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DYNAMIC VISUALIZATION OF THE SPREAD OF COVID-19 IN MEDAN CITY USING HEATMAP WITH PYTHON

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Abstract: The rapid and widespread transmission of COVID-19 has posed significant challenges for public health management, particularly in densely populated urban areas like Medan. Manual data reporting often fails to convey the dynamic nature of the virus's spread in a clear and actionable manner. This study aims to address this gap by developing dynamic visualizations of COVID-19 distribution using heat maps created with Python programming. The study utilized official COVID-19 datasets sourced from platforms like Kaggle, which include district- and municipal-level data across North Sumatra. Methodological steps included data collection, preprocessing, and visualization using Python libraries like Pandas and Matplotlib. These tools enable the transformation of static tabular data into interactive heat maps that highlight spatial and temporal trends in infections, recoveries, and mortality. The visualizations reveal that Medan City recorded the highest number of confirmed and recovered cases, while Deli Serdang had the highest number of deaths. Conversely, North Nias and South Nias showed the lowest mortality rates. The resulting spreadsheets provide a practical solution for monitoring the pandemic's development and serve as decision-support tools for policymakers and health authorities. In conclusion, dynamic data visualization improves understanding of COVID-19 patterns and supports effective pandemic response strategies.

Keywords: dynamic visualization; COVID-19; python; heatmap.

Abstrak: Penularan COVID-19 yang cepat dan meluas telah menimbulkan tantangan yang signifikan bagi manajemen kesehatan masyarakat, terutama di daerah perkotaan yang padat penduduk seperti Kota Medan. Laporan data manual sering kali gagal menyampaikan sifat dinamis penyebaran virus dengan cara yang jelas dan dapat ditindaklanjuti. Penelitian ini bertujuan untuk mengatasi kesenjangan ini dengan mengembangkan visualisasi dinamis distribusi COVID-19 menggunakan peta panas yang dibuat dengan pemrograman Python. Penelitian ini menggunakan kumpulan data resmi COVID-19 yang bersumber dari platform seperti Kaggle, yang mencakup data tingkat kabupaten dan kotamadya di seluruh Sumatera Utara. Langkah-langkah metodologis meliputi pengumpulan data, prapemrosesan, dan visualisasi menggunakan pustaka Python seperti Pandas dan Matplotlib. Alat-alat ini memungkinkan transformasi data tabular statis menjadi peta panas interaktif yang menyoroti tren infeksi, pemulihan, dan mortalitas secara spasial dan temporal. Visualisasi tersebut mengungkapkan bahwa Kota Medan mencatat jumlah kasus terkonfirmasi dan sembuh tertinggi, sementara Deli Serdang memiliki jumlah kematian tertinggi. Sebaliknya, Nias Utara dan Nias Selatan menunjukkan tingkat mortalitas terendah. Heatmap yang dihasilkan memberikan solusi praktis untuk memantau perkembangan pandemi dan berfungsi sebagai alat pendukung keputusan bagi para pembuat kebijakan dan otoritas kesehatan. Kesimpulannya, visualisasi data dinamis meningkatkan pemahaman pola COVID-19 dan mendukung strategi respons pandemi yang efektif.

Kata Kunci: visualisasi dinamis; COVID-19; python; peta panas.

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INTRODUCTION

The Coronavirus, or Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV), is a virus that attacks the respiratory system, causing respiratory disorders, acute pneumonia, and even death. Coronaviruses themselves are a large family of viruses that cause illnesses ranging from mild to severe. At least two types of coronavirus are known to cause disease that can cause severe symptoms (Information et al., 2023) . Coronavirus Disease 2019 (COVID-19) is a new type of disease that has never been previously identified in humans. Common signs and symptoms of COVID-19 infection include acute respiratory symptoms such as fever, cough, and shortness of breath. The average incubation period is 5-6 days, with the longest incubation period being 14 days.

According to the Indonesian Ministry of Health, the Coronavirus, or COVID-19, is part of a large family of coronaviruses that cause disease in humans and animals. In humans, it typically causes respiratory infections, ranging from the common cold to serious illnesses such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS), new types of coronaviruses discovered in humans since the outbreak began in Wuhan, China, and cause Coronavirus Disease 2019 (COVID-19) (Nur Rohim & Zuliarso, 2022).

The rapid spread of COVID-19 has had a far-reaching impact on people in various countries around the world. While there is currently no vaccine or definitive treatment for COVID-19, various public health interventions (non-pharmaceutical) have been used to control its spread (Nomor et al., 2021).

The research previous discusses coronavirus case data visualization by displaying the number of confirmed cases, deaths, and recoveries from various provinces in Indonesia. This data visualization is expected to provide a solution to address coronavirus-related issues. The available data and information visualization dashboard is quickly understandable thanks to its use of graphics and can be made more engaging with the interactive dashboard options provided by Tableau (Informasi et al., 2023).

When datasets are too large or too complex, interactive visualizations become a useful tool in exploratory data analysis. Interactive visualizations can enable, among other things, the display of information at varying levels of detail, exploration of data using coordinated views, and dynamically changing graphs to focus on user interests. While notebooks are traditionally used with static visualizations, advanced interactive visualizations can be embedded and support sophisticated and rapid visual analysis (Data et al., 2022).

In this research, three simple yet effective methods that data scientists can use to create interactive visualizations in Jupyter Notebook: matplotlib callbacks, visualization toolkits, and custom HTML embedding. This research demonstrates the spread of the COVID-19 disease through heatmaps. Each of these approaches has advantages and disadvantages that developers need to consider to make informed decisions regarding their visualization tasks. The purpose of this study is to develop a deeper understanding of these three methods and to select the appropriate implementation approach based on the desired level of interaction, customization, and data flow.

METHOD

This research was conducted with several stages written in image 1. The initial diagram shows the stages in this research starting from the problem. The next stage is data collection, dataset preprocessing, data visualization, and evaluation and results.

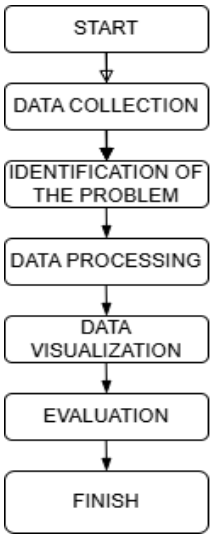

Image 1. Research Flowchart

Data Collection

COVID-19 data was collected from the Kaggle platform, specifically district/city data in North Sumatra Province, including the number of cases, recoveries, and deaths.

Problem Identification

Observed gaps in the presentation of COVID-19 data, which remained static and lacked interactive features.

Data Preprocessing

The data was cleaned, formatted, and transformed into a structure that could be processed by Python (e.g., a DataFrame with Pandas).

Data Visualization

Visualization was performed using Python through the Matplotlib and Pandas libraries to create a heatmap. This heatmap illustrates the spatial and temporal distribution of COVID-19 cases.

Evaluation & Analysis

The visualization results were analyzed to identify distribution patterns, high-risk areas, and areas with the highest and lowest recovery and death rates.

In this study there are several stages, including data collection, namely the collection of COVID-19 data. At this stage, data will be taken through the kaggle site and data from the province of North Sumatra will be tested to find out the problem and the data is processed to be visualized.

First of all, it is necessary to integrate the data on the current COVID-19 data using Python. Matplotlib and pandas are methods to make data visualization more interactive, easy to read, and easy to analyze. The visualization carried out is to change rigid table data into graphs, diagrams, and so on that are able to show changes and differences in data more clearly (Fahri & Ramdhani, 2023).

As a result, the display of ordinary analysis data becomes more beautiful and in the form of graphs with good visuals using matplotlib and pandas, from the test results it is clear that the most significant spread of covid 19 is Indonesia, where it has soared since day 65 (Salim et al., 2022).

RESULTS AND DISCUSSION

Research data collection was conducted at the beginning of COVID19 entering Indonesia until December 31, 2021 using datasets from Kaggle. First of all, it is necessary to integrate data into current COVID-19 data using Python. Matplotlib and pandas are methods for making data visualization more interactive, easy to read, and easy to analyze. The visualization carried out is to change rigid table data into graphs, diagrams, and so on that are able to show changes and differences in data more clearly. As a result, the display of ordinary analysis data becomes more beautiful and in the form of graphs with good visuals using matplotlib and pandas (Heldayani et al., 2021),

Table 1. Regency Covid19 Data

Regency /City	Confirmed Cases	Recovered Cases	Recovery Rate (%)	Death Case	Mortality Rate (%)
Nias	243	237	97.53	4	1.65
Mandailing	688	661	96.08	27	3.92
South Tapanuli	800	771	96.38	28	3.50
Central Tapanuli	944	893	94.60	51	5.40
North Tapanuli	1,865	1,832	98.23	33	1.77
Toba	1,426	1,388	97.34	38	2.66
Labuhanbatu	1,790	1,716	95.87	73	4.08
Sharpening	2.408	2.230	92.61	173	7.18
Simalungun	3.153	2,946	93.43	191	6.06
Dairy	1,989	1,900	95.53	89	4.47
Karo	1,993	1,952	97.94	37	1.86
The Greater Delhi Area	15,750	15,326	97.31	410	2.60
The Land of the Rising Sun	2.243	2.136	95.23	107	4.77

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Regency /City	Confirmed Cases	Recovered Cases	Recovery Rate (%)	Death Case	Mortality Rate (%)
South Nias	190	190	100.00	0	0.00
Humban Hasundutan	503	480	95.43	23	4.57
Pakpak Bharat	330	320	96.97	10	3.03
Samosir	1.386	1,350	97.40	36	2.60
The Serdang Bedagai	2.376	2.303	96.93	73	3.07
Coal	1,492	1.418	95.04	74	4.96
North Padang Lawas	275	261	94.91	14	5.09
Old Field	335	310	92.54	25	7.46
South Labuhanbatu	782	752	96.16	28	3.58
North Labuhanbatu	1.148	1.101	95.91	47	4.09
North Nias	177	177	100.00	0	0.00
West Nias	165	164	99.39	1	0.61

Data in the table above is the covid19 regency data which means that it is in the regencies in North Sumatra. Based on the table above, the highest number of deaths is Deli Serdang with a figure of 410 and the highest death rate based on the table above is Asahan with a death rate of 7.18%, and the lowest number of deaths is North Nias and South Nias with a death rate of 0 and the lowest death rate is North Nias and South Nias with a death rate of 0.00%. Based on the table above, the highest number of recoveries is Deli Serdang with a figure of 15,326 and the highest recovery rate based on the table above is North Nias and South Nias with 100.00% and the lowest number of recoveries is West Nias with a recovery rate of 164 and the lowest recovery rate is Padang Lawas with a recovery rate of 92.54%.

Table 2. Covid19 Municipality Data

City	Confirmed Cases	Recovered Cases	Recovery Rate (%)	Death case	Mortality Rate (%)
Sibolga	797	768	96.36	29	3.64
Tanjung Balai	569	537	94.38	32	5.62
Pematangsiantar	3.915	3,836	97.98	79	2.02
High Cliff	1.233	1.201	97.40	32	2.60
Medan	49,416	48,436	98.01	965	1.95
Binjai	2,055	2.002	97.42	53	2.58
Padangsidempuan	1,082	1,035	95.66	47	4.34
Gunung Sitoli	1.187	1.162	97.89	25	2.11

The data in the table above is the covid19 municipality data, which means that it is found in cities in North Sumatra. Based on the table above, the highest number of deaths is Medan with a figure of 965 and the highest death rate based on the table above is Tanjung Balai with a death rate of 5.62%, and the lowest number of deaths is Gunungsitoli with a death rate of 25 and the lowest death rate is Medan with a death rate of 1.95%. Based on the table above, the highest number of recoveries is Medan with a figure of 48,436 and the highest recovery rate based on the table above is Medan with 98.01%, and the lowest number of recoveries is Tanjung Balai with a recovery rate of 537 and the lowest recovery rate is Tanjung Balai with a recovery rate of 94.38%.

Table 3. Total for North Sumatra

Total Cases	Total Healed	Recovery Rate (%)	Total Deaths	Mortality Rate (%)
106,119	103.151	97.2	2,893	2.73

Medan has the highest recovery rate and the lowest death rate due to improved healthcare infrastructure, widespread vaccination access, and high testing and early detection capacity. Conversely, Tanjung Balai recorded the highest death rate and the lowest recovery rate, likely due to limited medical facilities, delayed treatment, and a lack of healthcare resources. Meanwhile, Gunungsitoli has the lowest death rate, possibly due to its low population density and more controlled spread of the virus .

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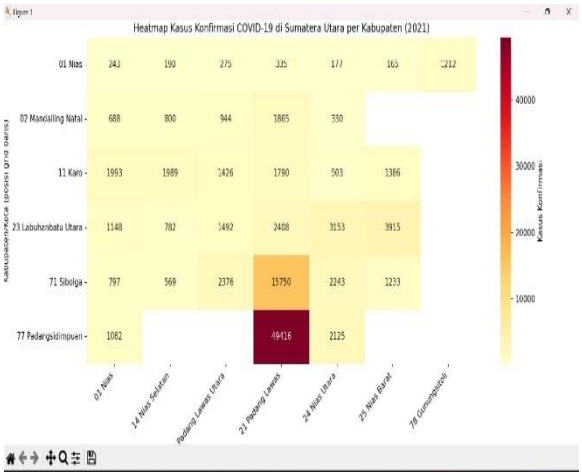

Image 2. Heatmap of The Number Confirmed COVID-19 Cases in North Sumatra Province in 2021

The image above shows the number of confirmed cases of Covid-19 in North Sumatra province in 2021. based on district and city. On the vertical axis (left column), there is a list of names of several districts/cities such as Nias, Mandailing Natal, Karo, North Labuhanbatu, Sibolga, and Padangsidimpuan. Meanwhile, the horizontal axis (top) displays other districts/cities such as South Nias, North Padang Lawas, Padang Lawas, North Nias, West Nias, and Gunungsitoli.

The following heatmap shows the recovery rate and mortality rate due to COVID-19 for each district/city. Warmer colors (red) indicate higher values, while cooler colors (blue) indicate lower values.

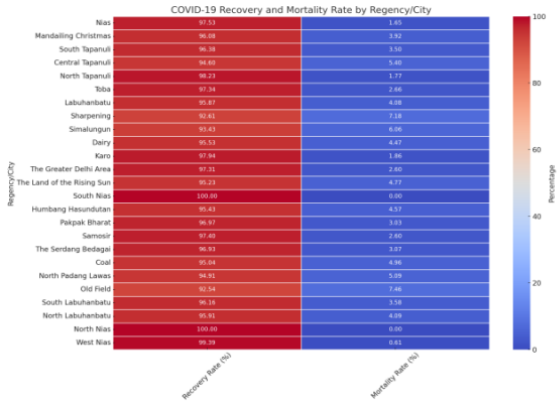

Image 3. Heatmap of Recovery and Mortality

The higher recovery rate in Medan can be correlated with the presence of several referral hospitals and better access to COVID-19 vaccination programs. In contrast, regions like Tanjung Balai might suffer from limited healthcare access and delayed case detection, contributing to the higher mortality rate. Furthermore, population density and mobility patterns likely influenced the spatial distribution of confirmed cases across districts. These patterns align with previous findings by Heldayani et al. (2021) and Salim et al. (2022), which suggest urban centers tend to report higher caseloads but better recovery outcomes.

CONCLUSION

This study successfully developed a dynamic visualization of the spread of COVID-19 in Medan City using heat maps generated in Python. By transforming raw COVID-19 data into a visual format, this study provides a clearer and more interactive understanding of infection, recovery, and mortality patterns across districts and cities in North Sumatra. The results show that Medan has the highest number of confirmed and recovered cases, while Deli Serdang has the highest number of deaths. Conversely, North Nias and South Nias recorded the lowest mortality rates. The use of Python libraries such as Pandas and Matplotlib proved effective in transforming complex data sets into user-friendly visuals (Permana, 2022). Overall, this heat map serves as a valuable tool to support government and community efforts in monitoring, preventing, and responding to the COVID-19 pandemic.

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