# PROJECT TITLE

**A Bokeh-Based Tool for Real-Time Function Visualization**

**CAPSTONE PROJECT REPORT**

***Submitted in the partial fulfillment for the award of the degree of***

**BACHELOR OF ENGINEERING**

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Learning

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# Abstract

Data visualization plays a crucial role in extracting insights from complex datasets. Traditional static plots often limit user interaction and exploration. This project aims to develop an interactive plotting tool using the Bokeh library in Python, which provides dynamic visualizations, enabling users to explore data more effectively.

The tool allows users to create interactive plots such as line charts, scatter plots, bar charts, and heatmaps with features like zooming, panning, and hover tooltips. Data is loaded and processed using Pandas, while Bokeh is utilized to generate interactive dashboards. The implementation demonstrates the advantages of interactive visualizations in enhancing data analysis and user engagement.

This project highlights how Bokeh can be leveraged for interactive and scalable data visualization, benefiting researchers, analysts, and data scientists. Future improvements could include integrating additional data sources and implementing machine learning-based visual analytics.

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# Chapter 1: Introduction

**Background Information:**

Data visualization is an essential aspect of data analysis, allowing users to uncover patterns, trends, and insights. However, static plots often fail to provide the level of interactivity needed for exploratory analysis. Bokeh, a powerful visualization library in Python, enables the creation of interactive plots that facilitate better data exploration.

**Project Objectives:**

* To develop an interactive plotting tool using Bokeh.
* To implement interactive features such as zooming, panning, and tooltips.
* To enable real-time data updates and customizable visualizations.

**Significance:**

This project demonstrates how interactive plotting improves data analysis and decision-making by providing a more engaging and insightful user experience.

**Scope:**

This project includes development of an interactive plotting tool using Bokeh and Machine learning integration and large-scale real-time data streaming.

**Methodology Overview:**

* Requirement Analysis: Identifying the need for interactive visualizations and defining project goals.
* Tool Development: Implementing interactive visualizations using Bokeh, incorporating features like zoom, pan, and hover tools.
* User Interface Design: Designing an intuitive and user-friendly interface for users to interact with the visualizations.
* Tools Used: Python, Bokeh, Google Colab.

# Chapter 2: Problem Identification and Analysis

**Description of the Problem:**

Data analysts and researchers often face challenges when working with static visualizations, as they limit exploration and interaction with data. Traditional plots do not provide features such as zooming, filtering, or dynamic updates, making it difficult to analyze complex datasets effectively.

**Evidence of the Problem:**

The need for interactive visualizations has been highlighted in various industries, including finance, healthcare, and research. Reports show that decision-making improves when data is presented interactively, allowing users to focus on specific details and extract meaningful insights efficiently.

**Stakeholders:**

* Data Analysts and Scientists: Require interactive tools to explore datasets efficiently.

* Business Professionals: Need visualizations that aid in decision-making and trend analysis.

* Researchers: Utilize interactive plots to present findings dynamically.

**Supporting Data/Research:**

Studies indicate that interactive visualizations enhance user engagement, reduce data misinterpretation, and allow real-time updates. According to academic research, tools like Bokeh provide a significant advantage over static charts by allowing users to modify and refine visual elements interactively.

# Chapter 3: Solution Design and Implementation

**Development and Design Process:**

1. Data preprocessing using Pandas.
2. Implementing interactive plots using Bokeh.
3. Creating a user-friendly dashboard.

**Tools and Technologies Used:**

* Python: The primary programming language used for data handling and visualization.
* Pandas: Used for data manipulation and preprocessing.
* Bokeh: The core library for interactive visualization.

**Solution Overview:**

This project scopes to use the different tools for plotting which helps to data visualization.

**Engineering Standards Applied:**

Data visualization best practices and statistical analysis techniques were followed to ensure clarity and accuracy.

# Chapter 4: Results and Recommendations

**Evaluation of Results:**

* The interactive plots provided a seamless and intuitive user experience, allowing users to explore data dynamically.
* The zooming, panning, and hover tooltip features significantly improved the readability of complex datasets.
* Large datasets were handled efficiently with Bokeh's optimizations, although performance challenges were encountered with extremely large files.
* Real-time updates were tested and worked effectively, making the tool suitable for applications requiring live data visualization.

**Challenges Encountered:**

* Handling Large Datasets: Some performance issues were noted when dealing with extensive datasets. Optimizations, such as reducing rendering resolution and pre-aggregating data, helped mitigate these issues.
* Compatibility Issues: Ensuring compatibility across various browsers and devices required additional testing and debugging.
* User Experience Design: Designing an interface that was both feature-rich and easy to use required iterative improvements.

**Possible Improvements:**

* Implementing machine learning models to suggest trends based on user-selected data points.
* Enhancing backend optimizations to support larger datasets without sacrificing performance.

**Recommendations:**

* The tool can be integrated into business intelligence platforms for better data-driven decision-making.
* Future work should focus on improving scalability and usability based on user feedback.

# Chapter 5: Reflection on Learning and Personal Development

**Key Learning Outcomes:**

* Technical Skills: Gained expertise in using Bokeh for interactive plotting, along with Python libraries such as Panel and NumPy for data visualization and manipulation.
* Interactive UI Design: Learned to integrate widgets such as Select, Slider, and ColumnDataSource to create a dynamic visualization tool.
* Event Handling and Updates: Understood how to use event listeners like .on\_change() to dynamically update plots in real-time based on user input.

**Challenges Encountered and Overcome:**

* Integrating Panel with Bokeh: Initially faced issues integrating panel with Bokeh for interactivity. This was resolved by ensuring proper pn.extension() initialization and using pn.pane.Bokeh() to render plots.
* Handling Large Data Processing: Large datasets led to performance bottlenecks, which were addressed by optimizing data handling through ColumnDataSource and reducing unnecessary computations.

**Application of Engineering Standards:**

* Modular Coding: Used structured functions for visualization, user input handling, and data processing.
* Code Optimization: Ensured efficient execution by implementing event-driven updates instead of redundant computations.

**Insights into the Industry:**

* Growing Demand for Interactive Visualization: Businesses and researchers increasingly rely on real-time interactive dashboards to gain insights into large datasets.

# Conclusion

The development of the interactive plotting tool using Bokeh demonstrated the power of dynamic visualizations in data analysis. The tool provided an engaging and insightful way to explore large datasets interactively, with features such as zooming, panning, and real-time updates enhancing the user experience. The challenges of performance optimization, compatibility, and usability were addressed through iterative development and testing.

Expanding the tool to support real-time data streaming for financial and IoT applications. Enhancing collaboration features to allow multiple users to interact with the same visualization simultaneously.

# References

1. Jolly, Kevin. Hands-on data visualization with Bokeh: Interactive web plotting for Python using Bokeh. Packt Publishing Ltd, 2018.

1. Chai, Chengping, et al. "Interactive visualization of complex seismic data and models using Bokeh." Seismological Research Letters 89.2A (2018): 668-676.

1. Fröhlich, Josua, Renato Pajarola, and Rafael Ballester. "Tensorplot: Interactive Visualization of High-Dimensional Data." (2017).

1. Zhang, Tianyu, and Long Mei. "Analysis and research on computer visualization in data science with bokeh and JavaScript." Journal of Physics: Conference Series. Vol. 2033.

No. 1. IOP Publishing, 2021.

1. Rosenthal, Fabian, and Master Medientechnologie. "Spotlighting THE Participant: An Interactive Bokeh Visualization App FOR Soundscape Data Exploration." (2023).

1. Khan, Abdullah S. Engineering a scalable and interactive web tool for JRO data exploration using Python's bokeh library. Diss. University of Illinois at Urbana-Champaign, 2021.

# Appendices

**Code:**

!pip install bokeh panel

!pip install panel jupyter\_bokeh

!pip install panel jupyter\_bokeh

import numpy as np

from bokeh.plotting import figure

from bokeh.models import ColumnDataSource, Select, Slider

import panel as pn

pn.extension('bokeh')

x = np.linspace(0, 10, 100)

source = ColumnDataSource(data={'x': x, 'y': np.sin(x)})

plot = figure(title="Interactive Plot", x\_axis\_label='X', y\_axis\_label='Y', width=700, height=400)

plot.line('x', 'y', source=source)

func\_select = Select(title="Function", value="Sine", options=["Sine", "Cosine"])

freq\_slider = Slider(start=0.5, end=5.0, value=1.0, step=0.1, title="Frequency")

phase\_slider = Slider(start=-np.pi, end=np.pi, value=0.0, step=0.1, title="Phase")

amp\_slider = Slider(start=0.5, end=2.0, value=1.0, step=0.1, title="Amplitude")

def update(attr, old, new):

    freq = freq\_slider.value

    phase = phase\_slider.value

    amp = amp\_slider.value

    if func\_select.value == "Sine":

        y = amp \* np.sin(freq \* x + phase)

    else:

        y = amp \* np.cos(freq \* x + phase)

    source.data = {'x': x, 'y': y}

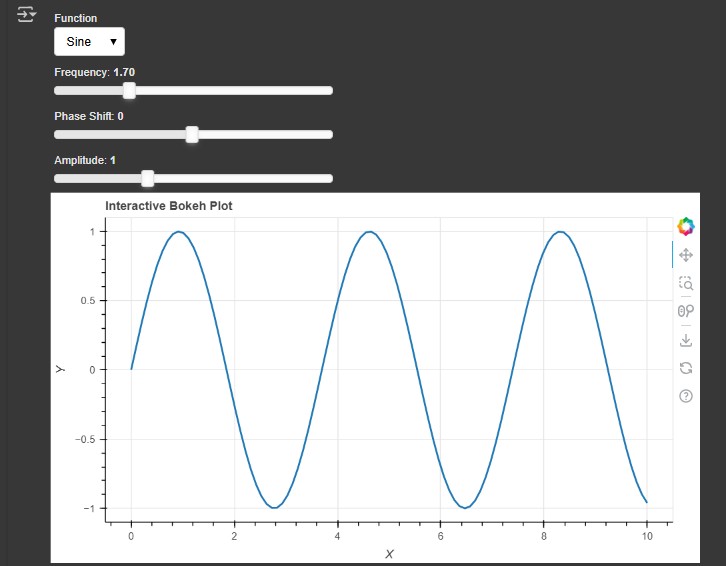
for widget in [func\_select, freq\_slider, phase\_slider, amp\_slider]:

    widget.on\_change('value', update)

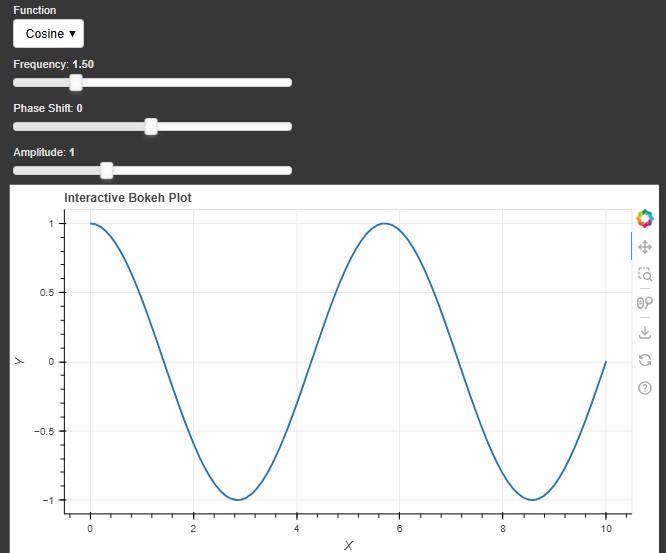
layout = pn.Column(func\_select, freq\_slider, phase\_slider, amp\_slider, pn.pane.Bokeh(plot))

layout.servable()

**Figure:**



fig(1): This shows the Interactive Bokeh Plot for **“Sine function with different frequency”**.



fig(2): This shows the Interactive Bokeh Plot for **“Cosine function with different frequency”**.