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Popularity and Geospatial Spread of Trends on Twitter: A Middle Eastern Case Study

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Abstract. Thousands of topics trend on Twitter across the world every day, making it increasingly challenging to provide real-time analysis of current issues, topics and themes being discussed across various locations and jurisdictions. There is thus a demand for simple and extensible approaches to provide deeper insight into these trends and how they propagate across locales. This paper represents one of the first studies to look at geospatial spread of trends on Twitter, presenting various techniques to provide increased understanding of how trends on social networks can spread across various regions and nations. It is based on a year-long data collection ($N=2,307,163$) and analysis between 2016-2017 of seven Middle Eastern countries (Bahrain, Egypt, Kuwait, Lebanon, Qatar, Saudi Arabia, and the United Arab Emirates). Using this year-long dataset, the project investigates the popularity and geospatial spread of trends, focusing on trend information but not processing individual topics, with the findings showing that likelihood of trends spreading to other locales is to a large extent influenced by the place in which it first appeared.

Keywords: Trends, topic spread, popularity, network graphs, Twitter

1 Introduction

With the huge daily volume of generated content on Twitter – c.500 million tweets per day – trending topics serve as valuable sources of real-time information highlighting what is going on in the world, or in specific locations. Apart from the “official” trend lists provided by the platform (on the website or through API endpoints), generating insight from trends and topics detection has been receiving increasing attention from across a variety of big social data-driven research domains, with varying results; in health for example, monitoring and analysis of trending topics on social media has been adopted to measure emerging

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public health issues, such as the spread of influenza [1, 2]. Furthermore, across marketing and business domains, topic detection and classification are valuable approaches in extracting knowledge and insight on public opinions from posts on social media [3–5], including analysing voting intentions and political view of users [6]. With the increasing popularity and use of social networks across a wide range of domains, the impact of trends on public opinion and perceptions has transformed social media campaigns and public relations strategy. This has made trends a valuable target for manipulation [7], stuffing [8], spamming [9, 10], and hijacking [11]. Interestingly, deeper analysis of trend hijacking cases suggests that increasing social media engagement may not always be beneficial for public relations strategies [12].

A common approach in analysing Twitter trends is through clustering and classification of trending topics based on content [13–16]. The study in [17] presented a content-independent method to model trends progression through the dynamics of users interactions; other studies have also attempted to provide real-time classification or detection of trends [18, 19]. Many studies have dealt with trending topics, in terms of topic detection, for example. To the best of our knowledge, no study has investigated how trends spread spatially, and this study aims to provide methods for evaluating trending topics in regard to specific locales and how they spread from one place to another, without the need to collect tweeting activity of individual topics. The approach presented in this study provides a framework for understanding how topics capture interest of public across places and how likely it is for a topic to trend in other places based on its origin.

2 Methodology

The study is based on generating graph structures and conducting analyses of their properties, a widely-used approach (although we recognise there are other approaches and methodologies [20]). The graph construction approach presented in this paper was adopted as a simple way of capturing trends and related places, as well as temporal relationship between them. Furthermore, it can be used to produce simple visual representations of those data. The analysis approach involves constructing two graphs; the *temporal base graph* that captures the structure of trend raw data, and the *weighted aggregated graph* which is generated from the base graph to further explore its structure to provide additional insights. Figure 1 illustrates these graphs; the nodes and direction orientation of edges are the same in both graphs. Thus, nodes with zero indegree identify places, while trend nodes feature zero outdegree.

The *temporal base graph* is a directed graph that consists of three trend entities: *place*, *trend* and *timestamp*. Nodes represent place and trends, and edges are labelled with timestamps to indicate the time at which the trend appeared in a location. This graph is used to examine temporal properties, such as spread. The *weighted aggregated graph* is a graph that combines temporal edges between two nodes (in the base graph) into a single weighted edge. The feature of weighted

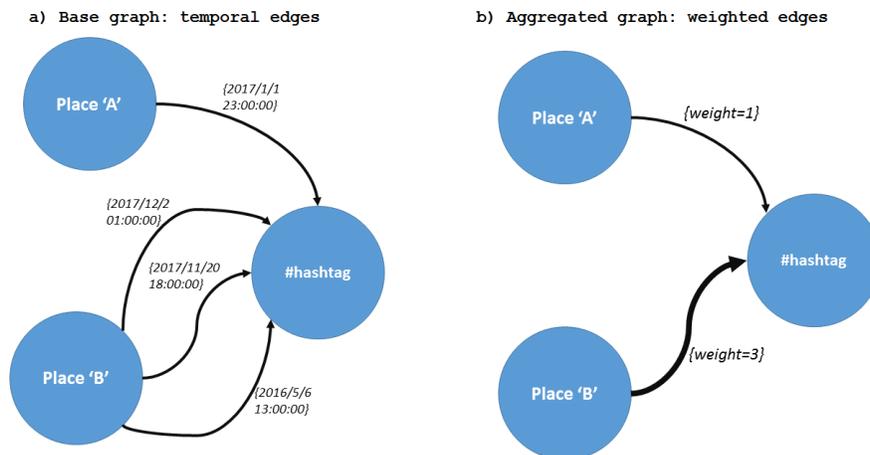


Fig. 1. Graphs constructed during analyses

edges in this graph is used to measure the popularity of trends, repetition rate, participation of countries, and the volume of the engagement.

2.1 Locales

Seven Middle Eastern countries were selected for this study: Bahrain, Egypt, Kuwait, Lebanon, Qatar, Saudi Arabia, and the United Arab Emirates (UAE). The selection includes countries with relatively large population (e.g. Egypt: 97,553,000) and relatively small populations (e.g. Bahrain: 1,493,000) [21]. Kuwait is reported to have the most active daily users on Twitter [22]; as of March 2016, Saudi Arabia and Egypt generated 33% and 20% of the tweets in the Middle Eastern region. Bahrain is the most balanced location in terms of gender breakdown of active users. Interestingly, between March 2014 and March 2016, Lebanon was the only location in the Middle Eastern states that has not seen growth in active users, while UAE increased by 60%. The Gulf Cooperation Council countries – Bahrain, Kuwait, Qatar, UAE, and Saudi Arabia – were reported to have the highest penetration rates [22].

2.2 Data Collection

Trending topic lists in the seven countries were monitored for the year between October 2016 and October 2017. Every hour, trending lists were collected through the Twitter REST API, which resulted in 7,948 hour's worth of records for all the countries, totalling 2,307,163 trend records. It is important to note that the Twitter API does not necessarily provide trends data for every request; for example, it is possible to receive no information for tweet volume.

For each location, the list of available trending topic is returned. From this list, four pieces of information are extracted from each trend record: *woeid*: the Yahoo! Where On Earth ID (WOEID) of the location; *name*: text of trending topic (e.g. ‘#Call_For_Action’); *as_of*: recorded timestamp of the trend; *tweet_volume*: volume of tweets over the past 24 hours, if available.

While the Twitter API returns a list of trending topics for a specific *woeid* location, the tweet volumes do not provide a comprehensive measure of the tweeting activity in that location. Rather, the tweet volume refers to the overall number of tweets containing the trend, regardless of their location. Although the Twitter documentation⁴ does not provide the necessary detail on this, it was apparent after observing trends that showed up in various locations. Trends were found with the same tweet volume across all locations and, hence, participation volume of each location was not possible to be accurately measured. Therefore, the context of this study does not include any reference to this volume entity.

3 Results

Observation of the weighted graph provided an overall evaluation of activity for trends and places. In total there were 76,266 distinct trends that trended 2,307,163 times across all locations; this suggests that trends may appear repeatedly over time. The overall repetition ratio in the dataset was 97%, and ranged from 80% to 98% for individual locations, with Saudi Arabia scoring lowest and Qatar scoring highest rate. *Indegree*, *outdegree*, and *edges* were used to conduct subsequent results, with further explanation to follow in the relevant sections.

3.1 Commonality and Popularity of Trends

The node indegree indicates the number of locations at which the trend showed (*commonality*), and the weighted indegree is used to measure the total number of times a trend showed (*popularity*). Therefore, grouping trends based on indegree has revealed 7 indegree groups, as shown in Table 1. Also, weighted indegree was used to analyse activity in these groups. Although 83% of trends have appeared in one location only, their total weighted indegrees was 40%; in other words, there were less common trends amongst locations, but their popularity was higher than isolated trends⁵ – this implies that trends showing across multiple locations does not necessarily imply the prominence or importance of activity or topic.

3.2 Location Participation

The node outdegree reflects how many unique trends a location is connected to (*diversity*), and weighted outdegree measures the ability of the location to generate trends (*activity*). The outdegree descriptive statistics, presented in Table 2,

⁴ <https://developer.twitter.com/en/docs/trends/trends-for-location/api-reference/get-trends-place>

⁵ Isolated trends are those that have trended in one place, i.e. their indegree equal 1.

Table 1. Trends indegree groups

| Indegree | No. trends | Ratio | Total W. | W. Ratio | Max. | Mean | Std |
|----------|------------|-------|----------|----------|-------|--------|--------|
| 1 | 62,959 | 0.826 | 936,959 | 0.406 | 2,146 | 14.88 | 43.26 |
| 2 | 7,338 | 0.096 | 335,073 | 0.145 | 1,957 | 45.66 | 77.45 |
| 3 | 2,840 | 0.037 | 220,805 | 0.096 | 1,842 | 77.75 | 96.29 |
| 4 | 1,538 | 0.020 | 216,524 | 0.094 | 2,797 | 140.78 | 201.03 |
| 5 | 850 | 0.011 | 184,127 | 0.080 | 3,604 | 216.62 | 297.36 |
| 6 | 463 | 0.006 | 192,968 | 0.084 | 3,998 | 416.78 | 581.76 |
| 7 | 278 | 0.004 | 220,707 | 0.096 | 5,367 | 793.91 | 994.66 |

shows that Saudi Arabia came at the top of the list, with 42% of outgoing edges and weighing 20% of the total weight of the graph. Closeness in the table shows how close a location node is to all other trend nodes; it shows that Saudi Arabia has connections to 56% of trends in the graph. Nevertheless, Saudi Arabia was found lowest in terms of maximum edge weight, mean and standard deviation; Qatar was found to have the reverse values. This can be interpreted as the trends activity in Saudi Arabia was more diverse in total, but more consistent. In contrast, Qatar is connected to a limited number of trends with more focused activity. Also, Qatar’s outdegree is just 60% of Bahrain’s, although its weighted degree was 1.9 higher.

Table 2. Location outdegree descriptive statistics

| Location | Outdegree | Out. ratio | W. Out. | W. Ratio | Closeness | Max. | Mean | Std |
|--------------|-----------|------------|---------|----------|-----------|-------|-------|--------|
| Bahrain | 7,424 | 0.07 | 133,069 | 0.06 | 0.10 | 1,949 | 17.92 | 78.48 |
| Egypt | 14,282 | 0.14 | 383,830 | 0.17 | 0.19 | 1,408 | 26.88 | 58.68 |
| Kuwait | 13,891 | 0.14 | 397,960 | 0.17 | 0.18 | 1,400 | 28.65 | 51.67 |
| Lebanon | 6,044 | 0.06 | 294,761 | 0.13 | 0.08 | 2,146 | 48.77 | 133.64 |
| Qatar | 4,484 | 0.04 | 248,003 | 0.11 | 0.06 | 2,173 | 55.31 | 146.79 |
| Saudi Arabia | 42,767 | 0.42 | 468,081 | 0.20 | 0.56 | 1,175 | 10.95 | 17.43 |
| UAE | 12,389 | 0.12 | 381,459 | 0.17 | 0.16 | 1,655 | 30.79 | 70.75 |

3.3 Edges Properties

Edge weights in the graph were utilised to evaluate location activity in indegree groups. Overall, most of location activity went to common trends. Although Saudi Arabia was the highest in terms of total activity, the majority of its activity (61.26%) was identified as isolated trends. Moreover, observing originating locations for isolated trends shows that 30% of inbound edges came from Saudi Arabia, as shown in Figure 3. Egypt contributed the most in 2 and 3 indegree trend groups, UAE in 4, 5 and 6 indegree trends, and for 7 indegree trends most of in edges originated from the Lebanon.

3.4 Common Trends

Based on results so far, following is further exploration of common trends amongst countries. In the context of this study, trend is regarded common between two places, if it appeared in the trend list of both places. While this network graph excludes weight of edges taken from weighted country-trend graph, edge weights here reflect number of common trends between two linked countries. Accordingly, undirected graph was constructed as shown in Figure 2. Although, it was found with lowest tendency to relate to multi-indegree trends previously, Saudi Arabia was found with highest degree in this graph. This confirms that low weighted outdegree in common trends of a place does not necessarily imply low number of shared trends

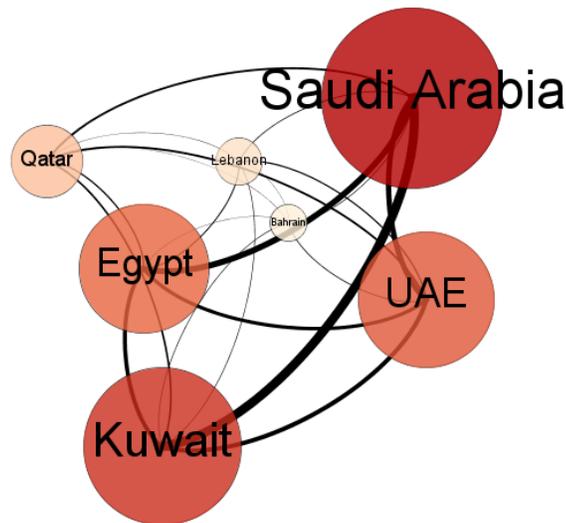


Fig. 2. Common Trends Graph

3.5 Temporal Spread and Reach

As shown in Table 1, 60% of weighted indegree was associated with common trends. To further examine temporal changes on those trends, timestamps on in-edges of trend nodes in the temporal graph were observed. Those timestamps were used to measure temporal order of locations for trend, as shown in Table 3. For instance, about 42% of first appearance of trends was in Saudi Arabia, while 36% of 7th trend appearance was in Bahrain.

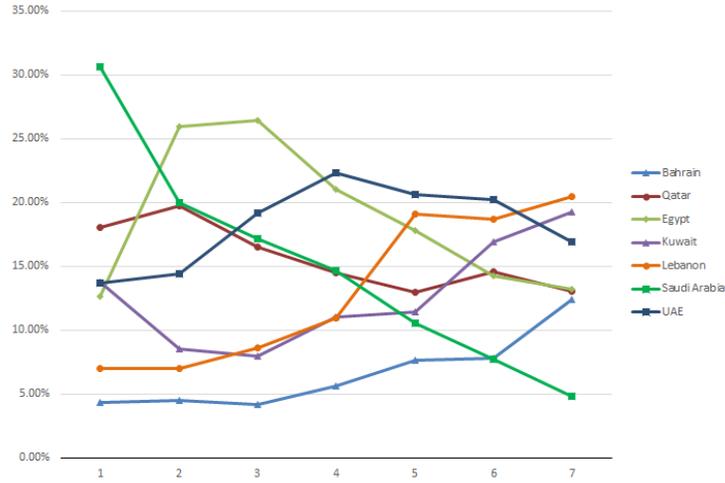


Fig. 3. Weighted contribution of countries toward trends indegree groups

Table 3. Distribution of temporal orders of location for multi-indegree trends

| Location | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th |
|--------------|------|------|------|------|------|------|------|
| Bahrain | 2.3 | 3.0 | 3.5 | 6.3 | 14.9 | 26.0 | 36.0 |
| Egypt | 16.3 | 13.2 | 21.3 | 22.8 | 16.8 | 11.7 | 2.5 |
| Kuwait | 16.5 | 29.5 | 23.8 | 15.1 | 13.2 | 11.2 | 8.3 |
| Lebanon | 5.7 | 5.4 | 6.2 | 7.0 | 8.7 | 11.3 | 23.7 |
| Qatar | 4.1 | 4.9 | 8.9 | 16.1 | 25.1 | 25.6 | 12.6 |
| Saudi Arabia | 42.2 | 28.7 | 10.2 | 7.1 | 7.3 | 8.1 | 14.4 |
| UAE | 12.9 | 15.2 | 26.0 | 25.4 | 14.0 | 5.9 | 2.5 |
| <i>Total</i> | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

A similar observation was made on the outdegree measures, with timestamps on out-edges of place nodes in the temporal graph observed; the results are presented in Table 4. The highest portion of activities in Saudi Arabia, Egypt and Lebanon made them 1st locations for trends to appear in. However, Bahrain, UAE, Qatar, and Kuwait were more active with trends that have appeared previously.

Additionally, the reach of trend was measured to examine how many other locations a trend is likely to reach based on the location in which it first appeared. Therefore, edges and related nodes relating to the first column in Table 3 were used. The results presented in Table 5 show that 62.3% of trends that first appeared in Kuwait have also appeared in exactly one more location, and 5.1% of those that first appeared in Qatar have also appeared in six more locations.

Finally, Table 6 shows the origin of common trends grouped by their indegree (connected places). As can be seen, 31.7% of trends that appeared in seven

Table 4. Distribution of appearance orders of locations

| Order | Bahrain | Saudi | Egypt | UAE | Lebanon | Qatar | Kuwait |
|--------------|---------|-------|-------|------|---------|-------|--------|
| 1st | 18.4 | 53.6 | 34.6 | 26.9 | 32.2 | 19.1 | 26.3 |
| 2nd | 24.2 | 36.4 | 28.0 | 31.9 | 30.5 | 22.9 | 47.1 |
| 3rd | 12.8 | 5.8 | 20.3 | 24.4 | 15.8 | 18.6 | 17.1 |
| 4th | 12.1 | 2.1 | 11.4 | 12.5 | 9.3 | 17.6 | 5.7 |
| 5th | 14.5 | 1.1 | 4.3 | 3.5 | 5.9 | 13.9 | 2.5 |
| 6th | 11.8 | 0.6 | 1.4 | 0.7 | 3.6 | 6.6 | 1.0 |
| 7th | 6.1 | 0.4 | 0.1 | 0.1 | 2.8 | 1.2 | 0.3 |
| <i>Total</i> | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Table 5. Further reach of trends per locations

| Reach | Bahrain | Egypt | UAE | Lebanon | Qatar | Kuwait | Saudi |
|--------------|---------|-------|------|---------|-------|--------|-------|
| 1 | 54.8 | 59.2 | 54.2 | 50.1 | 41.2 | 62.3 | 53.1 |
| 2 | 19.3 | 22.7 | 21.2 | 21.3 | 24.3 | 18.9 | 21.7 |
| 3 | 8.3 | 9.8 | 11.1 | 10.4 | 12.6 | 10.1 | 13.2 |
| 4 | 8.3 | 4.4 | 6.4 | 8.1 | 12.0 | 4.1 | 7.2 |
| 5 | 4.7 | 2.7 | 4.3 | 6.5 | 4.7 | 2.6 | 3.3 |
| 6 | 4.7 | 1.2 | 2.8 | 3.7 | 5.1 | 2.1 | 1.6 |
| <i>Total</i> | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

locations have originated from Saudi Arabia, and 5% from Bahrain. Nevertheless, Bahrain was better in terms of further reach.

Table 6. Origin of trends per reached locations

| Location | 2 | 3 | 4 | 5 | 6 | 7 |
|--------------|------|------|------|------|------|------|
| Bahrain | 2.2 | 2.0 | 1.6 | 2.9 | 3.0 | 5.0 |
| Egypt | 17.5 | 17.3 | 13.8 | 11.3 | 12.5 | 9.4 |
| Kuwait | 18.7 | 14.6 | 14.4 | 10.5 | 12.3 | 16.5 |
| Lebanon | 5.2 | 5.7 | 5.1 | 7.2 | 10.6 | 10.1 |
| Qatar | 3.1 | 4.7 | 4.5 | 7.8 | 5.6 | 10.0 |
| Saudi Arabia | 40.7 | 42.9 | 48.1 | 47.4 | 40.2 | 31.7 |
| UAE | 12.7 | 12.8 | 12.4 | 12.9 | 15.8 | 17.3 |
| <i>Total</i> | 100 | 100 | 100 | 100 | 100 | 100 |

4 Discussion and Conclusions

From the results presented in this first study, we can see that isolated trends were found to be most common across all countries, although the study includes countries with a high proportion of active users and high tweet generation rate,

such as Saudi Arabia and Egypt [22]. As previously mentioned, the number of trends returned by the Twitter API does not accurately reflect the true activity of the location. Low trending topics may indicate low consensus on these discussed topics and does not necessarily reflect tweeting activity. Also, the number of trending topics is very likely to include repeated ones, and therefore a high number of trends does not necessarily imply more new topics. Furthermore, the number of trends was not found to correlate with the tendency of location to participate in common trends. For example, Saudi Arabia was found to be connected to 56% of trends, however 61% them were isolated trends i.e. trends that only appeared in Saudi Arabia. Meanwhile, most of Qatar's trends (73.6%) were common ones, although it had edges with 6% of trends; this indicates that the activity of certain location is more focused on internal issues and concerns.

Also, the further reach of trends (i.e. appearing in other locations) was observed for each location. Although a specific location may do well in reaching other locations, the number of trends it generates may affect the total reach. For example, Qatar was highest in reaching other locations, however it was the 5th in being the origin of trends that reach all locations. This was certainly clear in the case of Saudi Arabia: its scores in reaching other locations were not comparable to its scores in being the origin of common trends, as shown in Tables 5 and 6.

In summary, this study has presented a new approach to analysing Twitter trends data using graphs and their properties. It has reinforced the utility of graph construction approaches to capture raw trends data, resulting in the temporal base graph. Then, we demonstrated how aggregated weighted graph can be generated from the base graph. The temporal graph was used to measure temporal properties such as spread and reach; the weighted graph was used to measure overall activities, such as commonality and popularity of trends, and diversity and activity of locations. This approach demonstrates how trends data can be used to evaluate topics and location activity without the need to crawl individual topics, a burdensome process. Furthermore, it shows how to measure spread of trends and reach based on their historical records as well as the originating location. This approach can be extended and applied to identify trends of other important features; for example, to extract high-spread trends, or how likely it is for a trend to reach a specific location from another one.

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