COMPUTATION OF SOME PEDESTRIAN DELAY AND TRAFFIC FLOW MODELS

BY

JOHN OLUSEGUN
(PGD/MCS/487/97/98)

A PROJECT SUBMITTED TO THE DEPARTMENT OF MATHEMATICS/COMPUTER SCIENCE, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA. IN PARTIAL FULFILMENT FOR THE AWARD OF A POST-GRADUATE DIPLOMA (P.G.D.) IN COMPUTER SCIENCE, OF FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

MARCH 2000

APPROVAL

This work has been read and approved as meeting the requirements of the department of Mathematics/Computer Science for the award of Post-Graduate Diploma in Computer Science, Federal University of Technology, Minna.

____________________________   ________________________

Prince R.O. Badmus   **Date**
Project Supervisor

____________________________   ________________________

Dr. S.A. Reju   **Date**
Head of Department

____________________________   ________________________

External Examiner   **Date**

DEDICATION

This work dedicated to God for His immense love and protection over me.

To my mother: Mrs. L.R.A Olatayo and to my father: Mr. J.S. Ocholi.

ACKNOWLEDGEMENT

I am very grateful to God Almighty for His love that has seen me through the course of my work in school. I am also very grateful to my supervisor Prince R.O. Badmus whose advice and encouragement was a booster for the success of this study. My thanks goes to the Head of Maths/Computer Science department Dr. Reju and the lecturers in the department for their selfless services rendered to me.

I shall not forget to mention Professor and Dr. (Mrs) Gbodi and family whose home was like my second home, I appreciated all your efforts and concern.

To all course mates also go my heartily thanks for their understanding and help during the course. I am indeed grateful to my fellow course mates: Mr. Tony Gyipo, Mr. Olusegun Afon(Prof.), Mr. Rotimi Omotosho, Mr. Bruce Ajakaye, Mr. Olumide Animashaun (Hero) for their moral and financial support. They have become friends indeed.

To my friend Mr. Akintoye Olusegun Kehinde, I say thank you very much. To my cousin Mr. James Onalo. I say thank you very much.

ABSTRACT

For some years now, the importance of both counting and gap distribution in road traffic flow has been recognised. One reason for their importance is that they are linked to three important aspects of road traffic viz: flow, concentration and capacity. Another reason is that the distribution of vehicles on a road can be considered as a succession of moving gaps and dealt with on that basis.

It has been discovered that the displaced exponential distribution is a good model for low-medium flow rate of up to 800 vehicles per hour (v/h) in one lane of traffic, but it breaks down for higher flows. A number of alternatives to this model are considered in this work.

There is however no real proof to show that the displaced exponential model can be improved upon much as a model. The mixed exponential distribution improves the fit some what.

For the purpose of this study the BASIC programming language was used to evaluate the various models discussed. Useful recommendations were made based on the findings of the study.

TABLE OF CONTENT

CHAPTER FOUR: Software Development And Implementation

CHAPTER FIVE: Result Discussion, Summary and Conclusion

BIBLIOGRAPHY

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Traffic flow theory is that body of knowledge which is concerned with the analytic formulation of traffic phenomena and mechanisms and the extension of these formulations to realize greater understanding or utility in traffic. This particular discipline is marked by the use of mathematical analysis and modelling, the techniques of system and control engineering, and computer simulation and process control.

Many researchers have reviewed traffic flow theory from different perspectives. Some of these views and considerations are discussed below.

2.2 CAR-FOLLOWING AND MACROSCOPIC FLOW

A car-following model is a mathematical expression relating the movement of a single vehicle to that of the vehicle it follows. Such expressions may be manipulated to yield some descriptive expressions for the flow of an entire traffic stream.

Major work in car following was undertaken at the General Motors research laboratories by Herman and Rothery (1959). The basic principle of this work is that the driving pattern of an individual driver can be effectively model by differential equation relating him to other drivers in a single lane traffics.

Typical of the equations considered is $\frac{d\,V_n(t)}{dt} = \frac{K\ V_n\ (t-T) - V_{n-I}\ (t-T}{X_n(t-T) - X_{n-I}(t-T)}$

where V_i = speed of the i^{th} driver

X_i = position of the i^{th} the driver

T = a delay on response lag.

The equation states that the acceleration of a driver (number n) is determined by the difference between his speed and that of the vehicle in front of him (number n-1) with the sensitivity to speed discrepancies determined by some constant k, and the spacing between the two vehicles; the further away the lower the sensitivity

2.3 OTHER FLOW DENSITY MODELS

In addition to the car following derivations of macroscopic flow relationships, such expressions have been arrived at by curve-fitting hypothesis (Green Shield, 1964), by observation of safe headway (Morrissons, 1964), by heat flow analysis (Harold Lean, 1961) and by fluid flow analogies (Morrisson , 1964). The heat and fluid analogies centres on equilibrium conditions for partial differential equations expressing a heat or mass_balance equation of continuity. The derivation on safe headway allows for space headway which include a vehicle length l, a reaction-time distance C_1V (where c_1 is the reaction or 'dead' time), and a deceleration distance $C_2 V^2$ (where C_2 is determined by braking capability) $\triangle x = L+C_1V + C_2V^2$ or $Q = VD= v/x$

$$Q = \frac{V}{L + C_1V + C_2V}$$

and it may be shown that the maximum flow Qn is attained a speed
$V = \sqrt{L/C_2}$ spacing $\triangle x = 2L + C_1\sqrt{L/C_2}$.

It should be noted that it is generally taken that the density D is the basic

X_i = position of the i^{th} the driver

T = a delay on response lag.

The equation states that the acceleration of a driver (number n) is determined by the difference between his speed and that of the vehicle in front of him (number n-1) with the sensitivity to speed discrepancies determined by some constant k, and the spacing between the two vehicles; the further away the lower the sensitivity

2.3 OTHER FLOW DENSITY MODELS

In addition to the car following derivations of macroscopic flow relationships, such expressions have been arrived at by curve-fitting hypothesis (Green Shield, 1964), by observation of safe headway (Morrissons, 1964), by heat flow analysis (Harold Lean, 1961) and by fluid flow analogies (Morrisson , 1964). The heat and fluid analogies centres on equilibrium conditions for partial differential equations expressing a heat or mass_balance equation of continuity. The derivation on safe headway allows for space headway which include a vehicle length l, a reaction-time distance C_1V (where c_1 is the reaction or 'dead' time), and a deceleration distance $C_2 V^2$ (where C_2 is determined by braking capability) $\triangle x = L+C_1V + C_2V^2$ or $Q = VD= v/x$

$$Q = \frac{V}{L + C_1V + C_2V}$$

and it may be shown that the maximum flow Qn is attained a speed
$V = \sqrt{L/C_2}$ spacing $\triangle x = 2L + C_1\sqrt{L/C_2}$.

It should be noted that it is generally taken that the density D is the basic independent variable, with speed V and thus flow Q being dependent on it. This is reflected in the above derivations. Other notable models on flow-density relationships include the classic treatment by Lighthill and Witham via kinematics waves of the propagation and growth of disturbance by shock waves (Light hill and Whitham, 1964) and the description of individual vehicle speeds. The former also an interesting theory of bottlenecks, and some notes on traffic flow functions.

The mechanism of the bottleneck formulation by Light hill and Whitham are illustrated in the figure below.

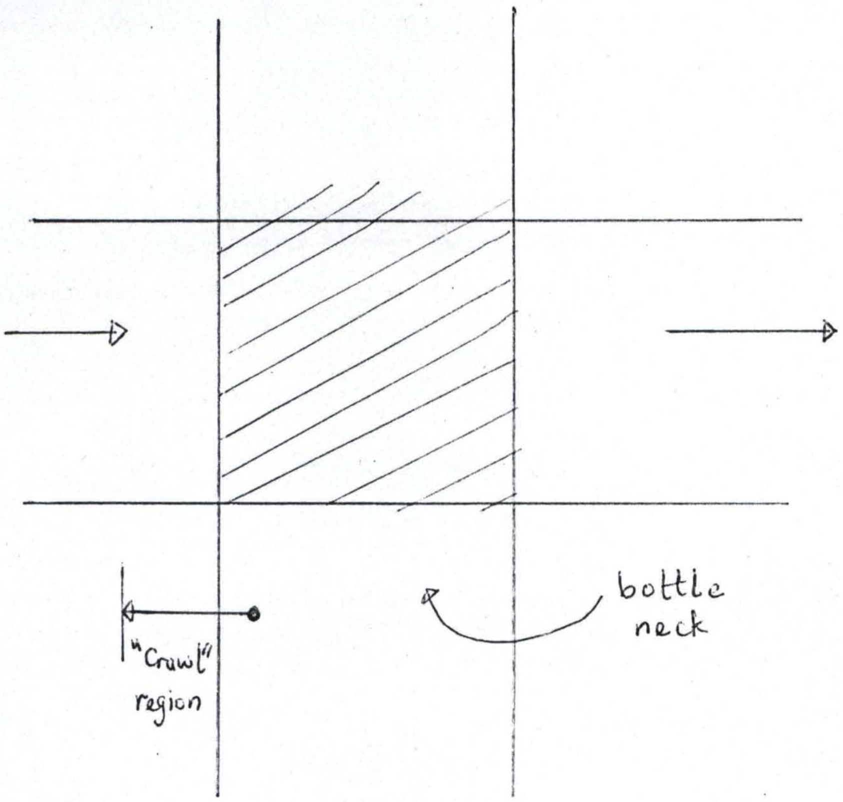


Fig 2.1(a) Location of bottleneck.

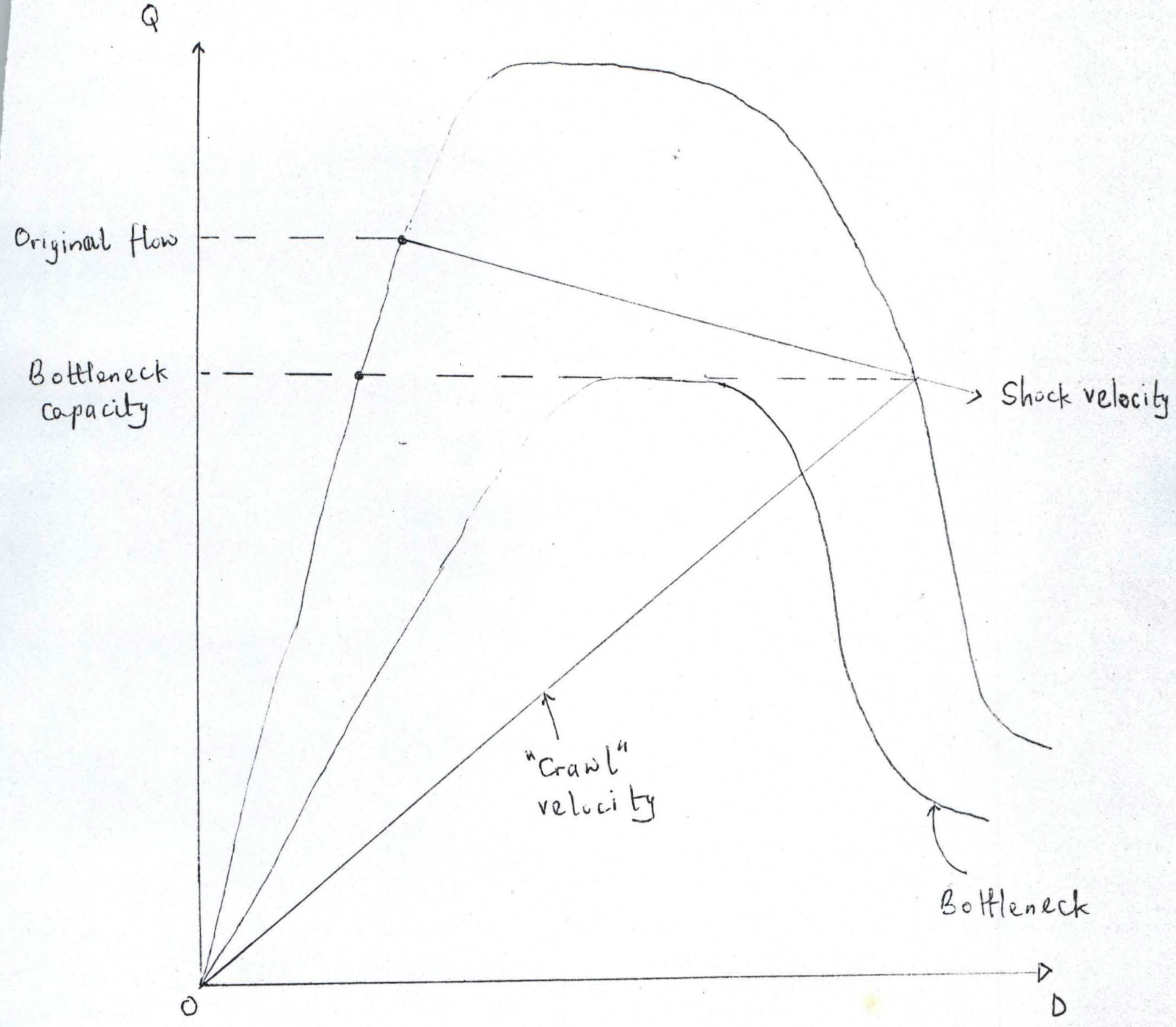


Fig 2.1(b) Flow density

In which, the flow-density relationship of both the main road and its bottleneck sector are shown. Given an arriving low (point a) in excess of the bottleneck capacity, a capacity operation (point B) is realized above the bottleneck are, and the same flow is realized beyond it (point F), but at considerably better level of service. This is because the chord (the line OF) which indicates the speed is significantly faster than that indicated by chord OB. The propagation of the "shock wave" is at a velocity given by the interface of the two flows (the chord AB) and , being negative is "turned back" upstream.

Its position may be computed by it direction and propagation speed. Vehicles between its position and the physical bottlenecks are forced to a " crawl" at speed OB.

The approach for dense flow as treated here (Light hill and Whitham, 1955) are effected using classical methods. These methods are macroscopic in that the properties of individual vehicles do not enter, so such theories cannot be expected t explain traffic behaviour in any detail. Dynamic or car-following models on the other hand, are microscopic in the sense that attention is focussed on the behaviour of two consecutive vehicles moving down a road. Both of these type of models are deterministic in nature.

2.4 PROBABILISTIC MODELS

A quite different kind of model from those already mentioned is the probabilistic of stochastotic model in which a random element is incorporated. Here traffic flow is considered as a stochastic point process, the probabilistic structure of which is to be inferred as far as possible from data collected in real situations. Such formulations, involving statistical variables, need sophisticated mathematical techniques to exploit them (Ashton, 1971).

2.5 QUEUING THEORY

The arrival of vehicles and pedestrian at either intersection or at crossing point are considered random. Like most waiting line phenomena (a queue is a waiting line). The arrival of traffic and pedestrian could be thus considered.

Barrer (1957), says it all in the tittle of his paper "queuing with impatient customers and indifferent clerk". Barrer says in certain queuing process, the potential customer is considered 'lost" if the system is busy as at the time the service is demanded. The telephone subscriber hangs up when he gets a busy signal. a man trying to get a hair cut during his lunch hour does not wait unless a chair is immediately available. Another form of this general situation is that in which customers wait for service, but wait for a limited time only. If not served during this time, the customer leaves the system and is considered lost. Such situation occur in the processing or merchandising of perishable goods. Many types of military engagement are similarly characterized. An attacking air plane engaged by an anti-aircraft gun or missiles is available for 'service" that is within range for only a limited time. The theory of queues or waiting line theory has its origin in the work of A.K. Elang, starting 1909. he experimented on a problem dealing with the congestion of telephone traffic. During busy periods, intending callers experience some delays because the operators were unable to handle the calls as rapidly as they were made. The original problem Elang treated was the calculation of this delay for one operator, and in 1917 the result were extended to the case of several operators. This was the year that Elang published his well known work, "Solution of Some Problems In Theory of Probabilities of Significance in Automatic Telephone In charge." Development in the field of telephone traffic continued largely along the line initiated by Elang, and the main publication were those of Molina in 1927 and Thronton. D. Fry in 1928. It was not until the end of World War two that this early work was extended to other general problem involving queues or waiting line.

Inspite of the catching title which is descriptive of the common feeling about queues, Barrer's paper is an innovative application of queuing theory to the destruction of attacking war-planes, not to general queuing theory.

We must join a Queue when we want to get cash from an automatic teller machine (ATM), buy stamps, pay for groceries, purchase a movie ticket, obtain a table in a crowded restaurant e.t.c. Larson (1987) discussed some of the psychological implications of queues. He says: "Queues involve waiting, to be sure, but one's attitude towards queues may be influenced more strongly by other factors. For instance many become infuriated if they experience social injustice defined as violation of First In First Out (FIFO). Queuing environment and feed back regarding the likely magnitude of the delay can also influence customer attitude and ultimately in many instances, a firm's market share. Even if we focus on the wait itself the "outcome" of the queuing experience may vary non-linearly with the delay, thus reducing the importance of average time in queue, the traditional measure of queueing importance. This speculative paper uses personal experiences, published and unpublished cases, and occasionally "the literature" to begin to organise our thoughts on the important attributes of queueing. Larson further discussed some techniques that help to make queue more bearable for humans.

In any system that can be modelled as a queueing system, there are trade offs to be considered. If the service facility of the system has such a large capacity that queues rarely form, then the service facility is likely to be idle for a large fraction of the time so that unused capacity exist. Conversely, if almost all customers, must join a queue (wait for service) and the serves are rarely idle, there may be customer dissatisfaction and possibly lost -customers as Barrer (1957) noted.

In general, queueing situations arise either because of the variability (or stochastic nature) of the traffic flow or because of the capacity models. Thus some of the queueing models that are directly related to road traffic are presented below.

2.6 CONVENTIONAL QUEUING MODELS

Queuing situation develops when items arrive at a serving channel for some type of service. The service of each arrival takes some length of time and can be provided from one or more than one serving channel.

The figure below illustrates this situation for a single channel queue. It shows a queuing system with a single serving channel. Units arrive at the system and enter the serving channel if it is idle or enter the queue to wait for service if the server is busy. The arrival rate is usually termed λ and the average service rate (when service is being provided) is usually termed μ.

λ= arrival rate → O O O O O O→ μ = service rate
Queue Service channel

Frequently both the arrival and service rate vary and these variations causes the length of the queue to vary (from transportation and traffic engineering handbook). Drew (1968) developed a delay model for free way entrance ramp merging situations, but the same model applies equally well to the use of pedestrians or vehicle crossing a stream of flow at an intersection. This is true since the model produces the delay to a vehicle that is first in line waiting for a gap. In other words, there is no accounting for the time the vehicle spends in the queue. Drew found the average delay to a vehicle ready and waiting to merge or cross a stream to be:

$$E(t) = \frac{e^{aqt} - \frac{(aqt)^i}{i}}{q^T - \frac{(aq^T)i}{i}}$$

where T = the critical headway
q = the flow rate in the stream to be crossed.

Thus, for the case in which the stream to be crossed has a negative exponential distribution (a = 1), the average delay becomes,

$$E(t) = q^{-1}(e^{aq_T} - 1 - q^T)$$

Queueing at signalized intersections occur during the red face on each approach and the queuing becomes more severe as the volume of an approach near the capacity of the approach. Webster 1958 developed an equation for the average delay per vehicle on an approach of a given intersection controlled by a pre-timed signal control.

His formula is,

$$d = \frac{c(1-\lambda)^2}{2(1-\lambda)} + \frac{x^2}{2q(1-x)} - 0.65\left(\frac{c}{q^2}\right)^{1/3} X^{(2+5\lambda)}$$

where d = average delay on the intersection sec/vehi;
c= cycle length/second
λ= proportion of the cycle which is green on the approach i.e g/c ratio.
q= flow on the approach, v p h
i.e vehicles per hour.
s = saturation flow, vph on the approach
x= the degree of saturation on the approach = g/λ s.

requires, say a gap of at least 8 seconds in which to cross the road, then the probability of his being able to cross without delay is $e^{-8/6}$ = 0.2636. If the pedestrian has to wait for the first vehicle to pass, he repeats the decision process with the second gap, and so on. The actual delay incurred is then obtained by summing random gaps. This dealt within the next section.

Before proceeding, let us consider how the model can be made more realistic. To begin with, since vehicles have a finite length, the headway between two vehicles is always non-zero. Thus, a displaced exponential distribution is more appropriate (see fig. 3.2). If the minimum time gap is a, where a is probably of the order of 1 second, the required distribution is $\varphi = \lambda^{e-\lambda(t-a)}$, $t > a$ ______ 3.6

The mean headway of the exponential distribution (for which a=o) is easily shown to be $1/\lambda$, for the displaced exponential distribution it is $1/\lambda ta$

$f(t) = \lambda e^{-\lambda t}$, $t > o$ (zero length vehicles)

$\varphi(t) = \lambda e^{-\lambda(t-a)}$, $t > a$ (finite length vehicle)

The restriction in the model which ensures that a pedestrian's arrival coincides exactly with the passage of the vehicle can also be removed. The restriction that traffic moves in a single lane may also be fitted. If there are two random streams with flow rate of λ_1 and λ_2 moving independently in the same direction, then it can be shown very simply that gaps in the combined streams are given by the probability density function. $\varphi(t) = (\lambda_1 + \lambda_2)\, e^{-(\lambda 1+\lambda 2)t}$, $t > o$ - 3.7.

For this stream the main gap is $1/(\lambda_1+\lambda_2)$

and the probability of a pedestrian arriving in gap of length greater than T is given by $e^{-(\lambda_1+\lambda_2)T}$. This result could be extended to more than two random streams and to other distributions.

It is important to note here that if a pedestrian is to cross a road having more than stream of traffic, he may do so in at least two ways. He may consider gaps in t he combined streams, then decide to cross in one go, or he may consider the streams separately - in which case there is an additional (or perhaps actual) island in the middle of the road. The result are different for the two models.

The case two streams of traffic, one in each direction, is intractable unless an island is postulated, in which case the model result are essentially the same as those for two streams in the same direction.

It was found that a very good and simple representation of the formula for average delay per vehicle is $d=0.9\left[c(1-\lambda)/2(1-\lambda x) + x^2/2q(1-x)\right]$

If d is the average delay per vehicle, the average queue length on the approach can be found by:

$$E(n) = \frac{qd}{3600}$$

where E(n) = the expected queue length on the approach

q = the flow rate on the approach, vph

d = average delay per vehicle, sec/veh. of course, the queue length would vary considerably from the average length because of the periodic nature of the service rate.

CHAPTER THREE

MODEL DESCRIPTION

3.1 INTRODUCTION

A case is considered here, where a pedestrian wishes to cross a road along which traffic is flowing at a given rate; the assumptions made here are that:

i. The flow of traffic is restricted only to a single lane.

ii. The pedestrian requires a given minimum time to completely cross the road and

iii. The pedestrian arrives at the crossing point just as a vehicle passes.

Basically the interest is in obtaining the probability of a pedestrian being delayed and how long such delay takes for the purpose of precision, we need to consider the rules that governs the behaviour of both pedestrian and vehicles.

3.2 RULES GOVERNING PEDESTRIANS DECISION

To cross the road, often, the pedestrian bases his decision on some factors;

- Proximity of nearest vehicle
- Speed of the vehicle
- Width of the road (single lane)
- The time gap currently faced by the pedestrian and
- What is called pedestrian critical gap.

Similar rules govern traffic flow on roads except that their distribution is different it is given as:

$$\Gamma(t) = \begin{cases} o, t \leq to \\ t\text{-}to/t_1\text{-}to, to < t \leq t_1 \\ 1, t > ti \end{cases}$$

$$\Gamma^I(t) = \begin{cases} 1, t > t_1 \\ o, t \leq to \\ 1, -\exp[-\lambda(t\text{-}to)], t > to \end{cases}$$

The most important of these several factors include the speed and proximity of the nearest vehicle. These factors can be accounted for by considering the time the nearest vehicle will take to reach the pedestrian (i.e. the time gap currently faced by the pedestrian). More often than not; these are intuitively considered by the pedestrian at the instant of crossing the road.

We may assume that each individual has a so called critical-gap, that varies from one individual to another and also from one situation to another. It is however interesting to note that any one individual in a specific situation will always reject or accept gaps depending on whether they are less than or greater than their critical gaps respectively. We nevertheless, can visualize situations of emergency, or when individuals are either under pressure or tension and they cross the road irrespective of the position or proximity of the nearest vehicle. In such situation like these individuals tend to accept gaps that they would normally have rejected.

The aforementioned situation gives rise to the simplest model for gap acceptance that can be set up and this can be represented by the step function $\Gamma(t)$ and graphically depicted below in figure 3.1

$$\Gamma(t) = \begin{cases} \phi, & t \leq T \\ 1, & t > T \end{cases}$$

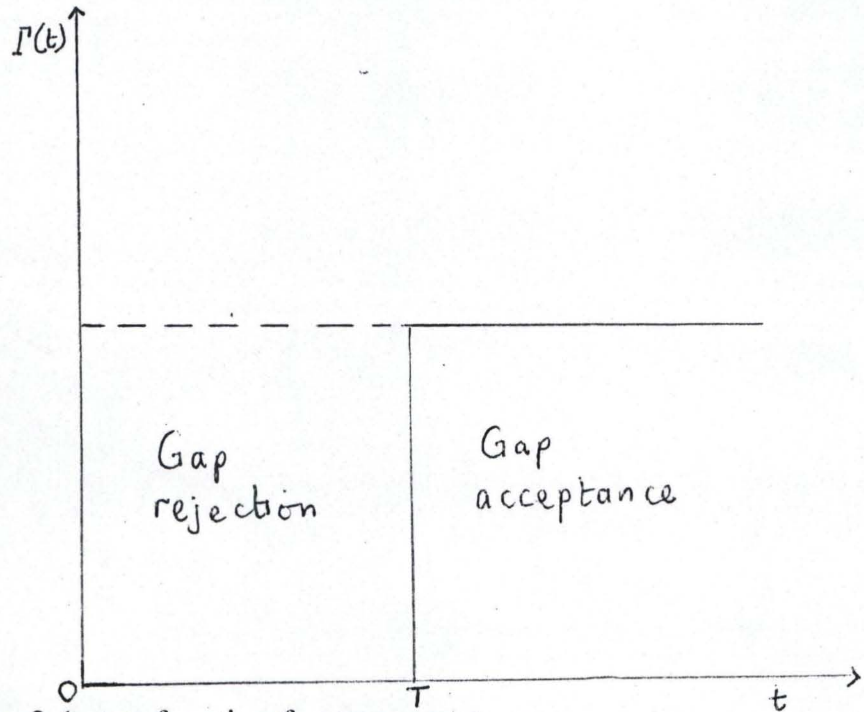


Figure 3.1 step-function for gap acceptance

If T is the critical gap of pedestrian and t is the proximity of the nearest vehicle, then the function $\Gamma(t)$ = o (i.e gap was rejected). This happens when proximity of the nearest vehicle is less than or equal to his critical gap t. The pedestrian thus reject such gaps and wait for the next available gap e.t.c. until a favourable gap is obtained where vehicle proximity to pedestrian is larger than his critical gap and this gives rise to the situation where $\Gamma(t)=1$ (i.e gap was accepted).

We may consider the way vehicles are distributed (in time) along a particular road.

It is not usually specified in probabilistic models how any particular vehicle is placed on the road. Instead a probability distribution for the headway between vehicles in a single lane of traffic.

A series of events, the arrival times of a series of vehicles at a point on the road is said to be random if the following condition hold:

I. The probability of an event in a small time internal $(t, t + \delta t)$ is $\lambda \delta t + O(\delta t)$, where λ is a constant.

ii. The probability of two or more events in $(t + \delta t)$ is $O(\delta t)$

iii. The number of events in $(t, t + \delta t)$ is independent of what has happened in (o, t).

λ is a constant value which defines the rate i.e the mean number of vehicles per unit time and $O(\delta t)$ indicates a small-order quantity which can be neglected.

The hypothesis above give rise two distributions which equivalently describe random flow:

I. The counting distribution gives the probability of any given number of vehicles arriving at a point in unit time interest of arrival.

This turns out to be the Poisson distribution which can be defined as:

$$P(t) = \frac{e^{-\lambda} \lambda^{k}}{k!} \quad \text{where } k = 0,1,2,3 \ldots\ldots \qquad 3.1$$

The plot of this distribution is depicted below in figure 3.2

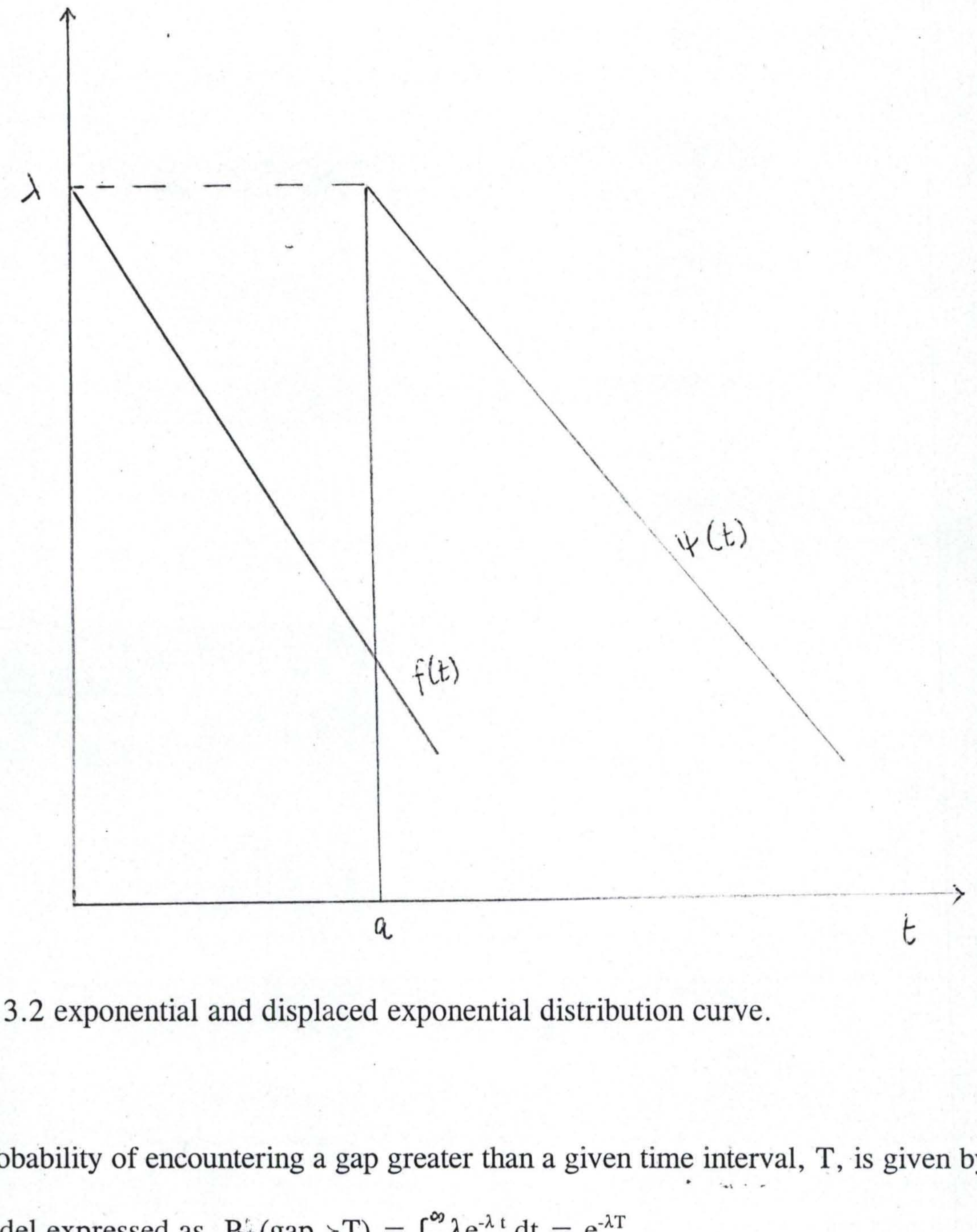


Figure 3.2 exponential and displaced exponential distribution curve.

The probability of encountering a gap greater than a given time interval, T, is given by the model expressed as, $Pr(gap > T) = \int_T^{\infty} \lambda e^{-\lambda t}\, dt = e^{-\lambda T}$

For flow rate of say 600 r.p.h, say, $\lambda = 600/3600 = 1/6$ i.e 1/6 v.p.s. If the pedestrian

CHAPTER FOUR

SOFTWARE DEVELOPMENT AND IMPLEMENTATION.

4.1 INTRODUCTION

This chapter concentrates on the development of software and its implementation. Here discussion will focus on the choice of programming language/the features of the chosen language, software requirements and its features, software development and testing, operational manual of the developed software and how to quit or exit the program.

4.2 CHOICE OF PROGRAMMING LANGUAGE/FEATURES OF THE CHOSEN LANGUAGE.

For the purpose of this study, the QBASIC Language was used because of the following features:-

a) Absence of line-numbering which is a must in all BASIC interpreters.

b) It is user - friendly. It support the use of pull-down menus for system commands (like RUN, SAVE, LOAD, EXIT e.t.c.). This allows for quicker execution of these commands.

c). QBASIC supports blocked operations, particularly useful for structured programming. For instance, the blocked IF........THEN... ELSE...ENDIF statement is support by QBASIC.

d) QBASIC program files can be converted to executable files, (that is, files with extension EXE) which can be ran from the DOS prompt.

e) QBASIC also support instant syntax checking as instructions are entered and it gives instant help on errors.

f) The QBASIC compiler also comes along with a TUTOR which allows the user to learn more about the compiler and how to use it when writing programs.

4.3 SOFTWARE REQUIREMENTS AND FEATURES.

The software developed in this work can only run on computers with Micro-Soft Disk Operating System (MS-DOS) version 5.0 or other higher versions of DOS.

4.4 SOFTWARE DEVELOPMENT AND TESTING

When a software is to be developed, it becomes necessary to express the requirement in a number of ways. The requirement must initially be expressed in terms that the user can understand and agree to. Ultimately these requirements will be presented to the computer in the form of a set of instructions which the computer can obey i.e program.

The principle of modular programming was applied in this research work. Instead of writing a single bulky and cumbersome procedure in which errors would have been difficult to detect and correct, three separate subroutines were written namely: Opening, Main and Critical and were all linked together using the GOSUB-command.

The first subroutine(Opening) displays the opening message which shows the names of the writer of the program and the project supervisor and a copy-right message.

The second subroutine (Main) executes the following:

a) P.D.F for pedestrians on single lane

b) P.D.F for pedestrians on double lane with different flow rates

c) Poisson distribution model for a single lane

d) Mixed exponential model for single lane and

e) Semipoisson and mixed exponential models

The third and final subroutine (Critical) is the critical-gap evaluation subroutine which is an intuitive test for a pedestrian's decision about crossing a single lane road.

4.5 OPERATIONAL MANUAL

Software development will be incomplete until the program have been written, thoroughly tested for a substantial period of time and documented. The operational manual is an important part of the documentation. The following steps are taken when activating the program.

Step 1: Booting the system from the hard disk, successful booting will lead the user to C Prompt. (i.e C:\>)

Step 2: At C:\> Type CD - QBASIC press the Enter key. Note: QBASIC is the directory on the harddisk that contains the compiler.

Step 3: Insert the floppy diskette that contains the project programs into drive A.

Step 3: At C:\QBASIC> Type QBASIC- a: Project Program and press the Enter key. This activities the program.

Carry out instructions displayed on the screen based on your choice.

4.6 MENUS DESCRIPTION

4.6.1 OPENING MESSAGE

On the activation of the program, the computer displays the message below,

COMPUTER EVALUATION OF PEDESTRIAN DELAY

AND TRAFFIC FLOW MODELS

WRITTEN BY

JOHN OLUSEGUN

(PGD/MCS/487/97/98)

COPYRIGHT © 1999, F.U.T, MINNA

SUPERVISED BY: PRINCE R.O BADMUS

DEPARTMENT OF MATHS/COMPUTER SCIENCE.

There is a fifteen - second delay before the screen is cleared for the next menu.

4.6.2. THE MAIN MENU

After the screen of the previous menu (i.e the opening menu) has been cleared, what appears on the screen is displayed below,

ENTER THE VALUE OF N FOR NUMBER OF ARRIVALS:-

If the value of N is typed and the ENTER key pressed, the next statement that would be displayed is;

ENTER THE VALUE OF THE NUMBER OF COMPUTATION(S) TO BE CARRIEDOUT - The next statement is :

ENTER THE VALUES FOR LAMDA 1, LAMDA 2

This allow the values of LAMDA, LAMDA1 AND LAMDA 2 to be entered for as many computation(s) to be carried out. The screen is then cleared and the next display on the screen is given below,

1. P.D.F. FOR PEDESTRIANS ON SINGLE LANE
2. P.D.F. FOR PEDESTRIANS ON DOUBLE LANE WITH DIFFERENT FLOWRATES
3. POISSON DISTRIBUTION MODEL FOR A SINGLE LANE
4. MIXED EXPONENTIAL MODEL FOR A DOUBLE LANE
5. SEMI POISSON AND MIXED EXPONENTIAL MODELS

6. CRITICAL-GAP EVALUATION PROGRAM

Ø. QUIT

ENTER YOUR CHOICE (1→ 6) AND Ø TO QUIT.

This is the main menu from which the various programs can be run. The cursor continues to blink on the bottom R.H.S. of the screen until a choice is made and the Enter key pressed.

4.7 QUITTING THE PROGRAM

To quit the program, all the user has to do is select the Ø option and press the ENTER key. This takes the user to the DOS Prompt.

CHAPTER FIVE

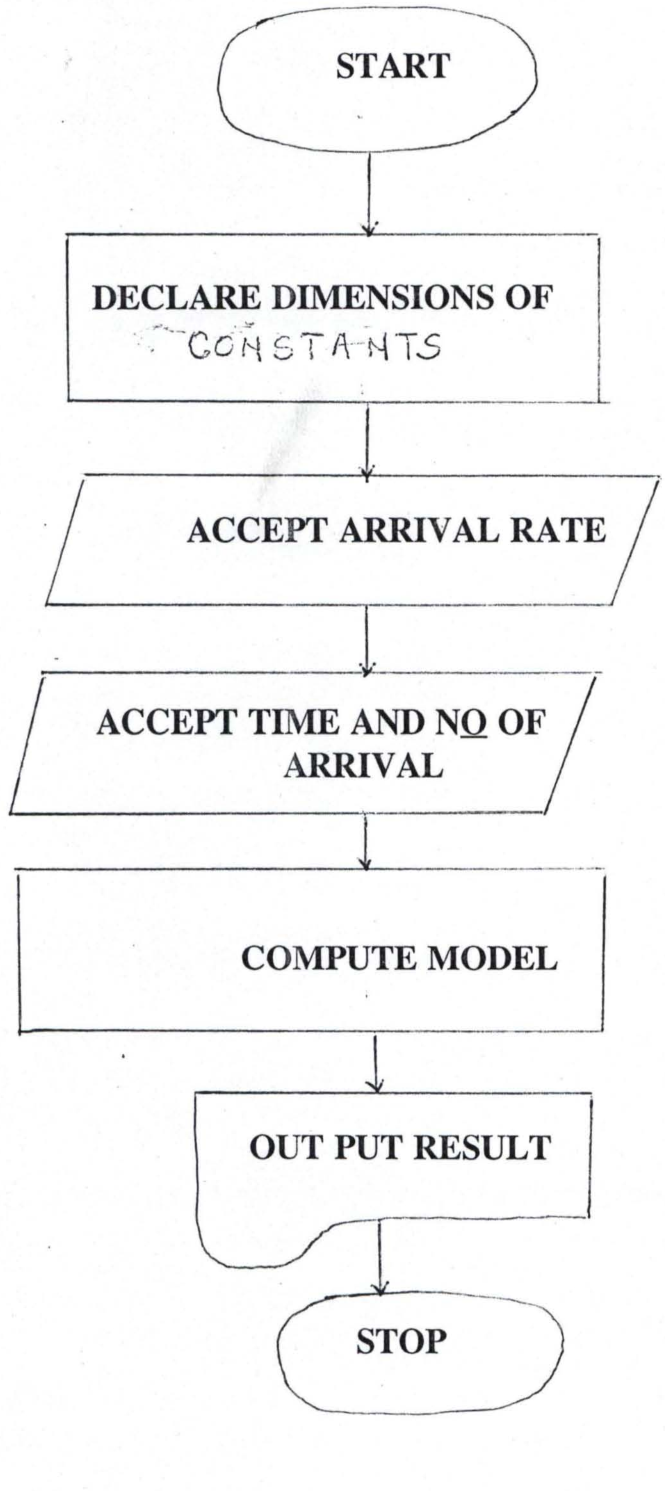
RESULT DISCUSSION, SUMMARY AND CONCLUSION

5.1 INTRODUCTION

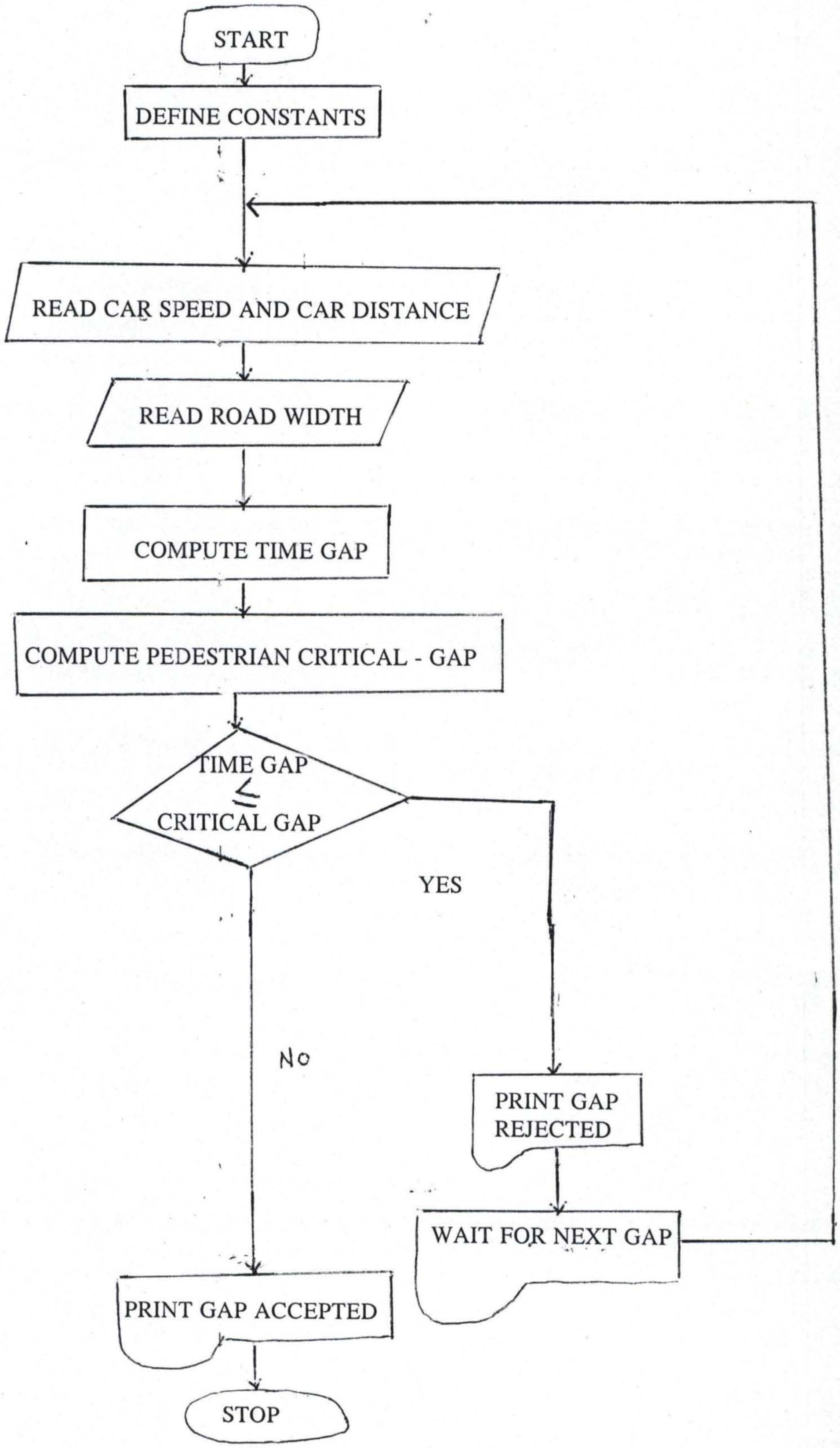
This chapter focuses or analysis of the models in the main program summary and conclusions made and recommendations stated. The chapter opens with two flowcharts depicting the two main subroutines in the program i.e the Main Subroutine and the critical - gap evaluation subroutine. These flow charts are shown on the next page.

5.2 MODEL EVALUATION FLOW CHARTS

5.2.1 FLOWCHART FOR THE MAIN SUBROUTINE



5.2.2 FLOW CHART FOR THE CRITICAL-GAPSUBROUTINE



5.3 PROGRAM DESCRIPTION

5.3.1 MAIN SUBROUTINE

This program evaluates the value of each model and generates the results as output for corresponding inputs. All inputs were taken in the limit of seconds so as to allow for easy computation. Variables used in this program were defined in the program. The program evaluates the following models.

(a) The Poisson Distribution Model

This model uses a function called FACT (N) which computes the factorial value for the rate of arrival per time which is considered hourly. It is given as $P(k)=\lambda^{e-k}/k!$

The final output gives the probability that a certain proportion of vehicles will arrive between certain period at given point or at intersection.

(b) The displaced exponential distribution model

The model which is given as $F(t) = \lambda e^{-\lambda(t-a)}$, $t > a$

A constant for the minimum heading between vehicle flowing at a particular rate per unit time is defined. This used to shift the exponential distribution a little to the right. At all instance the value of t he constant a must be less than the time interval t. However, when $a = t$ we have the exponential distribution evaluated as, $f(t)= \lambda e^{-\lambda}$, $t>O$ while the displaced exponential is as described above.

C. The mixed exponential and semipoisson distribution model

This model splitted into two parts named F1(z) and F2(z) representing both distributions. The combined distribution is given as:-

$F11(z) = p1.\ F1(z) + (1-p1).\ F2(z)$ which

gives $$F11(z) = \frac{p1t^{K-1}e^{-t/\beta}}{\beta^k T(k)} + \frac{1-p1)\lambda e^{\lambda L}\gamma(k,\ x/\beta)(1+\lambda\beta)^k}{\Gamma(k)}$$

The incomplete gamma function [illegible]

[illegible] $\gamma(k,\ x/\beta)$ was evaluated using the Maclaurine's series expansion for exponential series. This is given as: $\int_o^x e^{-t}\, t^{k-1}\, dt$ which give $\gamma(k,\ x/\beta) = (1+t/\beta)^{k-1}e^{-t/\beta}$

Thus the models were evaluated and results obtained and are shown in the appendices.

5.3.2 The Critical Gap Procedure

The critical - gap or gap acceptance model given by $\Gamma(t) = \begin{cases} 0, & t \leq T \\ 1, & t > T \end{cases}$

was also evaluated. The results are also given in the Appendices.

5.4 SUMMARY

All results obtained from the different models evaluated, describes the following:

- the probability that a certain number of vehicles or pedestrian would arrive at some certain point at a given time.
- the probability of obtaining some particular headway at some certain time.
- whether a gap was rejected or accepted depending on the critical gap a pedestrian will allow.

5.5 APPLICATION

The acceptance model program or procedure if developed further can serve as a useful tool in road crossing equipment for both pedestrian and vehicle at crossing points, non-signalized intersections and at T-junctions.

It can also serve as an input to trigger an alarm or put on a light to tell pedestrian(s) (deaf or blind) that it is time to cross, although an additional machinery may be needed.

Beside, the result obtained from this work, can be a helpful tool for the design of roads.

5.6 RECOMMENDATIONS

- Raw data should be made handy
- People should be educated (enlightened) on the proper use and observance of road signs, e.t.c..
- Measuring facilities for speed of object on motion (vehicles) should be made available for the purpose of this kind of research work (courtesy FRSC).

5.7 CONCLUSION

To evaluate models using computer capability, it is needful for such models to be expressible in terms understood (an can be manipulated by the computer). All input and output parameters should be well spelt out. This will facilitate good computation. We may safely conclude that all models that can be expressed mathematically can be evaluated and thus computed using he computer's capability. The major problems as discussed earlier may be in the interpretation of notations and parameters used i.e what each notation and parameter represents in actual values as compare to 'abstract value'.

REFERENCE

ANDREW, J.G. and MOLONES R.R.	Mathematical Modelling (Butterworths & Co. Limited, 1980).
ARNOLD, O. A.	Probability, Statistics and Queuing Theory with Computer Science Applications (Academic Press, 1990). 2nd Edition.
COLIN, O.M. and DAVID P.F.,	Statistics: A Dictionary of Terms and Ideas (Arrow Books Limited, 1981).
DERECK, P.A.	Concise Encyclopaedia of Modelling and Simulation (Pergamon Press, Japan, 1992).
ERWIN K.,	Advance Engineering Mathematics (Don Ford, 1988); 6th Edition.
FRANCIS N.,	Computer Simulation and Modelling (John Wiley and Sons Ltd., 1991).
IRWIN M. and JOHN E.F.	Probability and Statistics For Engineering (Prentice-Hall of India Private Limited 1987), 3rd Edition.
ODAMA J.S.,	Glossary of Statistical Terms and Formulae (Koda Publishers Limited, 1982).
KENDALL and BUCK LAND	A Dictionary of Statistical Terms (Longman Company Limited 1982).
LORIS J.P.,	Traffic Engineering Theory and Practice (Prentice-Hall, 1973).
RICHARD C.L.	Perspectives on Queues: "Social Justice and the Psychology of Queuing", Opns. Res., 3(6), 1987.
WINFRED D.A.,	"Distribution for Gaps in Road Traffic J. Inst. Math Appl. 7, 37-46 (1971).

Appendix 1

The Program Code

```
'This program was designed by Mr. John Olusegun in partial fulfilment of
'the requirement of the award of P.G.D in Computer Science of the
'Federal University of Technology (F.U.T), Minna.
'COPYRIGHT (1999).

CLS : SCREEN 0: COLOR 10, 9
LOCATE 1, 1: PRINT "................................................................................"
LOCATE 2, 1: PRINT "................................................................................"
LOCATE 3, 20: PRINT "COMPUTER EVALUATION OF SOME PEDESTRIAN"
LOCATE 4, 27: PRINT "AND TRAFFIC FLOW MODELS"
LOCATE 8, 34: PRINT "WRITTEN BY"
LOCATE 13, 33: PRINT "JOHN OLUSEGUN"
LOCATE 14, 30: PRINT "(PGD/MCS/487/97/98)"
LOCATE 17, 22: PRINT "COPYRIGHT (C),1999,F.U.T, MINNA"
LOCATE 18, 22: PRINT "SUPERVISED BY:PRINCE R.O BADMUS"
LOCATE 19, 21: PRINT "DEPARTMENT:MATHS/COMPUTER SCIENCE"
LOCATE 20, 1: PRINT "............................................................................"
LOCATE 21, 1: PRINT "............................................................................"
SLEEP (15)
'________________OPENING SUBROUTINE STARTS HERE________________

'The function below computes factorial value for a given N
DEF fnFact (n)
FACT = 1
IF n <= 0 THEN 3
FOR i = n TO 1 STEP -1
FACT = FACT * i
NEXT i
3 END
END DEF

 CLS

'Different models programs start here
'This section declares dimensions of variables used
DIM PHI(500), F(500), SHI(500), LAMDA(500), LAMDA3(500)
DIM F1(500), F2(500), F11(500), P(500), MN1(500), MN2(500)
DIM MN3(500), FF(500), P1(500), R5(50), LAMDA1(500), LAMDA2(500)

'The A's specify Mean Distance gap between successive
'vehicles. Expo is the natural log. to base 2
A = 1: A1 = 1: A2 = .95
EXPO = 2.71828
INPUT "ENTER THE VALUE OF N FOR THE NUMBER OF ARRIVALS:", n
INPUT "ENTER THE VALUE FOR THE NUMBER OF COMPUTATION(S) TO BE
CARRIED OUT", T1
PRINT "ENTER THE VALUES FOR LAMDA,LAMDA1,LAMDA2"
```

```
PRINT "----------------------------------------"
FOR j = 1 TO T1
INPUT LAMDA(j), LAMDA1(j), LAMDA2(j)
NEXT j

'MAIN MENU
CLS
LOCATE 3, 1: PRINT "1. P.D.F. FOR PEDESTRIANS ON SINGLE LANE"
LOCATE 5, 1: PRINT "2.P.D.F. FOR PEDESTRIANS ON DOUBLE LANE WITH DIFFERENT FLOWRATES"
LOCATE 7, 1: PRINT "3. POISSON DISTRIBUTION MODEL FOR A SINGLE LANE"
LOCATE 9, 1: PRINT "4. MIXED EXPONENTIAL MODEL FOR DOUBLE LANE"
LOCATE 11, 1: PRINT "5. SEMIPOISSON AND MIXED EXPONENTIAL MODELS"
LOCATE 13, 1: PRINT "6 CRITICAL-GAP EVALUATION PROGRAM"
LOCATE 15, 1: PRINT "0. QUIT"
LOCATE 19, 1: INPUT " ENTER YOUR CHOICE (1 -> 6) AND 0 TO QUIT ==>", CH
IF CH = 1 THEN GOSUB 10:
IF CH = 2 THEN GOSUB 20
IF CH = 3 THEN GOSUB 30
IF CH = 4 THEN GOSUB 40
IF CH = 5 THEN GOSUB 50
IF CH = 6 THEN GOSUB 60
IF CH = 0 THEN SYSTEM

'COMPUTATIONS OF THE VARIOUS MODELS STARTS HERE.

10 'P.D.F. FOR PEDESTRIANS ON SINGLE LANE
CLS
FOR k = 1 TO T1
PHI(j) = LAMDA(j) * (EXPO ^ (-LAMDA(j) * (T1 - A)))
MN1(j) = (1) / (LAMDA(k) + A)
F(j) = LAMDA(j) * EXPO ^ (-LAMDA(j) * T1)
MN2(j) = (1) / (LAMDA(j))
NEXT k
FOR P = 1 TO T1
PRINT "Phi(j)", "Mn1(j)", "Mn2(j)"
PRINT PHI(k), MN1(k), MN2(k)
NEXT P
END
20 ' P.D.F. FOR PEDESTRIANS ON DOUBLE LANE WITH DIFF.FLOW RATES
CLS
FOR L = 1 TO T1
SHI(j) = ((LAMDA1(j) + LAMDA2(j) * (EXPO ^ (-LAMDA1(j) + LAMDA2(j)) * T1)))
MN3(j) = 1 / (LAMDA1(j) + LAMDA2(j))
NEXT L
FOR Q = 1 TO T1
PRINT " Shi(j)", "Mn3(j)"
PRINT SHI(j), MN3(j)
```

```
NEXT Q
RETURN
END

30 'COMPUTATION FOR THE POISSON DISTRIBUTION MODEL FOR A SINGLE LANE
STARTS HERE
CLS
FOR M = 1 TO T1
P(j) = (EXPO(-LAMDA(j)) * (LAMDA(j) ^ n)) / FACT(n)

PRINT "P(j)", "LAMDA3(j)", "P1(j)"
PRINT P(j), LAMDA3(j), P1(j)
NEXT M
RETURN
END

40 'COMPUTING FOR THE MIXED EXPONENTIAL MODEL FOR DOUBLE LANE
FOR n = 1 TO T1
L1 = EXPO ^ (-LAMDA1(j) * (T1 - A1))
L2 = EXPO ^ (-LAMDA2(j) * (T1 - A2))
P1(j) = (LAMDA1(j) + LAMDA2(j) * (EXPO ^ (-LAMDA1(j) + LAMDA2(j) * T1)))
FF(j) = P1(j) * LAMDA1(j) * L1 * (T1 - A1) + (1 - P1(j) * LAMDA1(j))
NEXT n
FOR R = 1 TO T1
PRINT "L1", "FF(J)"
PRINT L1, FF(j)
NEXT R
RETURN
END

50 ' SEMIPOISSON AND MIXED EXPONENTIAL MODEL COMPUTATION
CLS
INPUT "ENTER THE RANGE FOR COMPUTATION ", NN
FOR Z = 1 TO NN
BETA = 1 / Z: R4 = -T1 / BETA: R1 = EXPO ^ R4: R2 = T1 / BETA
R3 = R2 ^ (Z - 1): R6 = R3 * R1: R5(Z) = 1 + R6: R7 = BETA ^ Z
R8 = EXPO ^ (-LAMDA(Z) * T1): R9 = (1 + LAMDA(Z) * BETA) ^ Z
NEXT Z

FOR Y = 1 TO NN

'ACTUAL COMPUTATION STARTS HERE
RR1 = P(Z) * (T ^ (Z - 1)) * R1
R12 = FACT(k - 1)
RR2 = R7 * R12
RR3 = (1 - (k)) * LAMDA(k) * R8
RR4 = R5(Z) * R9
RR5 = (RR3 * R9 * R5(k)) / R12
```

```
F1(Z) = RR1 / RR2
F2(Z) = F1 / RR2
F2(Z) = RR5
F11(Z) = F1(k) + F2(k)
NEXT Y
FOR W = 1 TO NN
PRINT "Z", "BETA", "F1(Z)", "F2(Z)", F11(Z); ""
PRINT Z, BETA, F1(Z), F2(Z), F11(Z)
NEXT W
RETURN
END

'_____________CRITICAL STARTS HERE___________________

60 'CRITICAL EVALUATION PROGRAM STARTS HERE
 'THIS PROGRAM GIVES AN INTUTIVE TEST FOR A PEDESTRIAN'S
 'DECISION ABOUT CROSSING A ROAD (A SINGLE LANE)
 'WRITTEN BY JOHN OLUSEGUN COPYRIGHT(C) 1999, F.U.T, MINNA

 SCREEN 0: CLS

 'THIS SECTION DECLARE THE DIMENSIONS OF VARIABLES USED
 DIM CGAP(50), T(50), T1(50), RODWDT(50), T2(50)
 DIM CARSPD(50), CARDST(50), PEDDST(50), JECT(50)

    'ON THE AVERAGE PEDESTRIAN SPEED RANGE BETWEEN 3.6-4FT
9APPROX.1.2M/S)
 ' PEDSPD -1.2

 INPUT "ENTER NUMBER OF GAPS TO BE COMPUTED FOR:", n

 FOR i = 1 TO n
 INPUT "ENTER DISTANCE AND SPEED OF APPRAOCHING CAR (M/S):", CARDST(i),
CARSPED(i)
 NEXT i
 TI(i) = CARDST(i) / CARSPED(i)
 INPUT "ENTER ROAD-WIDTH(ONE LANE) TO CROSS (3.6-4.8)", RODWDT(i)
2 IF (RODWDT(i) < 3.6) OR (RODWDT(i) > 4.8) THEN
 PRINT "ROAD WITH NOT BETWEEN THE GIVEN RANGE (3.6-4.8M)"
 SLEEP (5)
 GOTO 2
 ELSE
 PRINT "WE MAY CONTINUE"
 END IF
 PRINT RODWDT(i)
 T(i) = RODWDT(i) / PEDSPD
 'JECT TAKES A VALUE OF 0 OR 1 DEPENDING ON REJECTION OR ACCEPTANCE
 PRINT "CAR TIME TI=", TI(i)
```

```
'THE INCREMENT IN T(I) BY 1.5 IS FOR SAFE CROSSING
IF TI(i) < (T(i) + 1.5) THEN
JECT(i) = 0
PRINT "GAP HAS BEEN REJECTED", JECT(i)
T2(i) = T(i) + 1.5
PRINT "WAIT FOR NEXT AVAILABLE GAP"
PRINT "CURRENT GAP IS REJECTED", JECT(i)
PRINT "WAITING FOR NEXT GAP": SLEEP (3)
GOTO 10
ELSE
JECT(i) = 1
PRINT "GAP HAS BEEN ACCEPTED ", JECT(i)
T2(i) = T(i) + 1.5
END IF
FOR j = 1 TO n
PRINT "PED-C-GAP(SEC)", "CAR-TIME", "REJECT/ACCEPT"
PRINT T2(i), TI(i), JECT(i)
NEXT j
STOP
END
```

Appendix 2

Number of Computation(s), Arrivals and the values of Lamda, Lamda1 and Lamda1

```
the value of N for the number of arrivals:3
the value for the number of computation(s) to be carried out:5
the values for lamda,lamda1,lamda2
----------------------------------------
```

```
ss any key to continue

er the value of N for the number of arrivals:3
er the value for the number of computation(s) to be carried out:5
er the values for lamda,lamda1,lamda2
----------------------------------------
,1
,2
,3
,3
,1
```

```
s any key to continue

r the value of N for the number of arrivals:3
r the value for the number of computation(s) to be carried out:5
r the values for lamda,lamda1,lamda2
----------------------------------------
```

Appendix 3
Output for P.D.F for Pedestrians on single Lane

(j)	Mn1(j)	Mn2(j)
8315688	.5	1
0670928	.3333333333	.5
00018432	.25	.3333333333
8315688	.5	1
0018432	.25	.3333333333

ress any key to continue

ni(j)	Mn1(j)	Mn2(j)
018315688	.5	1
000670928	.3333333333	.5
0000018432	.25	.3333333333
018315688	.5	1
000018432	.25	.3333333333

ss any key to continue

(j)	Mn1(j)	Mn2(j)
3315688	.5	1
0670928	.3333333333	.5
00018432	.25	.3333333333
3315688	.5	1
0018432	.25	.3333333333

Appendix 4

Output for P.D.f for Pedestrians on Double Lane with Different Flow rates.

```
(j)    Mn3(j)
         .5
         .25
         .11111111111
.0632998    .2
0213908     .33333333333
```

```
ress any key to continue

hi(j)    Mn3(j)
         .5
         .25
         .11111111111
42.0632998    .2
020213908     .33333333333
```

```
ess any key to continue

(j)    Mn3(j)
         .5
         .25
         .11111111111
.0632998    .2
0213908     .33333333333
```

Appendix 5

Output for Poisson Distribution Model for a Single lane.

j)	Lamda3(j)	P1(j)
61313281	2	.294665378
80447287	4	.256419634
24042259	6	.090322477
61313281	5	.028079005
24042259	3	.224042259

ress any key to continue

(j)	Lamda3(j)	P1(j)
.061313281	2	.294665378
.180447287	4	.256419634
.224042259	6	.090322477
.061313281	5	.028079005
.224042259	3	.224042259

ess any key to continue

j)	Lamda3(j)	P1(j)
61313281	2	.294665378
80447287	4	.256419634
24042259	6	.090322477
61313281	5	.028079005
24042259	3	.224042259

Appendix 6

Output for the Critical Gap Evaluation Program.

```
Enter the number of gaps to be computed for:2
Enter distance and speed of approaching car (in m/s):5,10
Enter road-width (one lane) to cross (3.6-4.8):4.8
Car time TI=0.5
Pedestrian Time for crossing T=4
Gap has been rejected:0
Wait for next available gap
Current gap is rejected
Waiting for next gap


Enter distance and speed of approaching car (m/s):30,5
Enter road-width (one lane) to cross (3.6-4.8:4.8
Car time TI=6
Pedestrian Time for crossing T=4
Gap has been accepted:1


Press any key to continue

Enter the number of gaps to be computed for:2
Enter distance and speed of approaching car (in m/s):5,10
Enter road-width (one lane) to cross (3.6-4.8):4.8
Car time TI=0.5
Pedestrian Time for crossing T=4
Gap has been rejected:0
Wait for next available gap
Current gap is rejected
Waiting for next gap

Enter distance and speed of approaching car (m/s):30,5
Enter road-width (one lane) to cross (3.6-4.8:4.8
Car time TI=6
Pedestrian Time for crossing T=4
Gap has been accepted:1


Press any key to continue

Enter the number of gaps to be computed for:2
Enter distance and speed of approaching car (in m/s):5,10
Enter road-width (one lane) to cross (3.6-4.8):4.8
Car time TI=0.5
Pedestrian Time for crossing T=4
Gap has been rejected:0
Wait for next available gap
Current gap is rejected
Waiting for next gap
```