International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 15, Issue 2 [February 2026] PP: 111-118

Visualisation of open data: development of a theatre web application using JavaScript libraries

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ABSTRACT: *This paper examines the role of open data in contemporary public administration information systems, with particular emphasis on their visualisation and practical application within a web environment. Building upon the concepts of open data and e-government, the study highlights the importance of data accessibility for enhancing transparency, efficiency, and innovation in the work of public institutions, while also addressing the challenges that continue to affect their functional implementation in the Republic of Serbia. Particular attention is devoted to data visualisation as an effective means of interpreting large datasets and presenting them in a comprehensible manner to end users. The paper analyses the fundamental elements of data visualisation, as well as the role of modern JavaScript libraries in the development of interactive web applications. A structured approach to the visualisation of open data is proposed and demonstrated through a case study involving the development of a web application for the visual representation of data on theatres in the Republic of Serbia. The findings indicate that the combination of open data and appropriate visualisation techniques facilitates easier access to information, improves analytical capacity, and enhances the practical value of publicly available datasets.*

Keywords: *Open data; Data visualisation; E-government; Web applications; JavaScript libraries*

Date of Submission: 15-02-2026 Date of acceptance: 28-02-2026

I. INTRODUCTION

In recent years, increasing attention has been devoted to the concept of open data and its role in contemporary public administration information systems. Although the general public is aware of the existence of open data, its actual significance and potential for the state, the economy, and citizens have not yet been fully recognised. Open data are most commonly defined as data that can be freely used, reused, and distributed without legal restrictions, thereby becoming an important resource for the development of various digital solutions and applications [1].

The importance of open data is reflected in its considerable practical, economic, and creative potential. Opening datasets held by public authorities enables the development of applications that facilitate access to information, enhance the transparency of public administration, and encourage the innovative use of available datasets. For this reason, open data are often referred to as the "oil of the 21st century".

Within the development of e-government, particular importance is attributed to the National Open Data Portal of the Republic of Serbia, which serves as a central platform for publishing datasets of public authorities, as well as a space for interaction with the community that uses these data. The introduction of modern information and communication technologies into public administration increases efficiency, transparency, and accessibility of information, while open data become a foundation for the development of various digital services [2].

Research in the field of e-government indicates that, regardless of the level of societal development, the implementation of digital tools and open data can contribute to improving the functioning of public administration, reducing administrative barriers, and increasing the transparency of public authorities [2, 3]. Nevertheless, in the Republic of Serbia, e-government has not yet been fully developed, particularly in terms of functionality and the practical use of available datasets [4].

One of the most commonly used approaches to leveraging open data is their visualisation. Data visualisation represents a clear and effective means of communicating information through charts, diagrams, maps, and other forms of interactive data presentation [4, 5]. When properly implemented, visualisation enables users to more easily identify patterns, interpret data, and acquire new knowledge [6].

With the growing volume of data available on online portals, the need for their clear and comprehensible presentation becomes increasingly pronounced. Users often encounter difficulties when independently exploring large datasets and extracting useful information, which is why visual representations become a key element in the processes of data interpretation and decision-making [6].

In this context, JavaScript libraries for data visualisation provide a powerful tool for the development of interactive web applications that enable simple and intuitive access to open data. By combining open data with modern visualisation technologies, it is possible to create applications that facilitate user insight into available information and support its practical application [5].

For the purposes of this study, data on theatres in the territory of the Republic of Serbia were obtained from the National Open Data Portal and used as the basis for the development of a web application intended for the visual presentation and search of these data [7]. Considering the importance of theatres as significant institutions of cultural life and cultural heritage, the aim of this paper is to demonstrate how open data can be utilised to develop an application that enables simple, structured, and interactive access to information on theatres.

The paper presents the elements and techniques of open data visualisation, with particular emphasis on the application of JavaScript libraries, as well as the web application developed in accordance with the proposed approach.

II. ELEMENTS OF DATA VISUALISATION AND JAVASCRIPT LIBRARIES FOR THEIR IMPLEMENTATION

Data visualisation plays an increasingly significant role in the presentation of information, as it enables large volumes of data to be displayed in a clear and intuitive manner. Graphical representations facilitate the identification of patterns, relationships, and structures within datasets, thereby allowing users to understand information more quickly and efficiently compared to textual or tabular formats [8].

A high-quality visualisation must satisfy three fundamental characteristics: engagement, functionality, and integrity of representation. These qualities are achieved through the proper application of core visualisation elements such as colour, shape, shading, and interactivity [8].

Colour plays an important role in distinguishing and classifying data elements. Appropriately selected colours enable users to rapidly identify differences between categories. Shapes are used to indicate affiliation with particular classes and to emphasise the importance of specific elements. Interactivity enables direct user engagement with the graphical representation through actions such as clicking, zooming, and panning [6, 9].

The most commonly used visualisation techniques include charts, diagrams, and maps. Charts and diagrams allow complex data to be transformed into meaningful and structured representations, while maps serve to effectively present geographically related data based on latitude and longitude coordinates [10].

One of the key characteristics of visualisation is its ability to attract users' attention, thereby facilitating a clearer understanding of the information presented [11].

Modern web applications for data visualisation largely rely on JavaScript libraries. These libraries can be classified according to the type of data being visualised, the types of charts they support, and their software licensing models [11].

In the development of the application, libraries enabling the presentation of analytical and geographical data were utilised, namely Highcharts.js, Leaflet.js, Chart.js, and D3.js [11].

2.1 Highcharts.js

Highcharts is a JavaScript library designed for the creation of interactive charts based on data in CSV and JSON formats, as well as real-time data streams. It enables the development of various chart types, including line, column, pie, bar, and 3D charts [12].

A particular advantage of this library lies in client-side data processing, which enhances the performance of the user interface. The implementation process involves creating a container, rendering the chart, and linking it to data from an external source through appropriate functions [12].

Given that datasets available on the Open Data Portal are most commonly provided in CSV format, it was necessary to convert them into JSON format in order for the library to process them. This conversion was performed using the Python programming language [13].

2.2 Leaflet.js

Leaflet is an open-source JavaScript library designed for creating interactive web maps adapted for use across different devices. It is developed with a focus on simplicity, performance, and usability, and features a well-documented application programming interface (API) [14].

Web maps created using the Leaflet library consist of multiple layers. Background layers include raster images or vector tiles, while foreground layers contain vector elements such as points, lines, and polygons, which are adapted to the specific requirements of the application.

Map interactivity enables users to navigate within the display, zoom in and out, and obtain additional information by clicking on a marker. Within the developed application, markers represent the locations of theatres [14].

The library is integrated into the application via the <script> command, after which the objects and functions used in further implementation are defined [14].

2.3 Chart.js

Chart.js is a JavaScript library suitable for the rapid and straightforward creation of charts. It is characterised by a simple interface and ease of integration with other JavaScript solutions. The library enables the customisation and transformation of graphical representations in accordance with application requirements, while ensuring efficient communication of information through visual elements [15].

2.4 D3.js

D3.js is employed when a more complex and highly customisable graphical representation of data is required. The library is characterised by compatibility with other JavaScript libraries, strong performance, and the capability to implement advanced interactive elements [15].

However, it is important to carefully calibrate the level of interactivity, as excessive dynamism may distract users from the core information being presented [15].

2.5 Comparative role of JavaScript libraries in data visualisation

Each of the aforementioned libraries fulfils a specific role in the data visualisation process. Highcharts and Chart.js are primarily used for presenting analytical data through charts and diagrams, whereas Leaflet enables the geographical representation of data via interactive maps. D3.js provides additional capabilities for more advanced and customised graphical representations when standard chart types are insufficient.

Such a division allows for the selection of an appropriate tool depending on the type of data and the objective of the application. Through the combined use of these libraries within the theatre application, it was possible to present analytical and geographical data simultaneously, thereby offering users a comprehensive, structured, and intuitive insight into the available information [15].

III. APPROACH TO THE VISUALISATION OF OPEN DATA AND ITS APPLICATION IN A WEB ENVIRONMENT

In order to achieve effective visualisation of open data, a structured approach was developed and implemented in this study, enabling the systematic transformation of raw data into comprehensible and interactive visual representations. The proposed approach is based on a clearly defined sequence of steps, including the selection of visualisation parameters, the acquisition of open data, their processing and preparation, and the final stage of visualisation.

Figure 1 illustrates the fundamental steps of the open data visualisation process. The first step involves defining the visualisation parameters, which includes the selection of appropriate libraries, types of graphical representations, and other technical configurations. This step reflects the understanding that visualisation is not merely the display of data, but requires prior adaptation of tools and methods to a specific dataset. This is followed by the loading of open data, which may be carried out through API calls or by directly retrieving data from a web server. The third step encompasses data processing and cleansing, during which the data are adjusted, filtered, and prepared for use. The final step consists of the visualisation itself, in which the processed data are presented through appropriate graphical and cartographic forms.

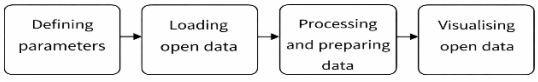

Fig. 1. Steps in the visualisation of open data

Figure 2 presents a more detailed implementation scenario of the proposed approach within the web application. The approach is based on a client–server architecture, with the system operating as a web application. Once the user initiates the application on the client side, an initial request is sent to the application server, which subsequently returns a response to the client. In the next phase, the client sends an HTTP request to the open data server in order to retrieve JSON records. Upon receiving the data, processing is performed on the client side, after which the data are presented to the user in a visual form. Such a scenario enables a clear separation between the stages of data acquisition, processing, and presentation, while emphasising the flexibility and efficiency of the application.

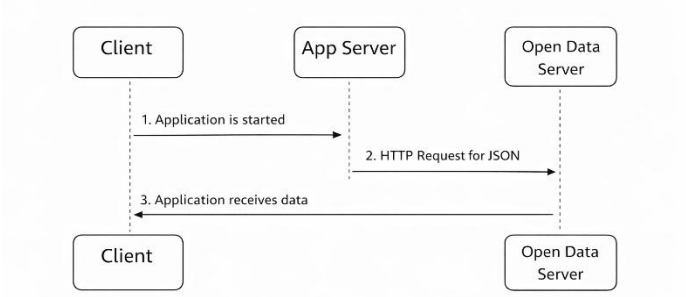

Fig. 2. Implementation scenario of the proposed approach

The application of the proposed approach was demonstrated through a case study focusing on the visualisation of open data on libraries in the Republic of Serbia. A dataset available on the National Open Data Portal was utilised, and the implementation was carried out using JavaScript libraries for data visualisation.

IV. PRIKAZ IZGLEDA MAPE I DOBIJENIH GRAFIKONA KORIŠČENJEM BIBLIOTEKA

The development of the application for searching and visualising data on theatres was based on the analysis of datasets available on the National Open Data Portal of the Republic of Serbia [15]. Among the available datasets, those relating to theatres in the Republic of Serbia were identified, enabling their further processing and application within a web application intended for visual presentation and analysis.

Within this research, a dataset obtained from the National Open Data Portal of the Republic of Serbia was utilised, comprising information on theatres across the territory of Serbia. The dataset was subjected to a process of filtering and transformation, after which relevant data suitable for further processing and integration into the developed web application were extracted [16].

Data on theatres, as institutions of significance for cultural and social life, were consolidated within the application and presented in a single location. In this way, users are provided with simplified access to information, as well as the ability to review and search the data through an interactive user interface.

The application developed for this purpose was implemented as a web application and developed within the Ubuntu operating system environment. The HTML language was used to define the structure of the application, while CSS was employed to design and enhance the visual appearance of the user interface [11, 17]. The Ubuntu operating system was used as the development environment and was installed on a virtual machine within a virtualisation environment. The virtualisation environment consists of both client and server components of the system, with Ubuntu representing a free and open-source operating system downloaded from the official website [18]. Although primarily intended for personal computers, Ubuntu can also be used for server applications, which makes it suitable for the development of this type of system.

The client-side component of the system is described in detail in the remainder of this chapter through the presentation of the implemented code, while the server-side component of the application is used for reviewing and testing the application via the Apache web server.

At the initial stage of development, the core functional modules necessary to fulfil the application's purpose were defined, including the map display, graphical representation of data, processing of JSON records, and the implementation of a drill-down mechanism. The drill-down mechanism was employed within the graphical component of the application in order to enable a more detailed presentation of data at lower levels of aggregation.

```
// Load and process JSON data
fetch('ustanovekulture.json')
  .then(response => response.json())
  .then(data => {
    // Filter only theatre institutions
    const theatres = data.filter(d =>
      d.tip_ustanove === 'Позоришта'
    );

    // Group by district and municipality
    const byDistrict = {};
    theatres.forEach(theatre => {
      const district = theatre.okrug;
      const municipality = theatre.opstina;
      if (!byDistrict[district]) {
        byDistrict[district] = { count: 0, municipalities: {} };
      }
      byDistrict[district].count++;
      if (!byDistrict[district].municipalities[municipality])
        byDistrict[district].municipalities[municipality] = 0;
      byDistrict[district].municipalities[municipality]++;
    });

    // Sort districts by count descending
    const sorted = Object.entries(byDistrict)
      .sort((a, b) => b[1].count - a[1].count);

    // Initialize map and add markers
    initMap(theatres);
    renderChart(sorted);
  });
```

Fig. 3. Code segment for loading,filtering, and sorting JSON data

Figure 3 shows a portion of the code responsible for loading, filtering, and sorting JSON data. It illustrates how the JSON file is retrieved from the appropriate directory, followed by its processing and preparation for further use. The data are examined sequentially, and for each individual theatre, the relevant attributes are extracted and used to generate the visual elements of the application.

Based on the retrieved data, a map is created using initial geographical coordinates that define the centre of the display. In the next step, markers are generated to indicate the theatres and display their geographical locations on the map. This is followed by the sorting and grouping of theatres by the cities and districts in which they are located. During this process, a counter is introduced, whereby the value of the corresponding category is incremented for each identified theatre.

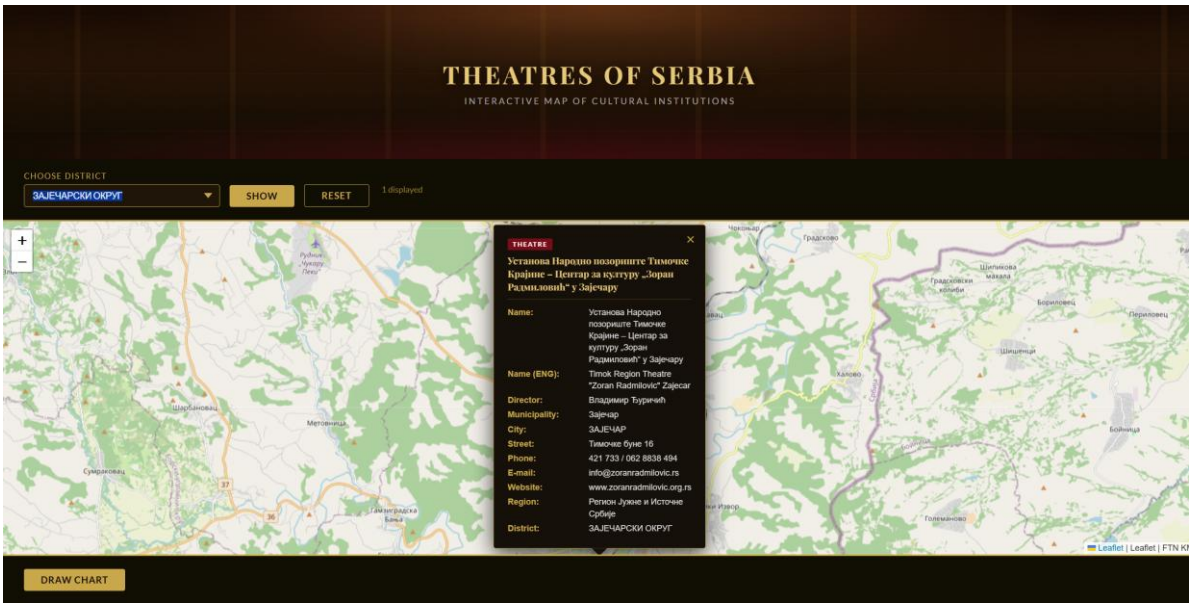

Fig. 4. Interface of the theatre search application

Figure 4 presents the interface of the theatre search application. The language selection option, located in the upper-right corner of the application, facilitates ease of use and enables users to more readily access relevant information. The visual appearance of the application has been further enhanced through the application of CSS styles, resulting in a clearer and more structured presentation of data.

Selecting a district from the drop-down menu directly affects the map display, which automatically centres on the coordinates of the selected district. The markers displayed on the map indicate the locations of theatres within the chosen district. By clicking on an individual marker, the user is provided with detailed information about the selected theatre, including the name of the institution, address, contact telephone number, and email address.

Figure 5 illustrates a graphical representation of the number of theatres by district. This type of visualisation enables a rapid overview of the territorial distribution of theatres across the Republic of Serbia. The chart is generated using the "Draw Chart" option, which provides the initial graphical presentation of the data.

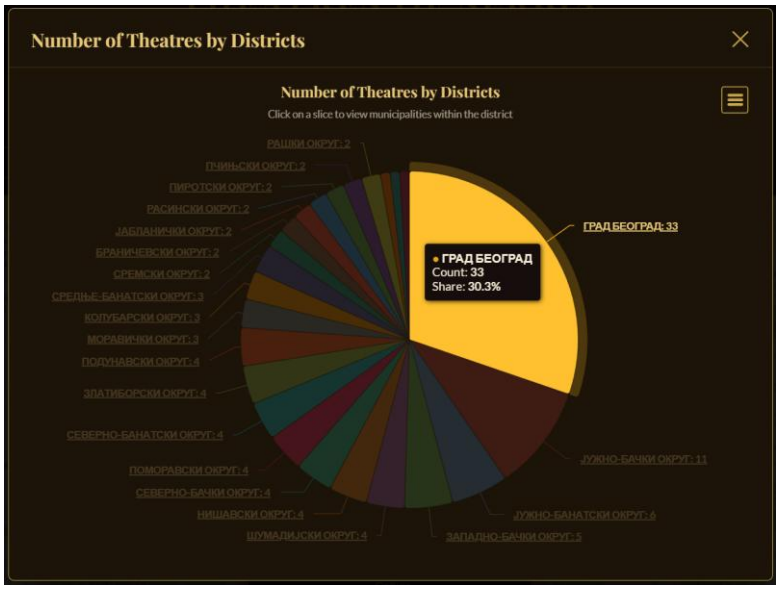

Fig. 5. Graph showing the number of theaters by district

By clicking on a specific district, that is, on the corresponding coloured segment of the chart, the drill-down mechanism is activated. This action opens a sub-chart providing a more detailed representation of the number of theatres by cities within the selected district, as illustrated in Figure 6. This level of detail enables users to gain insight into the distribution of theatres not only by district, but also by individual cities.

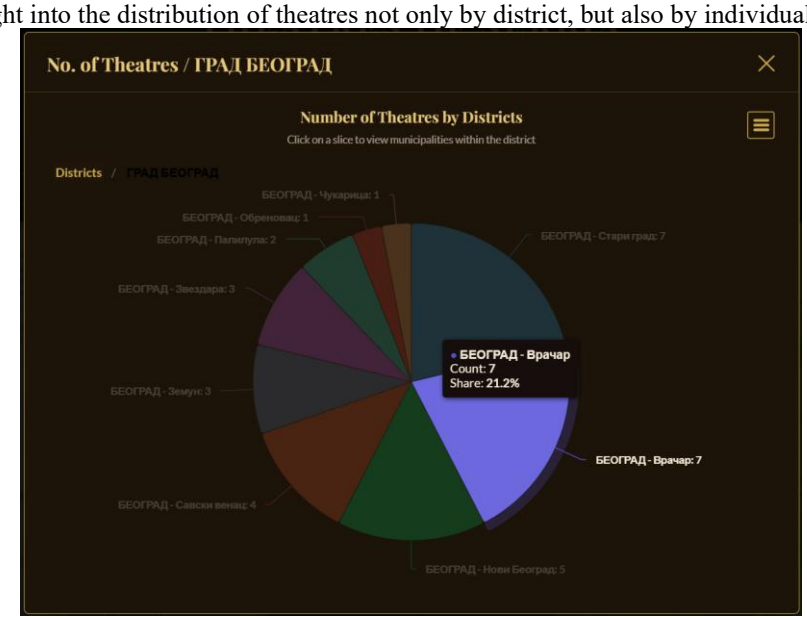

Fig. 6. Chart showing the number of theatres by cities within the selected district

The purpose of the presented graphical visualisations is to enable users to intuitively understand the data and draw conclusions regarding the spatial and administrative distribution of theatres in the Republic of Serbia. By combining cartographic and statistical representations, the application gains additional analytical value and serves as an example of the practical application of open data in the context of cultural institutions.

V. CONCLUSION

This paper has examined the role of open data in contemporary public administration information systems, with particular emphasis on their potential in the context of visualisation and practical application in a web environment. Building upon the theoretical foundations of open data and e-government, the study has highlighted the importance of data accessibility for enhancing transparency, efficiency, and innovation in the work of public institutions, while also addressing the challenges that persist with regard to their full functional implementation in the Republic of Serbia.

Special attention has been devoted to the visualisation of open data as one of the most effective means of interpretation and communication to end users. The fundamental elements of visualisation were analysed, along with the role of modern JavaScript libraries that enable the development of interactive, structured, and intuitive graphical data representations. Through a comparative analysis of the Highcharts.js, Chart.js, Leaflet.js, and D3.js libraries, it was demonstrated that the choice of tool depends on the type of data, the objective of the visualisation, and the desired level of interactivity, while their combined use allows for the creation of functionally rich applications.

The proposed approach to open data visualisation, based on clearly defined stages of data acquisition, processing, and presentation, was demonstrated through the development of a web application for the visualisation of data on theatres in the Republic of Serbia. The case study confirmed that open data, when appropriately processed and visually presented, can be successfully utilised to develop applications that facilitate user access to information, as well as its search and analysis through an interactive user interface. The combination of cartographic displays and statistical charts further enhanced the analytical value of the application and enabled the examination of the territorial distribution of theatres at different levels of aggregation.

Based on the conducted analysis and implementation, it may be concluded that the visualisation of open data represents a powerful mechanism for enhancing their usability and social value. The development of such applications contributes to a better understanding of available data, encourages their reuse, and creates opportunities for further development of digital services in the fields of culture and public administration. Future research may focus on expanding the functionality of the application, integrating additional datasets, and developing more advanced analytical tools, thereby further strengthening the practical application of open data across various social domains.

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