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Evaluation of Bi-Directional Coefficient of Causation Between Red & Green Signal Time for Varying Traffic Volumes

Konatham Tagore[1], K. Hari Krishna, PhD[2]
[1] *Student, M.E. Transportation Engineering, Department of Civil Engineering, Sanketika Vidya Parishad Engineering College, Visakhapatnam, Andhra Pradesh - 530041*
[2] *Professor & Head, Department of Civil Engineering, Sanketika Vidya Parishad Engineering College, Visakhapatnam, Andhra Pradesh - 530041*

Abstract **- In this research investigation, the author has evaluated Bi-Directional Coefficient of Causation Values between Red & Green Signal Time for Varying Traffic Volumes. The motivation for doing so is to know which Signal Colour (the Colours being Red & Green) is the Causation for another Signal Colour, so that we can design the minimization of the Undesirable Signal Times, according to context of concern. Furthermore, we can also design the correct Sequence of Signal Colours so that the Undesirable Signal Causation and its Time is also Minimized. This research however focuses only on the Evaluation of the aforementioned Bi-Directional Coefficient of Causation Values between Red & Green Signal Time For Varying Traffic Volumes, which Signal Colour causes which other Signal Colour for each of the cases Varying Signal Cycle Lengths and Varying Traffic Volumes and finally which Signal Colour should precede which other Signal Colour so as to Minimize Undesirable Causation, i.e., Undesirable Signal Colour Time. Also, a Computer Program is written to this end in R Programming Language. The Signal Cycle Lengths (Red Signal Time + Green Signal Time, for Maximum Traffic Volume case) are 50, 60, 70, 80, 90, 100, 110 and 120 seconds Cycle Length and the Traffic Volumes (Phase Volume Per Lane i.e., Veh/Hr/Ln) are considered in the Volumes of 100, 200, 300, 400, 500, 600, 700 and 800.**

Index Terms **- Bi-Directional Coefficient of Causation, Red Signal Time, Green Signal Time, Orange Signal Time**

I.INTRODUCTION

The Problem to be solved is detailed as followed:

1. What are the Bi-Directional Co-efficient of Causation Values for Red and Green Signal Times for each of the cases Varying Signal Cycle Lengths and Varying Traffic Volumes.
2. Which Signal Colour Causes which other Signal Colour for each of the cases Varying Signal Cycle Lengths and Varying Traffic Volumes.
3. Which Signal Colour should proceed which other Signal Colour so as to Minimize Undesirable Causation, i.e., Undesirable Signal Colour Time.
4. Automate the Computation of 1) by writing a Computer Program in MATLAB Programming Language.
5. Tabulate and Analyze the Results of 1), 2) and 3)

II LITERATURE SURVEY

Traffic signal optimization is the process of changing the timing parameters relative to the length of the green light for each traffic movement and the timed relationship between signalized intersections using a computer software program known as Traffic ware Syncro Studio.

Verma, et., al., [1] describe Indian traffic as typically composed of different vehicle classes like motorized two-wheelers, three-wheelers, four-wheelers, and non-motorized modes, which vary widely in their static and dynamic characteristics. Such diverse group of vehicle classes sharing of the same right-of-way (ROW) results in a type of traffic behaviour called “gap filling” and “virtual lane”. At signalized intersections, this behaviour is manifested by the Probably-First-In-Probably-First-Out (PFIPFO) queuing behaviour, which has been defined and described in this paper of the authors. A literature review of the topic reveals that previous delay models have focused on homogeneous traffic conditions and cannot be used for the heterogeneous traffic conditions in countries like India without significant modifications. Basic Webster's delay model is among the most widely used around the world, including India, for designing and evaluation of signalized intersections. In this model, the signalized intersection is treated as an M/D/1 queuing system with constant (or deterministic) service times and random arrival times. While this is a reasonable model for lane-disciplined, car-dominated traffic, its suitability for the heterogeneous traffic in India is dubious, as the service times are also rendered random in this case by the differences in vehicle characteristics. Hence an M/M/1 or M/M/N queuing model is more appropriate in such scenario. Considering these points, it is therefore necessary to modify Webster's basic delay model to make it suitable for heterogeneous, weakly lane-disciplined, saturated traffic conditions in India. In the present study, a new model for random delay component using multichannel queuing theory and PFIPFO queuing behaviour is derived by the authors for Indian traffic conditions. The proposed model is validated using the results from a micro-simulation and finally it is used to optimize the traffic signal timing for three intersections in Bangalore city.

Armas et., al [2] applied evolutionary computation and machine learning methods to study the transportation system of Quito from a design optimization perspective. It couples an evolutionary algorithm with a microscopic transport simulator and uses the outcome of the optimization process to deepen the understanding of the problem and gain knowledge about the system. The work focuses on the optimization of a large number of traffic lights deployed on a wide area of the city and studies their impact on travel time, emissions, and fuel consumption. An evolutionary algorithm with specialized mutation operators was proposed by them to search effectively in large decision spaces, evolving small populations for a short number of generations. The effects of the operators combined with a varying mutation schedule were studied, and an analysis of the parameters of the algorithm is also included. In addition, hierarchical clustering is performed on the best solutions found in several runs of the algorithm. An analysis of signal clusters and their geolocation, estimation of fuel consumption, spatial analysis of emissions, and an analysis of signal coordination provide an overall picture of the systemic effects of the optimization process.

Axer, et. al., [3] developed a staged methodology that allows the estimation of signal timing information like cycle length, green and red time intervals for time-dependent fixed-time controlled and actuated intersections based on floating car data (FCD). To be able to infer signal timing information based on low frequency FCD, the approach assumes as a basic condition the daily repetition of signal plans, whereby similar daytime and workdays are aggregated to reach a sufficient data density. The established concept utilizes only a very small number of trajectories that covers typical sampling intervals between 15-45 secs. The explained methodology considers three processing stages. Firstly, map matching, data decomposition and stop line estimation are realized in a basic data preparation. Secondly, the method calculates for each trajectory the specific moment, where each trajectory has crossed the inferred stop line position, whereby crossing times are projected by the application of a modulo operation into the time scale of different cycle lengths. A statistical data analysis allows the identification of daytime slices, where signal program stays constant. Finally, the last stage considers the precise estimation of red and green time intervals based on a histogram analysis. The basic applicability of the developed concept was demonstrated by the authors using a simulated trajectory dataset and which can be also successfully tested on a real-world case study. Data source used by the authors in their work allowed finally the exact estimation of cycle length, whereas red and green time interval could be estimated with an accuracy of ± 1 secs when comparing estimates against reference signal program documents.

Eriskin., et., al., [4] proposed that many methods used for traffic signal timing are useless if the conditions in the intersection are oversaturated. With an increase in the number of vehicles, the saturation degree approaches or exceeds the limit value at intersections. This creates a scenario where many signal timing methods become overwhelmed. The authors propose an elimination pairing system – a new method for designing traffic signal timing at oversaturated intersections. An object function with vehicle delay and stop-start numbers has been generated by the authors. Total cost value has been calculated according to the object function. The authors compared obtained results with Webster as a traditional traffic signal timing design method and

Transyt 14 signal timing software. While Webster gives exaggerated results, Transyt 14 and Elimination Pairing Systems provide better results. As a result of this study, the authors concluded that the elimination pairing system could be used for optimizing the traffic signal timings.

Wada., et., al., [5] considered an optimal coordinated traffic signal control under both deterministic and stochastic demands. The authors first present a new mixed integer linear programming (MILP) for the deterministic signal optimization wherein traffic flow is modeled based on the variational theory and the constraints on a signal control pattern are linearly formulated. The resulting MILP has a clear network structure and requires fewer binary variables and constraints as compared with those in the existing formulations. The authors then extend the problem so as to treat the stochastic fluctuations in traffic demand. The authors then develop an accurate and efficient approximation method of expected delays and a solution method for the stochastic version of the signal optimization by exploiting the network structure of the problem. Using a set of proposed methods, the authors finally examine the optimal control parameters for deterministic and stochastic coordinated signal controls and discuss their characteristics.

Chandan K., et., al., [6] state that in modern transportation systems, Connected Vehicle (CV) technology has shown its potential as a valuable traffic data source in providing real-time accurate traffic information. Connected vehicles transmit information wirelessly among vehicles and exchange the same with the traffic signal controller. The authors propose a connected vehicle signal control (CVSC) strategy for an isolated intersection, which utilizes detailed information, including speeds and positions of GPS equipped vehicles on each approach at every second. The proposed strategy first aims at dispersing any queue that was built up during the red interval, and then starts minimizing the difference between cumulative arrival flow and cumulative departure flow on all approaches of the intersection. Their proposed algorithm is well responsive to different traffic demand and fluctuations in arrival flows. The performance of their proposed strategy is compared with an adaptive signal control solution developed by PTV EPICS, which optimizes signal timings using the data collected from fixed detectors. Various traffic scenarios with 100% GPS market penetration rate were tested by the authors in the VISSIM 8 microscopic simulation tool. Results have shown that their proposed CVSC strategy showed outstanding performance in reducing travel time delays and average number of stops per vehicle when compared to the EPICS adaptive control.

Li., et., al., [7] proposed a model of multi objective optimization algorithm for traffic signal control for the purpose of improving the efficiency of traffic signal control for isolate intersection under oversaturated conditions. Throughput maximum and average queue ratio minimum are selected as the optimization objectives of the traffic signal control under oversaturated condition. A simulation environment using VISSIM SCAPI was utilized by the authors to evaluate the convergence and the optimization results under various settings and traffic conditions. The authors used C++/CRL to connect the simulation software VISSIM and the proposed algorithm. The simulation results indicated that the signal timing plan generated by the proposed algorithm has good efficiency in managing the traffic flow at oversaturated intersection than the commonly utilized signal timing optimization software Synchro. The update frequency applied in the simulation environment was 120s, and it can meet the requirements of signal timing plan update in real filed. Thus, the proposed algorithm has the capability of searching Pareto front of the multi-objective problem domain under both normal condition and over-saturated condition.

Hewage., et., al [8] argued traffic congestion is one of the worst problems in many countries. Traffic congestion wastes a huge portion of the national income for fuel and traffic-related environmental and socioeconomic problems. Computer simulation is a powerful tool for analyzing complex and dynamic scenarios. It provides an appealing approach to analyze repetitive processes. Simulation helps decision makers identify different possible options by analyzing enormous amounts of data. Hence, computer simulation can be used effectively to analyze traffic flow patterns and signal light timing. In this paper, the authors discuss a special-purpose simulation (SPS) tool to optimize traffic signal light timing. The simulation model is capable of optimizing signal light timing at a single junction as well as an actual road network with multiple junctions. It also provides signal light timing for certain time periods according to traffic demand. Traffic engineers at the University of Moratuwa, Sri Lanka are testing the developed tool for actual applications.

Hajbabaie., et., al., [9] say that choosing an appropriate objective function in optimizing traffic signals in urban transportation networks is not a simple and straightforward task because the choice likely will affect the set of constraints, modeling variables, obtained outputs, and necessary computer and human resources. A methodology for selection of an appropriate objective function for the problem of signal timing optimization was developed by the authors. The methodology was applied to a realistic case study network under four demand patterns (symmetric, asymmetric, undersaturated, oversaturated). Selection is made from a pool of five candidates: minimizing the delay, minimizing the travel time, maximizing the throughput-minus-queue, maximizing the number of completed trips (or trip maximization), and maximizing the weighted number of completed trips (or weighted trip maximization). Findings indicated that for all demand patterns, weighted trip maximization improved network performance compared with the other objective functions. Weighted trip maximization reduced system total delay by 0.1% to 5.2% in symmetric undersaturated demand, by 1.0% to 2.4% in asymmetric undersaturated demand, by 1.2% to 16.6% in symmetric oversaturated demand, and by 11.7% to 27.4% in asymmetric partially oversaturated demand. These figures indicated that the weighted trip maximization objective function is the most suitable of the candidates in oversaturated conditions, especially when demand is not symmetric. The authors concluded that throughput-minus-queue and trip maximization were the second most suitable objective functions for oversaturated conditions, and trip maximization was slightly more suitable when demand was asymmetric.

III INTRODUCTION

Traffic Signal Sequencing Scheme

The Three Light Colours at Traffic Signals are From Go to Stop, the Sequence Green to Amber (or Yellow) to Red, as you are on the move, need some time to Stop, gives enough time to stop as Amber Comes in between Green & Red for Safety Reasons. [10]

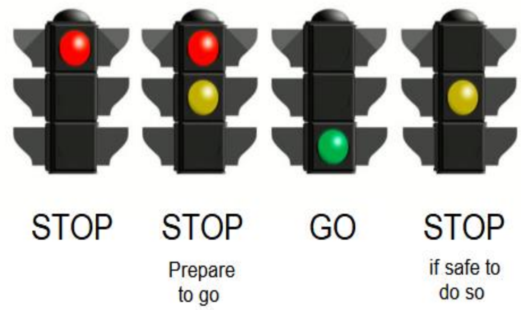

Fig 1: The Traffic Signals

Traffic Light Sequence

The following images depict the Traffic Light Sequence Scheme.

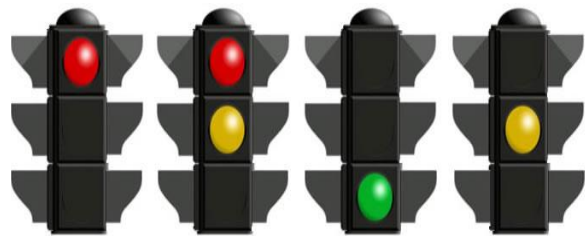

Fig 2: Traffic Light Sequence Scheme

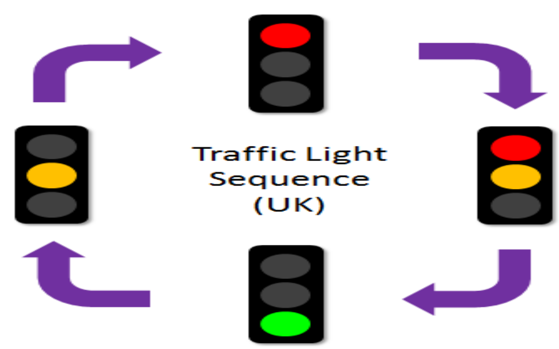

Fig 3: Traffic Light Sequence Scheme (UK)

Three or more aspects & positioning of aspects

The standard traffic signal is the red light above the green, with yellow between.

When the traffic signal with three aspects is arranged horizontally or sideways, the arrangement depends on the rule of the road. In right-lane countries, the sequence (from left to right) is red–yellow–green. In left-lane countries, the sequence is green–yellow–red. Other signals are sometimes added for more control, such as for public transportation and right or left turns allowed only when the green arrow is illuminated or specifically prohibited if the red arrow is illuminated.

IV BI-DIRECTIONAL COEFFICIENT OF CAUSATION [11]

R.C. Bagadi [11] detailed the Bi-Directional Coefficient of Causation as follows:
After the given Data is sufficiently pre-processed as detailed below:

Data Pre-Processing
Because of the squaring aspect in the above formula, the observed effect of Negative Deviations is same as those of the Positive Deviations with the same value. Hence, we need to Pre-Process the Data in the following fashion.
For the data (x_i, y_i) we first

a) Translate., shift., add all the $x_i \mapsto x_i + |Min(x_i)| + \delta$ where $0 < \delta < 1$.
b) For every x_i shifted thusly, we also find its corresponding y_i using Interpolation within the domain of old (x_i, y_i) values and also if this domain does not cover the domain of y_i, we use Forecasting Scheme detailed by R.C. Bagadi [12] to predict the updated y_i values due to such aforementioned translation of the x_i values.

Bi-Directional Coefficient of Causation
After the given Data (the x and y) is sufficiently pre-processed as detailed in Chapter 3 of [11], and Normalized (Euclidean or RL Norm Type) separately

We write the Coefficient of Causation as follows

$$cc(x \rightarrow y) = \left\{ \sum_{j=1}^{n-1} \left\{ \frac{\langle \Delta y \rangle_{(j+1,j)Mid}}{\langle \Delta x \rangle_{(j+1,j)Mid}} \right\} \right\}$$

$$where\ \langle \Delta y \rangle_{(j+1,j)Mid} = \left\{ \frac{\sum_{j=1}^{n-1} \Delta y_{(j+1,j)\,Mid}}{(n-1)} \right\}$$

$$and\ \langle \Delta x \rangle_{(j+1,j)Mid} = \left\{ \frac{\sum_{j=1}^{n-1} \Delta x_{(j+1,j)Mid}}{(n-1)} \right\}$$

$$with\ \Delta x_{(j+1,j)Mid} = \left(\frac{x_{j+1} + x_j}{2} \right)$$

$$and\ \Delta y_{(j+1,j)\,Mid} = \left(\frac{y_{j+1} + y_j}{2} \right)$$

Bi-Directional Coefficient of Causation with Higher Accuracy
Here, for every (x_i, x_{i+1}) we have two weightages $(wx_{iL}, wx_{(i+1)R})$
with $wx_{iL} = 1$ if $x_i > x_{i+1}$
and $wx_{iL} = \left\{ \frac{x_i}{x_{i+1}} \right\}$ if $x_i < x_{(i+1)}$
and $wx_{(i+1)R} = 1$ if $x_{i+1} > x_i$
$wx_{(i+1)R} = \left\{ \frac{x_{i+1}}{x_i} \right\}$ if $x_i < x_{(i+1)}$

If we use RL Norm Type Normalization of x_i we need to use the Prime Basis Position Numbers of x_i and x_{i+1} in the formula for wx_{iL} (in place of x_i and x_{i+1})
And
Furthermore,
$\Delta x_{(j+1,j)Mid} = \left(wx_{(j+1)R}\, x_{j+1} - wx_{jL} x_j \right)$

Also, for every (y_i, y_{i+1}) we have two weightages $(wy_{iL}, wy_{(i+1)R})$
with $wy_{iL} = 1$ if $y_i > y_{i+1}$
$wy_{iL} = \left\{ \frac{y_i}{y_{i+1}} \right\}$ if $y_i < y_{(i+1)}$
and $wy_{(i+1)L} = 1$ if $y_{i+1} > y_i$

$$wy_{(i+1)L} = \left\{ \frac{y_{i+1}}{y_i} \right\} \text{ if } y_{i+1} < y_i$$

If we use RL Norm Type Normalization of y_i we need to use the Prime Basis Position Numbers of y_i and y_{i+1} in the formula for wy_{iL} (in place of y_i and y_{i+1})

And

Furthermore,

$$\Delta y_{(j+1,j)\,Mid} = \left(wy_{(j+1)R}\, y_{j+1} - wy_{jL}\, y_j \right)$$

Traffic signal cycles

Generally, at least one direction of traffic at an intersection has the green lights (green aspect) at any moment in the cycle. In some jurisdictions, for a brief time, all signals at an intersection show red at the same time, to clear any traffic in the intersection. The delay can depend on traffic, road conditions, the physical layout of the intersection, and legal requirements. Thus, modern signals are built to allow the "all red" in an intersection, even if the feature is not used.

Some signals have no "all red" phase: the light turns green for cross traffic the instant the other light turns red.

Another variant in some locations is the pedestrian scramble, where all the traffic lights for vehicles become red, and pedestrians are allowed to walk freely, even diagonally, across the intersection.

V DATA

We have the following data from Traffic Timing Manual [13]

Traffic Volume Vs. Green Signal Duration

Table 1: Traffic Volume Vs. Green Signal Duration

Phase Volume Per Lane, Veh/Hr/Ln	Cycle Length							
	50	60	70	80	90	100	110	120
	Maximum Green							
100	15	15	15	15	15	15	15	15
200	15	15	15	15	16	18	19	21
300	15	16	19	21	24	26	29	31
400	18	21	24	28	31	34	38	41
500	22	26	30	34	39	43	47	51
600	26	31	36	41	46	51	56	61
700	30	36	42	48	54	59	65	71
800	34	41	48	54	61	68	74	81

Traffic Volume Vs. Green Signal Duration & Red Signal Duration

Table 2: Traffic Volume Vs. Green Signal Duration & Red Signal Duration for 50, 60, 70, 80 seconds Cycle Length

Phase Volume Per Lane, Veh/Hr/Ln	50		60		70		80	
	Green	Red	Green	Red	Green	Red	Green	Red
100	15	5.59	15	5.59	15	5.59	15	5.59
200	15	5.59	15	5.59	15	5.59	15	5.59
300	15	5.59	16	5.97	19	7.08	21	7.83
400	18	6.71	21	7.83	24	8.95	28	10.44
500	22	8.20	26	9.70	30	11.19	34	12.68
600	26	9.70	31	11.56	36	13.43	41	15.29
700	30	11.19	36	13.43	42	15.67	48	17.91
800	34	12.68	41	15.29	48	17.91	54	20.14

Table 3: Traffic Volume Vs. Green Signal Duration & Red Signal Duration for 90, 100,110, 120 seconds Cycle Length

Phase Volume Per Lane, Veh/Hr/Ln	90		100		110		120	
	Green	Red	Green	Red	Green	Red	Green	Red
100	15	5.59	15	5.59	15	5.59	15	5.59
200	16	5.97	18	6.71	19	7.08	21	7.83
300	24	8.95	26	9.70	29	10.82	31	11.56
400	31	11.56	34	12.68	38	14.17	41	15.29
500	39	14.55	43	16.04	47	17.53	51	19.02
600	46	17.16	51	19.02	56	20.89	61	22.76
700	54	20.14	59	22.01	65	24.25	71	26.49
800	61	22.76	68	25.37	74	27.61	81	30.22

VI COMPUTER PROGRAM

Computational Analysis: Computer Program for One Example Data

```
## Coefficient of Causation Program Kernel
(gr50new)
clear
x0= [15 15 16 21 26 31 36 41]
x=ones (1, length(x0))
x1=ones (1, length(x))
for j=1: length(x0)
x1(j)=(x0(j)) ^2
end
x1
l=sum(x1)
m=sqrt(l)
for j=1: length(x)
x(j)=x0(j)/m
end
x

dx=length(x)
g=ones(dx-1,2)
for i=1: dx-1
g(i,1) =x(i)
g(i,2) =x(i+1)
end
```

```
wx=ones(dx-1,2)
for j=1: dx-1
if x(j)>x(j+1)
        wx(j,1) =1
    else
        wx(j,1) =x(j)/(x(j+1) +0.000000001)
end
end

for j=1: dx-1
if x(j)<x(j+1)
        wx(j,2) =1
    else
        wx(j,2) =x(j+1)/(x(j)+0.000000001)
end
end
wx

Dx=ones(dx-1,1)
for j=1: dx-1
Dx(j)=(x(j+1) *wx(j,2)) -(x(j)*wx(j,1))
end

y0= [5.59 5.59 5.59 6.71 8.20 9.70 11.19 12.68]
y=ones (1, length(y0))
y1=ones (1, length(y))
for j=1: length(y0)
y1(j)=(y0(j)) ^2
end
y1
l=sum(y1)
m=sqrt(l)
for j=1: length(y)
y(j)=y0(j)/m
end
y

dy=length(y)
k=ones(dy-1,2)
for i=1: dy-1
k(i,1) =y(i)
k(i,2) =y(i+1)
end
wy=ones(dy-1,2)
for j=1: dy-1
if y(j)>y(j+1)
        wy(j,1) =1
    else
        wy(j,1) =y(j)/(y(j+1) +0.000000001)
end
end

for j=1: dy-1
if y(j)<y(j+1)
        wy(j,2) =1
    else
        wy(j,2) =y(j+1)/(y(j)+0.000000001)
end
end
wy

Dy=ones(dy-1,1)
for j=1:(dy-1)
Dy(j)=(y(j+1) *wy(j,2)) -(y(j)*wy(j,1))
end
Ryx=ones(dy-1,1)

for j=1: dy-1
Ryx(j)=Dx(j)/(Dy(j)+0.000000001)
end
CCytox=sum (Ryx)

Rxy=ones(dx-1,1)
for j=1: dx-1
Rxy(j)=Dy(j)/(Dx(j)+0.000000001)
end
CCxtoy=sum (Rxy)
header = fopen ('gr50otput.txt', 'w')
```

VII RESULTS & INFERENCES

The Results and Inferences are tabulated in the following Table 4.

Table 4: Results & Inferences

Time Cycle Length (Second)	Coefficient of Causation Green(x)→ Red(y)	Coefficient of Causation Red(y)→ Green(x)	Inference
50	4.9967	5.0033	Since Red(y)→ Green(x) is greater than Green(x)→Red(y), Red(y) Signal should precede Green(x) Signal
60	2.5527e+07	5.1832	Since Green(x)→Red(y) is greater than Green(x)→Red(y), Red(y) Signal should precede Green(x) Signal

70	6.0039	5.9961	Since Red(y)→ Green(x) is lesser than Green(x)→Red(y), Red(y) Signal should precede Green(x) Signal
80	6.0011	5.9989	Since Red(y)→ Green(x) is lesser than Green(x)→Red(y), Red(y) Signal should precede Green(x) Signal
90	1.7476e+07	6.1081	Since Green(x)→Red(y) is greater than Green(x)→Red(y), Red(y) Signal should precede Green(x) Signal
100	7.0031	6.9969	Since Red(y)→ Green(x) is lesser than Green(x)→Red(y), Red(y) Signal should precede Green(x) Signal
110	6.9984	7.0016	Since Red(y)→ Green(x) is greater than Green(x)→Red(y), Red(y) Signal should precede Green(x) Signal
120	6.9978	7.0022	Since Red(y)→ Green(x) is greater than Green(x)→Red(y), Red(y) Signal should precede Green(x) Signal

Representation of Results

The Coefficients of Causation are represented in the form of Bar Charts as shown below:

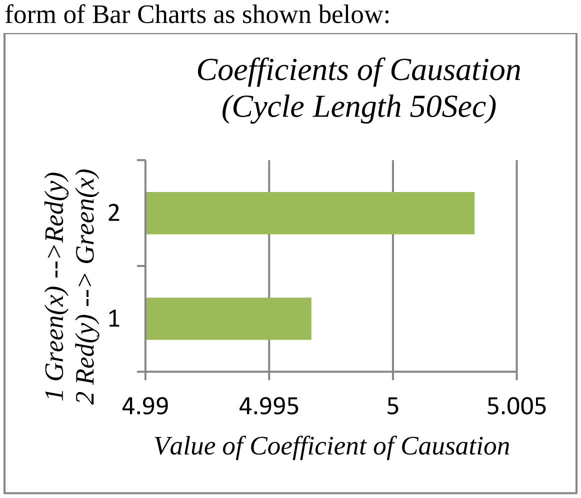

Fig4: Coefficients of Causation (Cycle Length 50 Sec)

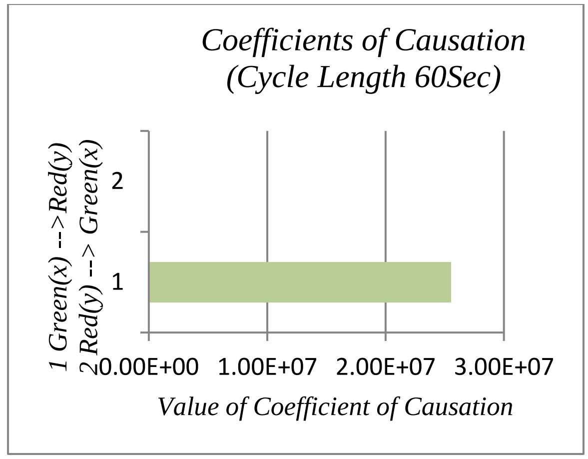

Fig5: Coefficients of Causation (Cycle Length 60 Sec)

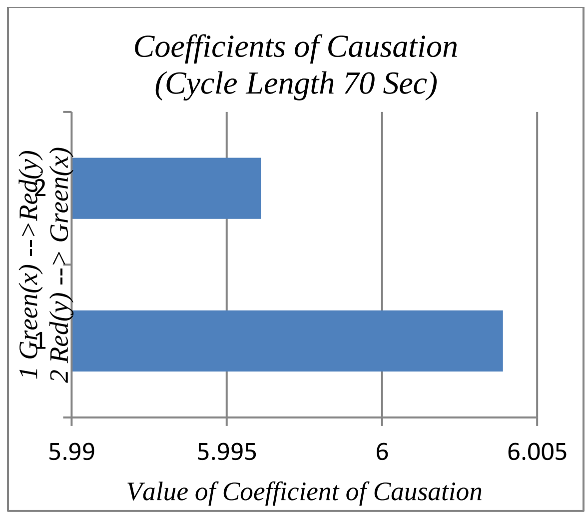

Fig6: Coefficients of Causation (Cycle Length 70 Sec)

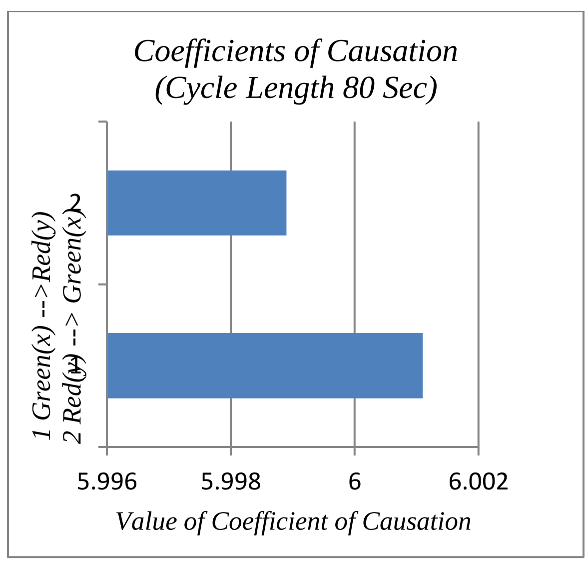

Fig7: Coefficients of Causation (Cycle Length 80 Sec)

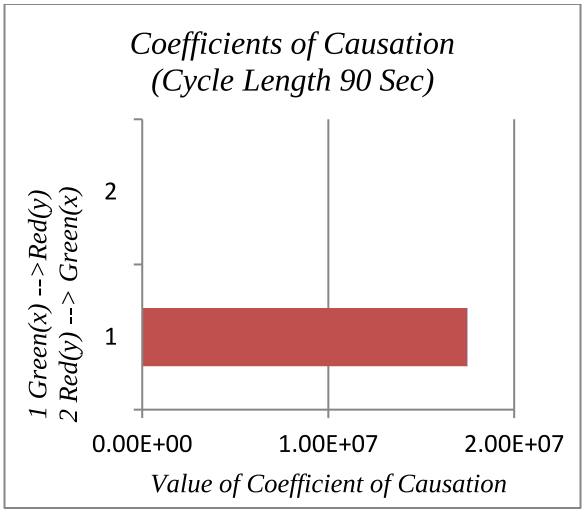

Fig8: Coefficients of Causation (Cycle Length 90 Sec)

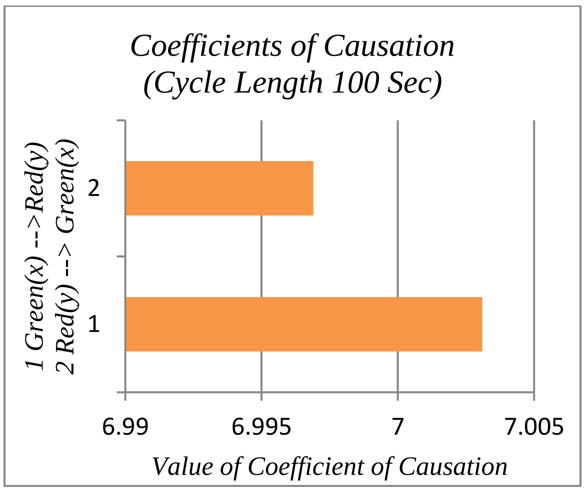

Fig9: Coefficients of Causation (Cycle Length 100 Sec)

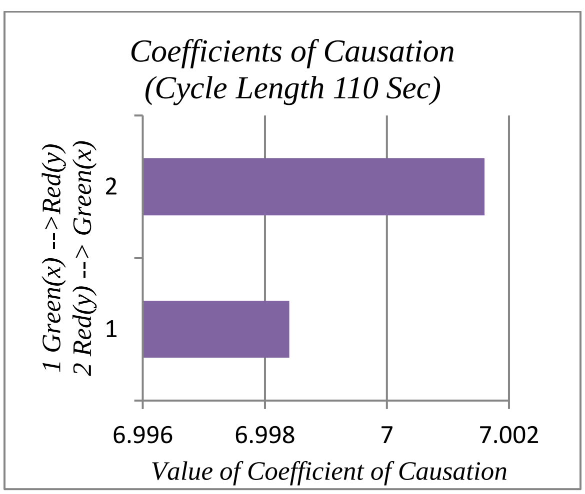

Fig10: Coefficients of Causation (Cycle Length 110 Sec)

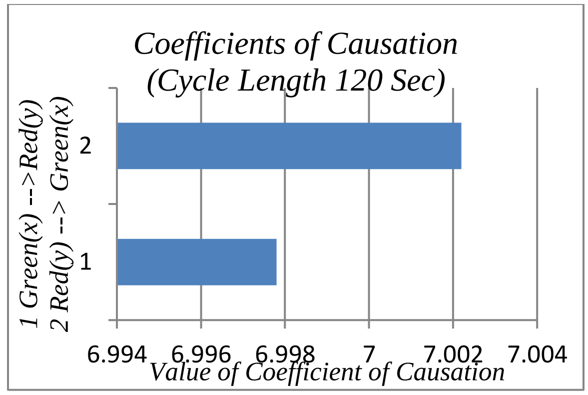

Fig11: Coefficients of Causation (Cycle Length 120 Sec)

VIII FUTURE SCOPE & INSIGHTS

In essence, we should calculate such Coefficients of Causation for every possible combination of x and y for every Cycle Length Time. That is, we have to calculate C (16,2) =120 cases. We then have to create a Table and Order the Coefficients of Causations for a given Timeline of arrangements of these 16 Signals. With respect to this, we can rearrange the order of these 16 Signals by looking at the computed 160 Coefficients of Causations so as to not have high causations of undesirable Signal Time, i.e., the Red Signal Time. This Optimizes the Red Signal Time for the considered Order of the 16 Signals. We also can repeat the procedure for all possible Orders, i.e., 16! =2.09227899e13 cases and can report that Particular Order of the 16 Signals which has the Least Red Signal Time and Maximum Green Signal Time using the afore-stated Scheme. Also, this procedure can be implemented in a Real Time Instantaneous fashion to Optimize Red Signal Time.

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