http://dx.doi.org/10.15576/GLL/2018.2.23

GLL

Geomatics, Landmanagement and Landscape No. 2 • 2018, 23–32

COMPARATIVE ANALYSIS OF THE PERFORMANCE OF SELECTED RASTER MAP VIEWERS

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Summary

Raster map viewers can be used by various entities, including public administration units. They are used in particular when there is no economic justification for creating extended and comprehensive mapping services, or when there is a need to quickly publish the given map. These viewers can be made using one of many available components. However, not all of them are optimal for such applications. Selected raster map viewers may be inefficient, which may make it difficult or even impossible to view the map. The aim of the present work was to conduct a comparative analysis of the performance of selected raster map viewers. The prototype applications were used to test the implementation of selected designing tools. The efficiency measurement was made using tools for test automation. The value of the ES-SCORE (Estimated Speed Score) synthetic performance meta-index has been determined. It has been shown that the application created with the use of the ImageViewer component (jQuery JavaScript) was objectively the best of the tests tested for the presentation of raster graphics (according to the adopted testing scheme).

Keywords

performance • image viewer • component • raster • jQuery JavaScript

1. Introduction

Recent years have brought about the dynamic development of information and communication technologies, in particular the Internet [Suchacka 2010]. The use of the Internet for the dissemination of map presentations has led to considerable progress in cartography, and it has opened many new possibilities [Brovelli et al. 2015]. Maps on the Internet are published using various techniques and designing tools. They may be made available in the form of dynamic applications, that is independent map services, including geo-portals [Król et al. 2016, Farkas 2017], or as components of other websites [Król and Szomorova 2015]. Some alternative for database-based technologies is provided by raster publications, which, despite their limitations, can find application in the presentation of various spatial data.

Viewers of raster graphics (image viewers) are often made available free of charge, and they can be used by a variety of entities, including public administration units. They are particularly useful whenever there is no economic justification for creating extensive map services, or when there is a need to quickly publish a map, for instance, for events or phenomena occurring at a given time, for example in the case of changing street names or ordinal numbering of buildings [Salata and Król 2012]. The limitations to the usability of such presentations are mainly due to the size of the raster itself, which is often loaded in the browser window entirely, and this may prove inefficient.

Internet users expect quick access to the content they have searched for. The speed of loading websites and applications in the browser window is influenced by many factors, which are primarily related to the performance of the hosting server, the source code (application structure), and the quality of the Internet connection [Barczak and Zacharczuk 2014]. The creators of websites and web applications have the greatest influence on their structure, resulting from the adopted designing solutions [Król and Zuśka 2017].

The use of an efficient hosting server and high-speed Internet connection may be insufficient to guarantee satisfactory performance of the application if the latter has been developed in a faulty way, using inefficient solutions, such as an excessive number of components, especially those downloaded from external sources [Król 2016]. In addition, the slow loading of websites and web applications is often caused by the use of overly large graphic files [Nielsen 2010]. The selection of an appropriate (that is, efficient) graphics viewer can therefore have a particular impact on the comfort of viewing the raster map. In selected cases, it may even condition its very availability or accessibility. The aim of the present work was to conduct a comparative analysis of the performance of selected raster map viewers.

2. Performance matters

Over the last decade, websites and web applications have increased their volume more than tenfold [Zhu and Reddi 2013]. However, this is not in the area of particular interests to users themselves, who simply expect, regardless of everything, the practical usefulness and attractiveness of the content they seek, as well as the functionality and usefulness of that content's presentation. Furthermore, performance is also of key importance to the users [Dickinger and Stangl 2013].

Performance is one of the most important measures, determining the quality of websites and web applications [Szyda 2017]. Among the main parameters of performance is the time of loading the applications in the browser window – around 39% of Internet users say that the speed of a website is more important than its functionality [Akamai 2017]. In addition, research has shown that to the average user, waiting time for a website to be fully loaded appears about 15% longer than it actually is [Stefanov 2010]. All this generates demand for high-performance computer systems and mobile devices that will ensure the comfort of viewing websites and applications, which provide increasingly complex functionalities [Ochim and Pańczyk 2016].

Time to first byte (TTFB), start render time, and visually complete metric are selected measures that determine the loading status of a website or web application. However, it is the fully loaded time (time of loading the website in the browser window) that belongs to the most basic and most underestimated performance parameters. According to a Dareboost study [2018], 67% of users demand that a page must be loaded within 4 seconds. Generally speaking, the factors that determine the time of loading the website in the browser window can come down to the reliability of the hosting server, the efficiency of the Internet connection, as well as the volume of content and the form of that content's presentation. Google research shows that users view fast-loading websites and web applications more willingly and for a longer time; furthermore, fast-loading websites and web applications are less expensive to maintain, and even a half-second delay will have a negative impact on user statistics [Singhal and Cutts 2010]. Website performance also has a significant impact on its effectiveness. Research has shown that delaying your website's load time in a browser window by 100 milliseconds (0.1 seconds) can decrease its efficiency by 7%, whereas a site rendered within 10 seconds gains 46% fewer views, and a 135% higher bounce rates. This also applies to portable devices. About 53% of mobile website visitors leave that website if it is loading for more than three seconds [Bixby 2010].

3. Material and methods

Subjected to a comparative analysis were selected components developed with the help of the jQuery JavaScript library, and made available under the MIT license, one of the most liberal licenses for open-source software [Król 2015c, Król and Prus 2017a]. The tools subjected to the testing enable dynamic viewing of raster graphics in the browser window. However, the result is carried out in a different way in each particular case (Table 1).

Table 1. Functionalities of the tested components

No.	Tool	Basic functionality
1	Mapbox	Zoomable jQuery Map Plugin. Zoom and pan map with several image layers. The plugin uses several images (from 2 or more) with different resolution. Map window with control panel.
2	MiniMap	A jQuery plugin that creates an interactive mini-map of an element and its children.
3	ImageViewer	Zooming and smooth panning plugin, support touch devices. Double tap to zoom in/zoom out. Pinch in/pinch out to zoom in/out.
4	ImageTrans	Displays any images in an image viewer interface with zooming, flipping and rotating features. Plugin based on HTML5 canvas and CSS3 3D transforms.

Source: author's study

Mapbox Zoomable jQuery Map Plugin [Mohler 2017] is used to create zoomable, draggable maps with multiple layers of content. MiniMap [Bai 2016] is an jQuery plugin that creates an interactive mini-map of an element and its children. ImageViewer [Yadav 2015] and ImageTrans [Yu 2016] are raster image viewers developed based on jQuery JavaScript. Their functionality comes down to the presentation of graphic files in the web browser window [Król and Prus 2016].

The research was carried out in the conditions of simulating a typical user session (reconstructing the user's interaction with the service). A user session is defined as a sequence of temporally and logically correlated requests sent by the user during a single visit to the website. During the session, the user performs some common, typical interactions, such as browsing the map, or searching for specific objects. Conducting simulations under the controlled conditions gives us the opportunity to assess the system's response to a load of a specific nature and intensity [Suchacka 2010].

The prototype applications were used in the testing, being the implementation of selected designing tools. Unit performance was measured (of the Request-level Metrics type), also referred to as initial performance, total performance, or performance occurring at the time of measurement. The research was carried out in an informal manner, in conditions of normal, typical use [Król 2015a, Król 2015b]. The measurement was conducted on desktop computers, that is, in desktop mode, using selected applications that facilitate automated testing (Table 2).

Table 2. Internet application in the testing of performance

Testing application	Unit of measurement
Lighthouse	Performance grade
GTmetrix	PageSpeed Score, YSlow
Pingdom	Google PageSpeed Performance grade, load time, page size
Dareboost	Performance grade, Speed Index

Source: author's study

3.1. Characteristics of tools for performance testing

In performance measurements, it is advisable to use authorized tools, because they ensure greater certainty as to the quality of measurement, and they are usually accompanied by documentation containing characteristics of the measures and the way they are calculated. One of the tools available free of charge (open-source) and authorized by Google is the Lighthouse browser plugin. This tool facilitates testing, among other things, of the performance of websites and internet applications. The world-recognized GTmetrix application was also selected for testing. GTmetrix measures, among other things, the time of loading the website in the browser window, and the size of its components. It also provides information on the values of synthetic performance indicators,

such as Google PageSpeed Score and Yahoo! YSlow. The values of both indicators are placed within the range from 0 to 100 percentage points, whereas the highest possible value is expected and desirable.

The Pingdom Website Speed Test, like GTmetrix, provides information about the website's performance, its load time in the browser window and the size of its components. In turn, Dareboost provides information about the performance of the application expressed using the Speed Index. Speed Index shows how quickly the contents of a page are visibly populated. The faster the rendering (that is, the better the performance), the lower the index value, with Google recommending that its value should not exceed 1000 units.

Thus obtained results of the measurements were normalized with the use of zero uniformization, using transformation (1) for the stimulants, and transformation (2) for the deterrents [Kukuła and Bogocz 2014]. The deterrents were: fully loaded time and the value of Speed Index. Next, the value of the ES-SCORE synthetic performance meta-index (Estimated Speed Score) was determined by adding up the values of all the standardized diagnostic features. This made it possible to describe the performance of each of the tested applications with a cumulative final rating. The higher the ES-SCORE index value, the better the application performance. On this basis, the ranking of applications was created, according to the degree of their efficient performance.

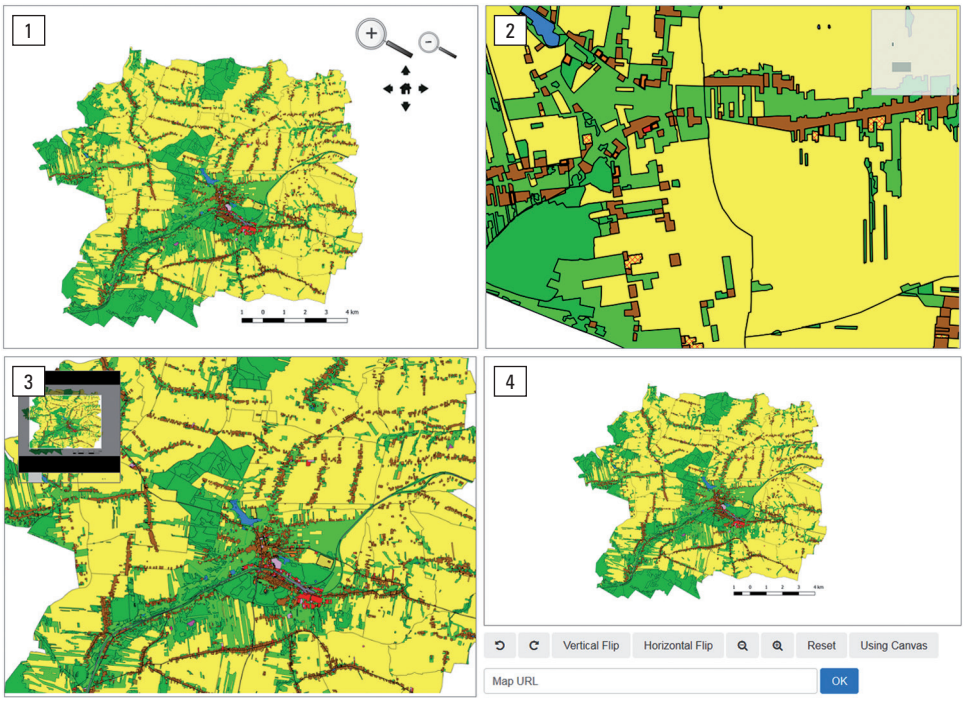
$$x_{ij}^{'} = \frac{x_{ij} - \min_i \{x_{ij}\}}{\max_i \{x_{ij}\} - \min_i \{x_{ij}\}} \tag{1}$$

$$x_{ij}^{'} = \frac{\max_i \{x_{ij}\} - x_{ij}}{\max_i \{x_{ij}\} - \min_i \{x_{ij}\}} \tag{2}$$

4. Research results

The result of the implementation of the scripts were four web applications, enabling viewing the raster map (Figure 1). For the presentation, the map of land cover in Wolbrom municipality (in Małopolska region, Poland) was used, developed with the aid of data acquired from the BDOT10k database. The map was prepared in the size of 4677 × 3307 px (about 4.25 MB), which was to guarantee a relatively heavy load on the browser. The measurement was made from servers located in different locations: (1) Gtmetrix in Vancouver, Canada, (2) Pingdom in Stockholm, Sweden, and (3) Dareboost in Paris, France.

The highest value of the YSlow index was obtained with the application created on the basis of the MiniMap plugin, and the lowest value was recorded for the application developed with the use of Mapbox. What is somewhat surprising is the very low value of the PageSpeed Score, which was obtained for the ImageViewer application in a measurement made with the aid of GTmetrix, especially since the value of the same index obtained using the Pingdom application was one of the highest (Table 3).



Source: author's study

Fig. 1. Presentation of the applications developed with the use of scripts, respectively: (1) Mapbox, (2) MiniMap, (3) ImageViewer, (4) ImageTrans (screen shot)

Table 3. Values of indices at the time of the measurement

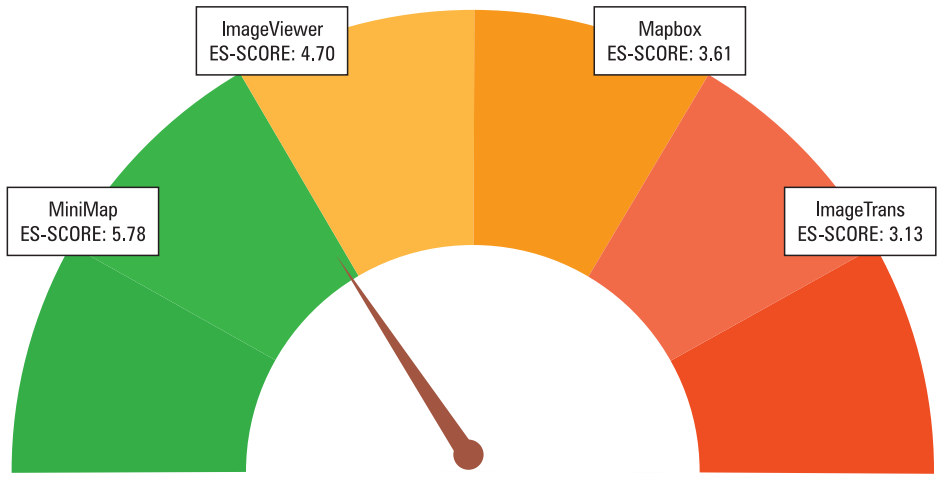
Application/Type of test	GTmetrix		Pingdom	Dareboost	Lighthouse
	YSlow Score	PageSpeed Score	PageSpeed Score	Speed Index	Performance grade
Mapbox	77	48	88	1397	36
MiniMap	97	95	79	2211	47
ImageViewer	87	9	88	1400	49
ImageTrans	91	50	74	6793	55

Source: author's study

The assessment of total performance (the ES-SCORE) consisted of measurements of the loading time of the application in the browser window (fully loaded time), as well as the values of the following performance indicators: PageSpeed Score, Speed Index, and YSlow. In total, 8 diagnostic variables were subjected to normalization, therefore

each of the applications could potentially obtain a maximum final score equal to 8 points, the smallest one being 0 points.

The highest value of the ES-SCORE was obtained by the application created with the MiniMap plugin, while the lowest was recorded for the application made with the use of ImageTrans (Figure 2). These results coincide with the ranking of performance created on the basis of the analysis of the loading time of the application in the viewer window. The most favourable values of the "fully loaded time" attribute were obtained by the MiniMap application, and the least favourable, by the ImageTrans application (Table 4).



Source: author's study

Fig. 2. Application performance according to the ES-SCORE performance index

Table 4. Performance ranking with respect to the loading time of the application in browser

Position in the ranking	Application/Type of test	Gtmetrix	Pingdom	Dareboost
		Fully Loaded Time (s)		
1	MiniMap	1.4	0.33	12.6
2	Mapbox	15	11.36	7.1
3	ImageViewer	17.2	4.58	7.76
4	ImageTrans	17.6	9.92	8.04

Source: author's study

5. Limitations to the research conducted so far

The research omitted the so-called "explosive" traffic that represents unexpected server overloads due to receiving too many requests over a short period of time. This is because it was assumed that the solutions tested are most often used to create presentations with a local reach, which enjoy a relatively small number of visits [Król and Prus 2017b].

The tests that have been carried out did not take into account the differences in the results of measurements resulting from the location (place) and time of measurement. They also did not reflect the average performance, which can be recorded during measurements conducted within the adopted time unit. In addition, application performance on mobile devices has not been verified. This resulted from the design architecture of the applications themselves, which were made for desktop computers.

6. Conclusions

The unit measurement (Request-level Metrics) delivers the temporary, "point" (partial) performance of the website. More detailed data on the performance of a particular website or a web application can be provided by constant monitoring and measurements made per a specific unit of time. In addition, it is possible that the results may be determined by the measurement mechanism, rather than the actual performance of the application. Therefore, it is advisable to complement the automated tests with usability tests.

The application created on the basis of the MiniMap plugin exhibited the highest performance in the adopted research model. The same application also obtained the most favourable values of the "fully loaded time" indicator. At the same time, however, this application has proven the least functional, although in the basic version, it is the simplest to create. The application made on the basis of the ImageTrans plugin offered a graphical service menu, which increased its usability and attractiveness for the user. At the same time, however, this application was the least efficient. The compromise between performance and usability was demonstrated by an application created on the basis of the ImageViewer plugin. And it is this latter application that should be pointed out as objectively the best for raster map presentation among all the tested ones (according to the adopted testing scheme).

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