Coffee Shop Quality Control

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Monday, December 20, 2021

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INTRODUCTION

The concepts of Statistical Process Control (SPC) were initially developed by Dr. Walter Shewhart in the 1920s, and Dr. W. Edwards Deming improved on them after WWII, when he brought SPC to Japanese industry.[1] Statistical Process Control has now been adopted by businesses and organizations all over the world as the main method for improving product quality by minimizing process variation, thanks to its early success with Japanese companies. Dr. Shewhart defined two sources of process variation: Assignable, Uncontrolled variation, which is unstable over time - the result of specific circumstances outside the system, and Chance variation that is ingrained in the process, and consistent over time. Chance variation was renamed Common Cause variation, while Assignable variation was renamed Special Cause variation by Dr. Deming. Besides, determining the quality has been recognized as one of the most essential influencing the advantages of companies. Enhancements in quality lead to productivity improvements because they require less rework and fewer errors. Otherwise, companies will suffer huge losses in income due to mistakes and more work.

DESCRIPTION OF THE PROCESS

Coffee preparation is the process of converting coffee beans into beverages. The process of preparing a cup of coffee differs depending on the type of coffee ordered. In general, a cup of coffee requires some basic steps starting with roasting the coffee beans. After roasting the coffee beans comes grinding the beans, then the ground coffee should be mixed with hot water. This process is known as brewing coffee. Brewing coffee should be done before drinking so that the coffee can maintain its heat and taste. There are many aspects that can benefit from SPC including the quality of the beans, the service time, and monitoring the quantity of donuts produced to reduce the number of expired donuts.

This research will focus mainly on the amount of time it takes for Dunkin Donuts' KFUPM branch to serve their customers. This paper will help the branch to know how many minutes they take to serve the students and how to improve their service quality and efficiency.

SOURCES OF VARIATION

Possible sources of variations include:

- Inherent variability in the coffee beans (chance) (raw material)
- Giving out wrong order (assignable)
- Machine breaks due to overuse (assignable)

- Machine breaks due to manufacturing defect (chance)
- Variation on time the machine spends grinding the coffee (chance)
- Slow operator (assignable)
- Slow service during the period of changing shifts between workers (assignable)
- Slow communication between cash register and barista (assignable)
- Inherent variability in the coffee machine (chance)

QUALITY CHARACTERISTICS

Some quality characteristics of a coffee shop are:

Time to serve (variable):

Service time can play a huge role in the overall quality and customer satisfaction of the product or service. Many people who order coffee in the morning heavily prefer to get their coffee as fast as possible in order to make it to work or class on time. Therefore, the time spent to serve the customer their coffee is imperative to the quality of the service .

Fraction of wrong orders delivered (attribute):

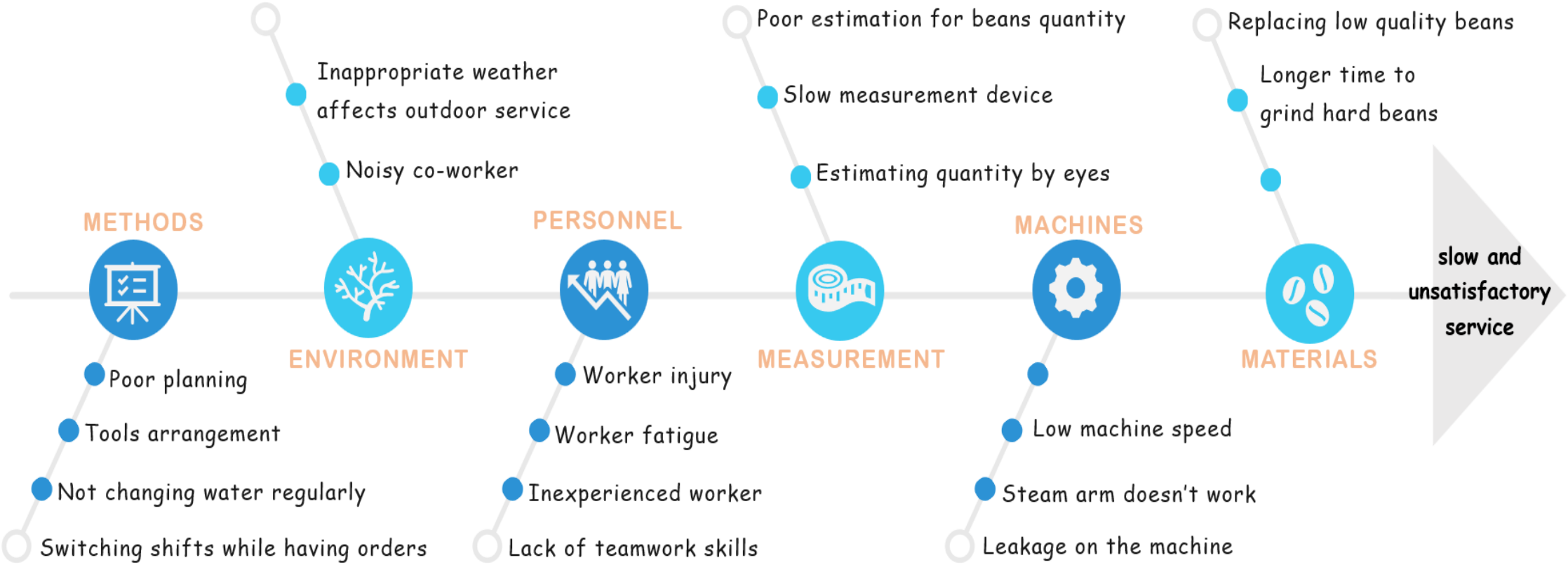
It is inevitable that mistakes in delivering the product will happen. However, the higher the fraction of wrong orders delivered, the worse the overall quality of the service. There are two major quality issues here. The first is of the product i.e. the coffee will be considered nonconforming to what was ordered and will have to be thrown out and replaced. The other is of the service i.e. increasing the overall time that it took to serve a customer and thus decreasing customer satisfaction and overall service quality.

Temperature of served coffee (variable):

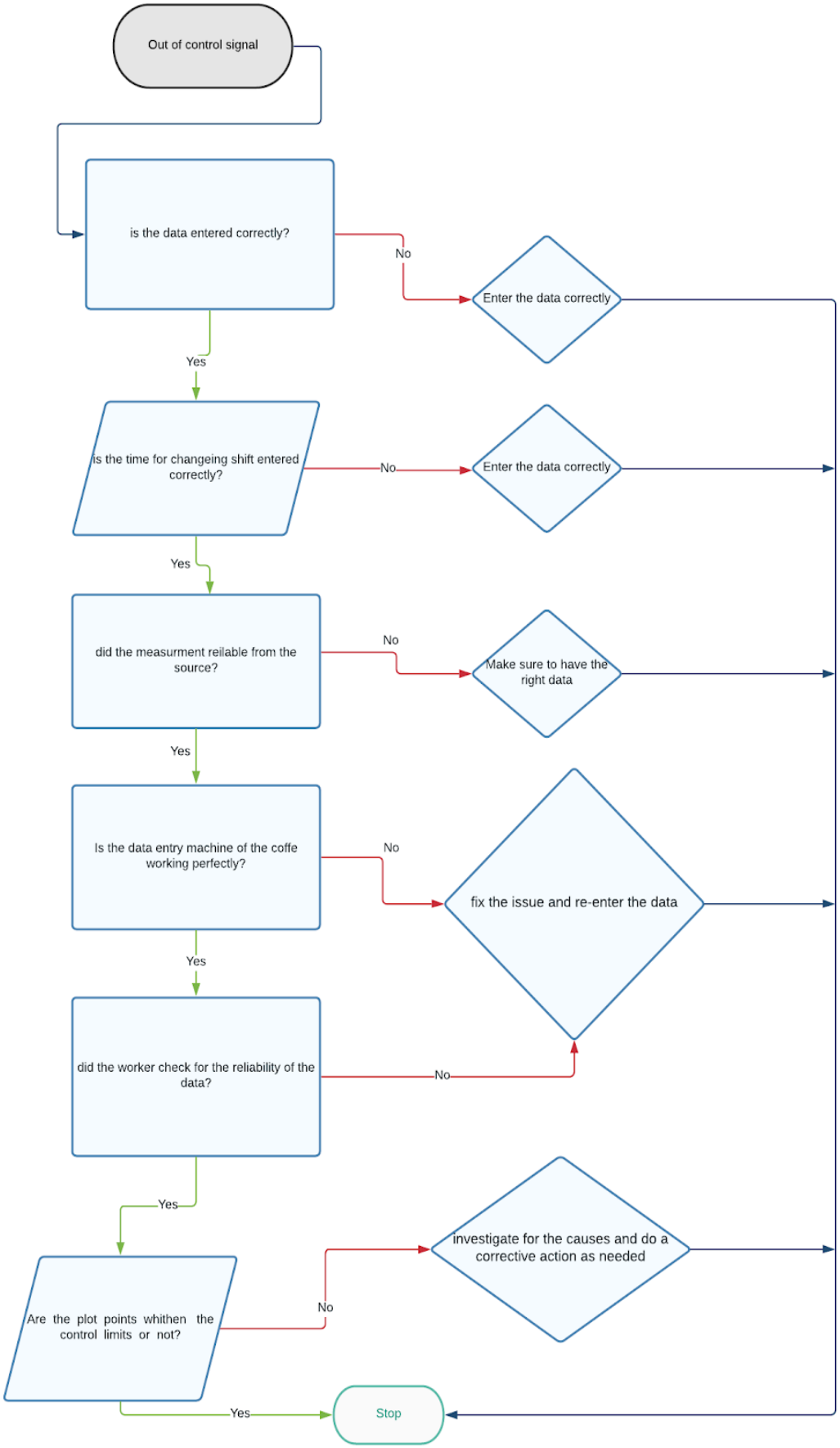
It is well known that temperature is an essential quality characteristic of coffee. The ideal temperature to drink coffee should generally be in the range of 50-80 °C (D, 2021).[2] If the temperature of the coffee served falls far from this range, then the quality of the product will be negatively impacted.

FISHBONE DIAGRAM

Here is the fishbone diagram visualizing some potential causes that might lead to slow and unsatisfactory service.



OUT-OF-CONTROL ACTION PLAN



SPC PROCEDURE FOR THE QUALITY CHARACTERISTIC

Statistical Process Control is dependent on data analysis, so the first step is to determine what data should be collected. The type of data utilized in a control chart is divided into two categories: variable and attribute. Temperature, time, distance, and weight are examples of continuous scale measurements that provide variable data. Attribute data is based on upon discrete categories such as good/bad, percentage defective, and the number of defective per hundred.

During peak periods, coffee shops need to serve their customers quickly so that the other customers can be served without waiting too long. Accordingly, the analysis was performed on Dunkin Donuts which is a coffee shop on the university campus. The most ordered type of coffee was black coffee. Thus, we chose black coffee to be the product of choice and the **time to serve** said black coffee to be the quality characteristic to be monitored. And the data utilized are classified as Variable Data according to Schwartz's classification.

individual measurements are fairly prevalent in many transactional commercial, and service operations because there is no foundation for reasonable subgrouping. The control chart for individual units is beneficial in such scenarios, such as the coffee shop's service time. The Moving Range of two successive observations is utilized as the foundation for estimating the process variability in several applications of the individuals control chart. This authorizes the creation of a moving range control chart for the chosen quality characteristic.

COMPREHENSIVE STUDY FOR SOME QUALITY CHARACTERISTICS

FALSE ALARM IDENTIFICATION

To calculate the false alarm, it is needed to find the type I error for each chart which is the probability to say the process is out of control when it is actually in control. Therefore, Pr(X<LCL) or Pr(X>UCL) need to be found. And, by calculating them, 0.0028 and 0.9917 are the values for the x-chart which give a value of false alarm to be 0.0057.

DETECTION DELAY COSTS

The cost of the inspection or the detection is estimated to be $350. This budget will insure to cover the cost of investigating any assignable causes. For the detection delay, there should be a considerable shift when the sample size is exceedingly small. For example, if u is chosen to be +9, it will have the better points that are closer to the LCL. Practically, there will be some points that are above the upper control limit which will lead us to investigate assignable causes to fix the problem. However, in the coffee shop process, there is no shift in the

mean value. In other words, the process is in control and there is no detection delay.

CHOOSING THE SAMPLE SIZE AND SAMPLING FREQUENCY

The number of individuals or observations included in a study is indicated as sample size. The sample size has an impact on two statistical properties: one of them refers to the precision of our estimations. However, here in the process n is chosen to be small. Choosing a sample size small is better when there is small data, and the data was not quite large. Another reason is that taking a small sample size leads to less cost, especially in time. This emphasizes the data was obtained by ourselves and then the choice of n=1 was decided because it is beneficial in these processes, there is no foundation for reasonable subgrouping, and to make data collecting easier and more efficient.

For choosing the frequency, the samples have taken once. So, there is no frequency. Although, when the sample size is small there should be a high frequency for taking the samples.

PHASE-I ANALYSIS FOR THE QUALITY CHARACTERISTICS

Since black coffee is the most popular item in demand during peak hours, Dunkin Donuts expects an influx of customers that will order it so they prepare it earlier and it can maintain its heat on the machine.

The data shown below were collected in the KFUPM Dunkin Donut branch between the hours 8 and 10 am of a business day. Each observation in the data shows how much time is required to serve a cup of black coffee. Since it is the most ordered type of coffee on the menu, the coffee shop prepares it earlier. So, the time recorded on the data represents how much time the cup takes from handling the cup by the worker until closing the cup. The initial plan was to record the time from starting to prepare until the cup reaches the customer's hand. But, because some customers order other things on the menu, the time chosen to represent how much time the barista takes from starting to work on the cup until closing it.

11.92	11.02	10.34	11.09	11.53
12.03	13.88	11.21	10.20	13.20
10.02	12.40	11.53	12.03	13.88
11.21	10.20	13.20	10.02	12.40
10.20	13.20	10.02	12.40	11.53
12.03	13.88	11.21	10.20	13.20

(n = time in seconds to serve 1 black coffee to 1 customer)

This report utilized python libraries such as pandas and matplotlib to calculate the Individual chart and MR chart for the quality characteristic chosen which was 'the time Dunkin Donuts takes to serve 1 black coffee for 1 customer' The code and graphs are shown below:

First step is importing the python libraries and then reading the data we collected from Dunkin Donuts in a csv file called "timeToServe.csv"

```
#importing necessary libraries
import pandas as pd
import matplotlib.pyplot as plt
```

```
#reading the file containing data points
df = pd.read_csv("timeToServe.csv")
```

```
#adding MRi column to the data
df['MR'] = abs(df['time'].diff()) #calculates MRi
```

Then the control limits are calculated:

```
#Calculations
X_Bar = df['time'].mean()
MR_Bar = df['MR'].mean()
standerd_d = MR_Bar/1.128
print(f"xBar= {X_Bar} \nMRbar= {MR_Bar}")
print(f"standard deviation for d2=1.128 is= {standerd_d}")
```

```
xBar= 11.705999999999994
MRbar= 1.8441379310344834
standard deviation for d2=1.128 is= 1.6348740523355352
```

```
#Individual Chart
UCL = X_Bar + 3 * standerd_d
CenterLine = X_Bar
LCL = X_Bar - 3 *standerd_d
print(f"for the individual chart:\nUCL: {UCL}\nCL: {CenterLine}\nLCL: {LCL}")
```

```
for the individuals chart:
UCL: 16.6106221570066
CL: 11.705999999999994
LCL: 6.801377842993388
```

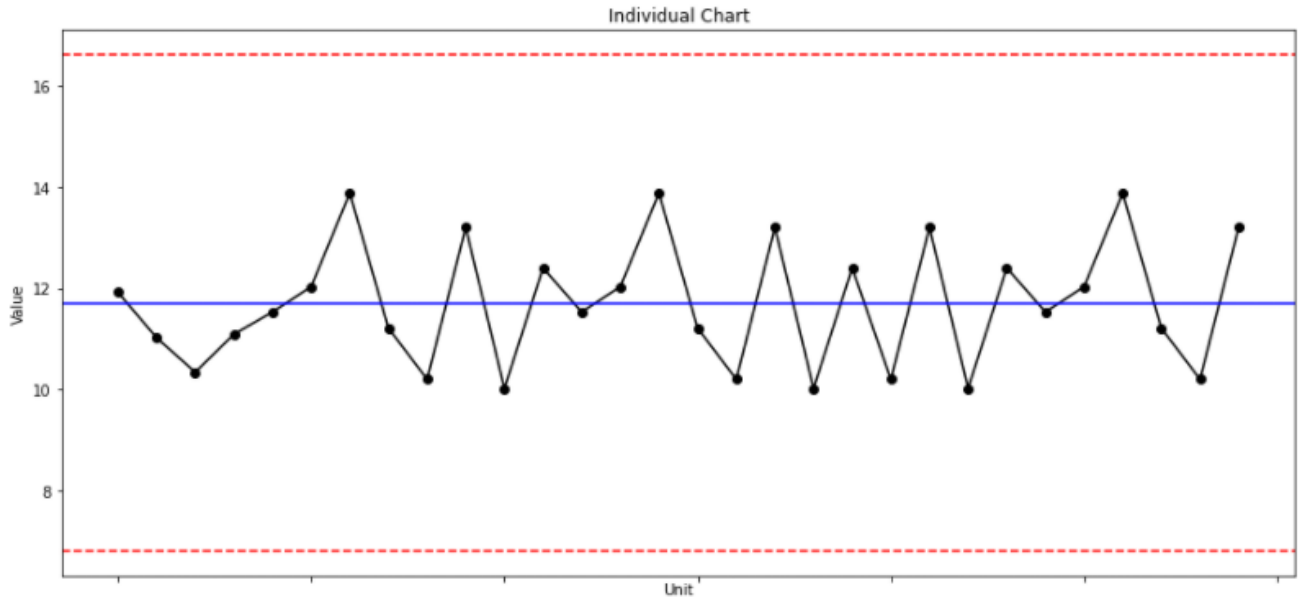
```
#MR Chart
MR_UCL = 3.267 * MR_Bar
MR_CenterLine = MR_Bar
MR_LCL = 0
print(f"for the MR chart:\nUCL: {MR_UCL}\nCL: {MR_CenterLine}\nLCL: {MR_LCL}")
```

```
for the MR chart:
UCL: 6.0247986206896575
CL: 1.8441379310344834
LCL: 0
```

Finally, the graphs are plotted:

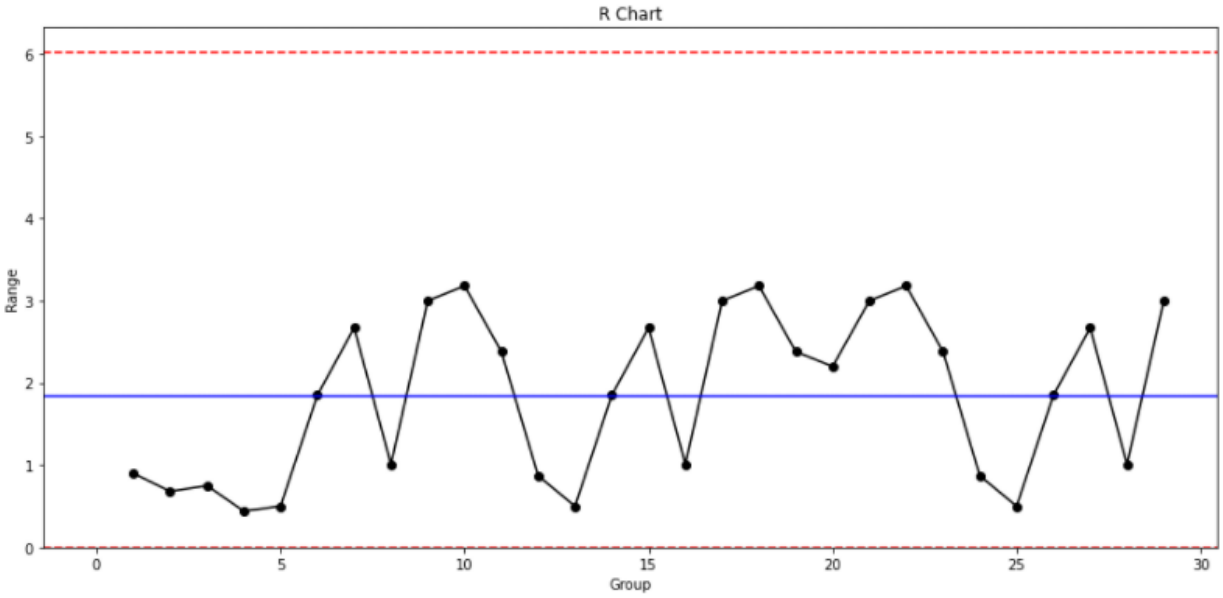
```
#plotting the charts
fig, axs = plt.subplots(2, figsize=(15,15), sharex=True)

#Individual Chart
axs[0].plot(df['time'], linestyle='-', marker='o', color='black')
axs[0].axhline(CenterLine, color='blue')
axs[0].axhline(UCL, color = 'red', linestyle = 'dashed')
axs[0].axhline(LCL, color = 'red', linestyle = 'dashed')
axs[0].set_title('Individual Chart')
axs[0].set(xlabel='Unit', ylabel='Value')

#MR Chart
axs[1].plot(df['MR'], linestyle='-', marker='o', color='black')
axs[1].axhline(MR_UCL, color='red', linestyle='dashed')
axs[1].axhline(MR_LCL, color='red', linestyle='dashed')
axs[1].axhline(MR_CenterLine, color='blue')
axs[1].set_ylim(bottom=0)
axs[1].set_title('R Chart')
axs[1].set(xlabel='Group', ylabel='Range')
```

Individual chart:



As we can see Dunkin Donuts does a great job in serving their customers as fast as possible during busy hours. All observations fall within the control limits and the process is in control

MR chart:



The MR chart shown above also shows the process is in control and the individual MR's are all within the control limit. As expected from a global coffee chain the process is within control

CONCLUSION

The use of statistical techniques to control processes is known as SPC. Studies show that SPC tools are not only suitable for production lines, but they are also suitable for the service industry. Nowadays it is not enough for coffee shops to just deliver high quality coffee, they must have a high-quality service as well. The most vital service quality characteristic for a coffee chain such as Dunkin Donuts is the time to serve. This report studied the process of serving coffee for Dunkin Donuts and designed an appropriate fishbone diagram and OCAP for the process. Due to the nature of the quality characteristic, an individual chart with the moving range chart were chosen to be conducted. The calculations and graphing of the aforementioned charts were done via python and the findings show that the process is in control.

In summary, this report monitored the service quality of Dunkin Donuts using the appropriate SPC tools and concluded that the time it takes Dunkin to serve its customers is within control.

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(2) D, J. (2021). The Ideal Coffee Temperature: THIS is How Hot Should Coffee Be. Retrieved 16 December 2021, from https://www.homegrounds.co/how-hot-should-coffee-be/

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