CycloTrends: Identifying Seasonal Patterns and Comparing Trends made simple

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***Abstract*—Understanding seasonal trends is critical for many analytical tasks. Platforms such as Google Trends leverage line charts to visualize trends for keywords. While line charts effectively visualize the trend over a time period, identifying seasonal patterns using line charts can be unintuitive due to the cognitive load involved. This issue is exacerbated when using Google Trends to compare the trends between multiple keywords due to the visualization approach used by the platform. To address these limitations, a concise visualization tool that seeks to minimize the mental effort required to recognize seasonal patterns and compare trends between various keywords across several years is proposed. The paper includes case studies that illustrate the practical application of CycloTrends. An evaluation study shows the merits of CycloTrends in discerning seasonal patterns and comparing trends across multiple categories.**

I. Introduction

Seasonal trends are patterns that occur at regular intervals within a given period, typically a year. These trends may relate to changes in consumer behavior, weather patterns, or other factors that are influenced by the time of year. Identifying seasonal trends is important because it allows individuals or businesses to better understand patterns in their data and make more informed decisions based on those patterns. For example, a retailer may use seasonal trend data to optimize their inventory and promotions for specific times of the year when demand for certain products is higher.

Google Trends is a powerful platform that helps users track the popularity and search interest of keywords or topics over a period of time. Researchers use the platform to understand the search patterns and behaviors of users, while marketers and analysts use Google Trends to monitor popularity and catch emerging trends. Over the years, governments have also relied on the platform to track awareness of COVID-19 symptoms and monitor social movements such as the #MeToo and #BlackLivesMatter.

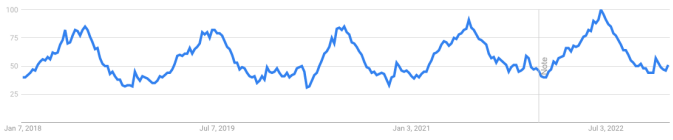

Fig. 1. Google Trend results for ‘Sunglasses’ between 2018 to 2022.

Fig. 2. Google Trend results for ‘Electric skateboard’ between 2018 to 2022.

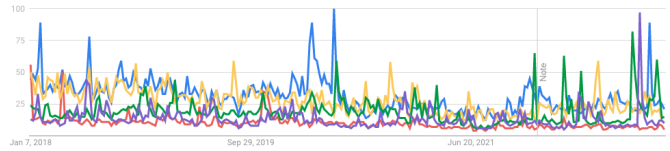

Fig. 3. Google Trend results for American TV hosts between 2018 to 2022. (Blue: Jimmy Fallon, Red: Seth Meyers, Yellow: Stephen Colbert, Green: Trevor Noah, Purple: James Corden)

II. Motivation

Google Trends provides users with an advanced filtering ability to retrieve results at the intended level of granularity. Trend results are visualized using a combination of line charts and heat maps. Figure 1 shows the trend for the keyword ‘Sunglasses’ between 2018 and 2022.

Line charts help visualize the overall trend in data but may not capture the seasonal fluctuations that occur during a time period effectively. This shortcoming can be observed in Figure 2, which shows Google Trends’ visualization for the keyword ‘Electric skateboard’. Through Figure 2 we can observe a scenario when the trend line does not have an intuitive seasonal pattern. Answering questions such as “What was the trend in April across 5 years?” or “What was the trend in January 2019 vs March 2020?” is a challenging task involving significant mental effort. Such tasks become even more challenging when attempting to compare the trends of multiple keywords over a range of years, as demonstrated by the cluttered line charts in Figure 3.

This paper presents, CycloTrends, a visualization tool designed to reduce the cognitive load involved when using Google Trends to:

1) Identify seasonal trends within the data.
2) Compare trends across multiple keywords.

III. Related work

The Computational Design & Visualization Lab at the University of Coimbra, Portugal, created the 'Radial Calendar of Consumption' [1] to aid analysts at SONAE, a Portuguese retail company, in identifying periodic patterns and deviations from normal consumption values. The visualization divides a radial plot into twelve equal wedges, corresponding to the twelve months of the year, with each month's wedge further divided into seven parts representing the days of the week. A circle with a different radius denotes each week of the month, with the first week in the smallest radius circle and the following weeks in subsequent circles. The design allowed for an easy comparison of consumption value evolution among each week of every month, enabling the swift identification of weekly patterns. The effectiveness of radial charts in capturing seasonal patterns were demonstrated through this research. CycloTrends was developed by taking inspiration from various design elements of "Radial Calendar of Consumption" such as the polar chart that encodes the months along the angular axis.

The study "Uncovering Strengths and Weaknesses of Radial Visualizations—an Empirical Approach" [2] compared Cartesian and radial visualizations. Experimental findings from this study were used while building CycloTrends. One of the study's outcomes indicated how trained users do not find it difficult to comprehend radial visualizations. Additionally, the experiments conducted during the research revealed that sector positions are easier to remember than ring positions. Consequently, the researchers suggested encoding important dimensions in sectors instead of rings. This insight was helpful while designing CycloTrends, where the months are distributed along the sector edges.

Year	Month	Value
2018	1	41
2018	1	35
2018	1	30
2018	1	36
2018	2	28
2018	2	35
2018	2	32
2018	2	42
2018	3	38
2018	3	38
2018	3	36
2018	3	46

Fig. 4. Glimpse of Dataset 1 before transformation

IV. Dataset

Users can analyze the search interest of keywords on Google Trends, either by treating the keyword as a 'term' or a 'topic'. A 'topic' is a group of terms that share the same concept in any language, while a search 'term' only includes data for that language. When analyzing trends for a keyword as a 'term', users will not get results for misspellings, spelling variations, synonyms, plural, or singular versions of the term. On the other hand, analyzing a keyword as a 'topic' provides a more comprehensive understanding of the overall interest and trends related to that particular concept or theme. For consistency, all the datasets used by CycloTrends contain trend metrics for keywords that were queried as 'topics'.

Year	Month	Category	Value
2018	January	E-Skateboard	142
2018	February	E-Skateboard	137
2018	March	E-Skateboard	158
2018	April	E-Skateboard	226
2018	May	E-Skateboard	186
2018	June	E-Skateboard	209
2018	July	E-Skateboard	246
2018	August	E-Skateboard	210

Fig. 5. Glimpse of Dataset 1 after transformation.

Two datasets were used, one for a single keyword (Dataset 1) and the other for multiple keywords (Dataset 2), both covering a five-year period. Snapshots of Dataset 1 before and after the data processing are shown in Figures 4 and 5. Although the data cleaning process varied slightly between the two datasets, it involved splitting and grouping the date column, followed by aggregating the values for each group. In addition, the month numbers within both datasets were mapped to the corresponding month names.

The data wrangling process for both datasets was performed using the Python programming language. The decision to opt for the past five years of data was to strike a balance between obtaining sufficient historical data and not having an overwhelming amount of data.

V. Visual Design

Designing an uncluttered visualization that encodes trend values, months, and years for multiple keywords while reducing the cognitive load of identifying seasonal patterns is challenging. Polar charts are often a preferred approach to visualizing seasonality since their inherent circular nature makes spotting trends that repeat over time straightforward. The circular layout of a polar chart eliminates the issue of comparing different seasonal patterns across a horizontal timeline, which can be arduous with large amounts of data. These charts can visualize a broad range of information with a compact visual design.

CycloTrends is a pair of visualizations that represent trends for a single keyword and trends among multiple keywords over a range of years. The circular layout is divided into twelve equal sectors, and each month of the year is represented along the angular axis for both visualizations. The trend value is encoded using the radial axis such that the distance from the

center of the circle to the point is directly proportional to the trend value.

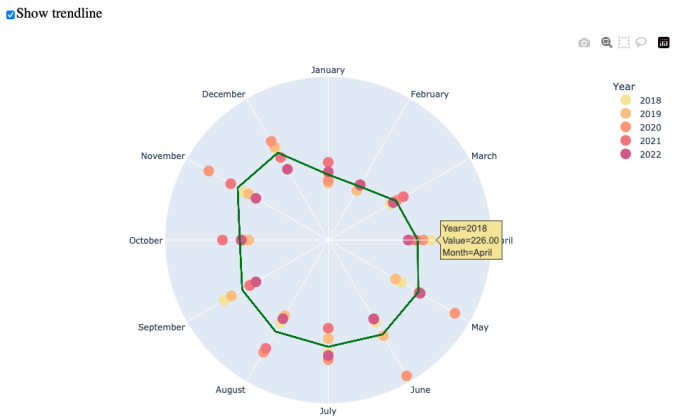

Fig. 6. CycloTrends visualizing trends for 'Electric Skateboard'.

Figure 6 shows CycloTrends visualizing the trend for the keyword 'Electric skateboard' over a period of five years. The year is encoded using a sequential "Sunset" color scale, with darker shades indicating later years. CycloTrends offers users the aility to select specific years to view by clicking on the legend. By enabling the trend line using the checkbox feature, CycloTrends facilitates identification of seasonal patterns. The trend line is computed by averaging the values for each month across all years, as represented by the green line in Figure 6. CycloTrends also offers a tool tip that appears when users hover over a data point, providing them with detailed information about the trend value, month, and year.

CycloTrends' ability to visualize trend results for multiple keywords spanning a range of years is shown in Figures 7 and 8. The tool automatically cycles through the time range with a three-second delay between each year, but users can pause or resume the animation using a button. The legend's toggle feature provides the ability to filter trends based on keywords, and the 'hover to connect' checkbox allows users to connect all trend points associated with a particular keyword across all months. Furthermore, a tool tip is available to provide users with details such as trend value, category, year, month, and the change in trend value compared to the previous year.

VI. User Evaluation

The user evaluation study involved a small test group of four graduate students, with three students from the field of Computer Engineering and one from the field of Architectural Design. Each participant was assigned two visualization tasks as part of the study. The first task required participants to compare the visualizations from Google Trends and CycloTrends for trend results of one keyword spanning five years. The second task also required participants to compare the visualizations from Google Trends and CycloTrends, but this time for multiple keywords spanning five years.

Participants in the user study unanimously agreed that CycloTrends outperformed the Google Trends' visualization

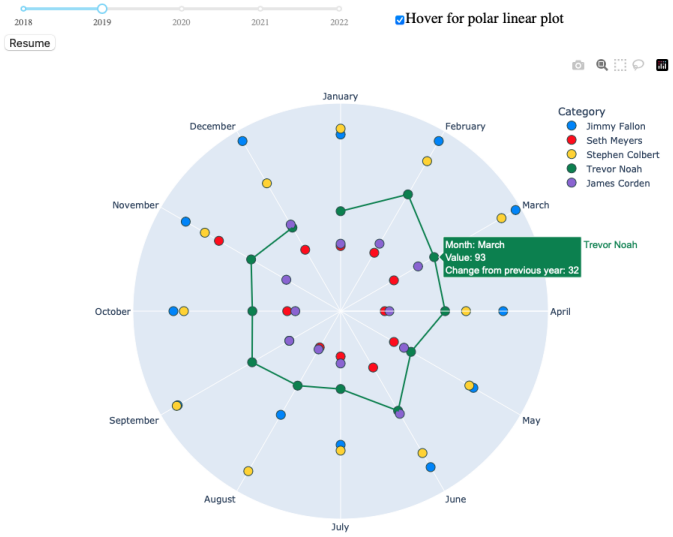

Fig. 7. CycloTrends visualizing trends for multiple American TV hosts in 2018.

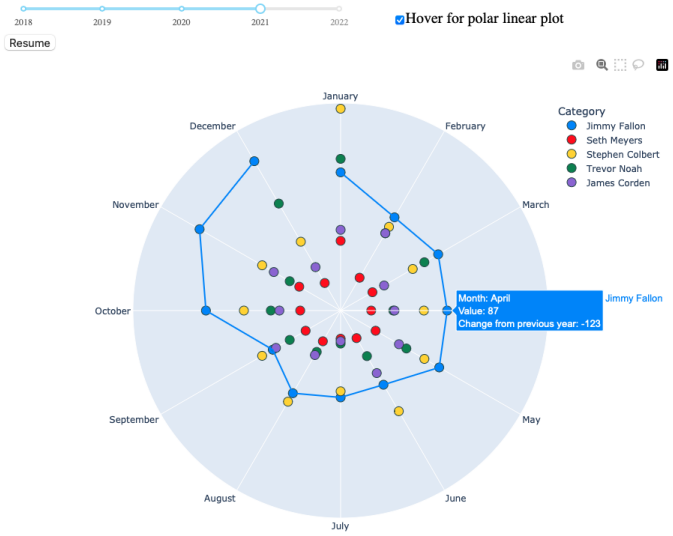

Fig. 8. CycloTrends visualizing trends for multiple American TV hosts in 2021.

in identifying subtle seasonal trends in the data. They also found it easier to discern a trending order when multiple keywords are involved. Additionally, the participants expressed that it was effortless to comprehend the monthly trend delta (difference between trend values at any given month) across multiple categories or years. They appreciated the compact yet uncluttered visual design of CycloTrends, which was a step up from Google's cluttered line charts. Some users specifically noted the ability to hover over and connect all data points belonging to a keyword, as well as the option to hide certain data points, which reduced visual clutter and made it easier to track trends.

The user study provided insights into areas where CycloTrends can be improved. One participant suggested that

adding marker values at regular intervals along the sector edges would be beneficial in gauging the value associated with a trend point rather than solely relying on tool tips. Participants also expressed that the ability for the trend line shown in Figure 6 to dynamically change when years are toggled using the legend would be a useful feature.

VII. Future work

The initial user study was essential in highlighting the areas of enhancement in CycloTrends. The next logical step would be to incorporate user feedback, which could involve adding dynamic trend lines and marker values along the sector edges. A transition effect that slowly animates the trend points in Figures 7 and 8 to their new positions as the year is changed could be a benificial feature. Furthermore, visualizing a confidence interval for the trend line shown in Figure 6 could help quantify the uncertainty associated with the estimated trend line. Finally, integrating a drop-down menu that allows users to specify the starting month and year would make it easier for users to compare trends for multiple keywords spanning range of years.

VIII. Conclusion

Identifying seasonal patterns within trends is an essential analytical task for making informed decisions and predictions. Google Trends is a platform that allows users to track the popularity and search interest of keywords over time. However, the platform's traditional visualization tool, line charts, can make it challenging to identify and compare seasonal patterns across multiple keywords. To address this limitation, CycloTrends, a visualization tool that reduces the cognitive load involved in recognizing seasonal patterns and comparing trends for various keywords, was designed. A small user study evaluated the tool's effectiveness and demonstrated CycloTrend's ability to identify seasonal patterns and compare trends effortlessly across multiple categories. The use of CycloTrends can be beneficial in various fields, including but not limited to academia, politics, business, and journalism.

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