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## CRIME BELT MONITORING VIA DATA VISUALIZATION: A CASE STUDY OF FOLIUM

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**Abstract:** Crimes and criminalities are rampant in various communities across the globe, to the extent that no community is free of at least one of criminal act. In Nigeria like other part of the world, the activities like that of Fulani herdsman have been leading to many criminal acts, claiming the lives of many innocent Nigerians. This study aims at monitoring crime belt via data visualization using Folium data visualization tool that has ability to superimpose text data on the Chloropleth map. It was used to place the types of crime and the date of the crime on the map as it's been provided in the dataset at each location where the criminal act of Fulani attacks can be monitored. The result was a simple and precise details of the dataset that shows important information and tells the stories of the dataset in a better way. The results were also clustered and the crime areas were evident in a good perspective and less congestion manner using Folium data visualization tools.

**Keywords:** *Chloropleth map, Crime Data, Data mining, Data science, Data visualization, Folium, Security, Visualization Techniques, Visualization Tools*

### 1.0 INTRODUCTION

Communication and presentation are very important parts of research, and data visualization is a component of research communications and presentations. It has the ability to synthesize large amounts of data to

give a good visual interpretations that is easy for the brain to understand an image than words and the visual or graphical representations is an important part of academic literature. The increasing accessibility and quantity of data require effective ways to analyze and communicate the information that datasets contain in an easy-to-comprehend manners. If human can see something, such things can be quickly internalized. Hence, in this data-driven decision-making world, data visualization tools are important to analyze large amounts of data. Choice of any of these tools depends on the dataset and purpose at which the visualization is aimed (Anoucia, Gohel, & Vairamuthu, 2020). Data visualization improves operations, provide better customer service delivery and, ultimately, increase profitability and productivity in case of business and security industries respectively. Also, since human eyes draw colors and patterns, such that red colors can be quickly identified from blue, likewise square from circle, then data visualization speaks volume in conveying, information to the audience. Data visualization can be used to view only excellent information in an easy and faster ways, emerging technological innovation brings about a data-driven world that

facilitates quick decision making. Hence, it is increasingly necessary for professional, particularly security operatives and government to be able to use appropriate data visualization tools to make decisions and use visuals to tell stories of how, who, when, where and what the data is saying. Folium is a powerful library in python and it helps the user in creating several types of leaflet maps. It is a very interactive library. The spatial data contains geographical (Latitude, Longitude and Altitude) feature that distinct folium for dashboard building. The details impression of the content can be viewed through zooming or clicking round the map, though some special characters affect display on the maps when using some browser like google chrome. It also allows data to be superimposed on the map (Roos, 2015; Ivan, 2018).

Fulani is one of the major ethnic group in Nigeria. The ethnic group dominates Borno, Sokoto, Kastina, Adamawa, Kebbi and Niger States of Nigeria. Fulanis are known to be farmers particularly livestock and cattle rearing. Fulani ethnic group through their farming profession have been contributing to the economy of Nigeria in terms of food production and job creation. Limited access to arable land and unreliable water sources have increased pressure on natural resource, resulting in blocked grazing routes and destruction of farmland by Fulani cattle. Farmers in response, both in groups or individual have been resulting into coalesced, cattle theft and killing in response to destructions of farmland. Fulani also walk about with weapons (Ajagbe, Idowu, Oladosu, & Adesina, 2020). These have accounted for violent clashes that have been claiming thousands of lives and rustling disputes that have a deadly tendency and also reprisal attacks playing out by the day and threaten national security. The concern for national security has risen significantly for about a decade now, but information overload hinders the effective analysis of

terrorist and other criminal activities. Data mining and visualization applied were view as tools for the law enforcement while intelligence analysis holds the promise of alleviating problems on insecurity. The review of crime data mining techniques and four case studies of ongoing COPLINK project were presented, but Folium was not included (Inemugha, 2018; Bagu & Smith, 2017; Chen, et al.). It is very important for academic to use data visualization tools (computer aided tools or computer application) to tell the stories of Fulani militia attack in Nigeria to call the attention of political leaders and security operatives to nip the menace in the bud. This paper is aimed at crime belt monitoring via data visualization: a case study of folium.

## STUDY ORGANISATION

This work is presented as follows. Section 2 contains data visualization tools and works, section 3 is the method and materials for the research, visualization results and analysis were presented in section 4, conclusion is made in section 5 and section 6 comprises of limitation and direction of future work.

## 2.0 DATA VISUALIZATION TOOLS AND RELATED WORKS

### 2.1 Data Visualization Tools

Data Visualization is a major method that aids data to get an absolute data interpretation and as well the discovery of data values. Data is represented visually to provide a basic interpretation to what data is saying without difficulties. Ajibade & Adediran, (2016) studied various data visualization tools and how they can be well understood and utilized in data mining. Contributions and discussion on adequacy and inadequacy of data visualization tools in research were made (Ajibade & Adediran, 2016). Wang, Wang, & Alexander, (2015) posted that data analytics and visualization should be integrated seamlessly so that they can work best in any project. The challenges

of data visualization tools were equally discussed and new methods, applications, and technology progress of data visualization were presented (Wang, Wang, & Alexander, 2015). There are some data visualization tools which are available as software that are simple and do not require serious coding skill. Data visualization tools are easier to operate than the traditional tools that make the data. Therefore, many organizations have drawn their insight into building their own

data visualization libraries or tools. Below is a table comparing different data visualization tools such as Modest Maps, Plotly, Tableau, Microsoft Power BI, Gephi and Folium, they have different features and allow the software to perform task in different project. Some of these tools require various degree of programming languages and are available at lower cost (Anouncia, Gohel, & Vairamuthu, 2020; Bhingarde & Vora, 2018).

**Table 1: Comparison of Data Visualization Tools**

S/N	Authors and years	Tools	Features	Inference
1	Anouncia, Gohel, & Vairamuthu, (2020)	Modest Maps	Modest Maps is an interactive tool with different functionalities such as maps. It comes free of charge for the intending	Unlike folium, geospatial leaflet features are not supported
2	Anouncia, Gohel, & Vairamuthu, (2020)	Plotly	Plotly is a tool that uses Python for data analysis and visualization. Plotly supports different charts such as bar charts, bubble charts	Unlike folium limited access and features (like 50 KB) are given to free users and not a map related tool
3	fastcompany, (2019)	iCharts	iCharts presents the output in the form of charts like spreadsheets, Google docs data for the users in sports, business, and many categories.	Unlike Folium, iCharts cannot handle location data.
4	Bhingarde & Vora, (2018)	Microsoft Power BI	It is a user-friendly tool that is used majorly for business analysis by taking the help of cloud. This tool provides interactives and flexible service to the users for easy visualization project.	Unlike Folium, Power BI will become slow when high volume of data is involved.
5	Miller, (2017)	Tableau	Tableau is one of the important data visualization tools that is common to business projects, it is a fast, flexible and map related tool. It supports all types of data formats.	Unlike Folium, Tableau will become slow when high volume of data is involved
6	Ali, Gupta, Nayak, & Lenka, (2016)	Gephi	It is a user-interactive data visualization tool in nature, and is applicable for complicated systems and networks.	Compare to folium, Gephi cannot handle location data.
7	Roos, (2015)	Folium	Folium is a powerful library in python, it helps user in creating several types of leaflet maps. It is a very interactive library, the spatial data contains geographical (Latitude, Longitude and Altitude) feature that distinct folium for dashboard building.	Folium can handle large location dataset using leaflet.js and then visualize it on choropleth map. The map is interactive and the locations can be clustered to avoid congestion.
8	Bernasco & Elffers, (2010)	Spatial	It is a user-interactive data visualization tool in nature, and is applicable for complicated systems and networks.	Compare to folium, Spatial cannot handle location data.

## 2.2 Related Works

Kester 2013 studied Criminal Geographical Profiling, using formal concept analysis (FCA) for visualization and analysis of crime data. The study considered the features and crime data attributes as crime type and location. Cartographic Visualization or Geography was another form of data visualization considered in the study but a promising tool like Folium was not considered. Bayoumi, et al, 2018 worked on interactive data visualization to provide insight to crime data. Tableau visualization tool was used as data visualization tool and Microsoft Excel for analysis. The results show a critical insight into cities which have the most frequent crimes (Bayoumi, AlDakhil, AlNakhilan, Al Taleb, & AlShabib, 2018). The Implemented geographical information system (GIS) to provided evident based support for crime analysis was carried out by (Subhashini & Milani, 2015). The study aimed at providing crime monitoring support using GIS to monitor crime locations based on open source google map tool. The crimes reported by users was analyzed using the application. It later visualizes the crimes list and plots the google map by marking the number of crimes at specific locations. Results helped officials to make decision quickly and concentrate on locations that have more crimes (Subhashini & Milani, 2015).

Vasiliauskas & Beconyte (2016) worked on Cartography of crime: Portrait of metropolitan Vilnius. The crime data collected for the study was reportedly categorized into three, namely: crimes of property, crime of violence, and other crimes. An understanding of cartographic methods and thorough spatial analysis of labeled data were needed for good crime map of a city according to the study (Vasiliauskas & Beconytė, 2016). In a study that aimed at showing the pattern and rate of crime in Nigeria using the data collected and to show the relationships that exist between various

crimes. Analyzed dataset provided insight on crime activities within Nigeria. The well-known crime in Nigeria includes burglary, bribery and corruption, cyber-crimes, murder, rape, kidnapping, terrorism, money laundering and so on were identified and analyzed. The existing linear relationship between the crime activities and correlation analysis were used in the study. It was further tested whether the linear relationship is significantly different from zero. The ten states that top crime list in Nigeria were pointed out in line with Nigerian National Bureau of Statistics in 2016 data, as follows: Lagos, Abuja, Delta, Kano, Plateau, Ondo, Oyo, Bauchi, Adamawa and Gombe States. Both descriptive and inferential of crime dataset obtained between 1999 and 2013 were analyzed (Oguntunde, Ojo, Okagbue, & Oguntunde, 2018).

Conclusively, all these studies used different data analysis and visualization tools for crimes and other data. However, they were unable to feature the type of crime and date which are important crime data at each location of the crime has been implemented in this study. Also, some of them did not support user interactive data visualizations. So, this study aims at filling this gap via superimposing type of crime and date on the crime locations.

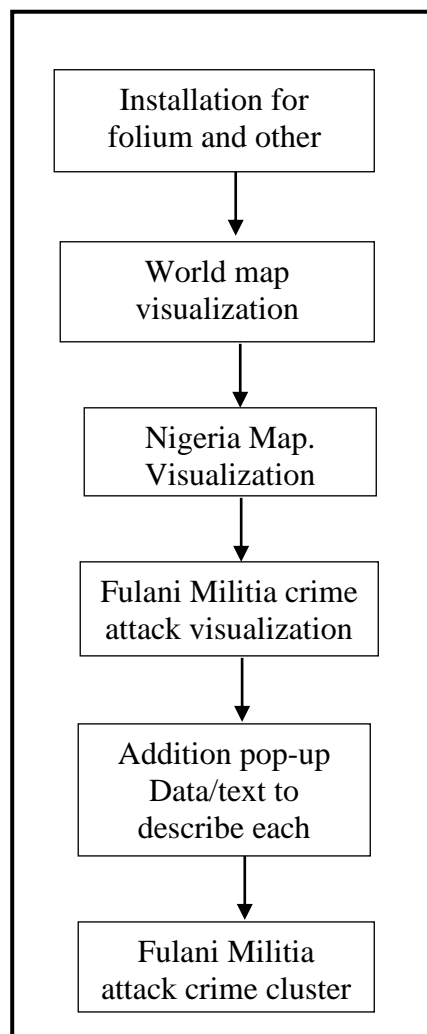
## 3.0 METHOD AND MATERIALS

The methods and materials used to ensure excellent implementation for the research are entailed in this session.

### 3.1 Study Design

The fulani ethnic militia attacks in Nigeria and crime data visualization in this study was designed using folium as data visualization tool. The selection of Folium as the visualization tool in this study was because it has so many advantages over other prominent visualization tools. Folium Choropleth map is interactive; which means users can actually interact with it by zooming

in and out, clustering, pop up text, location marker to mention few. Folium has a built in tilesets such as OpenStreetMap, Mapbox, and Stamen and also support custom tilesets too. Algorithm in Figure 1 was the proposed algorithm for the Fulani Ethnic Militia Attacks in the study.



**Figure 1: Proposed algorithm for Crime Belt Visualization**

### 3.2 Data Collection

The data used in this study was acquired from (Data World, 2018). It has about 185 Nigeria datasets covering Africa Conflict data, Africa Millennium Development Goals, Nigeria-health indicators, Nigeria financial sectors, Nigeria settlements, Nigeria 2006

population data, Fulani Ethnic Militia Attacks Jan 1 – Jun 23, 2018, Fulani Ethnic Militia Attacks Jan 1 - Dec 31 2016 etc. This database provides reliable dataset for planning and research in Nigeria and beyond over the years. The updated Fulani Ethnic Militia Attacks -Jan 1 - Jun 23 2018 dataset was given a particular attention and used in this study because of the features such as Event type and event date which was concatenated to form event\_type\_date, Location, Latitude, longitude, etc. and its relevance to data visualization that this research aimed at. Folium explored the following features specifically for this study to make the visualization unique. The dataset is available in <https://data.world/datasets/nigeria>. The link has not only over the years provided reliable dataset for research and planning but also makes it easy for everyone to get clear, accurate, fast answers to any business and research questions. Data World relies on popular Nigeria dailies and some foreign and local news agencies for their data source.

### 3.3 Study Setup

Aside from installation of Anaconda that has a lot of data processing tool for the study, another important library that was instrumental in this crime of Fulani Ethnic Militia Attacks visualization study was Folium. The installation of folium was confirmed using the code in Figure 2, and world map was displayed. The map was zoomed to focus on Nigeria map by setting the zoom start to 6, and Longitude and Latitude of Nigeria was called through google as 9.0819988, 8.6752768. The dataset was read by the model and 238 unique cases with 27 features in the dataset was observed from the dataset. Longitude and latitude were superimposed on the map to the location of each crime as well as other details like date at each location.

```

1 |conda install -c conda-forge folium=0.5.0 --yes
2 |import folium
3 |
4 |print('Folium installed and imported!')

```

**Figure 2: Folium installation**

#### 4.0 VISUALISATION RESULTS AND ANALYSIS

The use of data visualization is a topical issue especially for crime or security related issue and the results of this was a compact, dynamic and fantastic one that displayed data of Fulani militia attack and calls the attention of Federal Government of Nigeria and the security operatives to nip the menace in the bud. Since the crime locations can easily be seen at a glance using the result of this study, cutting edge technology was used to visualized the world map that was generated using folium visualization tool as shown in figure 3. Nigeria map was generated for data visualization showing important locations in Nigeria as shown in Figure 4. The table showing the features of the dataset as presented in Figure 5. The data features in the table makes data visualization through Folium possible and unique. The Nigeria map showing where criminal activities of Fulani militia attack took place in the period under review is presented in Figure 6. The

particular locations where the crime by Fulani militia attacks occurred in Nigeria.



**Figure 3: World map**



**Figure 4: Nigeria map**

	data_id	iso	event_id_cnty	event_id_no_cnty	event_date	year	time_precision	event_type	actor1	assoc_actor_1	...	latitude	longitude	geo_precision
0	1639795	566	NIG12584	12584	22 June 2018	2018	1	Violence against civilians	Fulani Ethnic Militia (Nigeria)	NaN	...	9.4500	12.0667	1
1	1639780	566	NIG12569	12569	20 June 2018	2018	1	Violence against civilians	Fulani Ethnic Militia (Nigeria)	NaN	...	9.5333	8.9000	2
2	1639775	566	NIG12564	12564	16 June 2018	2018	2	Battle-No change of territory	Fulani Ethnic Militia (Nigeria)	NaN	...	7.8155	8.8604	2
3	1634962	566	NIG12549	12549	14 June 2018	2018	1	Violence against civilians	Fulani Ethnic Militia (Nigeria)	NaN	...	7.1624	8.2409	1
4	1634959	566	NIG12546	12546	13 June 2018	2018	1	Violence against civilians	Fulani Ethnic Militia (Nigeria)	NaN	...	8.1333	8.8000	2

5 rows × 28 columns

**Figure 5: The table of the data visualization**



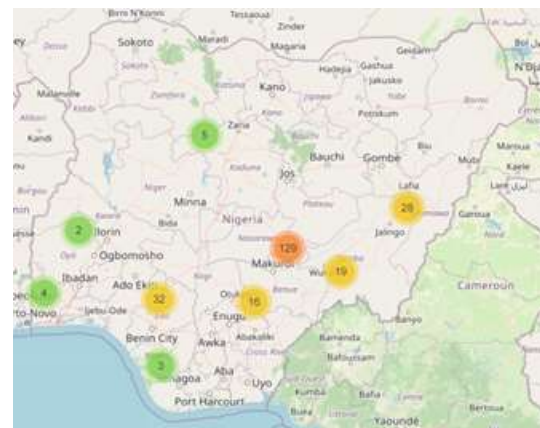
**Figure 6: Data visualization of Fulani militia attack**

The marker was introduced at each point of the crime for better visual, when any of the marker is clicked, unlike other map related data visualization work that will only show/write the name of the location, our research added type of the crime committed at that location and date, '*violence against civilians on 24 February, 2018*'. These will pup-up when the marker is clicked as shown in Figure 7. This is the heart of data visualization tool called folium, the data or text was able to be superimpose on the map, this gives a better, unique and interactive data visualization. It is observed that the markers are congested in the neighborhood, the data visualization results were clustered to produce simple visual of Fulani militia attacks in Nigeria in a period under review in a good perspective, less ambiguous and less congested manner as shown in Figure 8. The interactive feature of Folium also makes it possible to give the details of each clusters at

a click of button or zooming the cluster. Figure 8 was a product of zooming of clustered 16 in Figure 9.

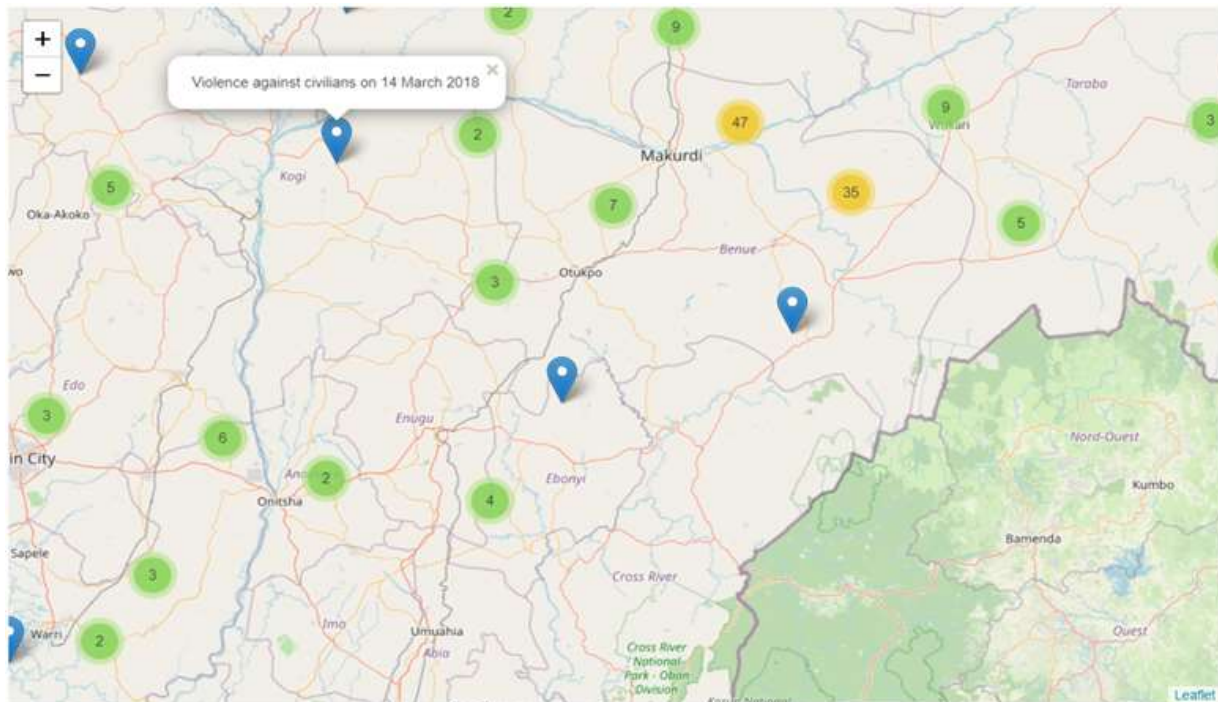


**Figure 7: Crime type and dates super-imposed on the map**



**Figure 8: visualization of clustered crime scene**





**Figure 9: visualization of the clustered crime scene**

## 5.0 CONCLUSION

In the world of information and communication technology (ICT) and data science, where every information is crucial, visual information is being relied on to find useful patterns, which the traditional methods of data visualization cannot provide in the world of dynamic crime. Data visualization tools that deal with all the characteristics of data and gives result that tells pattern in good time is required for crime related data. In this paper, some popular data visualization tools were reviewed and observed their merits and demerits. The crime and criminality of some Fulani ethnic group have occasioned visualizing their activities using a very promising data visualization tool that will be able to give the details and pattern of the crime as well as other information associated with a particular crime in the studied location. Unlike other map related data visualization work that will only show/write the name of the location. This study proposed algorithm for visualization of Fulani Ethnic Militia attacks in Nigeria and leveraged on

data visualization tool called Folium as a very promising data visualization tool to carry out the study. The study was able to experiment and added the type of the crime committed at that location and date using Folium data visualization tool on the Fulani militia attack data and Folium analyzed and visualized data in a better way compare to other data visualization works by Anouncia, Gohel, & Vairamuthu, (2020); Bayoumi, AlDakhil, AlNakhilan, Al Taleb, & AlShabib, (2018); Caldarola, Picariello, Rinaldi, & Sacco, (2016) that could not give details of the dataset. To the best of the researchers' knowledge, this is the first study to visualize the crime and criminality act of some members Fulani ethnic group in Nigeria with such interactive tool.

## 6.0 LIMITATIONS AND FUTURE WORK

This study is a useful case study of a crime belt monitoring scenario which the government and industry can learn from, and its usefulness also to the academic

community is very promising. It therefore recommends the deployment of security operative active areas immediately to curb the criminal act and restore law and order. This will also help the Federal Government of Nigeria to gain the trust of general populace by showing them ability to quickly respond to threats. Also, this study recommend that Folium should be considered for any data visualization project that requires superimposing of text data on the map for better visual. The limitation of this study was that Folium did not allow special characters which could have allowed the study to feature more details of the pop-up text on the Chlorople map in the dataset meaningfully. Again, the dataset used was for a limited period between Jan 1 - Jun 23 2018. We hope to address these in our future studies.

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