Predictive Methodology For enhancing Level of safety in traffic signals

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Abstract: **Traffic signals according to quickly building congestion with steep gradients on short temporal and small spatial scales with the rising standards of computational technology, single-board computers, software packages, platforms, and APIs (Application Program Interfaces), it has become relatively easy for developers to create systems for controlling signals and informative systems. Hence, for enhancing the power of Intelligent Transport Systems in automotive telematics, in this study, we used crowd sourced traffic congestion data from Google to adjust traffic light cycle times with a system that is adaptable to congestion. One aim of the system proposed here is to inform drivers about the status of the upcoming traffic light on their route. Since crowd sourced data are used, the system does not entail the high infrastructure cost associated with sensing networks. A full system module-level analysis is presented for implementation. The system proposed is fail-safe against temporal communication failure. Along with a case study for examining congestion levels, generic information processing for the cycle time decision and status delivery system was tested and confirmed to be viable and quick for a restricted prototype model.**

Keyword: **traffic-signal, optimization, cost**

I. INTRODUCTION

A modern traffic signal system consists of three basic subsystems: the signal lights in their housing, the supporting arms or poles, and the electric controller. The signal lights and housing are known as the signal light stack. A single stack usually consists of three lights: a green light on the bottom to indicate the traffic may proceed, a yellow light in the middle to warn traffic to slow and prepare to stop, and a red light on the top to indicate the traffic must stop. Because some people are red-green colour blind, there has been an effort to standardize on a vertical stack of lights with red at the top so that these people can perceive the signal condition by the position of the light rather than the colour. Each light has a fresnel lens which may be surrounded or hooded by a visor to make it easier to see the light in bright sunlight. A fresnel lens consists of a series of concentric angled ridges on the outer surface of the lens which bend the light to focus it in a parallel beam. The light stack may have a dark-coloured backing plate to make the signals more distinguishable by blocking out surrounding lights from buildings and signs. There are one or more signal light stacks for each direction of each roadway. The electric controller is usually mounted in a weather-proof box on one of the corners of the intersection. More elaborate traffic signals may also have electromagnetic sensors buried in the roadway to detect the flow of traffic at various points.[1]

A. Engineering Solutions to Enhance Traffic Safety Performance

Improving two-lane highway traffic safety conditions is of practical importance and has attracted significant research attention within the last decade. Many cost-effective and proactive solutions such as low-cost treatments and roadway safety monitoring programs have been developed to enhance traffic safety performance under prevailing conditions. A two-lane Highway Safety Enhancement Project (HSEP) was implemented on the major highway network in Beijing from 2004 to 2006 by the Ministry of Transport of the People's Republic of China. A series of engineering solutions was proposed and integrated to improve traffic safety performance network-wide. More than 170,000 hazardous sections of national or provincial highways were improved over 50,000 kilometers, which included improper curves, heavy gradients, insufficient sight distances, and vague clear zones. Cost-effective countermeasures against severe injuries and fatal crashes also included adding or replacing traffic signs, painting markings on pavement, installing different barriers on roadsides, and channelizing intersections.

Substantial work has been conducted on engineering-based countermeasure development for improvement of safety performance. Bagdade et al introduced specific traffic engineering improvements targeted at improving safety for seniors, which were developed to popularize the use of a number of engineering countermeasures throughout Michigan. Lab investigated the efficacy of roadway improvements in terms of crash reduction at various subclasses of rural two-lane highways using the empirical analysis method of the negative binomial modeling technique. However, most of these previous studies focused on only a single improvement that is, widening shoulders, adding passing lanes, or installing center left-turn lanes. Schneider et al. and Bauer and Harwood presented safety prediction models and conducted evaluations of safety effects of horizontal curves on rural two-lane highways. Their findings showed that the radius and length of each horizontal curve significantly influenced the frequency of crashes. Gross et al. and Schrock et al. explored the use of observational data to estimate safety effectiveness for changes in lane and shoulder width and found that adding passing lanes was an economical and effective safety improvement for rural two-lane highways. These findings can be used to help determine cost-benefit ratios to compare competing alternatives. Park et al. examined the safety effect of wider edge lines by analyzing crash frequency data for road segments with and without wider edge lines based on different statistical approaches. Their results showed positive safety effects of wider edge lines installed on rural, two-lane highways. Lyon et al. and Moreno et al. incorporated the Empirical Bayes method to determine the safety effectiveness of installing left-turn lanes and obtained operational effectiveness of passing zones from passing frequency. Their results indicated that these were cost-effective treatments for two-lane rural highways. Yuan et al. Yuan and Lu and Montella and Mauriello used the Empirical Bayesian method and Safety Indexes to evaluate safety benefits and suggest relevant improvements for highway intersections. Cruzado and Donnell evaluated the effectiveness of dynamic speed display signs in transition zones of two-lane, rural highways, and the results indicated that signs were effective in reducing free-flow passenger car operating speeds. There are many methods of evaluating the effectiveness of special improvements. The Bayes methods are widely used and effective. Li and Washburn presented an improved methodology for two-lane highway facility analysis and a new version of CORSIM with the capability of modeling two-lane highways. Zhu et al. discussed the relationship among driver's heart rates, variability of the vehicle in the running process, design speed consistency, operating speed coordination, speed reduction coefficients, and speed gradients in two-lane highways. Persaud et al.Mujalli and De ona and Vlahogianni and Golias used the Empirical Bayes and Bayesian Network method to estimate the safety of specific sites and analyze the injury severity of traffic accidents. Wu et al developed two Mixed Logit models based on crash data collected in New Mexico to analyze driver injury severities in SV and MV crashes on rural two-lane highways.

In this study, the HSEP research findings are presented to evaluate the engineering solutions and their effectiveness in reducing traffic crash severities on Highway G109 in Beijing, China. The potential causal factors were identified based on the proposed evaluation criteria, and primary countermeasures were developed against inferior driving conditions. Six cost-effective engineering solutions were specifically implemented to improve two-lane highway safety conditions: (1) traffic sign replacement, (2) repainting of pavement markings,(3) installation of roadside barriers, (4) intersection channelization, (5) drainage optimization, and (6) sight distance improvement. An Empirical Bayes (EB) model-based before-after study was conducted. The results indicate that the proposed engineering solutions effectively improved traffic safety performance by significantly reducing crash occurrence risks and crash severities.

1.3 Data Collection

G109 highway is a major corridor connecting the city of Beijing and the province of Hebei with a length of 119.2 kilometers. The two-lane highway system is comprised mostly of Class 2, Class 3, and Class 4 highway segments. The terrain conditions are mainly mountainous with some plains and hills along the highway. All traffic engineering solutions for G109 were designed and finished in 2004.

Detailed crash data for G109 were collected from the traffic accident database of the Beijing Traffic Management Bureau (2000–2008), and part of the minor accident data was gathered from the Beijing Municipal Roadway Administration Bureau. Traffic volume data and geometric data were obtained from the Annual National Highways Traffic Volume Statistical Handbook (2000–2008) and the Design Documents of G109 managed by the Transport Planning and Research Institute of the Ministry of Transport, China, respectively. Accident and traffic volume data for similar segments were obtained from the Traffic Police Corps of Guangxi Department of Public Security (2004-2005).[3]

1.4 Engineering Treatments Implemented

Based on the design documents of G109, all latent dangerous entities were identified following the above judgment criteria and accident data. A total of 612 traffic signs were installed or replaced; 27,000 m^2 of pavement markings were painted; 15,137 m of barriers were built or replaced; 8 intersections were channelized. The average cost to implement these changes was only 100,713 RMB per kilometer.

The problems with the traffic sign system before treatment were discontinuous signs, lack of warning signs, mistakes on locations and content of signs, occlusion problems, and too many characters on a tourism sign.

Based on the existing problems and characteristics of the highway curvatures and gradients, new traffic signs were designed and installed systematically to avoid redundant information. Furthermore, locations of different signs were established according to the operation speed of traffic flow and sight distance.

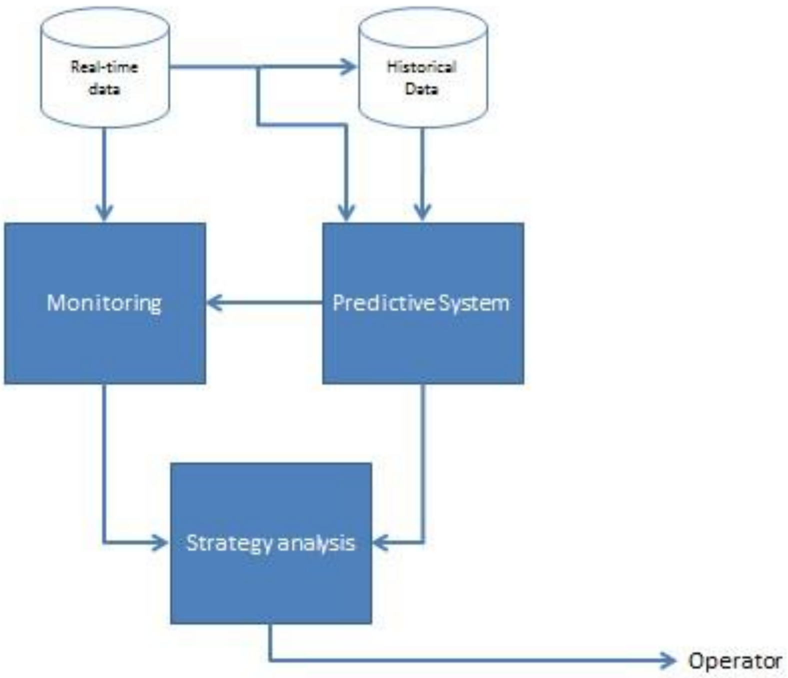
In total, 612 new traffic signs were installed, including 19 solar energy signs. Several oversized warning signs and indication signs with high visibility were fixed as reminders to reduce speed and drive carefully before segments of curves and slopes. Relevant solar horizontal induction signs and flat top tubular delineators and chevron signs were set up at borders of the roadside along curves with the combination of median delineators. In addition, more easily recognized guide signs and tourist spot signs replaced older signs along the entire highway. Finally, stop and yield signs were installed on minor road approaches.

1.4.1. Criteria for Development of Crash Hotspot Identification

HSEP mainly uses traffic engineering treatments to improve or eliminate potential crash hotspots to enhance traffic safety on highways. This is different from highway reconstruction and extension projects and aims to rehabilitate and improve traffic facilities. The objectives of HSEP are to decrease traffic accident fatality rates, especially in serious accidents and to supply a better highway traffic and safety environment with safer facilities. HSEP targets to maximize safety benefits with the lowest cost, least amount of engineering, and least time.

Assessments were first conducted due to limited construction funds. Five aspects of geometric features and roadway characteristics were chosen, including the horizontal curve radius and longitudinal gradient.

PROPOSED METHODOLOGY



4.1 The PSO Algorithm

In PSO algorithm, every bird is denoted as a particle and have their own intelligence and some social behaviour which coordinate their activities toward food or a destination. Initially, the process is started from swarm of particles. Each particle contains a solution to the related problem that is generated randomly and in every iteration it generates an optimal solution. The ith particle is bounded with a position in an s-dimensional space, in which s is the no. of particles involved in the problem. Position is determined by the values of s variables and possible solution to the problem after optimization. Ach particle i is determined by three vectors that are Current position L_i ,its best position in the previous cycles, M_i, and its velocity by N_i.

Current position $L_i = (l_{i1}, l_{i2}, l_{i3} \dots \dots .. l_{is})$ (1)

Best position in previous cycle $M_i = (m_{i1}, m_{i2} \dots \dots \dots m_{is})$ (2)

Flight velocity $N_i = (n_{i1}, n_{i2}, n_{i3 \dots\dots\dots}, n_{is})$ (3)

This algorithm is based on the communication between the birds during the search of the food. Each bird look at the specific direction (its best ever attained position M_i) and later, when they communicate themselves thy go to the bird which is in the best position from the food. All the birds move towards the best position bird with a velocity that depends on the present velocity. Search space is examined by each bird from its current position.

In each iteration, eq 4 calculate the current position and velocity

$$l_i' = l_i + N_i' \quad (4)$$

The new velocity is given by the equation 5.

$$N_i' = \omega N_i + a_i rand(\quad)(M_i - L_i) + a_2\, rand(\quad)(M^* - L_i) \quad (5)$$

Here,

- a_1, a_2 are two positive elements which show the learning factors.
- Rand () function generates the random number in eq 5
- ω is factor of inertia. Local and global search controls by it and it changes in every iteration of search.
- M_i best present solution among all.

Algorithm

Step 1: Generate random solutions.

Step 2: Search the best solution from the random solutions.

Step 3: Repeat the following step until the condition is not stopped.

3.1 Calculate the ω.

3.2 Loop i =1,2…..n

Begin

- Compute the value of objective function for solution i.
- If particle I gives the better value for the objective function, let I is the best solution.
- Compute new velocity for particle i using equation 5.
- Compute the new position for particle i using equation 4.

END

4.2 Genetic Algorithm

Genetic algorithm is adaptive heuristic search algorithm which is based on evolutionary ideas of natural selection and genetics. It is based on the random search which helps to solve the optimization problem. In genetic algorithm following terms are used as basic terminology. A Genetic Algorithm (GA) is a programming system that mimics normal headway as a basic deduction strategy. It is based on Darwinian's standard of improvement and survival of fittest to propel masses of candidate solutions towards a predefined fitness. GA uses an improvement and customary selection that uses a chromosome-like data structure and propel the chromosomes using selection, recombination and transformation operators. The process usually begins with randomly made masses of chromosomes, which represent all possible solution of an issue that are considered candidate solutions. From each chromosome diverse positions are encoded as bits, characters or numbers. These positions could be insinuated as genes. An assessment function is used to figure the goodness of each chromosome as demonstrated by the desired solution; this function is known as "Fitness Function". In the midst of the process of assessment "Crossover" is used to simulate regular engendering and "Change" is used to transformation of species. For survival and blend the selection of chromosomes is biased towards the fittest chromosomes.

- **Population**: Population is the sub-set of possible solutions of the given problem.
- **Chromosomes:** it is a solution given to the problem.
- **Gene:** it is an element position of a chromosome.
- **Allele:** value taken by a gene for a particular chromosome.

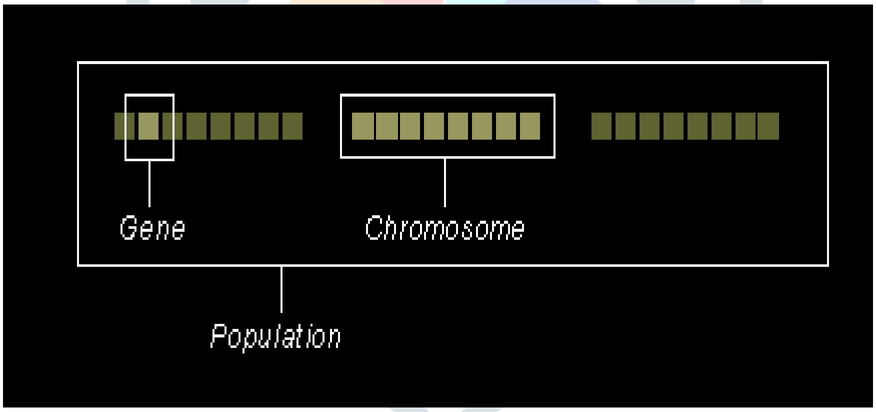


Figure 4.2 Search Space in G.A

Genetic Algorithm
Step1: u←0; Step2: Init Population[P(u)]; {Initialize the population} Step3:Eval Population[P(u)]; {Evaluate the population} Step4: **while** not termination **do** Step5: P'(u) ←Variation[P(u)]; {Creation of new Solution} Step6: Eval Population[P'(u)]; {Evaluate the new Solutions} Step7: P(u+1)← Apply Genetic Operators [P'(u)U Q]; {Next generation pop.} Step8: t ←t+1; Step9: **end while**

RESULT AND ANALYSIS

The graph represents the Infra structure line models for different functions like sigmoid function, convergence, and TAN. The comparison of the proposed approach which is using optimization and existing approach without optimization is also presented below.

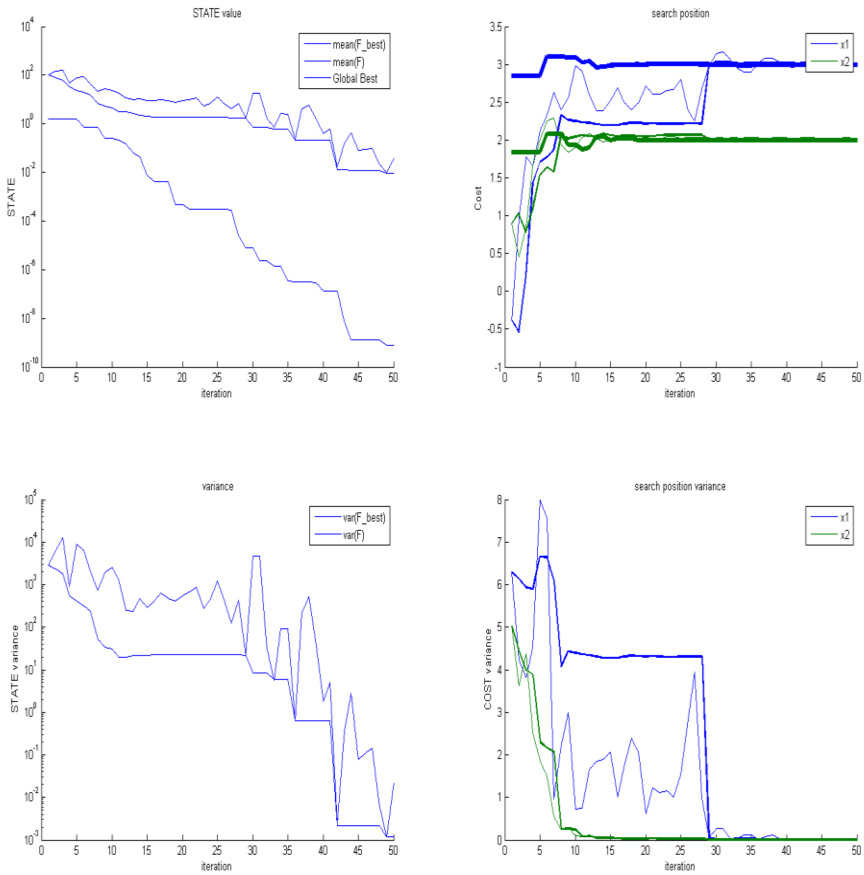


Figure 5.9 Graph of state value, Search Position, Variance and search position variance

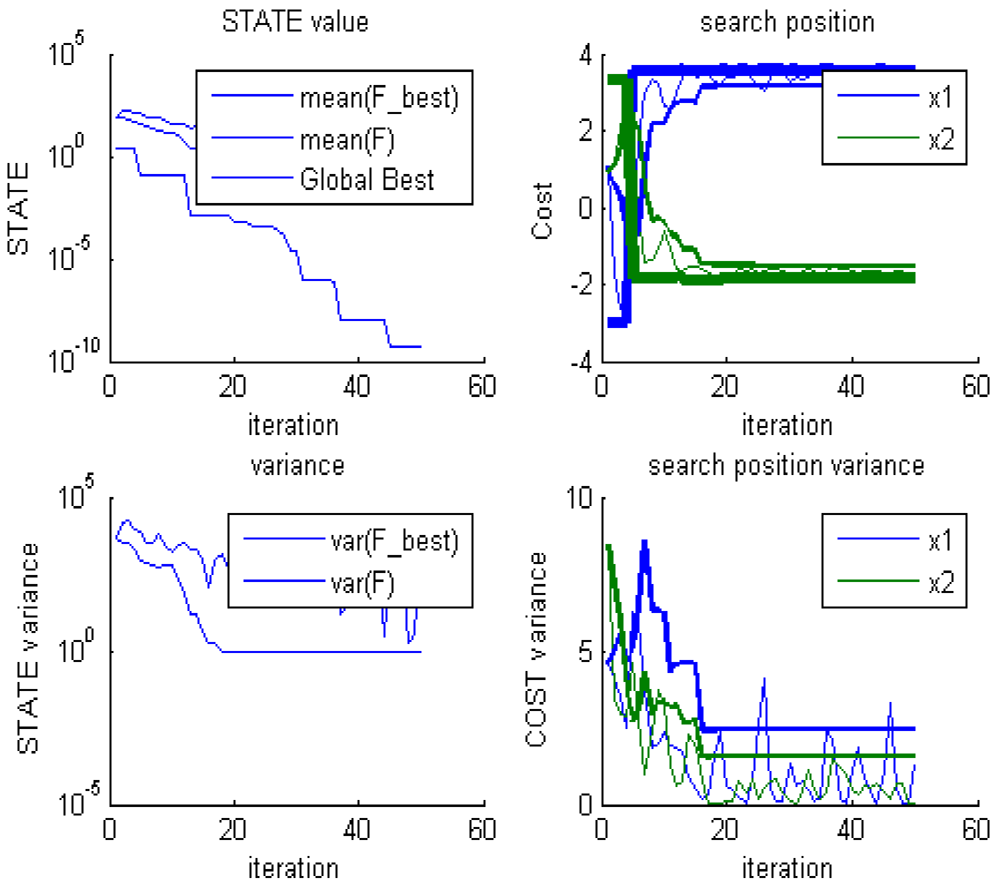


Figure 5.10 Graph of state value, Search Position, Iteration Variance and Iteration search position variance (without optimization)

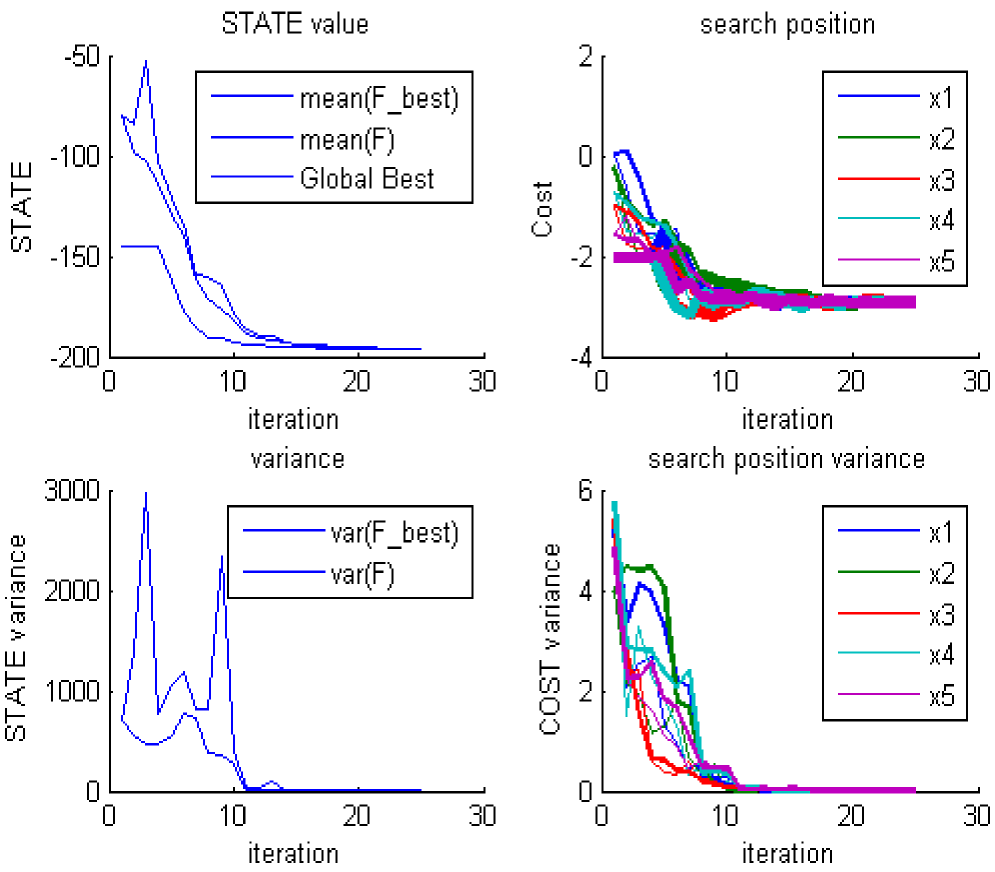


Figure 5.11 Graph of state value, Search Position, Iteration Variance and Iteration search position variance (PSO)

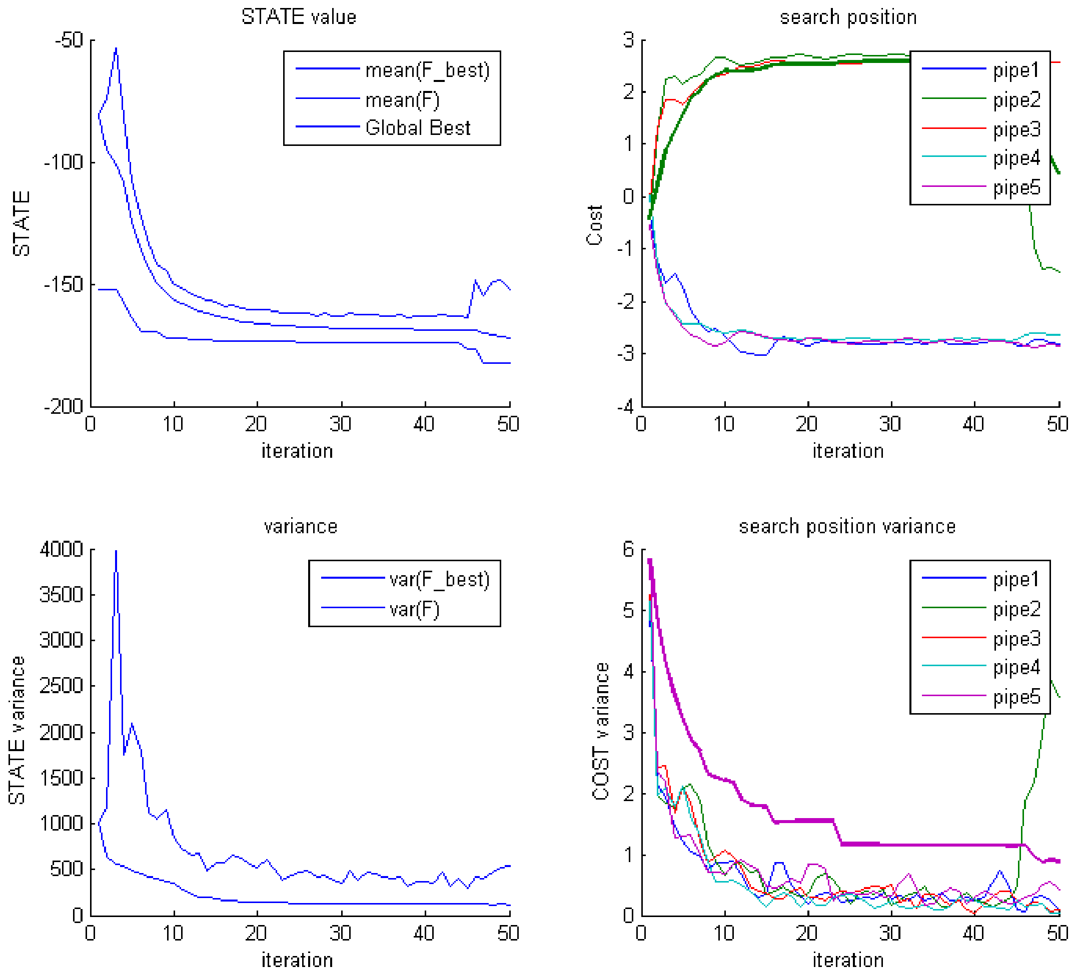


Figure 5.12 Graph of state value, Search Position, Variance and search position variance **(GA)**

III. CONCLUSION

Providing information that conveys the traffic light status to the driver the proposed traffic condition data collection solution is infrastructure-free and is thus scalable. The system implemented aims to obtain the status of the next traffic light in minimal time just after crossing the traffic light before it, given a certain route. Based on the traffic light status, the driver can decide to drive more smoothly to maintain a continuous journey by adjusting their speed, which helps to improve the flow of traffic and significantly reduces carbon dioxide emissions and fuel consumption. Hence, using this system divides congestion equally among links between traffic lights, and the network as an entity is completely utilized. The technology can be easily incorporated into the smart city concept and can save resources for any country, such as reducing the time of workers in traffic and preventing the damage and harm from accidents caused by RLR, as RLR is less likely to occur due to the method's stabilizing effect on the psychology of the driver. This whole system can be of much more use to transport engineers and traffic authority personnel to make spatial location-based reports using the database by acquiring accurate location logs of vehicles. This database can also be used to form an evacuation plan in case of emergency, optimize routes for public vehicles, detect the need for increasing the yellow (crossing) time, and much more

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