Prediction of Traffic Delay during the Constructions at Railway Sites

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***Abstract:* - This paper presents a method to predict the traffic delays during the Railway constructions using data from present investigators. The method is based on a technique where the data from adjacent investigators is processed to calculate the travel time between the two investigators. The travel time are taken as time-series data, and the problem of predicting the traffic delay is formulated as a time-series problem. Here an on-line approximate is used for the prediction of travel time based on current and past travel time estimates. Some examples are used to explain the traffic delay forecasting algorithm.**

***Keywords:* - Delay, Construction sites, On line approximation, Investigation.**

I. INTRODUCTION

Today Railway construction department is facing numerous challenges. Some challenges are centuries old but some are new. Construction work generally creates conflicts between trains and work activity. Railway construction is an important cause of delay. High congestion and non uniform traffic flow conditions are naturally formed in construction zones. In this situation we can approximate the traffic delay for low density traffic conditions and can estimation the travel time only. The conditions at railway sites are affected by many factors like the method of controlling the system, speed of trains, the behaviour of the drivers, and obviously the weather conditions. These factors make congestion at the construction sites. The problem is further worsened by the lower capacity of the stations. Experience shows that the delay of trains can vary from zero to any number of minutes depending on the conditions.

All of this makes the problems of estimation and prediction of traffic delays at railway construction sites very typical. Hence there is a need to develop of a safe and accurate traffic control system so that the railway authorities can reduce the expected delay of trains. So far, researchers have designed many algorithms to calculate expected delay by using simple assumptions.

II. RELATED LITERATURE

D.C. Gszis and C.H. Knapp (1971) presented On-line estimation of traffic densities from time-series of flow and speed data. C.J. Messer and C.L. Dudek (1974) proposed a development of a model for predicting travel time on an urban freeway. A. Kurkjian, S.B. Gershwin, P.K. Houpt, AS. Willsky and E.Y. Chow (1980) designed the Estimation of roadway traffic density on freeways using presence detector data. J.L. Memmott and C.L. Dudek (1984) presented the Queue and user cost evaluation of work zones. N.M. Rouphail and G. Tiwari (1985) proposed the Flow characteristics at freeway lane closures W. Bessel (1991) discussed the traffic flow and capacity at work sites on freeways, in highway capacity& and level of service. J.H. Papendrecht and H. Schuurman (1991) presented a paper Bottlenecks on freeways: Traffic aspects of roadwork, in highway. A.S. Weigend and N.A. Gershenfeld (1992), Editors, Time series prediction, presented forecasting the future and understanding the past. A. Faghri and J. Hua (1992) proposed Evaluation of artificial neural network applications in transportation engineering. M.M. Polycarpou and P.A. Ioannou (1992) Neural networks as on-line approximators of nonlinear systems. D.A. White and D.A. Sofge (1993), Editors, Handbook of Intelligent Control, presented Neural, Fuzzy, and Adaptive Approach. M.S. Dougherty, HR. Kirby and R.D. Boyle (1993) discussed the use of neural networks to recognize and predict traffic congestion. AR. Barron (1993) presented Universal approximation bounds for superposition of a sigmoidal function. B.L. Smith and M.J. Demetsky (1995) discussed the Short-term traffic flow prediction: Neural network approach. J. Hus and A. Faghri (1995) presented an application of artificial neural networks to intelligent vehicle highway systems. P.D. Pant and M.M. Polycarpou (1995) presented an intelligent traffic control system for highway work zones. M.M. Polycarpou and A.T. Vemuri (1995) designed the Learning methodologies for failure detection and accommodation. R.L. Cheu and S.G. Ritchie (1995) presented automated detection of lane-blocking freeway incidents using artificial neural networks. D.H. Nam and DR Drew (1996) designed a Traffic dynamics: Method for estimating freeway travel times in real time from flow measurements.

III. PROBLEM FORMULATION

Suppose a station with two platforms having one of the platforms closed due to construction. Figure 1 shows the construction area. The construction area is that section of the station where the actual construction is to be done.

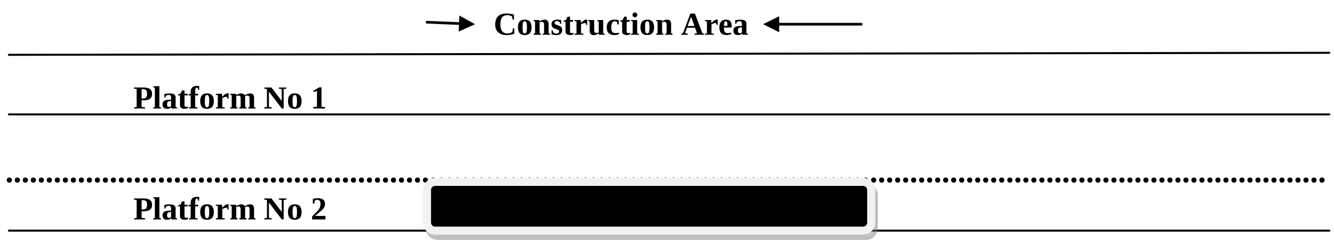

Figure1.

The Goal is to design an algorithm to forecast the actual time of traffic delays using advanced signal system. The railway placed the signal systems one Km. apart from the construction area. The computed traffic delay information is conveyed to drivers via the use of variable message signs.

One possible path to process the data obtained periodically from the signals is to use all the measurements together. We use a modular alternative approach by dividing the station into links. We represent a link as the segment of the station between two neighbouring signals. The measurements from the signals located at either end of the link are processed using the principle of conservation of vehicles to estimate the current time required to traverse the link.

Here the main problem is to compute the time required for a train to travel from the beginning to the end of the construction area. Generally, the solution to this problem is the summing up the travel time estimates for links downstream of the entry point. This is because, as the drivers traverse through the first downstream link, the initial travel time estimates for the second and subsequent downstream links may have changed. So to provide accurate information to drivers, the travel times for subsequent downstream links needs to be predicted ahead in time. The expected values are then added to find the overall traffic delay information.

Figure 2 represents the model used for forecasting the traffic delays in construction area as

1) Estimation of the current travel time for each link using the information provided by the presence detectors and the principle of conservation of trains.
2) Prediction of the future travel time for each link using current and past travel time estimation.
3) Forecasting of the overall traffic delay for the construction zone for drivers entering in the construction zone.

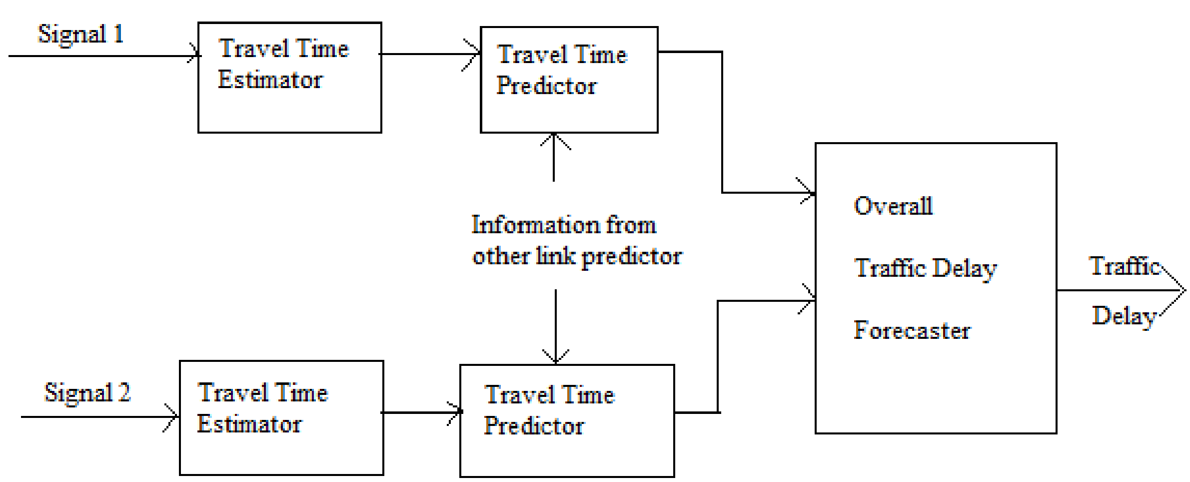

Figure 2

IV. TRAVEL TIME ESTIMATION

Here the problem is how to calculate the presence detector data. For this we consider the cumulative trains versus time given by Figure 3.

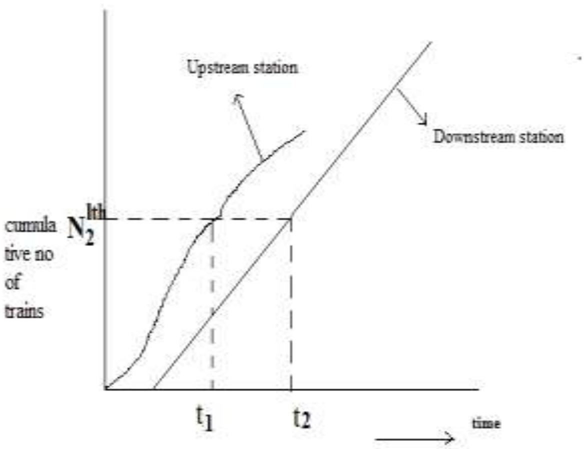

Figure 3

This diagram shows the total number of trains entering in link 1 at the upstream station and the number of trains leaving the downstream station. Now consider the time instant t_2. At this instant, the $N_2^{l\,th}$ train is detected at the downstream station. This implies that the $N_2^{l\,th}$ train would have been detected at the upstream detector station (assuming "first-in-first-out" behaviour) at the time instant t_1. Therefore, t_2- t_1 is the total amount of time spent by the $N_2^{l\,th}$ train that exited the freeway link 1 at the time instant t_2. We define t_2- t_1 as the current travel time for link 1 at time instant t_2.

We consider the problem of discrete nature of the presence detector data as follows: let the time interval between two successive data be T. Further, let t_2 = kT; i.e., t_2 corresponds to the k^{th} observation. Then t_2 in Figure 3 satisfies $nT \leq t_1 < (n + l)\, T$ for some n < k. This means that the current travel time can be computed by interpolating t_1 between the nT and (n + l) T. the occupancy measurements at the detector stations are used to obtain a rough estimate of the initial number of trains by using the formula:

$$N^{l}(0) = \frac{\lambda}{2}\left[w_u^l(0) + w_d^l(0)\right] \text{ (Trains/mile)}, \quad (1)$$

Where $N^l(0)$ is the initial number of trains in link 1 and w_u^l and w_d^l are the percent occupancy measurements at the upstream and downstream stations, respectively, where $\lambda > 0$ is a constant and given by

$$\lambda = \frac{52.8}{L+d} \text{ (Trains/mile)} \quad (2)$$

Where *L is* the average length of the trains and *d* is the effective detector beam length. Since occupancy provides a measure of traffic density, this method can be used to improve the estimate of the initial number of trains in the link. Note that inaccurate values for the average length of trains would cause an error in the estimate of the initial number of trains in the link. This would result in a constant bias in the travel time estimates.

V. TRAVEL TIME PREDICTION

Now the problem is to predict the future travel time for each link. This one is discussed by Figure 4. The time spent (in link l) by the $N_3^{l\,th}$ train which enters link 1 at time t_2 is given by t_3 - t_2. So the travel time prediction at t_2 is t_3 - t_2. Travel time Prediction in this case is a time series prediction problem, where the goal is to calculate the short-term evolution of the railway system by its past behaviour. This is an n-step ahead prediction, which requires relatively large values of n in case of high traffic congestion situations. Hence, the demand of travel time prediction problem is to capture the nonlinear characteristics of traffic flow dynamics in order to determine the future travel times in each link.

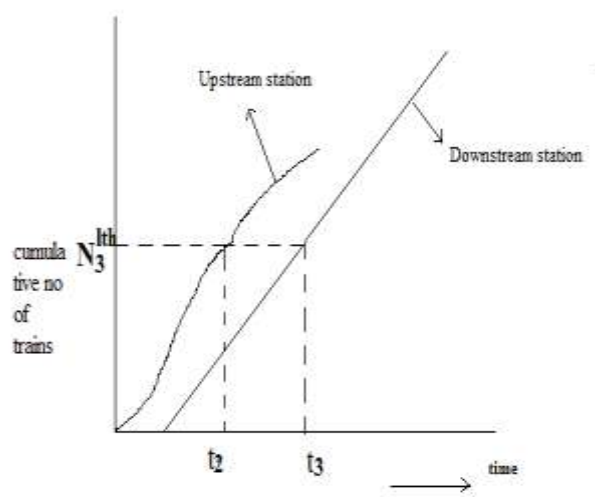

Figure 4.

Here we have to calculate the change in the travel time given by the past changes in the travel time. For example, the one step ahead travel time prediction is given by

$$x^l(k+1) = x^l(k) + \delta^l(k+1) \quad (3)$$

Where k is the discrete-time step index, $x^l(k+1)$ is the one-step-ahead predicted travel time in link l, $x^l(k)$ is the estimated travel time in the kth time step, and $\delta^l(k+1)$ is the predicted change in travel time in link l.

Short-term predictors determine the weights for forecasting the next step. The prediction of travel time in this paper requires the prediction of the travel time further than one step into the future. The number of steps ahead for a particular link depends on the travel time in the previous link. So we use the iterated single-step prediction theory for multistep predictions. This program is continued until prediction for the required future time is achieved.

VI. CONCLUSION

This paper presents a method for short-term forecasting of traffic delays in railway construction zones. This is based on an approach where the total construction zone is divided into links with presence detectors at each node. The travel time estimates are calculated using the principle of conservation of trains.

The simulation results indicate that the given approach is perfect on simulated data. The performance of the data needs to be investigated. The performance of the proposed approach is changed by a number of design parameters including the number of inputs to the predictor system. For some of these design parameters, the choice is decided by specific information about the construction zone. The development of a procedure for the selection of these design parameters is an important issue.

The prediction method in this paper is based on using only the previous travel time data of some link l to predict the future travel time in link 1. However, it is clear that the future travel time in link l is affected not only by traffic flow in link l but also by traffic flow in links l- 1, l -2, etc., as well as by traffic flow in links l+l, l+2, etc. The prediction problem leads to increase in the inputs to the system. Therefore, investigation of the design trade-offs by analytical results and extensive simulations are required to calculate the effects of a more global learning formulation.

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