ARIMA Model for Forecasting Short-Term Travel Time due to Incidents in Spatio-Temporal Context (TRB Paper # 15-5553)

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R. M. Zahid Reza, M.S.,E.I.[1], Srinivas S. Pulugurtha, Ph.D., P.E.[2] and Venkata R. Duddu, Ph.D., E.I.[3]

Department of Civil & Environmental Engineering, The University of North Carolina at Charlotte

UNC CHARLOTTE

ABSTRACT

- This paper focuses on an application of Autoregressive Integrated Moving Average (ARIMA) model to incorporate traffic information from neighboring links in forecasting short-term travel time along a corridor due to an incident.
- The spatio-temporal data was combined and analyzed through ARIMA model using pre-whitening cross-correlation function alongside lagged regression.
- The model was developed using 181 "Vehicle Accident" type incidents that occurred along a ~19-mile freeway segment in the city of Charlotte, North Carolina.
- Results indicate that the travel times for consecutive segments are highly correlated and, both, upstream and downstream segments has influence on the target segment. However, upstream segments are observed to have a higher effect than downstream segments.
- The mean absolute percent error (MAPE) and mean absolute deviation (MAD) of the developed lagged regression model for almost every considered segment was less than 10%. MAPE and MAD computed from validation data (26 incidents) were observed to be less than 10% for 95% of samples indicating an accurate estimation of the effect of incidents on travel time using the proposed method.
- Moreover, the results obtained from the validation of models at both segment- and corridor-level indicate that the estimated effect of incidents on travel time is close to the real-time observations.

INTRODUCTION

- Non-recurring congestion caused by incidents lead to significant delays on urban roads. Along with congestion, incidents have many effects such as increased delays, bottlenecking, and rubbernecking.
- Under free-flow or low flow conditions, travel time forecasting can be easily made based on the free flow speed. The travel time is still very predictable if the traffic state remains stable over time as well as across space even though the traffic volume has increased.
- However, traffic system becomes non-linear in nature when traffic volume levels are close to the saturated condition. In this situation, dynamic travel time and non-stationary traffic state is no means proportional. Furthermore, incidents induce even more complexities to the traffic system, which reduces the preciseness of travel time predictions.
- Although there are many benefits, very few studies have focused on evaluating the effect of traffic incidents on travel time due to the difficulty in obtaining reliable travel time data during incidents.

BACKGROUND

- The effectiveness of a multivariate method enhances with the incorporation of surrounding traffic conditions.
- Vythoulkas (1993) revealed that traffic forecasting accuracy is closely related to the use of neighboring segments' traffic information.
- Yang et al. (2014) also showed spatio-temporal relationships of speed at consecutive segments are highly correlated under different traffic conditions.
- Ahmed and Cook introduced ARIMA model for forecasting. They are widely accepted for modeling stationary time series owing to their accuracy in forecasting.
- Different types of ARIMA models have been successfully applied to forecast traffic characteristics in the past. Levin et al. (1980) used ARIMA to model the stochastic nature of the traffic. Williams et al. (2003) applied seasonal ARIMA model for short-term traffic flow forecasting. Gosh et al. (2005) adopted random-walk model for forecasting traffic flow.
- Past research indicates that ARIMA model outperforms the heuristic forecast benchmark method, smoothing technique, and Radial Bias Function Neural Network (RBFNN).

RESEARCH OBJECTIVES

- The primary objective of this research is to forecast travel time of segments during incidents by incorporating the effect of the characteristics of surrounding segments using ARIMA model.
- It also aims at evaluating spatio-temporal relationships among the surrounding segments through pre-whitened cross-correlations function alongside lagged regression under incident affected scenario.

RESEARCH METHODOLOGY

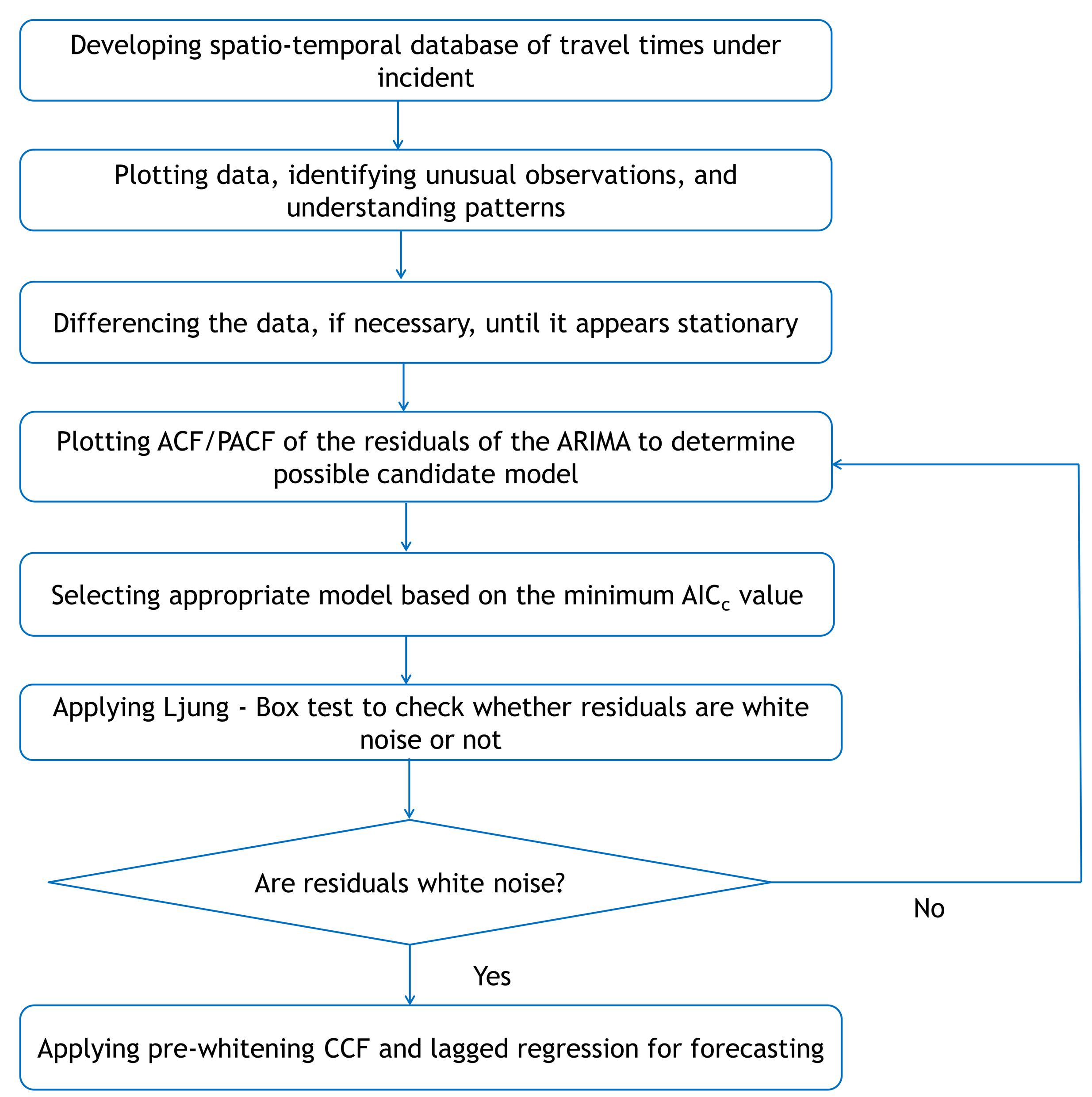


FIGURE 1: Travel time by distance - (L) without & (R) with incident

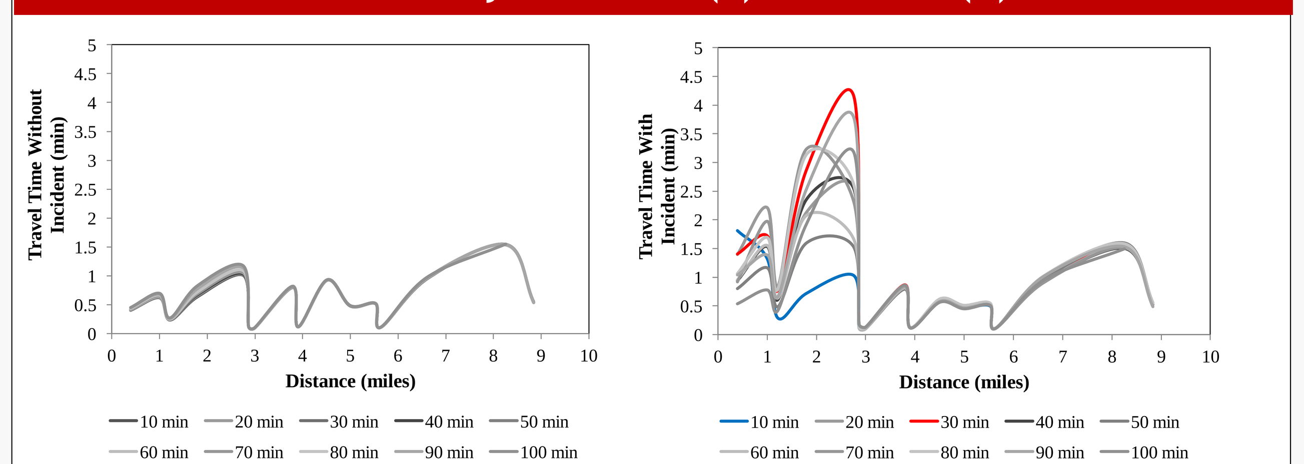


FIGURE 2: (L) CCF & (R) pre-whitened CCF

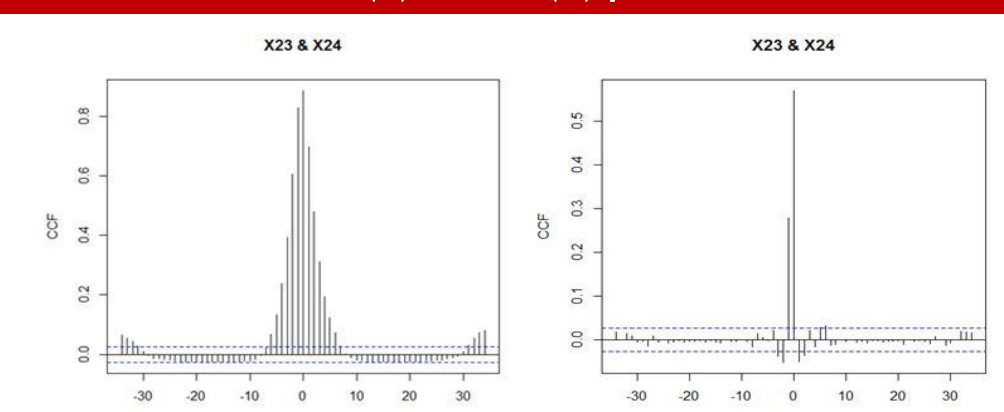


FIGURE 3: (L) 3-D views of |CCF| & (R) contour of |CCF| values

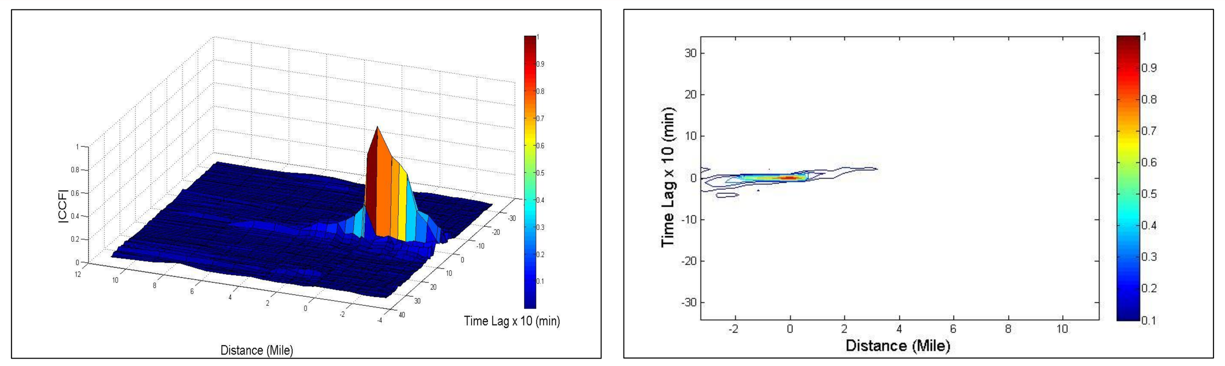


TABLE 1: Performance comparison of fitted model

Target Segment	Segment for Prediction		Holdout Performance	
	Downstream	Upstream	MAPE	MAD
X6	3,4,5	7, 8,9,10	2.42%	0.98
X7	4,5,6	8,9,10,11	2.46%	1.29
X8	4,5,6,7	9,10,11,12	3.11%	2.11
X9	5,6,7	10,11,12,15	3.79%	2.62
X10	6,7,8,9	11,12,13,15	2.83%	2.41
X11	7,8,9,10	12,15,17	0.98%	1.26
X12	9,10,11	13,14	3.43%	0.61
X13	12	14,15,16,17	3.41%	0.96
X14	-	15,16,18	4.39%	4.44
X15	-	16,17,18,19	5.25%	2.98
X16	-	17,18,19,21	5.09%	4.47
X17	15,16	18,19	4.42%	1.56
X18	13,16,17	19,20,21,22	6.98%	7.05
X19	16,17,18	20,21,22	5.78%	11.15
X20	17,18,19	21,22,23,25	6.38%	1.08
X21	18,19,20	22,23,25	4.96%	0.30
X22	21,20	23,24,25,26	5.38%	0.83
X23	19,20,21,22	24,25,26,28	3.66%	5.11
X24	22,23	25,26,27	4.17%	0.75
X25	21,22,23,24	26,27,28,30	3.76%	3.33
X26	23,24,25	27,28,29,30	15.20%	9.94
X27	24,25,26	28,29,30	5.25%	5.38
X28	26,27	29,30,31,32	5.59%	1.00
X29	26,27,28	30,31,32,33	5.17%	7.73
X30	27,28,29	31,32,33	3.69%	8.56
X31	28,29,30	32,33,34,35	5.39%	7.21
X32	30,31	33,34,35,37	7.56%	7.34
X33	30,31,32	34,35,36	3.34%	5.21
X34	32,33	35,36,37,38	2.56%	3.19

TABLE 2: Model validation

Target Segment	Model Validation	
	MAPE	MAD
X6	4.18%	1.80
X7	7.49%	3.77
X8	6.22%	3.95
X9	7.38%	6.18
X10	7.93%	10.0
X11	5.61%	5.42
X12	5.79%	1.68
X13	7.69%	16.84
X14	8.77%	10.89
X15	7.19%	10.02
X16	9.27%	4.85
X17	11.19%	16.76
X18	10.72%	26.23
X19	5.18%	1.07
X20	8.95%	0.81
X21	9.87%	1.86
X22	7.83%	11.89
X23	4.45%	1.12
X24	6.38%	7.02
X25	5.31%	4.34
X26	4.76%	3.72
X27	4.09%	0.52
X28	4.26%	5.60
X29	3.44%	5.32
X30	5.73%	4.56
X31	7.89%	7.81
X32	8.34%	9.12
X33	4.56%	3.32
X34	7.34%	9.56

CONTACT INFORMATION

[1] Graduate Student of INES Ph.D. Program, The University of North Carolina at Charlotte; Phone: (561) 927-5750; E-mail: rreza@uncc.edu.

[2] Director of Infrastructure, Design, Environment, and Sustainability (IDEAS) Center, Professor and Graduate Program Director of Civil & Environmental Engineering, The University of North Carolina at Charlotte; Phone: (704) 687-1233; E-mail: sspulugurtha@uncc.edu.

[3] Post-doctoral Researcher of Civil & Environmental Engineering, The University of North Carolina at Charlotte; Phone: (704) 687-1250; E-mail: vduddu@uncc.edu.

FIGURE 4: Comparison of observed & predicted travel time

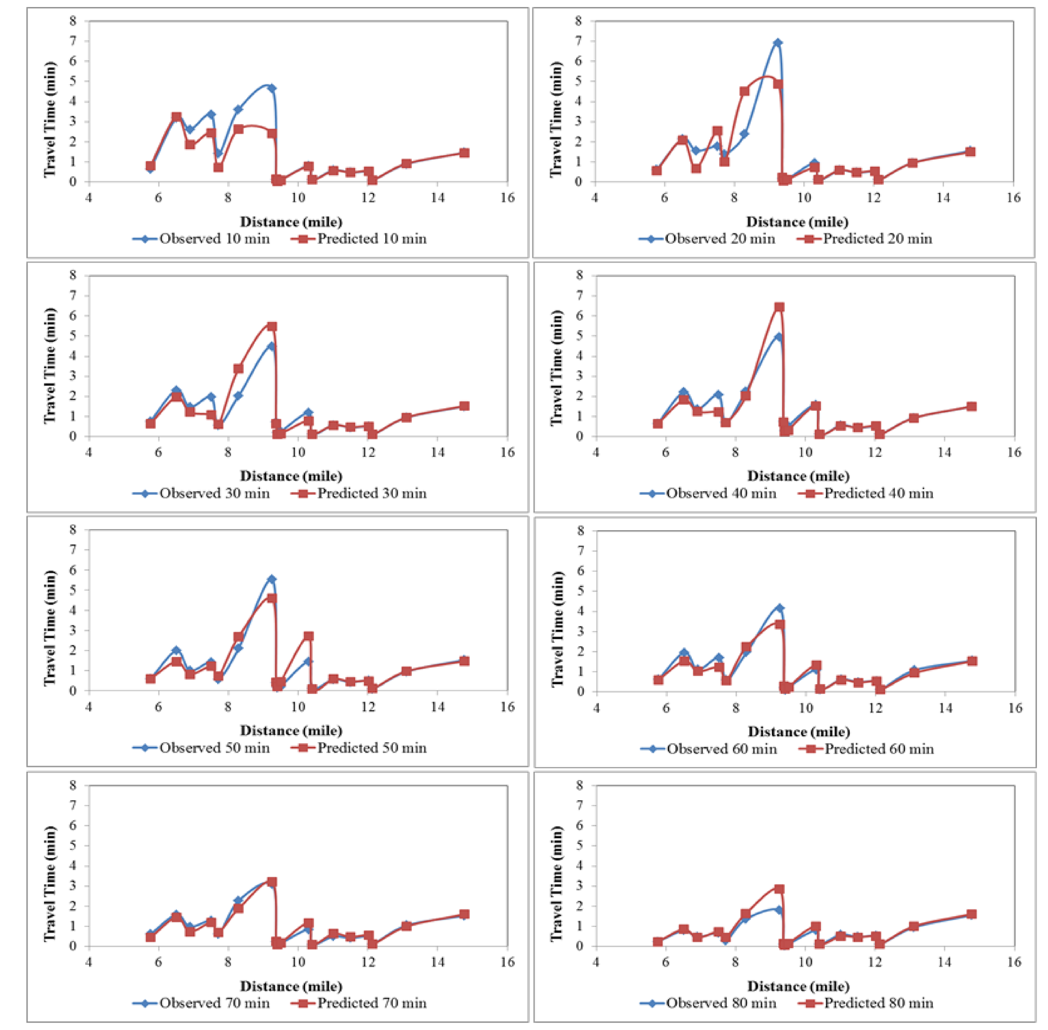
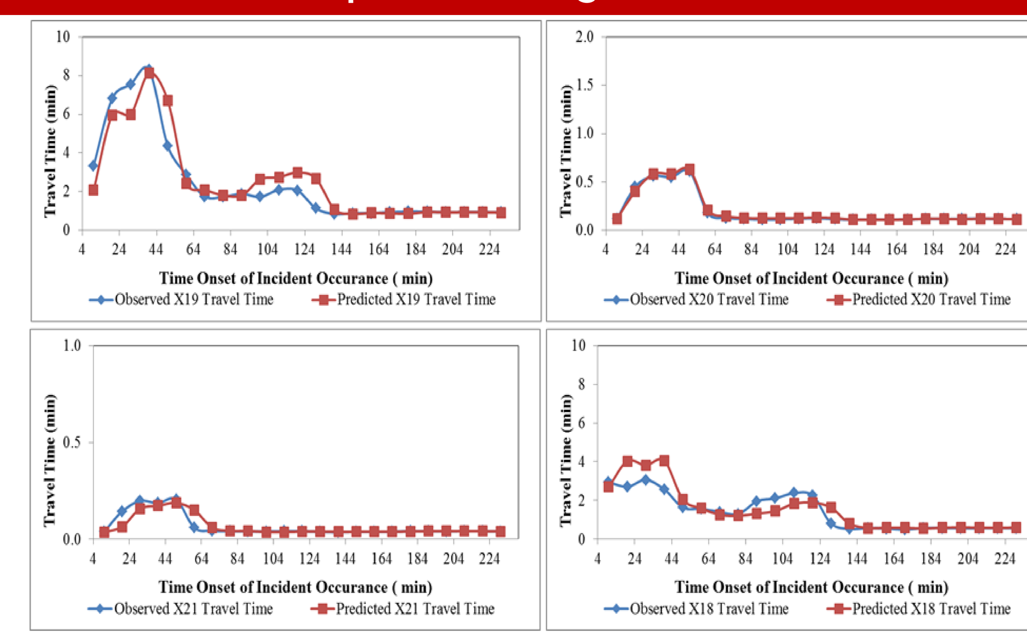


FIGURE 5: Comparison of segment level travel time



CONCLUSIONS & SCOPE FOR FUTURE WORK

- This poster presents the effect of incidents on travel time using ARIMA model, pre-whitening cross correlation function and lagged regression technique.
- The results demonstrate that the travel times on consecutive segments are highly correlated even in the presence of incidents. However, upstream segments seems to have higher influence than downstream segments.
- The MAPE and MAD computed from validation data are observed to be less than 10% for 95% of samples.
- Developing the models based on incident severity will help estimate its effect on travel time more accurately. This merits an investigation.

ACKNOWLEDGEMENT

This poster is prepared based on information collected for a research project funded by the United States Department of Transportation - Office of the Assistant Secretary for Research and Technology (USDOT/OST-R) under Cooperative Agreement Number RITARS-12-H-UNCC.

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