DEVELOPMENT OF A MICROSCOPIC CAR-FOLLOWING MODEL USING REAL TIME KINEMATIC GLOBAL POSITIONING SYSTEM DATA

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A car-following model describes how a following vehicle in a platoon responds to changes in driving behaviour of the leading vehicle. It plays an important role in microscopic traffic simulation programmes. Real time kinematic differential global positioning system enables convenient data acquisition for car-following studies. High quality observations of headway, speed, relative speed and acceleration were obtained in a multiple car-following experiment conducted in Japan, using real time kinematic global positioning system. Ten light vehicles, each with a receiver, participated in the experiment in a probing field driven by undergraduates. The expected accuracies of measuring position and speed were 10 mm and 0.16 km/h respectively. Different driving speeds were induced and the experiment gave sets of continuous observations of position and speed. Headway, relative speed and acceleration were derived from position and speed data.

High-resolution plots of acceleration and relative speed show that the acceleration lags behind the relative speed illustrating the general concepts of the stimulus-response car-following models in use. The data was used to check the validity of commonly used General Motors (GM) car-following model which predicts the acceleration or deceleration of the follower by the relationship,

$$\ddot{x}_n(t+T) = \alpha * \frac{[\dot{x}_n(t+T)]^m}{[x_{n-1}(t) - x_n(t)]^\ell} * [\dot{x}_{n-1}(t) - \dot{x}_n(t)]$$

where, $x_n(t)$ is the position of the n^{th} car at time t. T is the reaction time and dot implies derivative with respect to t. α, ℓ and m are parameters. Field data failed to fit in the GM model. The failure of the GM model is attributable to the wrong positioning of the independent variables. Correlation analysis showed that a better relationship for the predicted value of acceleration is given by a model called Excess Critical Speed (ECS) model,

$$\ddot{x}_n(t+T) = \beta_0 + \beta_1[E\,C\,S] + \beta_2[\dot{x}_{n-1}(t) - \dot{x}_2(t)]$$

The ECS is given by,

$$E\,C\,S = [\dot{x}_n(t)] - \sqrt{2 * f * [x_{n-1}(t) - x_n(t)]}$$

where f is the maximum decelerating rate. The model was calibrated using field data under acceleration and deceleration conditions separately. The resulting model is,

$$\ddot{x}_n(t+T) = 0.269 - 0.003[E\,C\,S] + 0.232[\dot{x}_{n-1}(t) - \dot{x}_n(t)] \quad \text{under acceleration condition}$$

$$\ddot{x}_n(t+T) = -0.288 + 0.057[E\,C\,S] + 0.308[\dot{x}_{n-1}(t) - \dot{x}_n(t)] \quad \text{under deceleration condition.}$$

In validation, the ECS model predicted acceleration very close to the observed acceleration. In a two tailed 'F' test, the model was successful in 12 out of 18 data sets. The parameters β_0, β_1 and β_2 depend on skillness of drivers, condition of vehicles and driving environment. Therefore, the model may need to be re-calibrated for use in different conditions.