The Industrialized Barbershop: A Model and Simulation in a Barbershop

Mark Jerald Bautista
Computer Science Department
BSCS NS – 3D
Technological University of the Philippines
Manila, Philippines
markjerald.bautista@tup.edu.ph

Kathlyn Brotherton
Computer Science Department
BSCS NS – 3D
Technological University of the Philippines
Manila, Philippines
kathlyn.brotherton@tup.edu.ph

Dominic Ibarra
Computer Science Department
BSCS NS – 3D
Technological University of the Philippines
Manila, Philippines
dominic.ibarra@tup.edu.ph

Louise Madison Tato
Computer Science Department
BSCS NS – 3D
Technological University of the Philippines
Manila, Philippines
louisemadison.tato@tup.edu.ph

***Abstract*— In this study, the researchers developed and designed a simulation-based project that can be used and implemented in various infrastructures and establishments for a better quality of their services. The researchers chose to implement the simulation-based project in a barbershop. The proposed design algorithm has various features that a barbershop can utilize to improve its sales and marketing strategy by providing a user with different time-varying features such as the number of customers that will arrive and the number of people in the queue and other features. The features can be improved depending on the system capability and the input criteria. It is also helpful in a modern barbershop, whether small scale or large scale since the shop owner can have an idea about its overall performance due to the data provided by the simulation-based project. The shop owner can quickly identify the pros and cons of the shop and make a long-term decision for the future outcome of the barbershop.**

I. INTRODUCTION

In this modern era, one of the promising technological advancements in the use of Artificial Intelligence and Simulation systems in predicting and imitating the real-life scenario that people experience every day. According to [1], Simulation is an effective management science method for analyzing different systems, such as traffic management systems, hospital data management systems, and communication systems. Other systems cannot be simulated and make a real-world representation in a model form due to the complexity of the system and underlying concepts that are challenging to interpret and understand. An analytical model is one of the methods used in dealing with complex systems, but it requires many sampling assumptions to generate a satisfactory solution for its implementation. The most effective way of representing an output in a simulation is by using a graphical representation. It is also feasible in which people can easily interpret and understand.

In this study, the researchers design a simulation system specifically for barbershops to predict the shop's present and future performance and represent it graphically. The system's design starts at the day input or the time the barbershops operate daily. The algorithm will proceed to the corresponding time slot, execute logical operations, and perform arithmetic calculations. In logical operations, it compares the number of people arriving at the shop to the number of servers activated. The primary purpose of that comparison is to provide data regarding the number of people in the waiting queue, the number of customers that have been served already, and the number of people rejected at the shop. The overall efficiency of the simulation system is also calculated and presented.

This paper is categorized into different sections, from I to IV. Section I is composed of the introduction to the simulation system. Section II is where the simulation design model was presented. It includes the features, simulation techniques, and processes used in the system. Section III is where the graphical representation of the simulation system can be seen. It also has the flow chart and the result of testing conducted in the simulation system. Lastly, section IV consists of the project's conclusion, the project's purpose, limitations of the system, and the recommendations that can be cited in the project, which future researchers can utilize and improve are also located in section IV of this paper.

II. SIMULATION MODEL

A simulation model is one way to understand and explain the underlying processes of a given system or the potential patterns associated with processes in a system. [2] It uses a discrete event simulation to represent the well-established manufacturing systems. Simulation is predominantly applied when evaluating manufacturing system design and rules and policies. A performance measurement system needs to be established to make full use of simulation-based decision support in operations and inventory management. [3] The model's accuracy is determined by various elements, including its starting circumstances and the time required to recreate a specific event. The simulation process has the following steps. [4]

Problem Formulation

- Objectives and Planning
- Data Collection and Model Preparation
- Verification
- Validation
- Experimental Runs
- Implementing Results

In the context of our design, we initially created a model to achieve the goals. We used a computer program to implement the design. To program, we used SIMIO software.

The method's underlying idea in this simulation procedure is to create a computer-based discrete-event model. This model operates a system as a sequence of events in time. Next-event time progression is a continuous simulation option in which the system state is altered continually throughout time. No change in the system is considered to occur between consecutive events, and simulation time skips immediately to the next event. Because it does not have to simulate every time slice, it can often run significantly quicker than an equivalent fixed-increment time simulation.

We may use a probabilistic technique to determine the number of individuals arriving at any given time. There are several sorts of distribution functions [5] that can be employed to achieve our goal. To determine how many individuals will come at any given moment, we may use one of the distribution functions listed below:

- Poisson Distribution Function
- Uniform Density Function
- Normal Distribution Function
- Exponential Distribution Function
- Triangular Distribution

We used Normal Distribution to construct the program code for compatibility with the system. Normal Distribution Function

Normal Distribution [6] is a hypothetical symmetrical distribution used to make comparisons among scores or make other statistical decisions. The shape of this Distribution is often referred to as "bell-shaped" or called "bell-curved." and is commonly named the "Gaussian distribution."

Two parameters define the normal distribution graph: the mean, or average, which is the graph's maximum and is always symmetric, and the standard deviation. [7]

$p(x) = e{-}(x - \mu)2/2\sigma2/\sigma\sqrt{2\pi}\ /\ \sigma\sqrt{2\pi}$

An exponential function e is the constant 2.71828. In graph theory, it is the mean and standard deviation. The normalizing coefficient, denominator ($\sigma\sqrt{2\pi}$), causes the entire area the graph contains to be equal to unity. Although these areas may be calculated, the tables for exceptional cases of = 0 and = 1 are now the standard normal distribution.

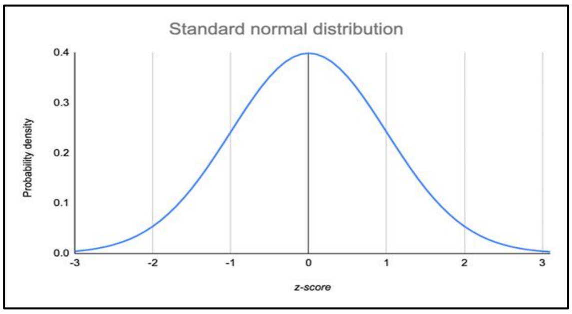

Figure 1: Normal Distribution

The normal distribution is easier to deal with conceptually than other distributions and offers acceptable estimate results. It is also a vital part and is generally used in statistical distributions. It is commonly utilized because many natural occurrences follow this pattern and may be efficiently described by fundamental functions.

A. Exponential Distribution Function

The exponential distribution is the probability of time distribution between the events in a Poisson point process or a process in which events occur continuously and independently at a fixed average rate. This distribution is used in probability theory and statistics. It is an instance of the gamma distribution in particular. In queueing systems, a queue connection between customers and barbers can be observed in the simulation project for a barbershop. The exponential random variables are frequently encountered. The formula for the Exponential Distribution Function is:

$$\boxed{f(x) = \begin{cases} \lambda e^{-\lambda * x}, x \geq 0 \\ 0,\ x < 0 \end{cases}}$$

III. SIMULATED OUTCOME

Figure 2 depicts a flowchart of how the simulation performs. It depicts the customer's arrival, the waiting queue, and the barber they have chosen. The simulation model conducts the required comparison, selection, estimation, and computations. Then it graphically displays many desirable performance parameters. Figure 3 illustrates the Barbershop Simulation using Simio Simulation Software for implementation.

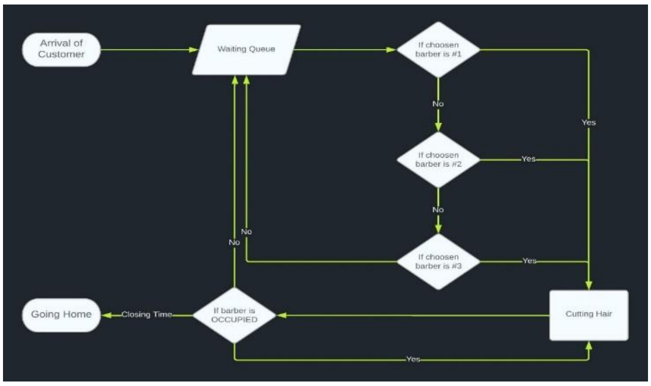

Figure 2: Flowchart of Industrialized Barbershop Simulation

Figure 3: Barbershop Design using Simio Simulation Software

Figure 4 depicts the overall number of customers at various times, peaking between February 9 and 10. It is the quantity determined from the normal probability distribution; initially, we establish our arrival section with a random exponential with a mean of 20 and units of minutes. In our process section, we have chosen a normal probability distribution with a mean of 15 and a standard deviation of 3. The barbershop is open from 9:00 a.m. to 6:00 p.m., for a total of 9 hours daily, and it has three barber chairs for customers to use. Figure 5 shows the number of customers in the waiting area at various times for the whole 2 weeks.

The simulation estimates the number of people arriving, the number of people being processed, the number of people waiting in line before servicing, and the system's efficiency at any given time based on the comparison result.

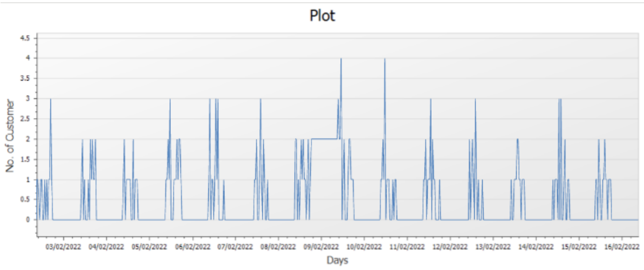

Figure 4: Graph of Number of Customer

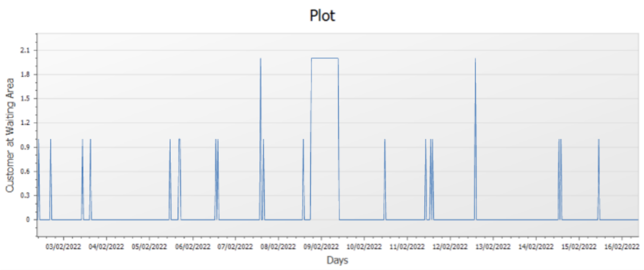

Figure 5: Graph of Customer at Waiting Area

Figure 6: Data Result from 3 Barbers

Figure 6 depicts the data result, where we can see the Input Buffer as the number of customers waiting for their preferred barber, Output Buffer as the number of customers previously processed, and Processing as the number of individuals being processed. From February 2 to February 15, their various data on the number of people who entered and left show that for barber #1, 119 people attended for his service, and every customer was handled. 115 people showed up for barber #2's service, and every single one of them was dealt with. Last but not least, 125 clients sought out barber #3 and were all attended to.

ResourceId	ResourceN	OwnerId	OwnerNam	StartTime	EndTime	Duration		Minutes
BARBER_2	BARBER_2	Customer.4	Customer.4	02/02/2022 9:00:29 AM	02/02/2022 9:19:01 AM	0.309002222		18.54013
BARBER_3	BARBER_3	Customer.4	Customer.4	02/02/2022 9:32:20 AM	02/02/2022 9:46:33 AM	0.236757778		14.20547
BARBER_3	BARBER_3	Customer.4	Customer.4	02/02/2022 9:46:33 AM	02/02/2022 10:00:06 AM	0.226058333		13.5635
BARBER_2	BARBER_2	Customer.5	Customer.5	02/02/2022 9:59:44 AM	02/02/2022 10:16:57 AM	0.286948056		17.21688
BARBER_3	BARBER_3	Customer.5	Customer.5	02/02/2022 10:10:01 AM	02/02/2022 10:20:07 AM	0.168111389		10.08668
BARBER_2	BARBER_2	Customer.5	Customer.5	02/02/2022 10:16:57 AM	02/02/2022 10:30:01 AM	0.217884444		13.07307
BARBER_3	BARBER_3	Customer.5	Customer.5	02/02/2022 11:09:44 AM	02/02/2022 11:19:55 AM	0.169964444		10.19787
BARBER_3	BARBER_3	Customer.5	Customer.5	02/02/2022 11:46:57 AM	02/02/2022 12:02:54 PM	0.265997222		15.95983
BARBER_1	BARBER_1	Customer.5	Customer.5	02/02/2022 1:24:13 PM	02/02/2022 1:36:54 PM	0.211313889		12.67883
BARBER_3	BARBER_3	Customer.5	Customer.5	02/02/2022 1:37:06 PM	02/02/2022 1:48:14 PM	0.185431111		11.12587
BARBER_1	BARBER_1	Customer.5	Customer.5	02/02/2022 2:12:35 PM	02/02/2022 2:25:18 PM	0.212059722		12.72358
BARBER_2	BARBER_2	Customer.5	Customer.5	02/02/2022 2:29:49 PM	02/02/2022 2:43:58 PM	0.235737222		14.14423
BARBER_1	BARBER_1	Customer.5	Customer.5	02/02/2022 2:48:54 PM	02/02/2022 3:05:12 PM	0.271634722		16.29808
BARBER_3	BARBER_3	Customer.6	Customer.6	02/02/2022 3:20:27 PM	02/02/2022 3:36:26 PM	0.266501111		15.99007
BARBER_2	BARBER_2	Customer.6	Customer.6	02/02/2022 3:23:59 PM	02/02/2022 3:37:27 PM	0.224282778		13.45697
BARBER_1	BARBER_1	Customer.6	Customer.6	02/02/2022 3:39:55 PM	02/02/2022 4:01:05 PM	0.352574444		21.15447
BARBER_2	BARBER_2	Customer.6	Customer.6	02/02/2022 4:07:07 PM	02/02/2022 4:19:05 PM	0.19946		11.9676
BARBER_1	BARBER_1	Customer.6	Customer.6	02/02/2022 4:24:48 PM	02/02/2022 4:37:34 PM	0.212795		12.7677
BARBER_1	BARBER_1	Customer.6	Customer.6	02/02/2022 4:37:34 PM	02/02/2022 4:52:04 PM	0.241750556		14.50503
BARBER_2	BARBER_2	Customer.6	Customer.6	02/02/2022 4:46:45 PM	02/02/2022 5:00:33 PM	0.229951389		13.79708
BARBER_1	BARBER_1	Customer.6	Customer.6	02/02/2022 4:52:04 PM	02/02/2022 5:02:12 PM	0.168942222		10.13653
BARBER_3	BARBER_3	Customer.6	Customer.6	02/02/2022 4:59:30 PM	02/02/2022 5:08:10 PM	0.144248333		8.6549
BARBER_2	BARBER_2	Customer.6	Customer.6	02/02/2022 5:08:06 PM	02/02/2022 5:26:10 PM	0.300964167		18.05785
BARBER_3	BARBER_3	Customer.7	Customer.7	02/02/2022 5:30:38 PM	02/02/2022 5:43:58 PM	0.222192222		13.33153
BARBER_2	BARBER_2	Customer.7	Customer.7	03/02/2022 9:55:28 AM	03/02/2022 10:13:21 AM	0.298094722		17.88568
BARBER_2	BARBER_2	Customer.7	Customer.7	03/02/2022 10:13:21 AM	03/02/2022 10:27:09 AM	0.230028333		13.8017
BARBER_3	BARBER_3	Customer.7	Customer.7	03/02/2022 10:24:31 AM	03/02/2022 10:35:45 AM	0.187309722		11.23858
BARBER_3	BARBER_3	Customer.7	Customer.7	03/02/2022 10:35:45 AM	03/02/2022 10:56:22 AM	0.343454722		20.60728
BARBER_2	BARBER_2	Customer.7	Customer.7	03/02/2022 11:11:49 AM	03/02/2022 11:29:07 AM	0.288350278		17.30102
BARBER_1	BARBER_1	Customer.7	Customer.7	03/02/2022 11:27:30 AM	03/02/2022 11:43:52 AM	0.272881111		16.37287
BARBER_2	BARBER_2	Customer.7	Customer.7	03/02/2022 12:31:47 PM	03/02/2022 12:45:04 PM	0.221471667		13.2883
BARBER_2	BARBER_2	Customer.7	Customer.7	03/02/2022 12:49:41 PM	03/02/2022 1:05:07 PM	0.25737		15.4422
BARBER_2	BARBER_2	Customer.7	Customer.7	03/02/2022 1:05:07 PM	03/02/2022 1:17:55 PM	0.213170833		12.79025
BARBER_1	BARBER_1	Customer.8	Customer.8	03/02/2022 1:23:02 PM	03/02/2022 1:40:15 PM	0.286929722		17.21578
BARBER_3	BARBER_3	Customer.8	Customer.8	03/02/2022 1:51:07 PM	03/02/2022 2:10:15 PM	0.318935833		19.13615
BARBER_1	BARBER_1	Customer.8	Customer.8	03/02/2022 2:49:45 PM	03/02/2022 3:03:49 PM	0.234228333		14.0537
BARBER_1	BARBER_1	Customer.8	Customer.8	03/02/2022 3:03:49 PM	03/02/2022 3:23:23 PM	0.326146389		19.56878
BARBER_3	BARBER_3	Customer.8	Customer.8	03/02/2022 3:28:06 PM	03/02/2022 3:43:33 PM	0.257541389		15.45248
BARBER_1	BARBER_1	Customer.8	Customer.8	03/02/2022 3:45:22 PM	03/02/2022 3:59:36 PM	0.237041389		14.22248

Figure 7: Logs of Barbers process time for each Customer

Figure 7 depicts the logs output from the Simio simulation program as an excel file, and the researcher has already converted the time from hours to minutes. We can see on the table that every barber and customer is being served. Also, the start and end times of their service for each customer. The Duration refers to the processing time in hours, which the researcher converted to minutes to easily determine the time it takes for each client to be processed.

As a result, the last time a customer is processed in 8.23 minutes, and the maximum time is 22.54 minutes. We can also notice a client with a starting time but no end time, which indicates that the consumer is being rejected owing to the barbershop's closing time.

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	NUMBER OF CUSTOMER					
DATE	ACTUAL	SIMIO (FORECA	SQUARED ERROR	ABSOLUTE PERCEN	Difference	Difference^2
02/02/2022	25	24	1	4.00	1	1
02/03/2022	26	22	16	15.38	4	16
02/04/2022	28	25	9	10.71	3	9
02/05/2022	32	30	4	6.25	2	4
02/06/2022	29	26	9	10.34	3	9
02/07/2022	26	22	16	15.38	4	16
02/08/2022	26	23	9	11.54	3	9
02/09/2022	28	31	9	10.71	-3	9
02/10/2022	29	28	1	3.45	1	1
02/11/2022	24	24	0	0.00	0	0
02/12/2022	29	27	4	6.90	2	4
02/13/2022	21	19	4	9.52	2	4
02/14/2022	31	33	4	6.45	-2	4
02/15/2022	28	25	9	10.71	3	9
TOTAL	382	359	95	121.37	23	95

PAIRED T-TEST		
ACTUAL MEAN	27.28571	
SIMIO MEAN	25.64286	
MEAN DIFFERENCE	1.642857	
SUM OF SQUARES	57.21429	
T-STATISTIC	$\frac{(1.642857 - 0)}{\sqrt{\frac{57.21429}{14(14-1)}}}$	
T-STATISTIC	2.930105	
degrees of freedom	13	a = .05
Table t	2.160	
MSE:	6.79	
MAPE:	8.67%	

Conclusion: There's a significant difference of number of customer between actual data and simio data since T-Statistic is greater than Table T

Figure 8: Validation of Data Result

Figure 8 shows the outcome of our simulation using Simio Simulation Software together with the validation data from the raw data of Roderick's Barbershop. As we can see, the data was subjected to a Paired T-Test and the results showed that the Mean Squared Error (MSE) was 6.79, the Mean Absolution Percentage Error (MAPE) was 8.67%. As a result, there is an 8.67 percent difference between the predicted data and the actual data, which is not a good sign. Additionally, the paired t-t-statistic test's is higher than table-t, which indicates a significant difference in the number of customers between the actual data and Simio output data.

IV. CONCLUSION AND RECOMMENDATION

CONCLUSION

- Based on our research, the random variable where the number of client arrivals is calculated is done using a random exponential with a 20 mean and units of minutes. At the same time, a normal probability distribution is used for the process server where the client or entity is being processed.
- The project we completed is useful in modern barbershops where maintenance is required; it aids in estimating the number of customers in a day and the number of chairs required. It also aids in assessing if the present flow mechanism in a barbershop is efficient in serving customers.
- Simulating a barbershop is useful for examining and observing how a thing function. In today's barbershop, simulation is essential. Using the graphical results, the shop's owner may select the number of servers (chairs) needed at any given time and use the current servers most.
- Obtaining MSE and MAPE from raw and Simio data reveals that the simulation produced good results, with an error prediction rate of just 8.67 percent.

RECOMMENDATION

- Researchers recommend creating a user-interface software that allows current barbershops to view various graphs. It comprises data such as the number of arriving customers, the number of customers in the waiting area, and the time it takes for a client to be processed at various times by injecting their data.
- It also recommends developing a mobile application that uses machine learning to estimate how many customers will arrive and how long it would take to process them, depending on gender. As a result, the barbershop may plan a more efficient system in their workshop.
- The researcher also recommends using different probability distributions when simulating a barbershop to compare results and determine which is more accurate and efficient in verifying from one of the barbershop data logs if feasible.

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