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DEVELOPMENT OF A COMPUTER SIMULATION FOR A CAR DECELERATION

A. M. Saliu and M. I. Kolo
Department of Computer Science
L. A. Nafiu
Department of Mathematics and Statistics, and
M. A. Kudu
Academic Planning Unit, Federal University of Technology, Minna, Nigeria
E-mail: salihu_adam@yahoo.co.uk +234-803-436-7414

Abstract

We always observe that some automobiles come to rest faster than others when brakes are applied, even if they look the same in both sizes and masses. This is very practical, technical, and it happens every day. In this paper, we studied the factors responsible for this event. Using a computer simulation that is based on a mathematical model, we implemented the simulation of a car braking model and showed how long it takes a car to come to rest while considering certain factors that greatly affect a car coming to rest by the application of brakes over a given period of time.

Keywords: Automobile, car, brake, model and simulation

Introduction

A computer simulation or a computer model is a program that attempts to simulate an abstract model of a particular system using a specific modeling technique or a combination of techniques as the basis for developing the model and making it operational (Ulgen, *et al.,* 1994). Computer simulations according to Grajo *et al.* (1994) have become a useful part of mathematical modeling of many natural systems in physics, chemistry and biology, human systems in economics, psychology, and social science and in the process of engineering new technology, to gain insight into the operation of those systems.

Traditionally, the formal modeling of systems has been via a mathematical model, which attempts to find analytical solutions to problems which enable the prediction of the behaviour of the system from a set of parameters and initial conditions. With a model, we can 'try out' the behavior of a system, by changing something and observing what effect this has. It also enables us to investigate the behavior of a system before it is constructed (Graehl, 1992).

Computer simulation proves to be a very powerful tool for analyzing complex dynamical problems such as traffic congestions (Damianou, 2006). Computer simulation of a car as it breaks or decelerates using a mathematical model is our aim in this paper. Computer simulation can be achieved using a host of several applications but for the purpose of this study, we used a spreadsheet application (Microsoft EXCEL package). Here, what is of interest is the time it takes for the car to stop and more importantly, the distance travelled before coming to rest.

Two vehicles start a short journey from point ***A*** to point ***B*** the first vehicle is a saloon car and the other a bus, they both take off at the same time and with the same speed and having different breaking force and overall mass, at time ***t*** they begin to decelerate after covering the same distance, it was observed that the bus came to a stop faster than the saloon car. We want to understand clearly why it took the car a longer time to decelerate than it took the bus putting certain parameters of the vehicles into consideration. These parameters include:

i. The overall mass of the car
ii. The speed of the car as it starts to decelerates
iii. The breaking force applied
iv. The time intervals

Methods and materials

We used a spreadsheet to create a model of what happens to a car when the brakes are applied. This allowed us to investigate the effect of the factors / parameters listed below:

i. The overall mass of the car
ii. The speed of the car as it starts to decelerates
iii. The breaking force applied
iv. The time intervals

The spreadsheet contains a table of time, deceleration, speed, distance and total distance travelled by the car at each time interval from when the brake is applied until it comes to rest. These are calculated from these factors enumerated below.

i. The overall mass of the car
ii. Its initial speed, and
iii. The breaking force applied

These values are contained in the heading of the spreadsheet. To create this spreadsheet, follow these steps:

(a) Run your spreadsheet program and open up a new spreadsheet.
(b) Choose a suitable typeface (font), type size and column width for the spreadsheet, and type the heading and the date.
(c) In rows 2 to 5, enter the parameters of the model: the mass, initial speed and breaking force of the car, and the time interval used in the calculations. Give suitable variable names to these parameters, so that you can easily use them in equations.
(d) Type the heading and unit in row 6 and 7, make them bold, and put the lines above and below them.
(e) In row 8, the initial time, distance and total distance are zero
(f) By Newton's law of motion, the deceleration is the breaking force divided by the mass of the car. Enter this formula in cell B8, using the variable names you have set up, for example:

B* = Breaking_force/Mass

Check to make sure that the result is what you would expect, and copy this formula into the remaining cells in column B
(g) The first value of the speed is the initial speed. This gives the formula for cell C8 as C8 = initial speed
(h) The values in the time column increase by the time interval. The formula for cell A9 is therefore:

A9 = A8 + Time_Interval

Check and copy this formula to the rest of the cells in column A inputting into each cell one at a time and changing their cell addresses as required.
(i) The speed at the end of each time interval is the previous speed minus the deceleration multiplied by the time interval, provided that this is positive if not, the car has already stopped and the model is no longer valid. This requires a conditional formula for cell C9:

C9 = IF(C8 – B9*Time_interval > 0, C8-B9 * Time_interval, 0)

Check that the result is what you would expect. Use this same formula in the remaining cells in column C inputting into each cell one at a time and changing their cell addresses as required. The speed should steadily decrease but not go negative.

(j) The distance travelled during each time interval is the average speed multiplied by the time interval. This gives the formula for cell D9 as:

D9 = AVERAGE (C8:C9) * Time_interval

Check that the result is what you would expect, and apply this same formula to the remaining cells in column D inputting into each cell one at a time and changing their cell addresses as required.

(k) The total distance is cumulative. At the end of each time interval, it is the previous total plus the distance travelled during the interval. The formula for cell E9 is therefore:

E9 = E8 + D9

Check and apply this same formula to the rest of the cells of column E inputting into each cell one at a time and changing their cell addresses as required.

(l) Add more rows if the car has not come to a stop at the bottom of the table.
(m) Your spreadsheet now contains the deceleration, speed, distance and total distance travelled by the car at each time interval since it started braking. Check, save and print the spreadsheet if need be.
(n) Produce a line graph of the speed, distance and total distance against time.

Results

Table 1 reveals the values of mass, initial speed, breaking force and time interval as a case study with the computed values of speed, distance and total distance. Also figure 1 gives a graph depicting the details of car breaking model.

Table 1: Values for Speed and Total Distance

	A	B	C	D	E
1	CAR BRAKING MODEL				
2	Mass	1200	kg		
3	InitialSpeed	40	m/s		
4	BreakingForce	3000	Newton		
5	TimeInterval	0.5	s		
6	Time	Deceleration	Speed	Distance	Total Distance
7	(s)	(m/s)	(m/s)	(m)	(m)
8	0.00	2.5	40	0	0
9	0.50	2.5	38.75	19.6875	19.6875
10	1.00	2.5	37.5	19.0625	38.75
11	1.50	2.5	36.25	18.4375	57.1875
12	2.00	2.5	35	17.8125	75
13	2.50	2.5	33.75	17.1875	92.1875
14	3.00	2.5	32.5	16.5625	108.75
15	3.50	2.5	31.25	15.9375	124.6875
16	4.00	2.5	30	15.3125	140
17	4.50	2.5	28.75	14.6875	154.6875
18	5.00	2.5	27.5	14.0625	168.75
19	5.50	2.5	26.25	13.4375	182.1875
20	6.00	2.5	25	12.8125	195
21	6.50	2.5	23.75	12.1875	207.1875
22	7.00	2.5	22.5	11.5625	218.75
23	7.50	2.5	21.25	10.9375	229.6875
24	8.00	2.5	20	10.3125	240
25	8.50	2.5	18.75	9.6875	249.6875
26	9.00	2.5	17.5	9.0625	258.75
27	9.50	2.5	16.25	8.4375	267.1875
28	10.00	2.5	15	7.8125	275
29	10.50	2.5	13.75	7.1875	282.1875
30	11.00	2.5	12.5	6.5625	288.75
31	11.50	2.5	11.25	5.9375	294.6875
32	12.00	2.5	10	5.3125	300
33	12.50	2.5	8.75	4.6875	304.6875
34	13.00	2.5	7.5	4.0625	308.75
35	13.50	2.5	6.25	3.4375	312.1875
36	14.00	2.5	5	2.8125	315
37	14.50	2.5	3.75	2.1875	317.1875
38	15.00	2.5	2.5	1.5625	318.75
39	15.50	2.5	1.25	0.9375	319.6875
40	16.00	2.5	0	0.3125	320
41	16.50	2.5	0	0	320

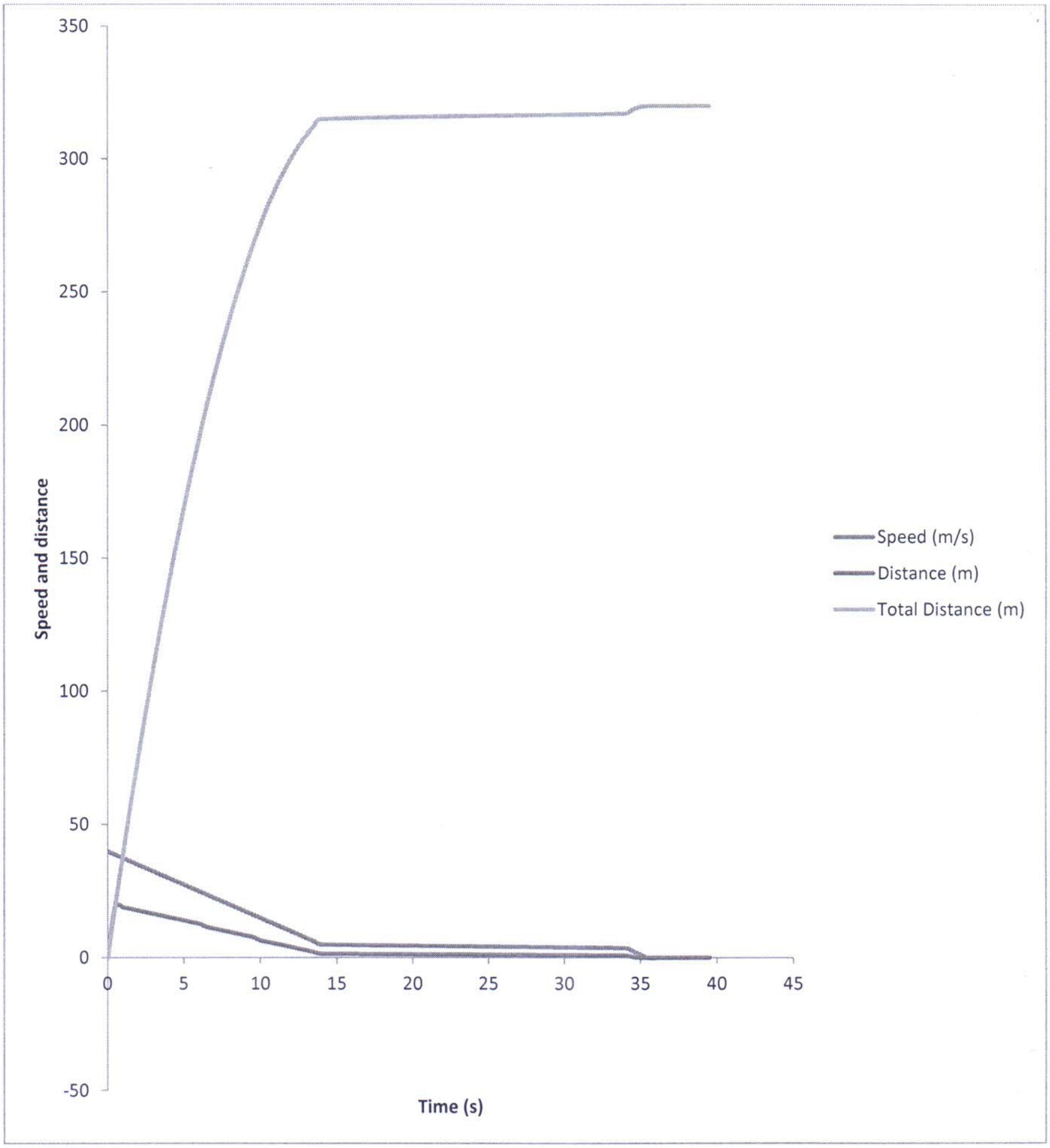

Figure 1: Car Breaking Model

Discussion

The illustration given in this study represents a medium-sized car of mass 1200 kg travelling at 40 m/s braked quite sharply. The deceleration of 2.5 m/s^2 means that the passengers would feel themselves thrown forward with a force of about 25% of their weight. Under these conditions, the car takes 16 seconds to stop. It also travels a distance of 320 meters while stopping. The results obtained from simulating the braking of a car using a mathematical model implemented on a spreadsheet show that certain factors / parameters of the car affect the way a vehicle would behave when the brake is applied.

Conclusion and recommendations

In conclusion, it is clearly observed that, computer simulation is a very good way of studying systems and analyzing what effects/roles certain factors play in the smooth operation of a real system. From the car braking model, we observed that factors like the *mass of the car*, *the initial speed*, *the breaking force*, and *time interval* play a very critical role in effectively bringing a car to rest after the brakes have been fully applied and different values for these parameters would yield different results. With this kind of facts, the braking system of a vehicle or any automobile could be effectively built. Model analysis and simulation suggest control strategies that could be implemented.

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