xIlkogretim Online - Elementary Education Online,2021; Vol 20 (Issue 1): pp.2349-2354
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.01.262

Crowd Tendency in Retail Shops and Machine Learning Algorithm for Reducing Queuing Time in Billing Counters

Palaniappan S*, Department of Computer Science and Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Chennai, India, jusmailkarthick@gmail.com*
Sreedevi A. G, Department of Computer Science and Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Chennai, India, agsreedevi@gmail.com
Susila M, Department of Electronics and Communication Engineering, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, India, susilasrm@gmail.com

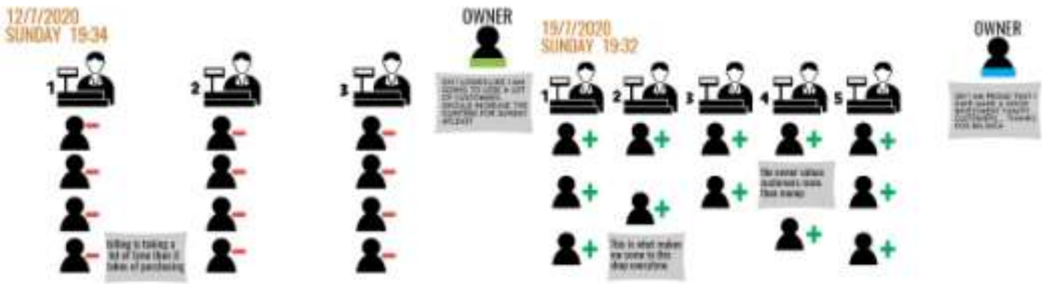
Abstract- Retail shops crowd and profit margin depends on the customer crowd in their shops. Waiting in long queues for billing increases customer dissatisfaction and reduces crowd in shops. This paper discusses a novel learning-based algorithm for such shops to reduce the customer waiting time in queues which in turn would lead to increased profit margin. The algorithm is based on supervised learning which uses slot-based approach on data from shops, learning it, finding the crowd factor and also possible error. It then predicts the upcoming crowd at the shop for coming days, slots required to keep the crowd in control and directs the retailer accordingly to bring in the needed changes in the number counters. The results of the proposed method show that this customer friendly tool can help reducing queuing time for customers at crowded time for coming days leading to customer satisfaction and increased productivity at shops.

Keywords: Crowd factor, data prediction, error factor, queuing time, slot-based approach, supervised learning.

I. Introduction

The trend for massive purchase in shopping is rising in many metro and non-metro cities. A retail shop to be successful, it has to take customer satisfaction as a major priority. Now-a-days a lot of foot-falls are seen at these places and there has been a significant increase in queue at the billing counter [1]. Customers easily get dissatisfied if they are forced to stand in queue for long time at billing. Since the trend of large queue in counters, clearly seem to be increasing, more investors come forward to have their own shopping mall, super market, or any such retail shop. From a situation where there were no malls at all two decades ago, the country had over 300 malls [2] and the trend is at peak by 2020. Even with increase in number of malls and super markets in city, the queue in billing counter doesn’t seem to decrease. The situation gets even worse when there is a smaller number of staff on duty. The scenario gets even worse when there are special offers and discounts available, as people appear in masses to purchase [3]. Moreover, standing for a long time in billing counter is a very important problem faced by the customers now-a-days [4]. With the advent of online shopping, many have started to move to it, as it saves their time and effort. As a result, many investors fear the disappearance of retail-shopping. Reducing the queue time and making the customer feel comfortable is an important challenge to be addressed [5].

The Figure 1 shows how customer waiting time in queues can be reduced by increasing counters, which intact will lead to customer satisfaction and increased shop productivity. As said in [10], “Lack of data is an important limit to studying the effectiveness of customer behavior”. The big data collected from retail shops is analyzed to propose machine learning based solution which constantly studies the updated data to give practical solution. This solution is independent of application and can be used at any place where there are large queues at billing section. Some applications of this proposed algorithm include: customer queues at super markets, malls, amusement park, museums, zoo, cinema theatres, parks, medical shops, railway stations, bus stands, and airport so on.



(a) (b)

Figure 1. (a) Showing large queues at billing and customer dissatisfaction. (b) Increase in counter and managing the crowd more efficiently the next day.

The main objective of this paper is to provide an efficient solution to reduce customer waiting time at billing counters in shops even at crowded timings. Predicting the crowd using crowd factor basis proves the novel approach of this paper. The entire process happens at retailer side and the customer is fully unaware of the approach but effected with its good results. The algorithm works over the 'big data' collected in such shops. The paper discusses the approach in 3 different stages: initially collecting the data, preprocessing it and then finally predicting the outcome. It uses crowd factor which is an indication of number of customers visiting the shops. More the crowd factor, more the time customers spend at counters. At the end of prediction, the algorithm predicts the upcoming crowd factor along with the counters to be incremented to make the crowd in control. The performance of algorithm is found to reduce queue time of customers efficiently leading to customer satisfaction.

II. RELATED WORK

Shopping becoming a daily routine and customer crowd increasing at shops are both normal. Retail owners aim to provide customer satisfaction in terms of product, price and promotion. The important factors being customer time and ease of shopping. Many researchers tried to investigate this problem of long queues in counters. One solution is using Radio Frequency Identification (RFID) technology. Paper [1] automates the billing using RFID technology, where every time the customer adds an item to his cart the bill is calculated [6]. But this method is vulnerable to hacking. If the server fails when there are more customers, it leads to a lot of confusion. Similarly, [7]every shop owner will not be able to deploy it in their shops and finally they also fear data loss which used to happen when they transfer data to billing system during payment. Papers [11] all focused on using RFID tags for solving long queues in retail shops. Other approaches include using device-to-device (D2D) [8], IoT based [14] approaches using LI-Fi, Zigbee technologies [9].

An interesting approach in paper [15] is applying queuing theory to minimize the customer waiting time at bill counters. Since some customers arrive at shop and leave without purchasing anything, this approach was found to be inefficient. Paper [10] analyses customer visiting times, crowded timings and offer days using statistical methods. Using Zigbee technology [11] an interactive cart was developed which could generate bill every time an item is added to it. Again, problems like failure of device due to overuse or overheating [16], the fact that not all customers who purchases needs a car and chances of customer illiteracy led to unsuccessful implementation. Similarly, paper [17] used Bluetooth technology for smart transfer of information from cart to billing system.

This paper proposes a noble approach where customers are free from any form of interaction. The shop retailer, himself, will be managing the number of billing counters based on preprocessed data avoiding long waiting queues [12]. Section 3 discusses the proposed method on how the algorithm works at phases and helps the shop retailer in managing the queues for better customer satisfaction. Section 4 discusses the efficiency and practicality of the algorithm in real world situations using crowd factor. Finally, section 5 concludes the paper [13].

III. LEARNING APPROACH FOR REDUCED BILLING TIME FOR CUSTOMERS

The algorithm is capable of recommending the number of counters to be opened at a particular slot of a day in a week based on the learning. It also provides retailer with a prediction table which contains the expected crowd at a particular time of the day. The algorithm works in 3 phases: phase 1 is the process of data collection, phase 2 is the process of data preprocessing and phase 3 is the process of data prediction.

Phase 1: Data Collection Phase: Here the system collects real time data from supermarkets which include day, date, time, and billing counter of each customer. Each collected data is stored in cloud for later use.
Phase 2: Data Preprocessing Phase: During this phase, the algorithm computes the total billing time and time lapse between each bill. Accordingly, it determines crowd in shop at each counter using crowd factor. It also calculates an error factor which determines the possible error when compared with previous results.
Phase 3: Data Prediction Phase: This is the main part of algorithm where, with determined crowd factor and error factor, the algorithm learns and predicts the expected crowd for coming slots. In this phase, the algorithm prompts the retailer on expected crowd and the number of counters to be increased to manage the upcoming crowd.

A. Data Collection

The initial phase, which is data collection, the algorithm collects customer information, billing information, timings and billing counter information. Based on different time slots, the collected data is grouped to know how many customers arrive at each counter during a particular time slot of a day. More the data, more accurate the analysis and the prediction will be.

B. Data Preprocessing

In phase two, the preprocessing algorithm works with the following logic.
Step 1: The algorithm gathers the needed big data information of each counter for each slot z ($T_{uz}^{B_i}$ to $T_{vz}^{B_i}$) where T_{uz} and T_{vz} are the starting and ending time of i[th] customer bill B_i.
Step 2: For each customer, at each counter the algorithm calculates the time-lapse. The average time lapses at each counter are averaged to find average total time lapse of slot z of the shop.

$$Time\ Lapse\ LT_{iz} = T_{uz}^{B_i} - T_{v(z-1)}^{B_{i-1}}\ \forall\ B_i\ where\ i > 0 (1)$$

Average time lapse of counter k, at slot z:

$$\overline{LT}_z^k = \frac{\sum_{i=0}^{N} LT_{iz}}{N} \quad (2)$$

Where N is the total number of bills generated at timeslot z at counter $k$and $\overline{LT}_z^k$ is the average time lapse found in counter k at slot z.The average of time-lapses' of all the counters in slot $z$is denoted by$\overline{LT}_z$and is given by:

$$\overline{LT}_z = \frac{\sum_{k=0}^{M} \overline{LT}_z^k}{M} \quad (3)$$

Step 3: Now, it calculates the crowd factor; an indicator of the intensity of crowd in supermarket at a particular time slot. It ranges from 0 to 1 and it depends on the no. of distinct items purchased by the customer, the no. of counters available at the shop, the time lapse which is the average of time gap between two bills for each counter, and total no. of customers present in the queue. The higher the crowd factor, the more time people spend at queues and more the shop is crowded. Crowd factor is calculated the following way:

$$\varphi = \frac{\frac{\sum B * N}{M * \overline{LT}_z}}{\frac{B_w * C_w}{\Delta w}} \quad (4)$$

where φ is the crowd factor B represents billing time, N represents the total number of bills entered or recorded, M represents the number of active counters and $\overline{LT}_z$ represents average time lapse. B_w represents the maximum allowable billing time for a particular slot z. C_w represents the maximum possible customers or maximum possible bills that can be recorded in a time slot z andΔwrepresents the total number of counters multiplied with 0.05 which is the minimum time lapse that can be recorded in a particular time limit. With many executions and trial, we have set the crowd factor threshold to be 0.4.

C. Data Prediction

This stage of the algorithm focuses on predicting the expected crowd factor for upcoming days at every time slot z. with the determined crowd factor (φ_d) the algorithm learns the crowd in retail shop and decides appropriate ways to manage crowd efficiently. It uses supervised learning method to predict the crowd by monitoring the billing counters. It is designed to be capable of guiding the shop-in-charge, to manage more or less counters accordingly. It also uses an error factor which will help in précising the predicted values to be in close with actual values. As the new values of counters and dates are updated in cloud, the next time it runs, it uses only the updated values and dates to calculate the expected crowd factor. This makes the algorithm and its learning more precise and smoother in predictions. The algorithm works in following way:

Step 1: The algorithm learns the previous data and predicts the expected crowd factor for future time slots. The prediction is done using regression analysis and expected crowd factor is calculated.

$$\varphi_e = \beta_1 t + \beta_2 \quad (5)$$

Where$\varphi_E$is the expected crowd factor,$\beta_1$and $\beta_2$are the coefficients determining theslope and intercept of crowd factor

Step 2: Using the crowd factor (φ_d) from preprocessing stage, and expected crowd factor (φ_e); the algorithm calculates the error factor.

$$Error_F = \varphi_e - \varphi_d \quad (6)$$

Step 3: Now, the algorithm includes the error factor also to the expected crowd factor to get a more promising result over the prediction.

Step 4: Based on this crowd factor, algorithm now decides the number of counters to be opened for that particular slot to monitor the crowd efficiently.

Step 5: Each time the values of counters, date and time slots change, the algorithm calculates the new prediction φ_e using only the new updated ones with 0 error factor. This makes the new predictions to come close to the actual crowd factors.

Step 6: Repeat steps from 1, for each new day for every time slots for better learning.

Algorithm prompts the retailer to increase the number of counters as per the prediction. Based on the decision by the retailer, new crowd factor and error factor is decided.

IV. RESULTS AND DISCUSSIONS

The performance of algorithm is studied for 3 different time slots of working hours of the retail shop: 7:00 to 12:00, 12:01 to 18:00, and 18:01 to 22.30. The number of customers visiting the shop for a period of 30 days is studied. The pattern showed increase in crowd during weekends. The collected data through stage 1 of algorithm is used in preprocessing stage. Here crowd factor is calculated and analyzed.

Figure 2 shows crowd factor for each slots of a day over a period of 30 days. Fridays, Saturdays and Sundays tend to show more crowd as they are offer days and weekends. Crowd factor is used as an indicator which shows more customers waiting in queue for longer time. Less crowd factor with more customers shows that customer waiting time getting reduced because of the precise prediction. Figure 3 shows the predicted crowd factor for 30 days which shows how the algorithm can reduce the customer waiting time in shops. The prediction helped to reduce customer waiting time in billing..

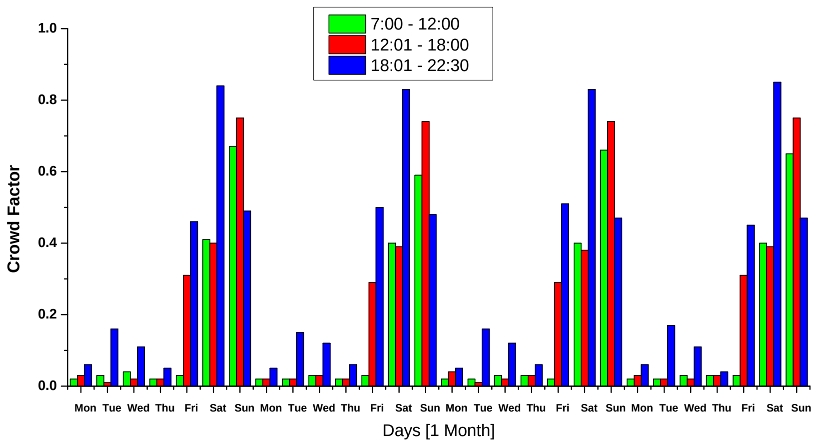


Figure 2. Crowd Factor for different time slots for a month

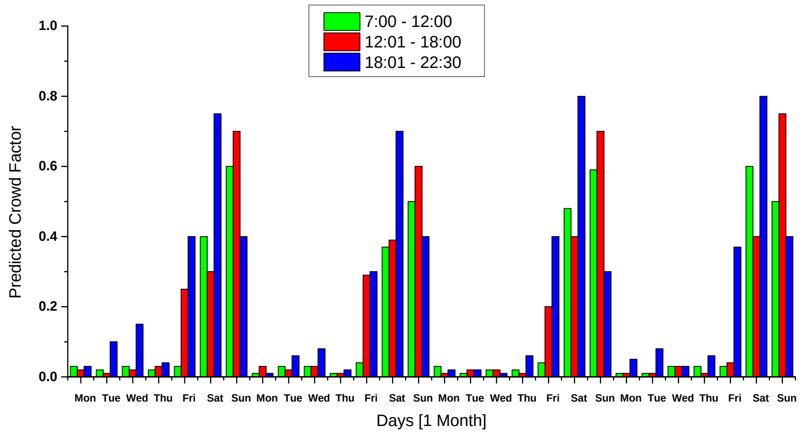


Figure 3. Predicted Crowd Factor for different time slots for a month

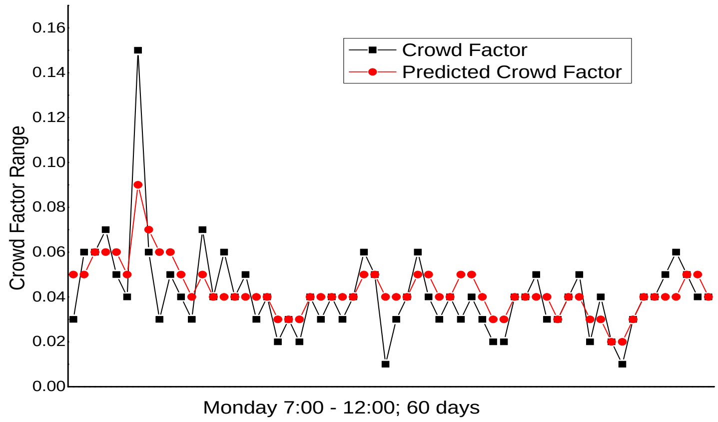


Figure 4. Crowd Factor for 7.00 to 12.00 time slot of Mondays for 60 days.

Consider Figure 4, which shows crowd factor and predicted crowd factor for 7:00 to 12:00 on all Mondays for a period of 60 days. It clearly shows implementing a learning technique at billing system can reduce waiting time for customers. In figure 4, as more data increases in the system, prediction was getting more precise. Considering error factor of previous prediction also contributed towards accuracy.

Thus, one could always choose to adopt learning-based software in shops billing system rather than RFID or any other methods. This requires no effort from customer side. Same time, the method will help for customer satisfaction by reducing his waiting time in queues for billing

V. Conclusion

Long waiting time in queues for billing is one problem each customer faces in shops. This paper provided a novel approach which retailers can use to predict the upcoming days crowd by which the retailer can arrange more counters in prior for customer satisfaction. The proposed algorithm generated a crowd factor based on data and used regressions to precisely predict and alert the retailer on efficient managing of crowd. The results show that algorithm can predict efficiently and thus help shop retailers for more productivity.

References

1. S. Rao, "Billing Automation for Supermarkets," in *2017 International Conference on Current Trends in Computer, Electrical, Electronics and Communication (CTCEEC)*, 2017, pp. 879-884.
2. K. H. J, "A study of problems faced by customers during visit of organized retail malls," *ASIAN JOURNAL OF MANAGEMENT RESEARCH*, vol. 2, 2011.

3. M. Chaudhari, A. Gore, and R. K. P. S. Patil, "Intelligent Shopping Cart with Goods Management Using Sensors," *International Research Journal of Engineering and Technology (IRJET),* vol. 3, 2016.
4. A. Yewatkar, F. Inamdar, R. Singh, and A. Bandal, "Smart cart with automatic billing, product information, product recommendation using rfid & zigbee with anti-theft," *Procedia Computer Science,* vol. 79, pp. 793-800, 2016.
5. V. V. Amrita and M. Suresh, "Factors influencing lean practices in Super market services using interpretive structural modeling," in *2016 IEEE international conference on computational intelligence and computing research (ICCIC)*, 2016, pp. 1-5.
6. K. Chaitanya, N. Gowda, A. Karthik, and N. Swithaja, "RFID Aided Automatic Billing Trolley System," *Perspectives in Communication, Embedded-systems and Signal-processing-PiCES,* vol. 2, pp. 131-135, 2018.
7. P. P. Saraf, A. D. Khanolkar, A. S. Pawar, U. B. Ghodake, S. J. Salokhe, and G. Patil, "D2D smart billing system," *Int J Adv Res Ideas Innov Technol,* vol. 5, pp. 1204-1207, 2019.
8. R. K. Megalingam, S. Vishnu, S. Sekhar, V. Sasikumar, S. Sreekumar, and T. R. Nair, "Design and Implementation of an Android Application for Smart Shopping," in *2019 International Conference on Communication and Signal Processing (ICCSP)*, 2019, pp. 0470-0474.
9. S. D. Pawar, A. Kushwaha, D. Kumar, and N. Alam, "Wi-FI Cloud server based User Operated Billing System in Mall," in *2020 5th International Conference on Communication and Electronics Systems (ICCES)*, 2020, pp. 1351-1355.
10. A. N. R. Ch. Hymavathi, "Queuing Time and Shopping Time of D-Mart Customers with Special Refrenceto Guntur City, Andhra Pradesh," *International Journal of Recent Technology and Engineering (IJRTE),* vol. 8, May 2019.
11. P. Chandrasekar and T. Sangeetha, "Smart shopping cart with automatic billing system through RFID and ZigBee," in *International Conference on Information Communication and Embedded Systems (ICICES2014)*, 2014, pp. 1-4.
12. S. Mekruksavanich, "Supermarket Shopping System using RFID as the IoT Application," in *2020 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI DAMT & NCON)*, 2020, pp. 83-86.
13. A. Sreedevi and T. R. Rao, "D2D communications performance analysis for LOS and NLOS scenarios with DAV algorithm," in *2017 IEEE International Conference on Circuits and Systems (ICCS)*, 2017, pp. 354-358.
14. R. Kanan and H. Arbess, "An IoT-Based Intelligent System for Real-Time Parking Monitoring and Automatic Billing," in *2020 IEEE International Conference on Informatics, IoT, and Enabling Technologies (ICIoT)*, 2020, pp. 622-626.
15. D. Shastrakar and S. Pokley, "Application of Queuing Theory to Minimize the Waiting Time of Customer at Bill Paying Counter of Supermarket," *International Journal for Research in Applied Science & Engineering Technology,* vol. 5, pp. 8-10, 2017.
16. A. Sreedevi and T. R. Rao, "SINR based association algorithm for indoor device-to-device communication networks," *Peer-to-Peer Networking and Applications,* pp. 1-10, 2020.
17. J. Arora, S. Gagandeep, and R. Kumar, "Smart Goods Billing Management and Payment System for Shopping Malls," *International Journal of Engineering & Technology,* vol. 7, pp. 456-461, 2018.