1. Research Question:

Terrorism has become ubiquitous in today's world. Since 9/11 and the beginning of war on terror, the enormity and sheer scale of terrorism related activities have increased manifold all around the world. In the past, a number of studies have been conducted to identify the causes of terrorism and to predict future attacks, but due to the complex nature of the phenomenon and a variety of perspectives in tools, methods and data used within analysis, these studies have led to conflicting results as shown by (Horgan and Boyle, 2008). After the 9/11 massacre, the United States of America started using weaponized drones as a measure to prevent future terror incidents . A huge number of drone attacks have been carried out in Afghanistan, Somalia, Yemen and Pakistan since the inception of this strategy. Views regarding effectiveness of these drone attacks are as conflicting as the terrorist attacks as some drone attacks have resulted in deaths of civilians, including women and children (Fair et al., 2014).

The context provided above forms of the basis of this research activity. In order to limit the scope of the research, it was decided to focus at Pakistan, author's home country that has suffered massively as a consequence of hundreds of drone attacks and thousands of terrorism related activities since early 2000s (Shah, 2010). A review of literature revealed the multiplicity of views around terrorism and drone activities in Pakistan. Some literature claims that drone strikes have been effective in curbing down terrorism attacks in Pakistan (Johnston and Sarbahi, 2012); however, some researchers hold the view that that death of innocent civilians and children in these strikes creates a sense of revenge and anger which fuels further terrorist acts, primarily as suicide attacks in Pakistan (O'Connell, 2010).

The research questions that have been posed for this practical focus on developing a visualization system for visual analytics of drone strikes and terrorism event data in Pakistan and whether one can find any temporal or spatial relations between drone strikes and suicide attacks in Pakistan. To cover the full spectrum of war of terror and era of drone strikes, it was decided to use relevant event data recorded between 2000 and 2015. Following research questions have been posed for this experiment.

- Can we find spatial and temporal patterns and relations between events of drone attacks and suicide bombings in Pakistan using geographic spatio-temporal visualization?
- Can we visually identify hotspot of suicide attacks and drones strikes in Pakistan?
- Is it possible to visually identify a relationship between frequency of suicide attacks and number of civilians and children killed drone strikes.

2. Data Source(s):

In order to answer the questions posed above, following open datasets were used for visualizations and resulting analysis.

- **Global Terrorism Database** (https://www.start.umd.edu/gtd/)
  The global terrorism database (also known as GTD), is the largest open source database and carries a record of 150,000 terrorism related activities globally from 1970 to 2015. This database has been used in numerous research activities and is currently being maintained by Gary LaFree at University of Maryland, USA. For the

experiment, we filtered the complete GTD dataset to include events of terrorism in Pakistan from 2000 – 2015.

- **Drone Strikes Data** (https://www.thebureauinvestigates.com/projects/drone-war) The Bureau of Investigative Journalism regularly collects data on US led drone strikes globally from international media and research publications and offers as open data. A subset of complete drone strikes data, covering strikes in Pakistan only was extracted from this dataset for visualizations and analysis.

3. User Instructions:

The visualization system contains two different views (tabs) in order to conduct detailed spatio-temporal and temporal only visual analytics exercises in the context of analytical questions posed earlier.

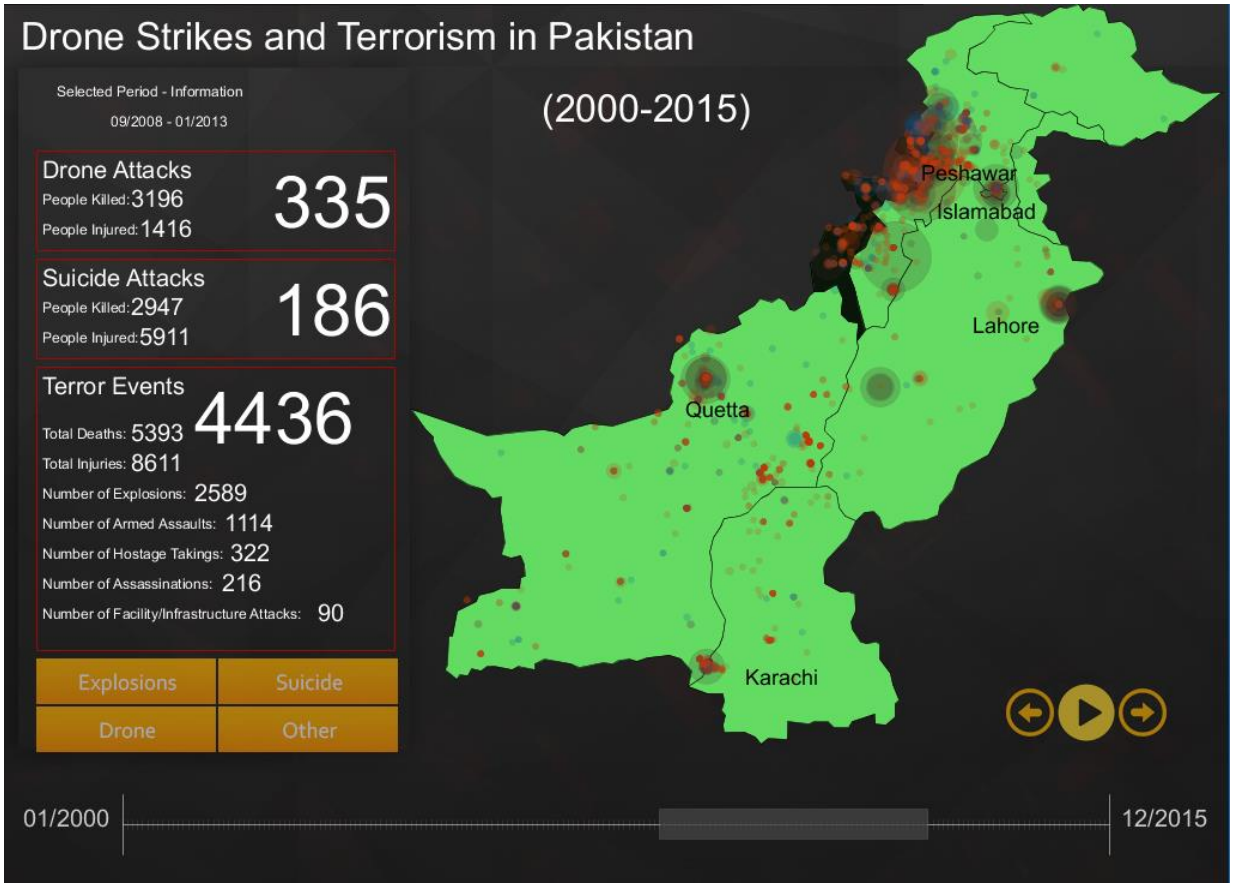

FIG 1. Geographical Spatio-Temporal Visualization of GTD and drone attack data

The primary view shows a geographic visualization with map of Pakistan and a draggable multiple-range slider which can be used to see the effect of drone attack, suicide bombing events and total number of terrorism events for selected period of time as shown in Fig 1. The slider also has animation features which can be activated using the play button or by pressing the spacebar. Users can go forward and backward on the timeline using either left/right buttons or cursor keys on the keyboard. This view graphically places events on the map from selected time range as drone attacks (choropleth coloring in FATA), suicide bombings (black) and other terrorism events (red). Filtering buttons have been provided to select the data to be displayed.

The second tab (FIG 2) shows the timeline view of the drone attacks with total number of suspected terrorists and civilian/children killed as aggregated data for each month, compared with number of suicide attacks. It's an interactive chart and hovering mouse over a certain month on the timeline provides a summary data generated as a result of drone attack activities in that month.

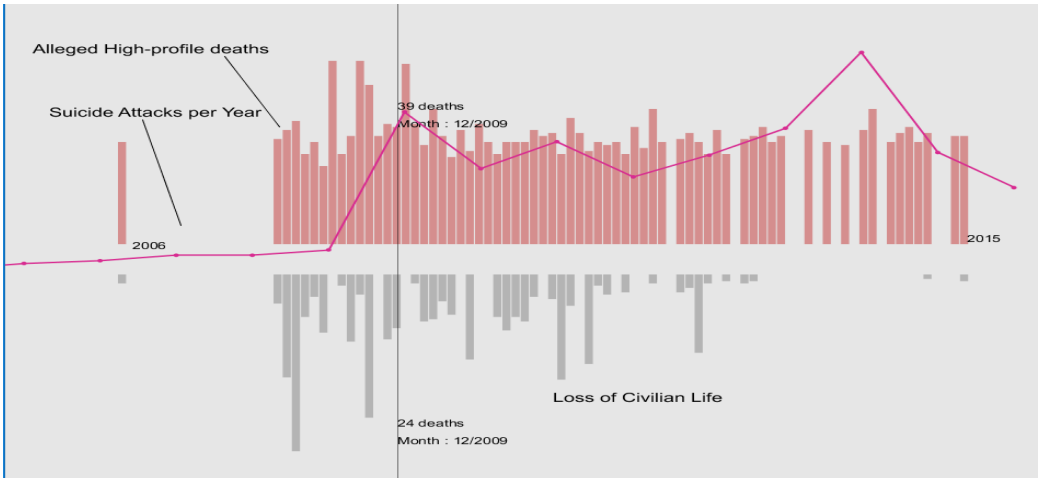

FIG 2. Timeline Visualization of drone attack casualties and suicide bombings

4. Design Justification:

The visualization design layout with visual and interactive component has been carefully selected in order to make maximum use of users' mental models that they might have developed while interacting with similar geospatial visualizations, as given in (Munzner, 2014). A map based layout was chosen to show event data with a multi-range slider to control the temporal selection and a split bar graph in second view. Relevant data from was graphically displayed using geographical mapping, colors and numbers.

4.1 Visual Encoding:

The GTD dataset events data exhibited a lot of variation in terms of their attributes i.e. attacks types, target types and weapon types etc. A dark background with light foreground was selected according to mood of analysis. In order to keep the focus on the research questions, graduating symbols were used to display event data following the ideas in (Munzner, 2014) and (Howard and MacEachren, 1996). The size of symbols represents the number of deaths caused by the particular incident. An overlaying of symbols, resulting in an increasing in contrast was used to identify the presence of hotspots for selected time range. Red colour was selected for terrorism events, distinguishing suicide events with black color.
In order to show the impact of drone attacks mainly in the FATA region, choropleth based contrast was used as the exact location of these attacks were not known.

For the second view shows a bar showing a temporal view of the number of deaths caused by drone strikes, split by number of alleged terrorists killed and number of civilians and children killed over time. The two sections of the bar graph helped visually identify the proportion of loss of innocent lives to number of alleged terrorists killed in the attack.

4.2 Interaction:

The primary mode of interaction for the first view required a control that could be used for analyzing observations over time and geography. It was decided that a controllable multi-range slider based interface would best serve the purpose of identifying any temporal or geographic patterns in the drone strikes and suicide attack attacks dataset put together, as mentioned in (McLachlan and Munzner, 2008)and (Kapler and Wright, 2005). A timeline interface was implemented based on the code developed by Till Nagel (Nagel, 2012). The visual layout and functionality of the Java code was modified to offer the required functionality. Buttons were added in addition to keyboard controls to offer better navigation.

Mouse-over interactions were also implemented for visualization in both views. In first view, mouse-over action at the provinces display province level details of terror attacks and suicide attacks. In the second view, this interaction is used to reveal the summary of drone strikes aggregated by months with data o

5. Data Insights:

The visualization system developed for this exercise did try to answer the analytical questions to some extent. For the first question, Some geographical relationships could be seen between the FATA province, where most of the drone strikes and KPK province which is affected worst by terrorism attacks in general and suicide attacks in particular. A temporal animation showed a rise of terror attacks right after the drone strikes started in 2005. Later surges in terror attacks in 2000 also slightly correlated with suicide attacks during that time.
It was also observed that KPK province turned out to be a major hotspot of terrorist activities and drone strikes were all centered at the FATA region creating a drone hotspot around the city of Peshawar (shown in black). After the creation of these hotspots, further centers of terrorism could be seen developing across all provinces, mainly in the provincial capitals. These observations can be truly observed by selecting an interval of one year and running the timeline animation. Screenshot of such a view can be seen in FIG.3..

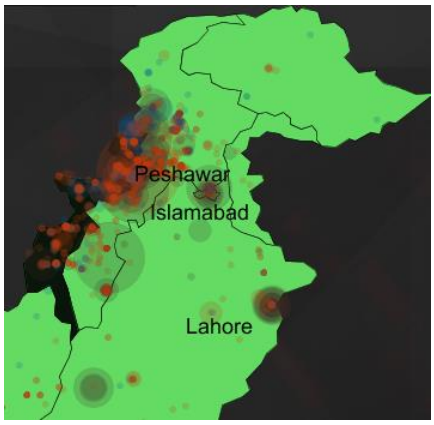

FIG 3. Drone strikes region, shown in black and related terror activities in adjacent areas.

In the second view (FIG. 4), splitting the data as bar graph helped highlight a rise in the deaths of civilians and children at particular times on the timeline and at some points, some correlations could be visually identified in the terror attack surges.

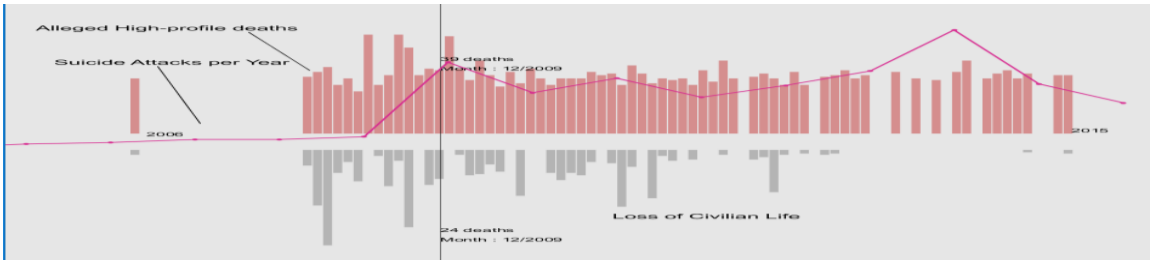

FIG 4. Timeline view of drone casualties vs suicide attacks

6. Critical Evaluation and Reflection:

The first visualization addresses the first two analytical questions by showing the existence of some geographical and temporal patterns and relationships between drone strikes and rise of terrorism activities particularly suicide attack in adjacent areas. Time-slider animation revealed that increase in terror events did have some temporal and geographical correlation with drone strikes; however, these patterns were not conclusive enough to identify a causal relationship between these events. The visualization did help identify existence of terror hotspots and how they geographically relate to areas under drone strikes.

The second view in the visualization, titled as timeline view does uncover some patterns of an increase in loss of civilian lives during certain time intervals i.e. between 2005 and 2010, but matching this data with GTD to measure the impact could not be fully performed because of some programming issues faced during the last hours. The view attempts to explore deeper relationship but could not uncover any definitive patterns for identifying a causal relationship. It was strongly felt that data about geopolitical circumstances of Pakistan, internal politics and unrest in neighboring countries should have been included to get a deeper insight. Most of the data in this regard was unavailable which, coupled with some shortcomings in programming limited the scope of this exercise and resulted as third question only being partially addressed.

It can be confidently said that first two research questions posed for this exercise have been addressed to a reasonable extent. However, towards the conclusion of this exercise and after gaining a deeper insight into the possibilities that processing language had to offer, it was realized that research questions could have been answered in a better way, had those possibilities become obvious earlier. Following observations can be stated in this regard:

1. A 3D cube could have been used to visualize the spatio temporal aspect of the analysis.
2. Numerical data presented on the main view could be better displayed graphically with animated pie charts and bar graphs, however, animating multiple visual objects caused lagging and hence numbers were displayed instead.
3. GTD carries information about terrorist groups involved terror incidents. Although this information is very sparse and most of the data has missing values. The available data could be used to identify movement of a particular group could be monitored by using movement visualizations and creating trajectories of these movements.

The data obtained from Global Terrorism Database and Bureau of Investigative journalism as the foundations for this visualization had been originally collected through public media, research articles and other such sources as indicated by the curators. The event data offered by these databases do not present an official narrative and hence becomes highly questionable.

Data about economic conditions, political stability, internal politics and major political events can be imported for much deeper analysis of the domain as these could indeed prove to be the hidden factors affecting the frequency of terror attacks and drone strikes. These shortcomings will be overcome in future experiments with terrorism related analytics by gaining further knowledge of processing and identifying potential datasets for deeper analysis.

7. References

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