International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 24 (2017) pp. 15055-15065

Crowd Simulation in Souvenir Market by Using Multi Agent System

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Abstract

Crowd simulation is an interesting research area, especially in safety or comfort aspect. In the previous work, crowd simulation has been modeled and implemented in daily goods traditional market. In this research, new modified model has been proposed so that it can be implemented to simulate crowd in souvenir market because there are some different characteristics between daily goods market and souvenir market. In souvenir market, customers are usually tourist, they do not know the site map, do not have specific purchasing plan, and enter the souvenir market for recreation or exploration. In the other side, in daily goods traditional market are usually local citizen, know the site map, and have specific purchasing plan. In this research, the proposed model is developed based on multi agent system. There are two types of agent: visitor and merchant. There are two sub models: walking model and interaction model. The walking model is developed based on cellular automata. In this research, the virtual souvenir market is generated during simulation. The simulation is run in 2 dimensional views. Based on the simulation result, parameters that affect crowd in souvenir market significantly are inter-arrival time and maximum tour time. In the other side, willingness to visit, budget, attractiveness level and interesting level does not affect crowd or affect less significantly.

Keywords: Crowd, Simulation, Multi Agent, Souvenir Market, Cellular Automata

INTRODUCTION

Souvenir market is one kind of traditional market. Many traditional souvenirs are offered in this market. Because of its uniqueness, souvenir market is usually positioned and promoted as tourism object [1-6]. In Indonesia, there are several well known souvenir market, such as: Klewer market in Surakarta, Beringharjo market in Yogyakarta, and Pasar Baru market in Bandung.

Because of its uniqueness and its positioning as tourism object, souvenir market does not compete with modern market. Souvenir is related to travelling activity [1], especially cultural travelling [2]. There are lots of visitors in souvenir market in tourism city, especially in holiday season. So, souvenir is one of important aspect to boost retail industry, especially in tourism area [3]. It is because shopping is the one of common tourist activity and tourist often buys something memorable [4-6].

Nevertheless, the crowd condition in souvenir market is still needed to be managed. Good visitor circulation means better customer's satisfaction. Good visitor distribution means visitor will travel not only in certain area in the market but around the market so that merchants that their booths are less strategic still have better selling opportunity. So, the crowd simulation is also needed to observe and to predict the crowd condition and visitor circulation for the given souvenir market map.

Unfortunately, the existing crowd simulation models are not suit to be used to simulate crowd condition in souvenir market directly. The crowd simulation models that the object characteristics are close to the souvenir market are crowd simulation model for mall and daily goods traditional market [7,8]. But, there are some different characteristics between visitor behavior in souvenir market and in the daily goods traditional market or in mall. In souvenir market, the visitors are usually tourist [1]. They do not know the market site map, do not have specific purchasing plan, and enter the souvenir market for recreation.

In daily goods traditional market, the visitors are usually local citizen that live near the market [7]. They know well the market site map because they visit the market almost every day. They usually have specific purchasing plan because they have plan about what they cook this day. So, they usually make the purchasing list before they go to the market [7]. They do not go to the market for recreation because there are not any special things in daily goods traditional market. So, after they complete the purchasing list, they will leave the market [7].

In mall, the visiting purpose is more complex. Some visitors enter the mall for specific purchasing plan. Some visitors enter the mall for recreation. The others enter the mall for specific purchasing plan and recreation.

Based on the explanation above, the main research question in this paper is what kind of crowd model that is suit to simulate crowd condition in souvenir market. The other word is how to improve the existing crowd simulation model so that it can be implemented to simulate crowd condition in souvenir market with its specific characteristics. The other question is what parameters that affect crowd in souvenir market.

This research purpose is to develop new crowd model based on the existing crowd model that can simulate crowd condition in souvenir market so that the crowd condition and parameters that affect crowd can be observed. The crowd model is developed based on multi agent system. Multi agent system is still chosen because visitor and merchant in souvenir market are autonomous so that they have their own intention and characteristics.

This paper is organized as follows. In section 1, the background, research question, and research purpose is explained. In section 2, the characteristics and condition in souvenir market are explained based on literature and field observation. In section 3, the proposed crowd model is explained. In section 4, the implementation of the model to the simulation application is explained. Section 5 consists of the result data and the discussion. Section 6 consists of the conclusion and the future work.

SOUVENIR MARKET

Souvenir market is type of market that sells unique or traditional product. Many traditional markets sell handicraft and art product based on local home industries, especially in Indonesia. Indonesia is a big country and consists of many cultures so that many traditional markets can be found with its specific products. For example, in Yogyakarta, Surakarta, and Cirebon, we can find batik easily but each city has its local pattern. Megamendung batik can be found easily in souvenir market in Cirebon. Dark brown batik, Keris, and Wayang can be found easily in Klewer Market in Surakarta. Batik with white background can be found easily in Beringharjo Market in Yogyakarta. In Bali, we can find painting and sculpture products in the souvenir market easily.

Because of its local content, souvenir market has been transformed into tourism object [1]. Lot of tourists visit some places because of its uniqueness. When the place is more unique, the value of the place is higher as tourism destination. For example, Borobudur is the biggest Buddhist temple in the world and Prambanan is the biggest Hindu temple in Indonesia. Because both temples are near Yogyakarta and the Yogyakarta is one of aristocracy in Indonesia, Yogyakarta is become one of famous tourist destination in Indonesia. The situation in traditional souvenir market is shown in Figure 1, which is Beringharjo souvenir market in Yogyarakta.

Figure 1: Situation in Beringharjo Souvenir Market

PROPOSED MODEL

In this research, the model is developed based on multi agent system. In this system, the agents are the visitor and the merchant. The world is the virtual souvenir market. During the simulation, some number of visitors is generated. The visitor activities are: enters the market, walks around, stands in front of the booth when he interacts with the merchant, and leaves the market. The visitor activity diagram is shown in Figure 2.

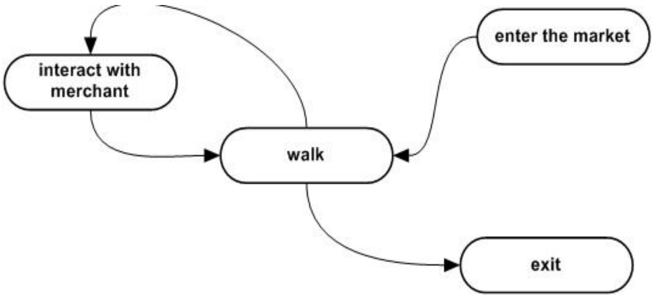

Figure 2: Visitor Activity Diagram

Based on Figure 2, there are four visitor's activities: enter the market, walk, interact with merchant, and exit. When visitor enters the market, his state is set active. All visitor initial parameters are set. After visitor enters the market, he will walk in the market with no specific destination because visitor does not have any specific goal. While he walks, he may be attracted to merchant around him. If he is attracted to the merchant, he will interact with the merchant. While the visitor interacts with merchant, visitor occupies some area in the corridor for certain time because usually in traditional market, merchant still stays inside the booth while visitor stays outside the booth. If transaction deal occurs, there is purchasing activity and payment. This payment will reduce the visitor's budget. After the interaction is end, visitor will continue walking. Visitor will exit or go to the exit door if his budget is empty or his maximum travel time is reached.

Based on these activities, some parameters are needed to be set for the visitor. Visitor state (s) is the visitor state during the simulation. The states are: active (0), walk (1), interact (2), and inactive (3). Visitor's position (p) is visitor's position in the market. The visitor position is stated in x and y. Visitor's budget (b) is visitor's current budget that can be used to purchase souvenir. Visitor's tour time is the time that visitor stays in the market. Visitor's maximum tour time ($t_{tourmax}$) is the maximum time that visitor stays in the market. Visitor's product interested list (L_i) is the list that contains the product class (c) that the visitor is interested and his interested level (i). So, the L_i can be described as $\{(c_1,i_1), (c_2,i_2), (c_3,i_3), \ldots, (c_n,i_n)\}$. Visitor's visited list (L_v) is the list that contains the merchants that have been visited by the visitor.

Merchant is agent that sells souvenir product to visitor. Different with the visitor, the merchant always stays in his position during simulation. The merchant stays in his booth.

The booth occupies some area in the market. Merchant has two activities: idle and interact. While there is not any visitor that interacts with the merchant, then the merchant's state is idle. While there are some visitors interact with the merchant, the the merchant's state is interact. In this model, the relationship between visitor and merchant is one-to-many. It means that a merchant can serve more than one visitors simultaneously.

Based on his activities, there are some parameters for merchant. The merchant's product class (c) is the product class that is sold by the merchant. The merchant's position (p) is the the merchant's position in the market and it is stated in two parameters: x and y. The merchant's booth (m) is the merchant's booth position and size. Because the booth occupies more than one cells so the merchant's booth is stated in four parameters <x,y,w,h>. x is the top left horizontal coordinate. y is the top left vertical coordinate. w is the booth width. h is the booth height. Transaction amount (a) is the average transaction amount for the merchant. Merchant's attractiveness level (l) determines how attractive the merchant is. Higher attractiveness level value means the merchant is more attractive.

This model is also developed based on cellular automata model. It is because many crowd simulation model is developed based on cellular automata too for computation efficiency [9-12] . By using cellular automata, the world, which is souvenir market, is abstracted as two dimensional arrays of cells. The cell shape is square. The cell has specific size. The cell is divided into two categories: booth and corridor. The booth cell is the cell that is occupied by the merchant booth. The corridor cell is the cell that the visitor can walk on it. The visitor can walk on the corridor cell that is not occupied by other visitor. So, the cell has three possible values: booth (-1), available (1), unavailable (0). If the visitor occupies the corridor cell, then the cell value is set 0. If there is not any visitor occupies the corridor cell, then the cell is set 1. Each visitor occupies one cell.

The proposed model consists of two models: walking model and interaction model. The walking model is the model that determines the visitor walking action. The interaction model is the model that determines the interaction time and the interaction result.

In the walking model, as a cellular automata model, the visitor walking direction is discrete. In this model, there are eight possible directions. These possible directions are described in Figure 3.

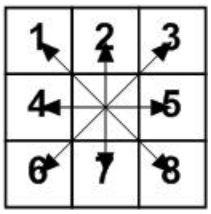

Figure 3: Visitor Possible Walking Directions

The visitor next cell movement is determined based on the score of visitor neighbor cells. Suppose that a is the visitor neighbor cell so that A is the set of visitor neighbor cells. The status of the neighbor cell is symbolized with δ where the value is 1 if the cell is available and 0 if the cell is unavailable. Then, the cell status is combined with the minimum cost method which means visitor will move to the tile that closest with the visitor target (D). So, the next tile determination method is described in Equation 1 and Equation 2. Based on Equation 1, if there is not any available cell beside the visitor then the visitor will stay on his cell.

$$a_{selected} = \max(s(a)) \middle| a \in A \wedge s(a) \neq 0 \quad (1)$$

$$s(a) = \frac{\delta}{\|a - D\|} \quad (2)$$

The destination must be determined so that the visitor can walk. In this model, there are three types of destination: exit door, merchant position, and checkpoint. Visitor will go to the exit door if he wants to leave the market. Visitor will go the merchant around him if he is attracted to merchant booth. Visitor will go to the certain checkpoint in the market while he still does not have specific destination. Checkpoint (cp) is the node in the cross of the corridor. The checkpoint is illustrated in Figure 4. In this model, all checkpoints are uniform. It is different with checkpoint in the previous model, where checkpoints are classified into some categories [7].

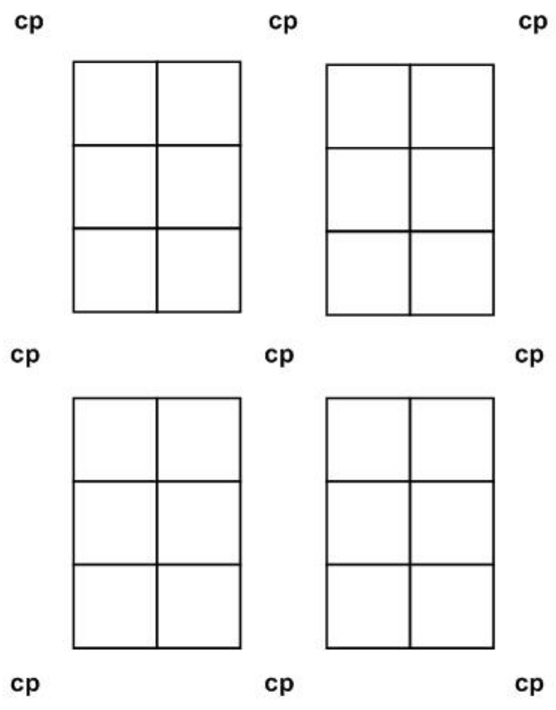

Figure 4: Checkpoint

The walking scenario is as follows. At the beginning, visitor observes the checkpoints that are in the market. Then, integer random number with range [0,n(cp)-1] is generated. The checkpoint is selected randomly because the visitor behavior in the souvenir market that he does not have specific destination. The visitor destination is the checkpoint location which the checkpoint index is same with the generated random number. The formula is described in Equation 3. In Equation 3, D is the visitor destination, e is the checkpoint index, and CP is set of checkpoints in the market.

$$D = cp_e \mid e = rand[0, n(cp) - 1] \wedge cp \in CP \quad (3)$$

During walking, the visitor may be attracted by the merchants around him. The visitor's decision, to still walk or visit a merchant around him is determined by several conditions. These conditions can be divided into two categories: internal condition and external condition. Internal condition is condition that is inside the visitor's mind and it doesn't have relation with the merchant. External condition is condition that is related with the merchant.

Internal condition consists of several aspects. First, the visitor tour time is still below the visitor's maximum tour time. Second, visitor's budget is still positive. Third, visitor's number of visit is still less than the visitor's maximum number of visit. Fourth, a generated random number is still less than or equal to the visitor's willingness to visit. These conditions are symbolized with w_1, w_2, w_3, and w_4 consecutively. The values of these variables are described in equation 4 to equation 9.

$$w_1 = \begin{cases} 1, t_{tour} < t_{\max tour} \\ 0, else \end{cases} \quad (4)$$

$$w_2 = \begin{cases} 1, b_t > 0 \\ 0, else \end{cases} \quad (5)$$

$$w_3 = \begin{cases} 1, n_{visit} < n_{\max visit} \\ 0, else \end{cases} \quad (6)$$

$$w_4 = \begin{cases} 1, rand(0,100) < f_{willvisit} \\ 0, else \end{cases} \quad (7)$$

$$w_{tot} = w_1.w_2.w_3.w_4 \quad (8)$$

$$Ac_v = \begin{cases} visit, w_{tot} = 1 \\ walk, else \end{cases} \quad (9)$$

Visitor may be attracted by more than one merchant at the same time. The visitor is attracted to merchants with several conditions. First, the merchant position must be in the visitor observation area (r). Second, the merchant's product class is in the visitor interested list. Third, the merchant has not been visited by the visitor. Fourth, the merchant attractiveness level is higher than the visitor interesting level for the specified product class. If there are more than one merchant that meet the condition, than the selected merchant is the merchant with the highest product class. The formula of selecting merchant is described in Equation 10 to 11.

$$m_{sel} = \max(m_{cand}) \mid M_{cand} \neq \phi \quad (10)$$

$$m_{cand} = m \mid \|p_v - p_m\| \leq r \wedge c \in L_i \wedge l > i \quad (11)$$

After the visitor decides the targeted merchant, then he will visit the merchant booth. While he visits the merchant booth, he will interact with the merchant for certain duration and it is called as interaction time (t_{int}). The interaction time is generated randomly and follows Poisson distribution for specified average interaction time (t_{intavg}). The interaction time at time t is determined based on Equation 12. The interaction may be ended with purchasing deal or not. If the deal is reached then visitor will pay some money as accepted transaction amount (q_{acc}). The accepted transaction amount is generated randomly and follows Poisson distribution for specified average transaction amount (q_{avg}). The accepted transaction amount at time t is determined based on Equation 13. The accepted transaction amount can be interpreted as price level that is accepted by merchant and visitor for specified negotiated product. This price level is usually between visitor reservation price and merchant reservation price.

$$t_{\text{int},t} = randompoisson(t_{\text{int}avg}) \quad (12)$$

$$q_t = randompoisson(q_{avg}) \quad (13)$$

The final transaction amount (q_{final}) is the amount of money that will be paid by the visitor for his transaction agreement. If the accepted transaction agreement is equal to or less than the visitor budget, the final transaction amount is the accepted transaction amount. If the accepted transaction amount is higher than the current budget, then the closed transaction amount is the current budget. Then the final transaction amount will reduce the visitor budget. These methods are described in Equation 14 and Equation 15.

$$q_{final} = \begin{cases} q_{acc}, q_{acc} \leq b \\ b, q_{acc} > b \end{cases} \quad (14)$$

$$b_t = b_{t-1} - q_{final,t} \quad (15)$$

When the final transaction amount is different with the accepted transaction amount, it does not mean that the accepted price level is shifted. It can be purchasing quantity reduction. For example, at the first time, visitor wants to buy ten batik shirt with the accepted price level is one hundred thousand rupiahs. So, he must pay one million rupiahs. If his budget is two million rupiahs, he will pay one million rupiahs as final transaction amount so that the remaining budget after this transaction is one million rupiahs. If his budget is five hundred thousand rupiahs, which means that the accepted transaction amount is higher than his current budget, he will pay five hundred thousand rupiahs for five batik clothes as final transaction amount so that the remaining budget after this transaction is zero.

After visitor decides to leave the market, he will determine the door location. In this research, visitor will choose the door that is nearest to him. The door selection is described in equation 16 and equation 17. In equation 16, the selected door (g_{sel}) will be the next destination for the visitor. In equation 17, g_{sel}, is the selected door. Variable g is the door so that G is set of doors that are available in the market.

$$D = g_{sel} \quad (16)$$

$$g_{sel} = \min(\|p_v - g\|) \mid g \in G \quad (17)$$

IMPLEMENTATION

The model then is implemented into souvenir market crowd simulation application. The application is developed by using Java programming language. The simulation visualization is 2-dimension simulation. The simulation object is virtual world that is represents souvenir market. The market consists of one floor. Visitor or buyer agent is represented in small circle and merchant booth is represented in square. The visualization can be seen in Figure 5.

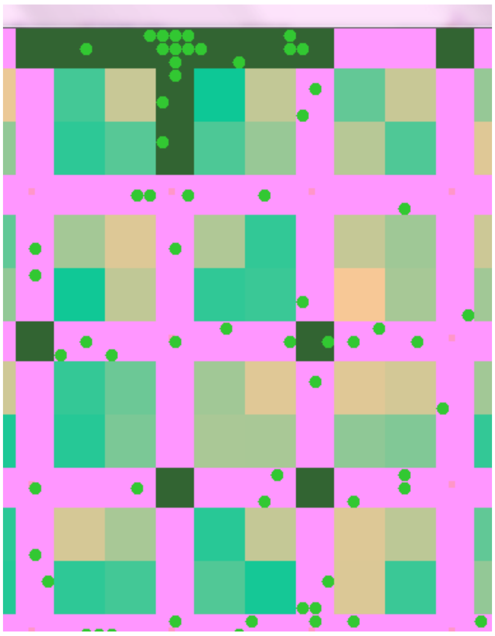

Figure 5: Simulation Visualization

The market description is as follows. The length is 45.2 meters. The height is 23.2 meters. This size is the real world size. The real world size then is transformed in cell size. The cell shape is square. The cell size represents 0.4 meter in the real world. One person occupies one cell.

The merchant booth is square and its size is 1.6 meter in length and 1.6 meter in width. So, each booth occupies 16 cells. There are 200 merchant booths. These booths are grouped into blocks. Each block consists of four booths. The block shape is square so that the merchant position in block is: top-left, top right, bottom-left, and bottom right. So, there are 50 blocks in the market. Merchant booths are generated when the simulation begins. All merchant parameters value is defined when the merchant is created. Merchants are still active until simulation ends.

When the simulation begins, all visitor agents are generated with all initial values but their status is still inactive. The visitor initial position is at the door. If there is more than one door in the market, then the visitors are distributed discretely based on the number of doors. For example, if there are two doors in the market. The probability of the visitor's initial position is 40 percents at the first door and 60 percents at the second door. So, for each visitor, random number is generated to set the visitor initial position. For example, the random number ranges from 1 to 100. If the random number value is below than 40 then this visitor's initial position is at the first door. Otherwise, the visitor's initial position is at the second door.

Visitors enter the market one by one. There is inter-arrival time between one visitor who enters the market and the next visitor. In this research, the visitor inter arrival time is generated randomly and follows exponential distribution. The exponential distribution is chosen because this distribution is proper for Poisson process. In Poisson process, the arrival rate follows Poisson distribution and the inter arrival time follows exponential distribution [13-16].

Visitor walks in his comfort speed. In this research, the visitor walking speed is 1.2 meter per second. It is based on the research by Bohannon that said that the comfort walking speed is 127.2 cm/s for women and 146.2 cm for men. These values are reduced to simplify the calculation because the cell size is 0.4 meter. So, the visitor will walk three steps in one second. Because the visitor walks every time step, so each time step in simulation is equal to 0.33 second in the real world.

Blocks are separated by corridor. In this simulation, the corridor width is 2.1 meter in real world or 3 cells in simulation world. So, the corridor can be passed by three visitors at one time. In this research, all corridors are booth corridor and have same width. It is different with in the previous research that there are two types of corridor: main corridor and booth corridor [7].

Door or doors location is not strict. In this research, the door is functioned booth as entrance and exit. There is not specific functioned door, such as for emergency exit.

In this research, based on product class, merchants are classified into five product classes. This classification is based on the condition in the real world that usually, in souvenir market, product can be classified into: traditional fabric (batik), ready to wear, curtain, accessories, and snacks. The product class for merchant is generated randomly when the simulation begins. The random process follows uniform distribution and each product class has equal opportunity.

Product zoning is not implemented in this research. It is because in many traditional souvenir markets, product zoning is not strictly implemented. It can be found easily that batik fabric booth is side by side with curtain booth. This condition is similar to condition in daily good traditional market. In daily good traditional market, zoning is usually implemented only for wet area and dry area [7]. Wet area is for fish, beef, and chicken products because this product is needed water for being processed. Dry zone is for vegetables, fruits, snacks, and soya products that are not needed water for being processed. In souvenir market, all products are dry so that water access is not needed.

In this research, for computing simplification, crowd is measured based on corridor block. Corridor block is small rectangle area in the corridor. There are three types of corridor block: horizontal corridor block, vertical corridor block, and intersection corridor block. Horizontal corridor block is corridor block between booths that the width is longer than the height. Vertical corridor block is corridor block between booths that the height is longer than the width. Intersection corridor block is corridor block that connects vertical blocks and horizontal corridor blocks. The illustration can be seen in Figure 6.

Identifying crowd is done by dividing number of occupied cells with the number of all cells in a corridor block. If the occupied cells ratio is more than 50 percents than the crowd is identified in that block. For example, intersection corridor block consists of 9 cells. If there are at least 5 visitors on this block then crowd is identified on this block. For horizontal or vertical corridor block, because this block consists of 24 cells, if there are more than 12 visitors on this block then crowd is identified on this block.

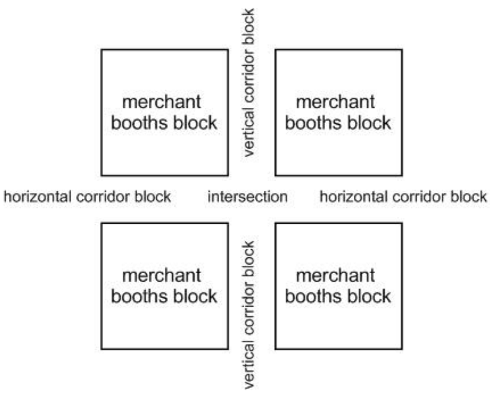

Figure 6: Corridor Block

When the simulation starts, all corridor blocks status is set 0. When the crowd identified on this block, then this block status is set 1 and the status will never change anymore until the simulation is end. In the end of simulation, the crowd ratio is calculated by dividing the number of corridor blocks that crowd ever occurs on them with the number of all corridor blocks. The ratio is presented in percent.

DISCUSSION

After the proposed model is implemented into Java code to create simulation, the simulation then is run to observe the condition in the souvenir market. There are several tests to observe the relation between the controlled variable and the observed variable. The observed variable is the crowd ratio. Each test is done by several simulation sessions. The summary of the controlled variable for every test is described in Table 1. In each simulation session, the simulation duration is two hours in the real world.

Table 1: Controlled Variable in Every Test Group

Test	Controlled Variable
1	inter arrival time ($t_{interval}$)
2	maximum tour time ($t_{maxtour}$)
3	interaction time (t_{int})
4	maximum number of visit ($n_{maxvisit}$)
5	willingness to visit ($f_{willvisit}$)
6	budget (b)
7	attractiveness level (l)
8	interesting level (i)

For every simulation scenario, there is default setting for controlled variable. The default setting is implemented both for merchant and visitor. Default setting for merchant and simulation is described in Table 2. Default setting for visitor is described in Table 3.

Table 2: Merchant and Simulation Default Setting

Parameter	Default Value
attractiveness level (l)	50
inter arrival time ($t_{interval}$)	30 second
number of doors	1

Table 3: Visitor Default Setting

Parameter	Default Value
interesting level (i)	50
maximum tour time ($t_{maxtour}$)	60 minutes
maximum number of visit ($n_{maxvisit}$)	10
initial budget (b_0)	500.000
transaction amount (q_{avg})	100.000
interaction time (t_{intavg})	10 minutes
willingness to visit factor ($f_{willvisit}$)	50

In the first test, the relation between inter arrival time and crowd ratio is observed. The the controlled variable is inter arrival time ($t_{interval}$) and the observed variable is crowd ratio. The average inter arrival time is set from 30 second to 90 second with the step is 10 second. Five simulation sessions is done for each inter arrival time step. The result is described in Table 4 and Figure 7.

Table 4: Relation Between Inter Arrival Time and Crowd Ratio

Inter Arrival Time (s)	Crowd Ratio (%)
30	5.97
40	2.32
50	1.33
60	0.88
70	0.77
80	0.55
90	0.55

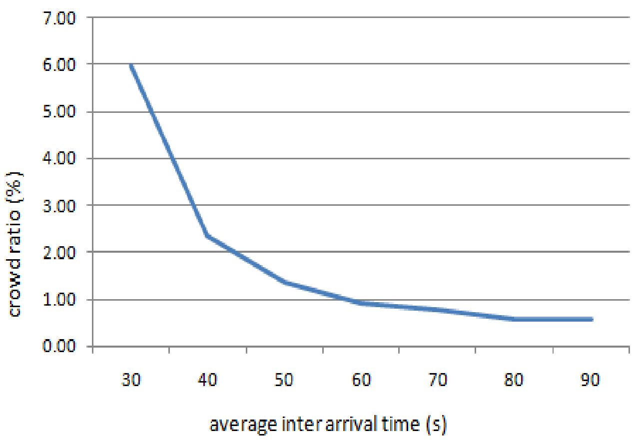

Figure 7: Relation Between Inter Arrival Time and Crowd Ratio

Based on data in Table 4, it can be seen that when the inter arrival time gets higher, the crowd ratio gets lower. This result is rationale because lower inter arrival time makes higher number of visitors enter the market in a period. Based on the trend in Figure 7, the crowd ratio declines fast until the average inter arrival time is 50 second. After that, the declination of the crowd ratio is slower.

In the second test, the relation between maximum tour time and crowd ratio are observed. The the controlled variable is maximum tour time ($t_{maxtour}$) and the observed variable is crowd ratio. The maximum tour time is set from 30 minutes to 90 minutes with the step is 10 minutes. Five simulation sessions is done for each maximum tour time step. The result is described in Table 5 and Figure 8.

Table 5: Relation Between Maximum Tour Time and Crowd Ratio

Maximum Tour Time (minutes)	Crowd Ratio (%)
30	1.99
40	2.87
50	3.65
60	5.52
70	7.18
80	8.84
90	12.71

Based on data in Table 5, it can be seen that the maximum tour time increases, the crowd ratio increases too. Based on trend data in Figure 8, the change of crowd ratio is linear. When the maximum tour time is below 50 minutes, the growth of the crowd ratio is low. When the maximum tour time is from 50 minutes to 80 minutes, the growth of the crowd ratio is moderate. The growth of the crowd ratio is high when the maximum tour time is over 80 minutes. This result is rationale because longer tour time makes the increasing of number of visitors in the market.

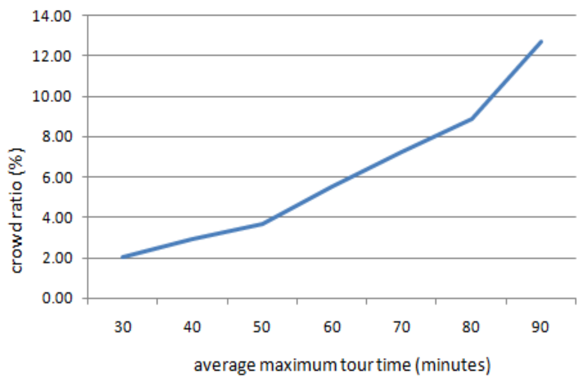

Figure 8: Relation Between Average Maximum Tour Time and Crowd Ratio

In the third test, the relation between interaction time and crowd ratio are observed. The controlled variable is average interaction time and the observed variable is crowd ratio. The average interaction time is set from 5 minutes to 15 minutes with the step is 1 minutes. Five simulation sessions is done for each average interaction time. The result is described in Table 6.

Table 6: Relation Between Average Interaction Time and Crowd Ratio

Average Interaction Time (minutes)	Crowd Ratio (%)
5	5.64
6	3.87
7	5.08
8	5.41
9	4.97
10	5.75
11	5.41
12	5.30
13	4.86
14	5.52
15	5.86

Based on the data in Table 6, it can be seen that the change in interaction time does not affects crowd ratio. The crowd ratio is still from 3.87 percent when the average interaction time is 6 minutes to 5.75 when the average interaction time is 10 minutes. Both when the interaction time is 5 minutes and 15 minutes, the crowd ratio is 5 percent.

In the fourth test, the relation between maximum number of visit and crowd ratio are observed. The controlled variable is maximum number of visits and the observed variable is crowd ratio. The average maximum number of visitations is set from 5 to 10 visitations with the step is 1 visitation. Five simulation sessions is done for each average maximum number of visitations. The result is described in Table 7.

Table 7: Relation Between Average Maximum Number of Visits and Crowd Ratio

Average Maximum Number of Visits	Crowd Ratio (%)
5	4.97
6	4.97
7	5.30
8	4.53
9	4.97
10	5.08

Based on data in Table 7, the maximum number of visits does not affect the crowd ratio. The lowest crowd ratio is 4.53 percent when the average maximum number of visits is 8. The highest crowd ratio is 5.30 percent when the average number of visits is 7.

In the fifth test, the relation between average willingness to visit factor and crowd ratio are observed. The controlled variable is average willingness to visit and the observed variable is crowd ratio. The average willingness to visit is set from 30 to 90 with the step is 10. Five simulation sessions is done for each step. The result is described in Table 8 and Figure 9.

Table 8: Relation Between Average Willingness to Visit and Crowd Ratio

Average Willingness to Visit	Crowd Ratio (%)
30	5.97
40	4.97
50	6.08
60	4.53
70	4.09
80	3.43
90	3.09

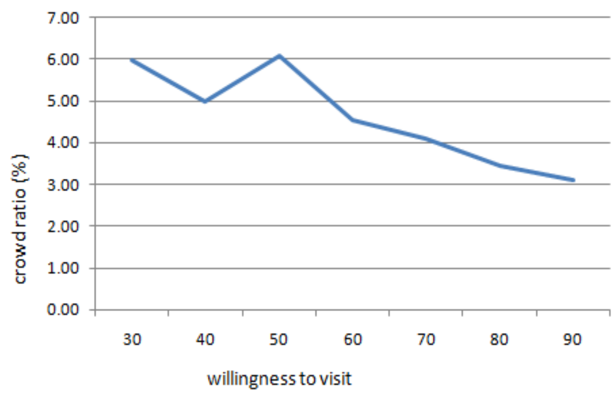

Figure 9: Relation Between Willingness to Visit and Crowd Ratio

Based on data in Table 8, the willingness to visits factor affects the crowd ratio. Higher willingness to visits makes the crowd ratio lower. The trend of the crowd ratio is linear with moderate gradient as it is seen in Figure 9. Highest crowd ratio is 6.08 percents when the average willingness to visit is 50. Lowest crowd ratio is 3.09 when the average willingness to visit is 90.

In the sixth test, the relation between average budget and crowd ratio are observed. The controlled variable is average average budget and the observed variable is crowd ratio. The average budget is set from 300,000 to 900,000 with the step is 100,000. Five simulation sessions is done for each step. The result is described in Table 9.

Table 9: Relation Between Average Budget and Crowd Ratio

Budget (000)	Crowd Ratio (%)
300	5.64
400	5.86
500	5.30
600	3.20
700	6.08
800	5.08
900	5.41

Based on data in Table 9, the budget amount does not affect the crowd ratio. The lowest crowd ratio is happened when the budget is 600,000. The highest crowd ratio is happened when the budget is 700,000. When the budget is 300,000 and 900,000, the crowd ratio is approximately 5.

In the seventh test, the relation between merchant attractiveness level and crowd ratio are observed. The controlled variable is average attractiveness level and the observed variable is crowd ratio. The average attractiveness level is set from 30 to 90 with the step is 10. Five simulation sessions is done for each attractiveness level. The result is described in Table 10.

Table 10: Relation Between Average Attractiveness Level and Crowd Ratio

Attractiveness Level	Crowd Ratio (%)
30	5.97
40	6.19
50	5.97
60	4.64
70	5.52
80	4.97
90	4.53

Based on data in Table 10, the attractiveness level does not affect the crowd ratio. The lowest crowd ratio is 4.64 percents and it occurs when the average attractiveness level is 60. The highest crowd ratio is 6.19 and it occurs when the average attractiveness level is 40.

In the eighth test, the relation between visitor interesting level and crowd ratio are observed. The controlled variable is average interesting level and the observed variable is crowd ratio. The average interesting level is set from 30 to 90 with the step is 10. Five simulation sessions is done for each interesting level. The result is described in Table 11.

Table 11: Relation Between Average Interesting Level and Crowd Ratio

Interesting Level	Crowd Ratio (%)
30	5.19
40	6.96
50	4.97
60	5.75
70	4.86
80	4.53
90	3.76

Based on data in Table 11, interesting level does not affect the crowd ratio. The lowest crowd ratio is 3.76 and it occurs when the average interesting level is 90. The highest crowd ratio is 6.96 and it occurs when the average interesting level is 40.

Based on the result, some parameters influent the crowd condition while other parameters does not influent the crowd. Parameters that influents the crowd condition are inter arrival time, maximum tour time, and willingness to visit. In the other side, parameters that does not influent the crowd condition are interaction time, maximum number of visit, budget, interesting level, and attractiveness level.

Based on those parameters, it can be found that the number of visitors in the market has significant influence to the crowd. It is represented in Figure 7 and Figure 8. Based on data in Figure 7, inter arrival time has negative relation with the crowd ratio. Based on data in Figure 8, maximum tour time has positive relation with the crowd ratio. So, both parameters have opposite influence to each other. Higher inter arrival time will reduce visitor inflow. In the other side, higher maximum tour time will increase the number of visitors in a period of time.

In the other side, it can be found that interaction between merchant and visitor or customer does not affect to the crowd condition. The only parameters that related to the interaction that affects the crowd ratio is willingness to visit but the gap between the lowest and the highest crowd ratio is small. Compared with inter arrival time and maximum tour time, willingness to visit factor has less significant influence to the crowd condition.

This condition is very different with the crowd condition in the daily goods traditional market. In daily goods traditional market, the most significant parameters that influence the crowd is the parameters that is related to the interaction duration between merchant and customer [7]. Longer interaction duration may trigger crowd in daily goods traditional market [7].

There is difference in crowd location between souvenir market and daily goods traditional market. In daily goods traditional market, crowd is concentrated in the strategic location, such as corridor blocks that are near to the door [7]. In the souvenir market, even the crowd frequently occurs in corridors that are near the door, many crowds occur in corridor blocks that are far from the door. In daily goods traditional market, traffic in less strategic corridor blocks is low [7]. In the other side, in souvenir market, the traffic in less strategic corridor blocks is still high.

This condition is rationale to the visitor behavior in the souvenir market. In souvenir market, which its most visitors are tourist, the visitor motivation is recreation or travelling [6]. In recreation, exploration is the key motivation. So, visitor will walk around the market for exploration. This activity makes the traffic in corridor that is far from the door is still high.

This condition is different with visitor in daily goods traditional market. In daily goods traditional market, the visitor is local resident and his motivation is purchasing [7,8]. When their purchasing list is complete, visitors will exit the market. For efficiency, visitors usually purchase from the merchants that stay near the door. This condition makes the traffic in corridor that is far from the door is low.

CONCLUSION AND FUTURE WORK

Based on the explanation above, the souvenir market crowd simulation model has been developed. This crowd model has been implemented successfully into crowd simulation application to observe the crowd condition in the souvenir market.

There are some parameters in the crowd model that affects the crowd condition while other parameters do not affect the crowd condition. Parameters that affect the crowd condition are inter- arrival rate, maximum tour time, and willingness to visit. Parameters that do not affect the crowd condition are interaction time, maximum number of visits, budget, attractiveness level, and interesting level. Maximum tour time has positive relation with crowd condition. Inter-arrival time and maximum tour time have significant influence to the crowd condition. Willingness to visit has less significant influence to the crowd condition.

In souvenir market, crowd occurs not only in the strategic corridor such as near the door. Crowd also occurs in the corridors that are are far from the door. It is because of the characteristic of the visitor. In souvenir market, most of the visitors are tourist and they like to walk around the market for observation. Visiting all sides of the market is part of recreation.

There are many research potentials in crowd modeling, especially in traditional market. Because the market is traditional and it is related with the local culture, beside the similarities, there are differences between traditional markets in some area with traditional markets in other area. Crowd modeling can be expanded not only simulating condition in the market but also condition outer the market, such as parking area, drop off zone, and the street around the market.

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