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ANALYSIS OF THE PASSENGERS WAITING TIME IN ESCALATORS AT THE RAILWAY STATION BY MONTE CARLO METHODS IN FUZZY QUEUING

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Abstract :

We consider an M/D/n queuing model. To find expected number of customers in a queue with a fuzzy arrival rate and fuzzy service rate, we are applying Monte Carlo methods in fuzzy queuing theory. We introduce this by using quasi-random number to generator 100,000 random sequence of fuzzy vectors to develop a better approximate solution.

Keywords: M/D/n Queueing model, M-C method, Fuzzified vectors.

1. INTRODUCTION

Nowadays escalator is an important part of buildings such as shopping malls, underground tunnels, railway stations etc. Some studies show that escalators consumers a large amount of the total energies used in buildings. While allocating an escalator the following are to be taken into consideration – the size of the building, environment, height and use of the building, passengers flow etc. For designing high-quality effective analysis of an escalator service system, we need a mathematical model of the escalator system. We have to analyse the operating features and served objects properly.

We are considering this flow of passengers as a simple flow. For an escalator system, we are considering an M/D/n queue where M stands for the passenger's arrival with negative exponential distribution, D stands for the probability distribution of operating time and n, the number of escalators.

Applying M-C method We will try to produce solutions to the problem. We shall generate fuzzified vectors $\tilde{V}_K = \left(\tilde{\lambda}_K, \tilde{\mu}_K\right)$ with $\tilde{\lambda}_K, \tilde{\mu}_K \in [0, 1]$ for K = 1, 2, . . . , n. We evaluate the characteristics of the model for each $\tilde{V}_K$ with n = 100,000. For this, we need to describe 2 things (i) how we can generate sequences of the fuzzified vectors $\tilde{V}_K$ (ii) how to determine the maximum values of the set. For this purpose considering $\tilde{V}_K$ we will introduce fuzzy values for λ and μ.

Consider the expected number of customers as our system performance measure. For an M/D/n queuing model the expected number of customers is given by $L_q = \frac{\lambda^2}{\partial\mu(\mu - \lambda)}$. We can also use Little's formula to find the number of passengers in the system given by $L_S = L_q + \frac{\lambda}{\mu}$.

Now we will consider the model FM/FD/n, having fuzzy arrival rate and fuzzy service rate. The expected number of passengers in the queue is $\tilde{L}_q = \frac{\tilde{\lambda}}{2\tilde{\mu}(\tilde{\mu} - \lambda)}$.The expected number of passengers in the system is $\tilde{L}_S = \tilde{L}_q + \frac{\tilde{\lambda}}{\tilde{\mu}}$.

Section 2 of the paper deals with the solution procedure, section 3 deals with a numerical example, section 4 will MAT LAB program and section 6 with the conclusion.

2. FUZZY QUEUING MODEL

In Chapter 3 of Buckely 2004, we have (1 - r)100% confidence interval for λ and μ. Using this one on top of the another, $0.001 \le r \le 1$, we obtain triangular fuzzy numbers $\tilde{\lambda}$ and $\tilde{\mu}$. With the given values of the variables next we will define fuzzy stead state probabilities $\tilde{W}_K, 0 \le k \le n$.

Let $\widehat{W}_k = \widehat{T}_k(\hat{\lambda}, \hat{\mu}, n)$ for $0 \le k \le n$. Using Zadeh's Extension Principle let $\widehat{W}_k(\alpha) = [\widehat{W}_{k_1}(\alpha), \widehat{W}_{k_2}(\alpha)], 0 \le k \le n$, where the α-cuts of $\tilde{W}_K$ are obtained by

$$\widehat{W}_{k_1}(\alpha) = min\{\widehat{T}_k(\lambda, \mu, n)/\lambda \in \hat{\lambda}(\alpha), \mu \in \hat{\mu}(\alpha)\}$$

$$\widehat{W}_{k_2}(\alpha) = max\{\widehat{T}_k(\lambda, \mu, n)/\lambda \in \hat{\lambda}(\alpha), \mu \in \hat{\mu}(\alpha)\} \text{ for all n and } \alpha.$$

3. SOLUTION PROCEDURE

We use M-C method to fuzzify the above. Generate random triangular fuzzy vectors $\tilde{V}_K = (\tilde{\lambda}_K, \tilde{\mu}_K)$ with $\tilde{\lambda}_K, \tilde{\mu}_K \in [0, 1]$ for K = 1, 2, . . . , n. We evaluate $\tilde{L}_q$ and $\tilde{L}_S$ with n = 100,000. First, generate crisp vectors $V_k = (x_{k_1}, x_{k_2}, x_{k_3}, x_{k_4}, x_{k_5}, x_{k_6})$ with all the x_{k_i} in [0, 1] $0 \le k \le n$.The first three numbers in V_k are ordered ascendingly. Assuming $, x_{k_3} < x_{k_1} < x_{k_2}$. Then the first triangular fuzzy number $\tilde{\lambda}_K = (x_{k_3}, x_{k_1}, x_{k_2})$. Use the succeeding three numbers in V_k to make $\tilde{\mu}_K$. Still, $\tilde{\lambda}_K$ and $\tilde{\mu}_K$ may not be in [0, 10]. We can try to map them into [0, 10] by using $10\tilde{\lambda}_K$ and $10\tilde{\mu}_K$ for fuzzy $\tilde{\lambda}$ and $\tilde{\mu}$. Now this can be in $\Gamma = [0, 10]^6$. If we use a pseudo-random number to make $\tilde{V}_K$ and if we plot their values in Γ, we get clusters and empty regions. If we use quasi-random numbers to make $\tilde{V}_K$ and if we plot their values in Γ, it will fill this region uniformly. We will use this sequence to build the sequence W_{K1}. There are so many methods to order these numbers. One of them is as follows. First, we define '<' between two fuzzy numbers $\tilde{u}$ and $\tilde{v}$.$v(\hat{u} \le \hat{v}) = \max\{\min(\hat{u}(x), \hat{v}(y)/x \le y)\}$ which measure how less is $\tilde{u}$ than $\tilde{v}$. We write $\tilde{v} < \tilde{u}$ if $v(\tilde{v} \le \tilde{u}) = 1$, but $v(\tilde{u} \le \tilde{v}) < n$ where n is some fixed fraction in [0, 1]. We have $\tilde{u} \approx \tilde{v}$ when both $\tilde{v} < \tilde{u}$ and $\tilde{u} < \tilde{v}$ are false. For fuzzification, we will apply this in M-C method. Let H_K be a set of fuzzy values which are not comparable. Suppose at some point $H_K = \{\tilde{L}_a, \tilde{L}_b, \tilde{L}_c\}$. After the first iteration let it produce a fuzzy value $\tilde{L}_0$. Compare $\tilde{L}_0$ with $\tilde{L}_a$, $\tilde{L}_b$ and $\tilde{L}_c$. There are nine possible outcomes.

Let one of them be $\tilde{L}_0 > \tilde{L}_a$; $\tilde{L}_0 \approx \tilde{L}_b$ and $\tilde{L}_0 \approx \tilde{L}_c$;. Then $H_K = \{\tilde{L}_0, \tilde{L}_b, \tilde{L}_c\}$. Since H_K is a set of undominated fuzzy value.

4. NUMERICAL EXAMPLE

We will describe a program in MATLAB for the fuzzification of this method. We will generate $\tilde{V}_K$, K = 1, 2, . . . , n. Generate the fuzzy number with the alpha cuts α = 0, 0.4, 0.8, 1. $F_1 = \{\hat{\lambda}(\alpha), \hat{\mu}(\alpha)/\alpha = 0,0.4,0.8,1\}$

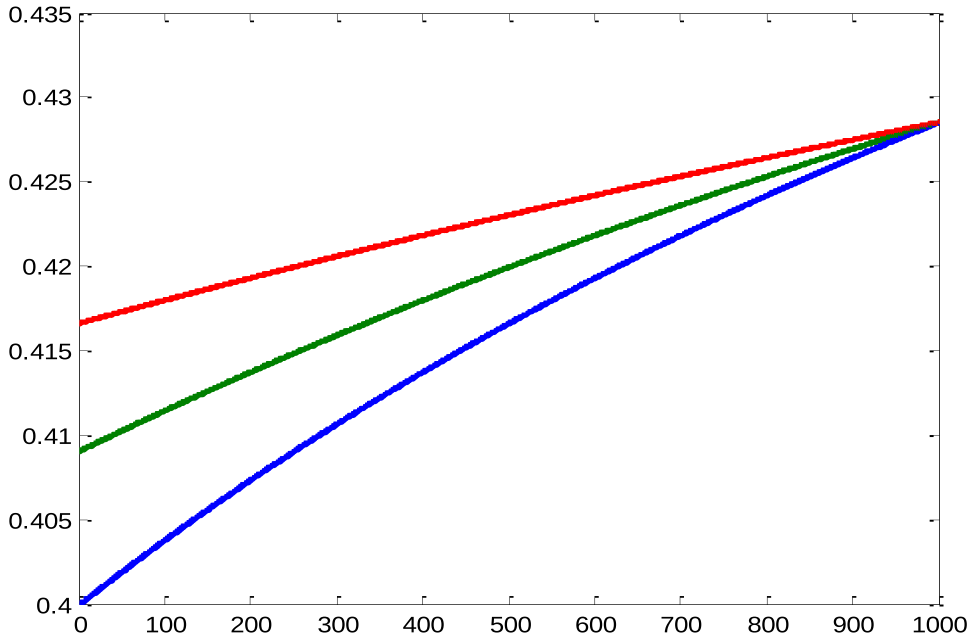
Use F_1 to determine the fuzzy steady-state probabilities $w_{ik}, j, k = 0,1, \ldots n$

Using the optimization toolbox. This makes the second file

$F_2 = \{w_{ik}, j, k = 0,1, \ldots n\}$ Use F_2 we determine $\tilde{N}_K(\alpha)$ using the optimization toolbox. This gives the file $F_3 = \{\tilde{N}_K(\alpha)/\alpha = 0, 0.4, 0.8, 1 ; K = 1, 2, . . . , I\}$. Then we get the following table.

Sl.No.	$\tilde{\lambda}$	$\tilde{\mu}$	L_q
1	(4.05, 4.15, 4.25)	(5.05, 5.15, 5.25)	(0.4010, 0.4029, 0.4200)
2	(5.05, 5.15, 5.25)	(6.05, 6.15, 6.25)	(0.4174, 0.4187, 0.4209)
3	(4.02, 4.12, 4.22)	(5.02, 5.12, 5.22)	(0.4004, 0.4023, 0.4032)
4	(5.55, 5.65, 5.75)	(6.55, 6.65, 6.75)	(0.4237, 0.4248, 0.4249)

The graph of 3 maximum L_q values is also found using MATLAB.



CONCLUSION

The basic idea of using this method is to produce fuzzy/crisp vectors to fill the search space uniformly. To make those fuzzy numbers we generated random quasi number. Sufficient iterations of the technique were used to produce a very good fuzzy approximate solution to the problem. MATLAB finding for the solutions of 100,000 iterations used to plot the graph. This new method can be used to solve a wide range of problems in Fuzzy queuing.

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