

Machine Learning for Predictive Targeting

Time Series Analysis: Uncovering Customer Purchase Patterns Over Time

What is the optimal timing for advertisements and promotions to maximize customer purchases, based on historical purchase behavior?

1. Overview

This project leverages time series analysis to examine customer purchase behavior throughout the day. By identifying hourly purchase trends from historical data, we aim to determine the most effective times for deploying targeted advertisements and promotional campaigns. The findings will help optimize marketing strategies, align outreach with peak customer activity, and drive revenue growth through smarter engagement timing.

2. Goal

- Determine the hourly purchase trends based on historical transaction data.
- Identify peak hours when customers are most likely to make purchases.
- Recommend the best timeframes to run ads and promotions for maximum impact.
- Provide actionable insights for marketing and sales optimization strategies.

3. Business Challenge

- Uncertainty about the most effective times to reach customers.
- Low engagement or conversion rates from untargeted promotions.
- Missed revenue opportunities due to poor timing of marketing efforts.
- Limited insight into customer behavioral patterns throughout the day.

4. Analysis Approach

- Utilize historical transaction data to group and count purchases by hour.
- Visualize hourly trends using time series plotting to highlight patterns.
- Identify hours with consistently high customer activity.
- Recommend time slots for targeted promotions and ad placements.
- Integrate insights into broader marketing and sales strategies.

Importing libraries

```
In [9]: import pandas as pd
import matplotlib.pyplot as plt
```

Loading the clean dataframe (post-ETL process)

```
In [11]: df = pd.read_csv("C:\\Monthly_Sales\\cleaned_data.csv")
```

```
In [12]: df.head()
```

```
Out[12]:
```

| | Order ID | Product Name | Units Purchased | Unit Price | Order Date | Delivery Address | Month | Month Name | Year | Day of the Week |
|---|----------|--------------------------|-----------------|------------|---------------------|--------------------------------------|-------|------------|------|-----------------|
| 0 | 160155 | Alienware Monitor | 1 | 400.99 | 2024-01-01 05:04:00 | 765 Ridge St, Portland, OR 97035 | 1 | January | 2024 | Monday |
| 1 | 151041 | AAA Batteries (4-pack) | 1 | 4.99 | 2024-01-01 05:04:00 | 964 Lakeview St, Atlanta, GA 30301 | 1 | January | 2024 | Monday |
| 2 | 146765 | AAA Batteries (4-pack) | 1 | 4.99 | 2024-01-01 05:20:00 | 546 10th St, San Francisco, CA 94016 | 1 | January | 2024 | Monday |
| 3 | 145617 | Amana Washing Machine | 1 | 600.00 | 2024-01-01 05:24:00 | 961 Meadow St, Portland, OR 97035 | 1 | January | 2024 | Monday |
| 4 | 156535 | Lightning Charging Cable | 2 | 14.95 | 2024-01-01 05:45:00 | 451 Elm St, Los Angeles, CA 90001 | 1 | January | 2024 | Monday |

Plotting Hourly Purchase Trend

```
In [14]: # Group by 'Hour' and counting the number of occurrences
hourly_counts = df.groupby('Hour').size()

# Print out the values
```

```
print("Hourly Purchase Counts:")
for hour, count in hourly_counts.items():
    print(f"{hour:02d}:00 - {count} purchases")

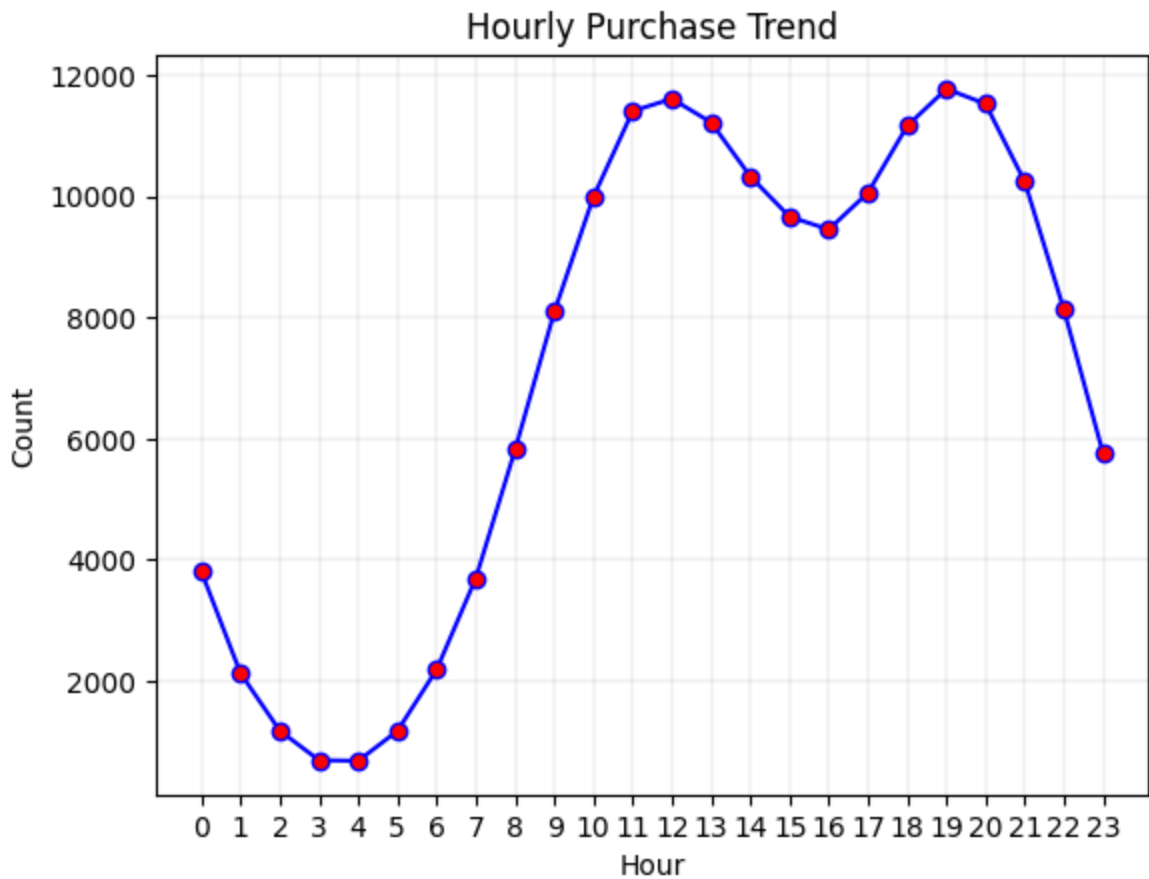
# Plot
plt.plot(hourly_counts, marker='o', markerfacecolor='red', linestyle='-', color='b')
plt.title('Hourly Purchase Trend')
plt.xlabel('Hour')
plt.ylabel('Count')
plt.xticks(range(0, 24))
plt.grid(linewidth=0.2)

plt.savefig(r"C:/Users/DELL/OneDrive - COVENANT UNIVERSITY/Desktop/1. Retail Sales .")

plt.show()
```

Hourly Purchase Counts:

00:00 - 3806 purchases
01:00 - 2127 purchases
02:00 - 1181 purchases
03:00 - 694 purchases
04:00 - 684 purchases
05:00 - 1178 purchases
06:00 - 2190 purchases
07:00 - 3700 purchases
08:00 - 5817 purchases
09:00 - 8093 purchases
10:00 - 9994 purchases
11:00 - 11407 purchases
12:00 - 11610 purchases
13:00 - 11220 purchases
14:00 - 10329 purchases
15:00 - 9663 purchases
16:00 - 9454 purchases
17:00 - 10059 purchases
18:00 - 11161 purchases
19:00 - 11774 purchases
20:00 - 11525 purchases
21:00 - 10239 purchases
22:00 - 8125 purchases
23:00 - 5750 purchases



Key Insights

1. Customer activity follows a clear daily rhythm, starting low in the early morning, building momentum mid-morning, peaking in the afternoon and early evening, and tapering off gradually at night.
2. Consistently high customer activity is observed between 11:00 AM and 8:00 PM, with the most significant spikes from:
 - 11:00 AM to 1:00 PM (Peak hours: 11 AM – 11,393; 12 PM – 11,594; 1 PM – 11,207)
 - 6:00 PM to 8:00 PM (Evening peak: 6 PM – 11,146; 7 PM – 11,757; 8 PM – 11,507)
3. Low engagement periods are between 2:00 AM and 5:00 AM, where customer activity is minimal.

Strategic Recommendations

To maximize conversions and get the most out of your ad spend:

1. Targeted Promotions Strategy
 - Run high-budget, high-impact campaigns between 11:00 AM and 1:00 PM, when

purchase intent is at its peak.

- Complement with reminder or follow-up ads in the evening (6:00 PM – 8:00 PM) when users have more downtime.
- Use lighter awareness-based campaigns in the morning (9:00 AM – 11:00 AM) to set the stage for peak time conversions.

2. Scheduling Tactics

- Segment marketing messages by hour: Informational in the morning, persuasive in the afternoon, urgency-based in the evening.

Recommended Time Slots for Ads & Promotions - Based on Peak Customer Activity

1. Primary Peak Block (Most Impactful):

- 11:00 AM – 1:00 PM — Lunch-time browsing and decision-making.

2. Secondary Peak Block (Evening Push):

- 6:00 PM – 8:00 PM — After-work, relaxed shopping mindset.

3. Morning Ramp-up Slot (Pre-Peak Nudge):

- 9:00 AM – 11:00 AM — Prepping customers mentally before their lunch-time conversion.

In []: