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Books of Interest

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Proceedings of the Seventh International Symposium on Transportation and Traffic Theory, T. Sasaki and T. Yamaoka (Eds.), The Institute of Systems Science Research, Kyoto, 1977, 944 pages.

Tributes

The sponsors of this symposium, Kyoto University and the Institute of Systems Science Research, had intended that this symposium serve as a retirement tribute to the many contributions of its chairman, Professor Eiji Kometani. Saddened, as we all were, by the untimely passing of Professor Reuben Smeed, an intended participant at the symposium, and for whose works we all are indebted, Professor Kometani thoughtfully dedicated the symposium as a tribute to the late Professor Smeed. We respectfully salute both of these great men.

In paying tributes, we note that Dr. Robert Herman, the father of these symposia and chairman of the original symposium in Detroit, 1959, is due to retire at about the time of the eighth symposium which is planned for the University of Michigan in 1980 under the chairmanship of Professor Donald Cleveland. It is fitting that the symposia will enter their third decade with a return to Michigan.

Contents

As with previous symposia, abstracts were screened in an attempt to ensure that papers were relevant to the symposium. Based on these, full manuscripts were invited to be referred, with about one-third of the manuscripts being published and presented. Nevertheless the quality of the papers varies considerably.

In attempting to reflect current interests while at the same time providing a forum for theoretical research, the theme of the symposia has evolved from Traffic Flow Theory, emphasizing Car Following and Queueing, to encompass a more general areas which includes theory related to all transportation modes. The papers of the last three symposia (Berkeley 1971; Sydney 1974, and Kyoto 1977) have essentially fallen into the following groupings:

Flow Theory
Network Theory
Public Transportation
Travel Behavior

Flow Theory still has the greatest representation, probably due to some inertia of interest and the fact that alternative fora for it do not exist. However, it is gradually expanding to encompass Signal Control and in turn Traffic Management, as we attempt to cope with our urban traffic problems with increased use of traffic signals and computers. Although a number of the papers transcend the above groupings, we feel it appropriate to summarize the proceedings in terms of these groupings at the expense of some injustice to individual papers and their authors. The present purpose is to report on the general flavor of the papers, rather than present an annotated bibliography of the forty individual papers.

A. Flow Theory

Using the above classifications, about one-half of the papers fall into the general category of flow theory. These are further stratified into the following subgroups: (1) car following, (2) traffic flow distributions and relationships, (3) traffic demand, (4) traffic capacity, (5) traffic models, and (6) traffic management.

1. Car Following

Herman, Rothery, and Rule studied the dynamic car-following characteristics of driver-vehicle systems using spectral analysis techniques and empirical data. They found driver-vehicle systems at close headways to be tightly coupled dynamically with the lead vehicle. Disturbances tend to be attentuated at spacings greater than about 40 meters, and amplified at the smaller spacings. Using spectral analysis they found sensitivities inversely proportional to average spacing and therefore established a nonlinear car-following model whose sensitivity is a function of the spacing.

Leutzbach and Wiedemann studied a bottleneck at a specific uphill grade using a simulation technique and plotted a volume-density diagram which illustrated a hysteresis effect.

Lam studied Robertson's platoon dispersion model, which uses a recursive exponential smoothing prediction technique. Comparisons with observed data indicated that the model predicts platoon behavior reasonably well. It was modified to achieve a higher degree of accuracy.

2. Traffic Flow Distributions and Relationships

Two papers addressed the problem of modeling non-stationary traffic flow. Ceder analyzed traffic flow data using time-sequence analysis for a freeway section which went from free-flow to maximum flow to congested flow and back to free-flow conditions. He introduced a two-regime car-following model to handle both free-flow and congested flow conditions. Cremer and Keller considered the problem of determining the steady-state speed-volume-density relationship from data collected under nonstationary traffic conditions. They simulated the dynamic effects using a nonlinear time discrete model to obtain a different steady state relationship. A paper by Brilon introduced the concept of "slowness," which is really the travel time per unit distance, to calculate space mean speeds. However, this had been pointed out in Edie's classic paper in the 1963 symposium.

3. Traffic Demands

Four papers addressed various aspects of traffic volume prediction using data from traffic detectors, while another dealt with the estimation of queue sizes at a signalized intersection. The latter, by Minh and Blunden, considered signalized intersections as discrete infinite storage systems at which the arrival process is a time-inhomogeneous compound Poisson process. They obtained transient solutions for the distribution of queue length at each discrete point in time and the departure time for each vehicle.

Eldor employed the Box-Jenkins time-series analysis to develop short-term demand predictors for a real-time traffic responsive freeway control system. He compared "second generation" control which uses both historical and real-time data to "third generation" control which relies on real-time data only. Gafarian, Pahl, and Ward modeled traffic density as a discrete time process for use in macroscopic simulations of large freeway systems. They analyzed their time-series data using Box-Jenkins techniques. Makigami developed a model to generate a traffic stream from a time series of detector occupancy data and another to evaluate the effects of detector errors. He combined these models to optimize the scanning interval, finding an optimum interval between 125 and 150 milliseconds. Gipps proposed the use of canonical variates of measures, obtained from vehicle detectors, which account for the greatest amount of variability, for predicting demands at signalized intersections. Canonical variates are mutually orthogonal linear combinations of the original measures.

4. *Traffic Capacity*

Pearce proposed a methodology for estimating the capacity and traffic delay of a minor road at its unsignalized intersection with a major 2-way road, where the traffic volume in at least one direction of the major road is sufficiently high that the Poisson assumption cannot be reasonably assumed. His method involved superposition of the traffic streams on the main road and development of the renewal properties of the resultant equivalent single stream. Sato and Igarashi applied nonlinear regression analysis to estimate the parameters of car-following models, finding an exponential model to provide the best fit. Models were fitted to both summer and winter data, and the practical capacity was estimated to be 40% lower in winter than in summer.

5. *Traffic Models*

Yagar discussed the philosophical differences of the various traffic models, with a specific comparison between the time-even oriented UTCS-1 and the more abstract TRANSYT. A comparison of the predicting capabilities of the above models, using empirical data, indicated that the greater cost and effort involved in using UTCS-1 was not justified. May, Clausen, and Kruger described the state-of-the-art of some traffic simulation and optimization packages that have been developed under May's direction during the past decade. They modified a FREQ based freeway model and a TRANSYT based arterial model to include energy and air pollution factors but did not elaborate on their modifications or the logic of their models. Silyanov described the stochastic computer simulation of a 2-lane road.

6. *Traffic Management*

Okutani developed a method for synchronizing traffic signals in a network where it is not possible to completely avoid oversaturation on all links of the network. Linear programming was used to obtain a common cycle time and green times while keeping any oversaturation off the internal links. Dynamic programming was then used to obtain offsets and green times which minimize delay on the uncongested portion of the network. Allsop considered the effects of providing priority bus access to a signalized junction on the calculation of the signal timings. He discussed the effects of bus lanes, exemptions from turning bans, and signal priority in response to bus detection. He derived equations for adjustments to signal timings when extended green and advanced recall of green are used upon the detection of buses.

B. Network Theory

About one-quarter of the papers are classified under network theory, and are discussed in the following subgroups: (1) route control, (2) traffic assignment, (3) mathematical programming, and (4) scheduling.

1. Route Control

Newell argued that there is not necessarily a unique shortest path traffic assignment equilibrium corresponding to a given network and set of demands. He derived a hypothetical example in which more than one equilibrium can logically occur, and used this to show that ramp controls which keep queues off the freeway can lead to the better traffic equilibrium. Akcelik discussed the use of controls to cause drivers to use routes which lead to an optimum distribution of traffic. He introduced the mathematics of route control analysis in terms of a two route single *O-D* network, and argued that his methodology was valid for more complicated networks and multiple *O-D* pairs. Chu argued that the mathematical programming and graph theory techniques do not apply to many networks which are characterized by time-varying stochastic behavior, and that real-time control strategies are needed. He developed dynamic allocation strategies using state feedbacks. He used decentralized control, which makes it feasible to handle large scale networks at the expense of some loss of communication between subnetworks.

2. Traffic Assignment

Nishikawa and Nakahori derived fundamental vector-matrix equations for the equal-cost assignment. These equations were used to construct new algorithms based on the incremental and modified Wayne methods, respectively. Anantharamaiah proposed an assignment technique for a network having a stratified *O-D* demand consisting of fast vehicles and slow vehicles. Drivers of the slow vehicles choose their paths based on grade and distance, so that their cost is independent of volume, while fast drivers use travel time as their criterion for path choice, so that their cost increases with volume. Charlesworth combined a technique for calculating delay minimizing traffic signal settings with one for traffic assignment by an iterative procedure, to obtain an algorithm which can estimate a mutually consistent set of signal timings and traffic assignment.

3. Mathematical Programming

Gartner described a number of applications of the Frank-Wolfe decomposition algorithm to the solution of large scale transportation network problems. Edamura and Moritsu proposed an algorithm which works through approximate solutions toward exact solutions and an optimal transportation network by varying the constraints. Black and Blunden discussed the shortcomings of behavioral models, calibrated to existing conditions, for long range land use/transportation planning. They discussed the virtues of optimization models in pointing planners and decision makers toward efficient sytems, and especially the analysis of the dual variables in mathematical programs, which reflect the constraints on the solution space.

4. Scheduling

Daganzo, Hendrickson, and Wilson presented a model for demand-responsive collection and delivery systems such as dial-a-ride transit or the delivery of packages. They proposed an algorithm which selects the nearest collection or delivery point as the next stop and studied variations of this strategy favoring the delivery of in-vehicle passengers. The nearest-point strategy was found to work well. It was also quite stable in the face of stochastic demands.

Levy, Lvov, and Lovetsky presented an interactive simulation and search type of methodology for scheduling the operation of a fleet of cargo ships.

C. Public transportation

Papers by Wirasinghe and by Vaughan and Cousins dealt with the optimization of transit routes. Wirasinghe considered an idealized metropolitan region with radial railroads or busways to the CBD with the residential zones served by either direct buses to the CBD or feeder service to the line-haul radial routes. He considered the optimal assignment or buses, in conjunction with the radial line-haul service, using simple linear cost functions. Vaughan and Cousins used the calculus of variations to obtain an integro-differential equation, which was solved numerically to locate a given number of bus stops along a route, such as to minimize the average travel time.

Watanabe, Miyahara, and Hasegawa derived expressions for average passenger queue length and waiting time at each station along a set of transit lines connected to a main station using random arrivals and batch services. They considered a steady state system using the imbedded Markov chain method, although discussants argued that the system was not Markovian. Rice presented an inventory of the train and passenger carrying capacities of the world's major urban rail transit systems, and an analysis of the basic factors which govern the theoretical and practical capacities of such systems. He found that there are numerous factors which have such a great influence on capacity that the practical capacity of a line can vary at least threefold among the various properties. He derived a relationship between average train speed and number of trains per hour. He also found average speed to increase approximately linearly with station spacing in the practical range which was studied.

Beckmann considered the problem of setting optimal fares and tolls such that an overall optimum self-allocation of trips to routes and modes is attained when riders select their individual modes and routes based on minimum personal generalized cost.

D. Travel Behavior

Smeed investigated the variability of traffic intensity for a linear town in which trip end densities, for both origins and destinations, had a negative exponential distribution as a function of distance from the center of town and the probability of any point being the destination from any origin was a negative exponential function of the distance between them.

Hautzinger analyzed the statistical properties of travel behavior data, finding a number of features that violate the assumptions of most of the classical and univariate statistical methods. He found instances of non-normality, heterogeneity of variances and covariances, collinearity of explanatory variables, and large differences in travel behavior between socioeconomic groups. He suggested less ambitious transformation to the normal linear model.

Erlander discussed methods for solving the gravity model, and showed that the Newton-Kantorovich method for solving systems of nonlinear equations can be used for this purpose.

Wigan and Paulley noted that mathematical programming techniques provided robust dynamic models of bus-car competition for use with different objective functions, but separable or quadratic programming was required if good models of both equilibrium and dynamic behavior were required.

Retzko and Hackelmann found that pedestrians who seek gaps in vehicle streams in crosswalks during the green indication for vehicles have similar gap acceptance patterns for the cases of "amber signal lights for pedestrians" and "no amber lights for pedestrians."

Vidakovic attempted to incorporate a distance parameter into the trip-chain model.

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Mathematical Models: Mechanical Vibrations, Population Dynamics and Traffic Flow, Richard Haberman, Prentice-Hall, Englewood Cliffs, New Jersey, 402 pages, $18.95.

Mathematical Models is a book on applied mathematics or, more specifically on differential equations and their applications. The author introduces the reader to the tools of applied mathematics through three application areas (mechanical vibrations, population dynamics and traffic flow) which require different analysis methods. This would of course be of little or no interest to most transportation researchers and educators except that each one of the application areas (including traffic flow) is covered in such detail that the book can also serve as an introduction to the application areas. The comments in the rest of this review apply only to the last third of the book (pp. 257–402) which deals with traffic flow.

This portion of the book contains a thorough development of the hydrodynamic theory of traffic flow as a means to present the theory of partial differential equations. In this reviewer's opinion the exposition and the train of thought of this piece of work are the most thorough, clear and logical available on the hydrodynamic theory of traffic flow. For instance, the equivalence between the characteristics of the differential equation describing traffic behavior and the time-space trajectory of small disturbances is established based on both the mathematics of differential equations and the physical interpretation of the problem. The process of formation of shockwaves and the behavior of accelerating traffic (say, after a light turns green) is another instance where the topics are discussed in physical and mathematical terms, and this greatly enhances the pedagogical value of the book. Because of this, this reviewer feels this book can be very valuable as a text or a source book for a course on traffic flow theory. This is particularly so since most concepts are illustrated with examples and there are several problems given at the end of each chapter.

The book contains 31 chapters (or sections) on traffic flow. However, the chapters are only about 4 to 6 pages in length and therefore 2 or 3 chapters can be covered in a one hour lecture. Furthermore, since some of the chapters are introductory in nature and some others can be skipped or left as a reading exercise for the student, it is possible to cover hydrodynamic approaches in about 9 lecture-hours.

The traffic flow section of the book is started (Chapters 56 to 58) with introductory material: the time-space diagram, velocity fields in time and space, the measurement of traffic flow and density, and a discussion of the conditions under which these can be modeled as continuous fields in time and space are topics covered in this part. Chapters 59 to 63 introduce the following relationships between the flow, density and velocity fields: the (flow = density × speed) equation, the conservation equation (which is the partial differential equation to which this part of the book is devoted), the speed-density relationship and the fundamental diagram of road traffic. Some mention of empirical observations is also made in these chapters. Chapter 64 contains a discussion of car-following models which this reviewer found somewhat out of place in the general context of the book, but can be ignored without loss of continuity. Chapters 65 to 67 cover the necessary background material on partial differential equations (e.g., the idea of characteristics of partial differential equations and their relationship to traffic waves). In the next few chapters (68 to 71) the behavior of uniform, nearly uniform, and accelerating traffic is explored based on the properties of the partial differential equation that describes it. The discussion culminates with a detailed example (Chapter 72) of traffic acceleration after a light turns green, a summary of previous results for Greenshild's linear model (Chapter 73), and yet another example on boundary conditions (Chapter 74).

The next five chapters (75 to 79) deal with decellerating traffic and the phenomenon of shockwaves. In the same spirit of previous parts of this book, the generation of discontinuities (shockwaves) in the flow-density-velocity fields is described both in terms of the properties of the differential equation and in physical terms; the theory is then illustrated with examples (Chapters 78 and 79). The last six chapters include miscellaneous topics such as shocks generated by continuous variations in the initial conditions, effect of a red light on an accident and some freeway merging problems.

The figures in the book are clear and a random sampling of the text indicated that the index was carefully developed. If one drawback of the book must be identified, it would probably be the lack of an extensive list of references. However, the value of such a list is questionable for the uninitiated reader or for an introductory course.

Summarizing, this book, aside from its value to applied mathematicians, also contains a well-done comprehensive presentation of the hydrodynamic theory of traffic flow which should be useful as a reference book or as a textbook for a course on traffic flow theory.

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