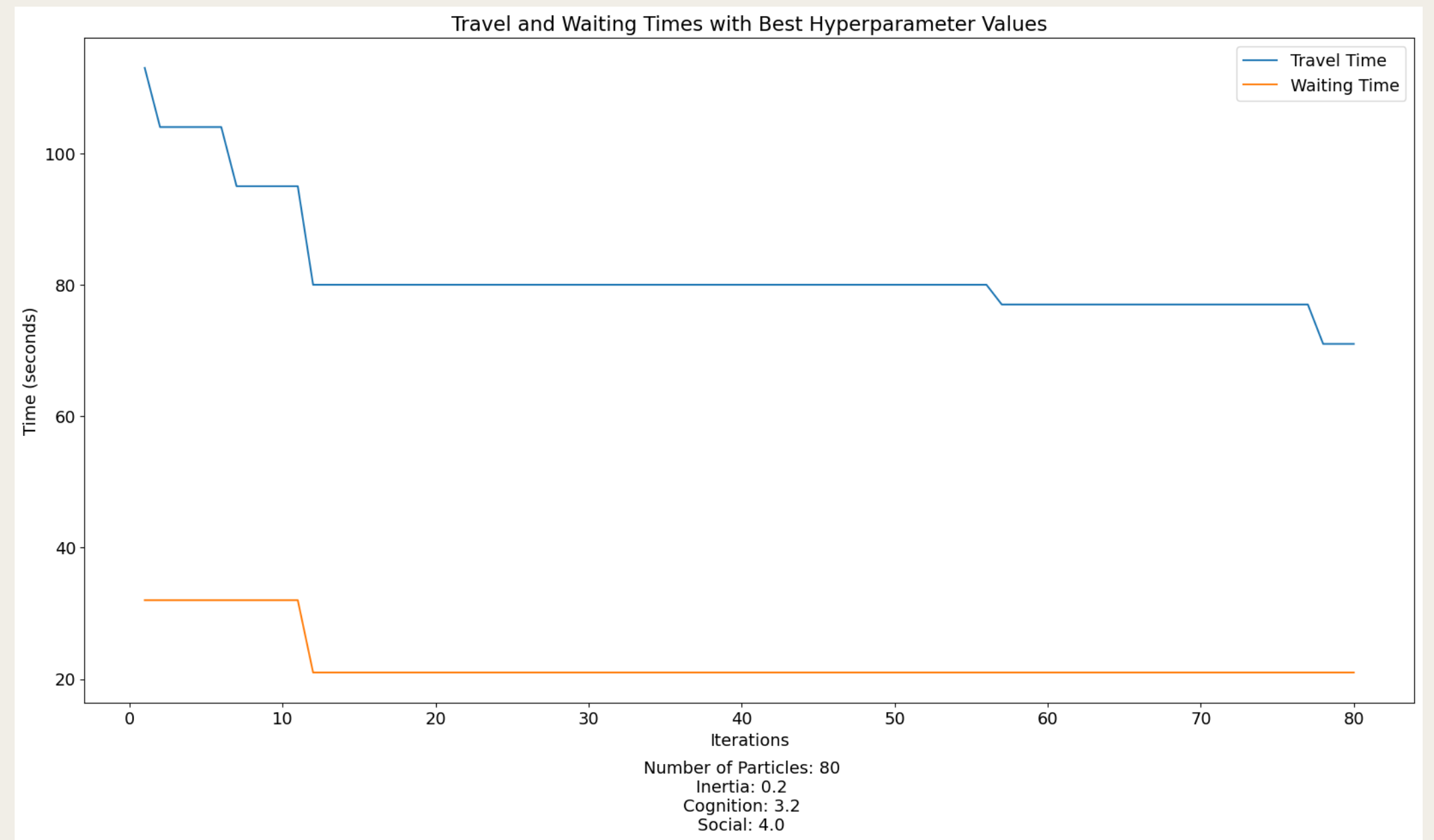
Results

Default Hyperparameters



Min travel time: 74 seconds - [30, 5, 35]
Min waiting time: 30 seconds - [28, 5, 33]

Best Hyperparameters



Min travel time: 71 seconds - [27, 5, 32]
Min waiting time: 21 seconds - [21, 5, 26]

Conclusion

- Our test bed for traffic flow optimization included a section of the Cumberland Avenue near the Hill which was mocked into the SUMO traffic simulator.
- After tuning the hyperparameters and conducting multiple tests, we can say that this was a successful attempt at improving traffic travel and waiting times.
- Our results indicating an approximate 4.05% improvement in travel time and a 30% improvement in waiting time.

Future Work

- Add sidewalks and pedestrian crosswalks
- More complicated network with numerous traffic lights and intersections
- Test more hyperparameter combinations
- Adopt PSO to optimize environmental factors like Fuel efficiency, and reduce pollution



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References

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- [2] <https://ieeexplore.ieee.org/abstract/document/5656214>