Synchronization of Traffic Light System for Maximizing Efficiency along Helmet Circle, Sal Junction and Mam Nagar

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Abstract: **The Traffic Signal Synchronization is a traffic engineering technique of matching the green light times for a series of intersections to enable the maximum number of vehicles to pass through, thereby reducing stops and delays experienced by motorists. Synchronizing traffic signals ensures a better flow of traffic and minimizes gas consumption and pollutant emissions. The objective function used in this work is a weighted sum of the delays caused by the signalized intersections. In this paper, we apply generalized 'surrogate problem' methodology that is based on an on-line control scheme which transforms the problem into a 'surrogate' continuous optimization problem and proceeds to solve the latter using standard gradient-based approaches while simultaneously updating both actual and surrogate system states. We extend a 'surrogate problem' approach that is developed for a class of stochastic discrete optimization problems so as to tackle the traffic signal synchronization problem to minimize the total delay (DTSS). Numerical experiments conducted on a test and a real networks show that the surrogate method converges in a very small area.**

Key words- **Signal Synchronization, Design hourly volume, Optimum Cycle Length, Effective green time, Saturation flow, Actual green time.**

Table 1-Nomenclature

DHV	Deign hourly volume
C_0	Optimum Cycle length
L	Total lost time
g_i	Effective green time per phase
G_i	Actual green time per phase
PCE	Passenger car equivalencies
CV	Commercial vehicle
HV	Heavy vehicle

I. INTRODUCTION

Transportation is one of the most important features that this planet possess, which involves the movement of human beings and material from one place to another. Transportation not only helps us transfer these objects but it also helps us perform or work efficiently and also makes sure that the right things are available at the right place and at the right time. Now for such an important thing which influences our lives in a substantial manner we need to see that this process is affected at the least by the other factors influencing this process. We know that traffic is a great problem in all the bigger cities of our country, and it is also increasing day by day at an exponential rate which is creating a lot of congestion resulting into hazardous accidents and a lot of delays which is affecting us economically and also causing a great amount of loss in terms of life and property. Thereby it has become an important task to synchronize these signals which has proven to be one of the best ways for tackling this huge problem and also the consequences caused by the same. We are at present targeting a smalls segment in Ahmedabad city which is one of the most populated cities of India and is facing a lot of problem with traffic.

II. RESEARCH SIGNIFICANCE

Synchronizing the signals via different observations made during the whole process. Video survey of different traffic signal spread over a straight road. Field survey after understanding the whole matter in brief.

III. LITERATURE REVIEW

In "A case study –Eastern Ring Road , Indore", Synchronization of Traffic Signals , Goliya,H.S. et.al. carried out traffic survey at different junctions on the road and based on that obtained signal time for each junction and synchronised these junctions such that traffic congestion is reduced.

From Module 34,Design principles of Traffic Signal ,Dr . Tom V . Mathew , IIT Bombay, we studied about basic terminologies of traffic signal like cycle time , green interval, red interval etc. and also about type of phase systems

From Module 42,Design principles of Traffic Signal ,Dr . Tom V . Mathew , IIT Bombay, we studied about designing of traffic signal with the help of data like critical lane volume in

vph which could be obtained by traffic survey.

From highway engineering by khanna and justo we studied the basics of traffic engineering and traffic volume flow. We also studied the traffic engineering characteristics.

IV. CALCULATIONS

4.1 Signal Design

4.1.1 Helmet Circle

Table-2

	TM	%TM	%CV
NORTH	T	97.4	16.7
	R	0	0
	L	2.6	20
SOUTH	T	94.9	14.6
	R	0	0
	L	5.1	18.2
EAST	T	0	0
	R	53.6	8.7
	L	46.4	25
WEST	T	0	0
	R	78.2	9.84
	L	21.8	23.53

Table-3

	SB	NB	WB	EB
VOLUME	3800	5184	1032	1560
T	97.4	94.9	0	0
L	2.6	5.1	53.6	78.2
R	0	0	46.4	21.8
TCV	16.7	14.6	0	0
LCV	20	18.2	25	23.53
RCV	0	0	8.7	9.84

Saturation flow for SB and NB=11678

Saturation floe for EB and WB=3600

$$\text{DHV} = Volume * \frac{T}{100} * \left(1 - \frac{\text{TCV}}{100} + 1.5 * \frac{\text{TCV}}{100}\right)$$

q_i=ST+LT+RT

$$\text{yi} = \frac{qi}{SF}$$

SB

- ST-pce=3392
- LT-pce=89
- RT-pce=0
- q_i=3841
- y_i=0.37

NB

- ST-pce=4560
- LT-pce=240
- RT-pce=0
- q_i=4800
- y_i=0.51

WB

- ST-pce=0
- LT-pce=484
- RT-pce=458
- q_i=942
- y_i=0.15

EB

- ST-pce=0
- LT-pce=1077
- RT-pce=323
- q_i=1400
- y_i=0.22

Y(Total)=Phase1(NB,SB)max+Phase2(EB,WB)max

=0.51+0.22

=0.73

LT1=2s,LT2=8s

Cycle Length

- $C_0=\frac{(1.5*LT+5)}{(1-y(Total))}$=75.47s

Total green time=C_0-LT=75.47-10=65.47

Green time

- PhaseA:g1=$65.47 * \frac{0.51}{0.73}$=45s
- PhaseB:g2=$65.47 * \frac{0.22}{0.73}$=20s

4.1.2 Sal Junction

Table-4

	TM	%TM	%CV
NORTH	T	62.2	12.4
	R	12.8	10
	L	24.8	10.3
SOUTH	T	54.1	10.71
	R	34.8	9.7
	L	11.1	26.1
EAST	T	78	14.44
	R	14.6	11.12
	L	7.4	21.43
WEST	T	66.2	8.65
	R	13.4	19.23
	L	20.6	23.1

Table-5

	SB	NB	WB	EB
VOLUME	6990	6210	4080	5330
T	62.22	54.1	78	66.2
L	4.89	11.11	7.4	20.6
R	12.87	34.8	14.6	13.4
TCV	12.4	10.71	14.44	8.65
LCV	10.3	26.1	21.43	23.1
RCV	10	9.7	11.11	19.23

Saturation flow for SB and NB=27000

Saturation floe for EB and WB=27000

$$\text{DHV} = Volume * \frac{T}{100} * \left(1 - \frac{\text{TCV}}{100} + 1.5 * \frac{\text{TCV}}{100}\right)$$

q_i=ST+LT+RT

$$\text{yi} = \frac{qi}{SF}$$

SB

- ST-pce=4618
- LT-pce=1829
- RT-pce=945
- q_i=7392
- y_i=0.27

NB

- ST-pce=3540
- LT-pce=780
- RT-pce=2266
- q_i=6586
- y_i=0.24

WB

- ST-pce=3412
- LT-pce=334
- RT-pce=629
- q_i=4375
- y_i=0.16

EB

- ST-pce=3709
- LT-pce=12255
- RT-pce=783
- q_i=5717
- y_i=0.21

Y(Total)=Phase1(SB)+Phase2(NB)+Phase3(WB)+Phase4(EB)

=0.27+0.24+0.16+0.21

=0.88

LT1=2s,LT2=2s,LT3=2s,LT4=2s

Cycle Length

- $C_0=\frac{(1.5*LT+5)}{(1-y(Total))}$=142s

Total green time=C_0-LT=142-8=134s

Green time

- PhaseA:g1=$134 * \frac{0.27}{0.88}$=41s
- PhaseB:g2=$134 * \frac{0.24}{0.88}$=37s
- PhaseC:g3=$134 * \frac{0.16}{0.88}$=25s
- PhaseD:g4=$134 * \frac{0.21}{0.88}$=31s

4.1.3 Memnagar Junction

Table-6

	TM	%TM	%CV
NORTH	T	53.36	8.16
	R	0	0
	L	44.63	12.65
SOUTH	T	85	12.04
	R	15	14.7
	L	0	0
EAST	T	0	0
	R	71.5	19.05
	L	28.5	16.67

Table-7

	SB	NB	WB
VOLUME	6372	6807	3793
T	55.36	85	0
L	44.64	0	71.5
R	0	15	28.5
TCV	8.16	12.04	0
LCV	12.65	0	19.05
RCV	0	14.7	16.67

Saturation flow for SB and NB=20511

Saturation floe for EB and WB=16565

$$\text{DHV} = Volume * \frac{T}{100} * \left(1 - \frac{\text{TCV}}{100} + 1.5 * \frac{\text{TCV}}{100}\right)$$

q_i=ST+LT+RT

$$\text{yi} = \frac{qi}{SF}$$

SB

- ST-pce=3671
- LT-pce=3024

- RT-pce=0
- q_i=6695
- y_i=0.32

NB

- ST-pce=6134
- LT-pce=0
- RT-pce=1090
- q_i=7230
- y_i=0.35

WB

- ST-pce=0
- LT-pce=2970
- RT-pce=1171
- q_i=4141
- y_i=0.25

Y(Total)=Phase1(SB)+Phase2(NB)+Phase3(WB)

=0.32+0.35+0.25

=0.92

LT1=2s,LT2=2s,LT3=2s

Cycle time

- $C_0=\frac{(1.5*LT+5)}{(1-y(Total))}$=175s

Total green time=C_0-LT=175-6=169

Green time

- PhaseA:g1=$169*\frac{0.32}{0.92}$=58s
- PhaseB:g2=$169*\frac{0.35}{0.92}$=62s
- PhaseC:g3=$169*\frac{0.25}{0.92}$=46s

V. SIGNAL SYNCHRONIZATION

For Signal Synchronization we have to equalize cycle time of each traffic signal on the path

- $C_0=\frac{75+175+142}{3}$=130s

So, revised signal design after synchronization would be

5.*1.1Helmet Circle*

Total green time=C_0-LT=130-10=120s

Green time

- PhaseA:g1=$130*\frac{0.51}{0.73}$=86s
- PhaseB:g2=$130*\frac{0.22}{0.73}$=34s

5.1.2 Sal Junction

Total green time=C_0-LT=130-8=122

Green time

- PhaseA:g1=$122*\frac{0.27}{0.88}$=38s
- PhaseB:g2=$122*\frac{0.24}{0.88}$=33s
- PhaseC:g3=$122*\frac{0.16}{0.88}$=22s
- PhaseD:g4=$122*\frac{0.21}{0.88}$=29s

5.1.3 Memnagar Junction

Total green time=C_0-LT=130-6=124

Green time

- PhaseA:g1=$124*\frac{0.32}{0.92}$=43s
- PhaseB:g2=$124*\frac{0.35}{0.92}$=47s
- PhaseC:g3=$124*\frac{0.25}{0.92}$=34s

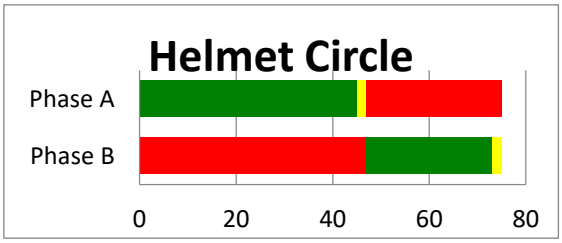
VI .RESULTS AND DISCUSSION

6.1. Signal Design

6.1.1Helmet Circle

Table-8

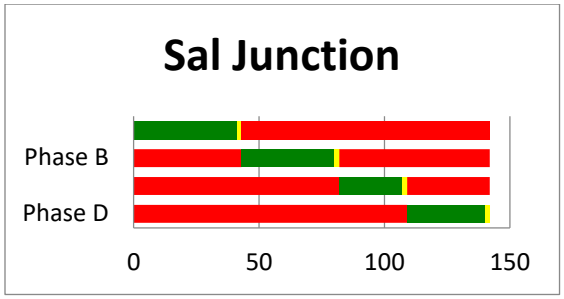
	Green time(s)
PhaseA	45
PhaseB	20



6.1.2 Sal Junction

Table-9

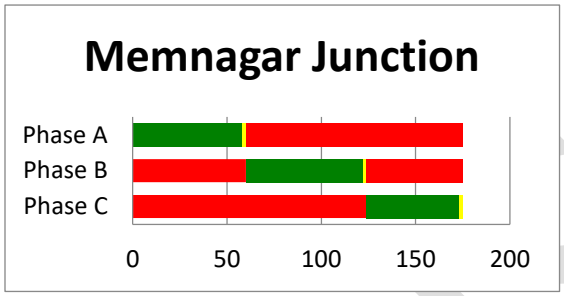
	Green time(s)
PhaseA	41
PhaseB	37
PhaseC	25
PhaseD	31



6.1.3 Memnagar Junction

Table-10

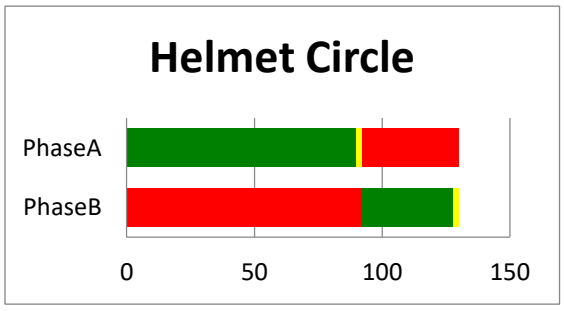
	Green time(s)
PhaseA	58
PhaseB	62
PhaseC	46



6.1.4 Helmet Circle

Table-11

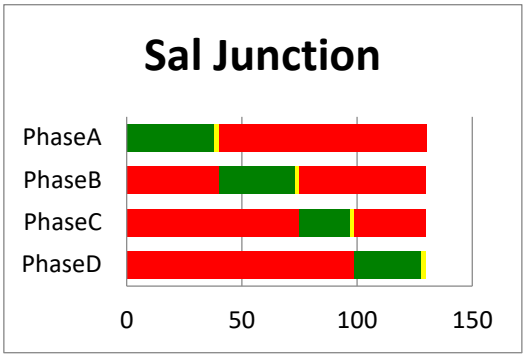
	Green time(s)
PhaseA	84
PhaseB	36



6.1.5 Sal Junction

Table-12

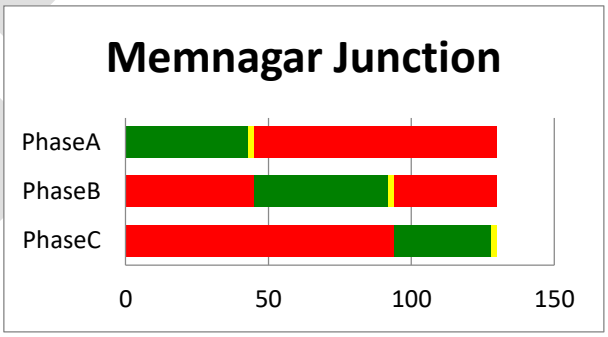
	Green time(s)
PhaseA	38
PhaseB	33
PhaseC	22
PhaseD	29



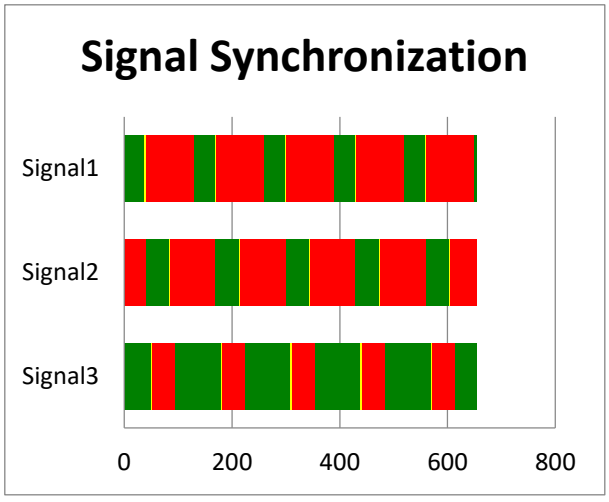
6.1.6 Memnagar Junction

Table-13

	Green time(s)
PhaseA	43
PhaseB	47
PhaseC	34



VII. PHASE DIAGRAM FOR SAL JUNCTION – MEMNAGAR JUNCTION-HELMET CIRCLE



VIII. SUMMARY AND CONCLUSIONS

Based on the analysis we found out there is a lot of bias into the signal design of the segment that we have selected. The results that we obtained after analysis showed major differences in the cycle time of each and every intersection point, thereby we took an average of all the cycle length eliminating the whole bias on to each and every signal point which would consequently help us reduce all the problems stated above arising as a result of traffic congestion.

ACKNOWLEDGEMENT

The authors are grateful to Nirma University, forfunding the present investigation under Minor Research Project.

We would like to extend our sincere gratitude towards **Dr. Paresh Patel** (H.O.D., Civil Department) to give us this opportunity to do this wonderful project.

We would also like to thank **Prof. Geetha Sivaji** to help us whenever required.

We would also like to thank our wonderful colleagues who were there for us and lent a hand to us while we worked.

Lastly, we would like to thank every person whom we could not mention here due to time and space constraint.

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