

Original research paper

UDC 004.738.5:004.432JAVASCRIPT

DOI 10.7251/IJECC2001024K

Issues in adapting web content to be displayed on devices with various screen shapes using a JavaScript built screen shape simulator

Tanja Krunic

The Higher education technical school of professional studies in Novi Sad, Serbia

E-mail address: krunic@vtsns.edu.rs

Abstract—This paper is devoted to an upcoming issue in web design: Styling web content to be displayed correctly on devices with various screen shapes. This issue is a consequence of the rapid development of LED displays with a wide variety of screen shapes. Many of them can be connected to a computer which means that one can display web content on them. Such displays are used as indoor and outdoor advertising panels, which makes them very important for business. Also, various smart devices are developing rapidly and they are often web browsing enabled. They come with various screen shapes, which is an imperative of modern design. Hence the need to style web pages in such a way that their content is displayed correctly on all those devices. By now, responsive web design has a solution only for styling web pages to be displayed on rectangular screens with various dimensions by using media queries and flexible grids. The W3C organization is currently working on media queries for round shaped displays, but all new suggested CSS rules are still in the working draft. It is obviously that the development of LED displays is running faster than the development of web standards. For these reasons, a responsive web design testing tool with a various screen shape simulator is built in JavaScript and is available on GitHub. Its main features are described herein. An example of styling a web site for various screen shapes using that testing tool is given in this paper in order to highlight the problems that arise during that process.

Keywords- screen shape; simulator; responsive web design; testing tool; JavaScript

I. INTRODUCTION

There is an increasing number of people using the internet from year to year. According to [2], in January 2019, 57% of the world's population are internet users. The same source claims that the average internet user spends almost seven hours a day surfing the web. On the other hand, there is an increasing number of smart devices developed for various purposes (tablets, smartphones, smart watches, smart glasses, TV sets, wearables for monitoring health, refrigerators and other smart home components that gather physical data like light, temperature, smart displays - voice assistants usually connected with smart devices, etc.), [3], [4], [5]. But in most cases they can also be used for surfing the web, since smart device manufacturers want to attract customers by enabling their favorite activity - web browsing on their products. This caused a rapid development of LED displays for various devices. Besides this, indoor and outdoor displays are also produced in various shapes and dimensions. Mainly they are touchscreens and can be connected to computers, so they can be used for displaying web presentations of companies and their products. Displaying web content is maybe not their main purpose for now, but the existence of such a possibility is worth of attention. Their popularity is rising globally since they can

heavily be used in marketing campaigns. They are claimed to be 'the heart of any business campaign', [6], [7].

As one can conclude, LED displays are nowadays produced in various shapes and dimensions, so it is obviously that the future of web design will go into the direction of adapting web content for various screen shapes. This was a motivation to create an online responsive testing tool which enables the users to choose the desired screen shapes, and to test the layout of their webpage subsequently.

This paper is organized as follows. The second section is devoted to devices with different screen shapes. Section three gives some known facts on adapting web content to be displayed on different screen shapes. Section four gives an overview and comments on the technologies used for building the responsive web design testing tool. A comparison of the new responsive testing tools with other responsive testing tools available on the web is given in Section five. The functionalities of the online responsive testing tool are presented in Section six. Styling a part of the Infoteh-Jahorina symposium website using the responsive web design testing tool with the screen shape simulator is given in Section six. Finally, issues in adapting web content for devices with various screen shapes of the Infoteh-Jahorina symposium website are provided in Section seven.

This paper is a revised and expanded version of the paper presented at the XIX International Symposium INFOTEH-JAHORINA 2020, [1]

II. DISPLAYS AND THEIR SHAPES

The rapid evolution of computer monitors started in 2000. , since the invention of LCD monitors, [8]. The same year, this was followed by the invention of smaller devices like tablets, [9], the iPhone in 2007, [10] and the smart watch in 2012. But the appearance of devices with screens of different dimensions was just the start of the revolution of displays. Nowadays, there are a lot of smart devices and displays with different screen shapes. Let us mention some of them: Smart watches with round (Figure 1. (a), [11]) and hexagonal (Figure 1. (b), [12]) displays, hexagonal (Figure 1. (c), [13]), triangular (Figure 1. (d), [14]), heart (Figure 1. (e) [15]) and round (Figure 1. (f) [16]) shaped indoor LED displays, and a triangular tablet (Figure 1. (g), [17]).

The idea to build a triangular tablet shown in Figure 1. (g), came from by Eric Calisto in 2011 and he launched a Kickstarter project to fund the development. There is no information if the project is released by now or not, but this is certainly the evidence that tablet constructors definitely started to think ‘out of the box’, or better said ‘out of the square shape’.

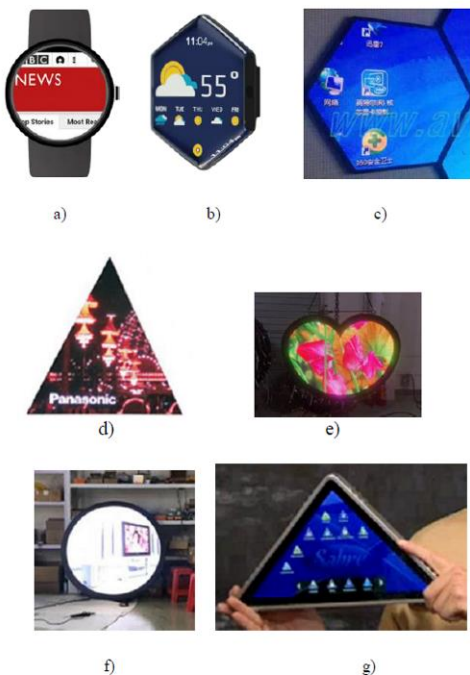


Figure 1. Various shapes of displays.

III. ADAPTING WEB CONTENT TO DIFFERENT SCREEN SHAPES

As mentioned in the previous section, the development of smart devices started with the appearance of smartphones. According to [10], the true revolution of development of smartphones started in 2007, when the first iPhone was created. From that moment, people started surfing the web with smartphones. But this was quite uncomfortable, since at that time, web pages were designed for viewing on desktop computers only.

The first respond of web designers to this issue was creating the so called m.dot websites, which indeed were separate simplified versions of the desktop version of the web

site. Mobile users were automatically redirected to the m.dot version of the web site, [18]. But nowadays, this is considered an outdated technology due to several reasons: it is quite uncomfortable to update two web sites at the same time; it wastes time and produces additional administration costs; two versions of the same web site is considered by Google crawlers as duplicate content which is a disadvantage for SEO (search engine optimization); such an approach is not social media friendly since a user can share the desired content of the mobile version with a friend who fails to reach the content with another device (PC, tablet, etc.), [18]-[22].

Due to the above mentioned reasons, web designers had to prepare a complete different approach in solving the problem of displaying web content on devices with various screen dimensions - responsive web design. Responsive web design is a relatively novel discipline which is developed in 2010, [23]. Its main idea relies on web design that responds to the user’s device screen size and orientation. It can be achieved by the use of CSS media queries and flexible grids, [24]. For example, a web page can show content in three columns on a wide screen, but the same content can be presented in two columns on a tablet, or even in only one column when viewed on a smartphone, [25]. This can be achieved by using CSS media queries. A media query allows using different styles for different screen widths and page orientations, [26]. Below are two examples of media queries. The appropriate style should be defined in the curly brackets.

```
@media (max-width: 768px) { }
@media (min-width: 600px) and (orientation: landscape) { }
```

Flexible grids are used in several CSS frameworks like Bootstrap, Foundation, Skeleton, W3CSS, etc. Roughly speaking, a grid system uses containers, rows and columns to layout and align content, [27]. Containers are used to center the content horizontally. Rows are wrappers for columns, which are the only immediate children of rows. Content is supposed to be placed within columns. There exist predefined column classes which indicate the number of columns out of possible 12. They are intended to be used for the placement of any HTML element. Column widths are set in percentages, which makes the layout responsive. Typically, there are the following grid breakpoints based on minimum width media queries: extra small, small, medium, large and extreme large. There are predefined column classes for them, too.

Also, the width of HTML elements is defined in units relative to the device screen width. Using such an approach, one avoids horizontal scrolling, which is not desired for at least two reasons. First of all, reading web content using the horizontal scroll requires constant attention of the user and physical effort. Also, since users don’t expect content to be accessible by using the horizontal scroll, such content may be ignored, [28]. Nowadays, web designers worldwide can use many responsive web design testing tools which are available for free (See you web site responsive, [29], Responsive test tool, [29], How responsive is your web design?, [31], etc.). Those tools give the preview of their web pages on a wide set of screen dimensions. But all these testing tools are created for rectangular screens.

A new issue in responsive web design appeared 2014 with the development of smart watches with round screens, [32].

This time web designers responded with a proposal of new media queries which would distinct devices with rectangular and round screens and load the appropriate CSS styles for each of these screen shapes. Below are the suggested media queries for rectangular and round screens.

```
<link media="screen and (shape: rect)" rel="stylesheet" href="rectangle.css" />
```

```
<link media="screen and (shape: round)" rel="stylesheet" href="round.css" />
```

But by now, this is in the CSS working draft, and is still not supported by web browsers, [33]. In the meantime, the only way to adapt content for round screen smart watches is to find a style that is suitable for smart watches with both round and rectangular screens. This was the motivation of the author of this paper to construct a responsive testing tool which enables previewing web pages on screens with rectangular and round shapes at the same time, [34].

In the meantime, while we are awaiting the media queries for round screens to be adopted and supported by web browsers, smart devices appear with a wider class of screen shapes, as seen in the previous section. It is clear that it will take time since media queries for different shapes, or even a complete different approach for this problem appears. However, it is obviously that the future of responsive web design is to adapt content to any screen shape and all dimensions, as presented in Figure 2. , [35]. This illustration is created according to Steve Perry's modification of Bruce Lee's speech [36]. While Bruce Lee explains that a Karate master has to be shapeless and his body adaptive to all situations, Steve Perry claims that the same holds for web content: It must be shapeless like water! Adapting web content to smart watch

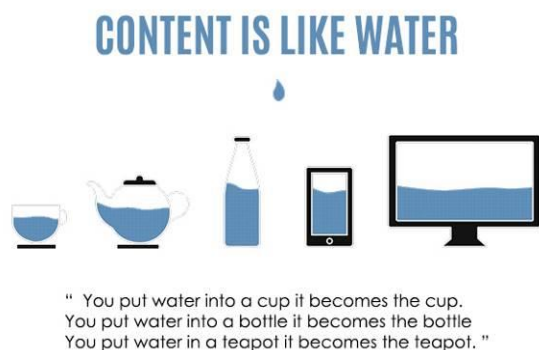


Figure 2. Responsive web design illustration, [35].

screens and other novel smart devices is listed in [37] as one of several future directions of web design which also include: adapting content to foldable screens (tablets which can be folded to smartphones), dealing with stretchable, bendable, and rollable screens, dual displays, touch screens for laptops and desktops, etc.

To make a small effort in the direction of the future of responsive web design, the author of this paper created a responsive web design testing tool for checking the layout of web pages on different screen shapes. It is briefly described in the Section five. But let us first say a few words about the technologies used for its creation in the next section.

IV. TECHNOLOGIES USED FOR BUILDING THE RESPONSIVE WEB DESIGN TESTING TOOL

The responsive web design tool created for the purpose of styling web pages to be displayed on devices with various screen shapes contains a screen shape simulator. Its functionalities are described in detail in Section five. In order to explain the technologies used for its creation, let us just explain its functionality in a few sentences: The screen shape simulator is a web page (created using HTML and CSS) which offers a list of checkboxes with various screen shapes. One can choose the desired screen shapes, and then the screens of the chosen shapes appear on the page. Those screens are iframes in fact. JavaScript is used to change their shape dynamically. Namely, when a page is loaded, the web browser creates a Document Object Model (DOM) of it, [38]. The DOM is an object-oriented representation of the page, which can easily be modified using JavaScript, [39]. In order to change the CSS style of an HTML element, JavaScript has to access the element first. Accessing HTML elements with JavaScript starts with finding references to the elements by id or tag name, [38]. After finding the desired element, its style can easily be changed using the following command:

```
document.getElementById(id).style.property = new style.
```

Among other similar technologies, JavaScript is chosen for this purpose, since it is a client-side technology. This means that it does not need a communication with the server, which increases the content load speed. This is one of the main advantages of JavaScript in general, [40].

As we will see in the next section, by now, the screen shape simulator offers six screen shapes, but the list of available screen shapes can easily be extended. As already mentioned, the iframes presenting screens take various shapes being dynamically styled using the ability of JavaScript to change CSS. For this purpose, the CSS 3 clip-path property which allows clipping an element to a basic shape, [41] is used.

The JavaScript function *createElement()* allows us to create HTML elements after user request. This is used to create an iframe after checking a screen shape from the given list. Of course, it is styled using the clip-path property, as already explained above. An undesired iframe can easily be deleted from the page by unchecking it from the list. This is realized using the JavaScript function *remove()*.

In order to make the responsive testing tool and its code available to other developers, it is published on one of the world's most famous software development platform GitHub, [42]. This platform allows storing files online and their development. For previewing the files in a web browser, one can use the GitHub & BitBucket HTML previewer, [43].

V. THE RESPONSIVE WEB DESIGN TESTING TOOL

Let us now describe the functionalities of the responsive testing tool. As already mentioned in the introduction, it is intended to be used for the simulation of various screen shapes. Its code is available online at GitHub on the following URL:

<https://github.com/screenShapeSimulator/responsiveTester/blob/master/simulator.html>

The functionalities of the tool can be used by pasting the above URL into the GitHub&BitBucket HTML previewer, or directly at the following URL:

<https://htmlpreview.github.io/?https://github.com/screenShapeSimulator/responsiveTester/blob/master/simulator.html>.

For now, there are six screen shapes available: square, round, triangle, octagon, hexagon and rhombus, Figure 3. But note that any other geometrical shape can easily be added to the list. Also, a square shaped screen can be rectangular if we change the dimensions of one of its sides. The same holds for the round shape: by changing its dimensions, it can become elliptic. The user can select the desired screen shapes from a list of checkboxes, and they will appear on the page in the form of iframes of dimensions 300x300px afterwards. The checking event of every checkbox creates a new iframe shapes as offered in the checkbox.

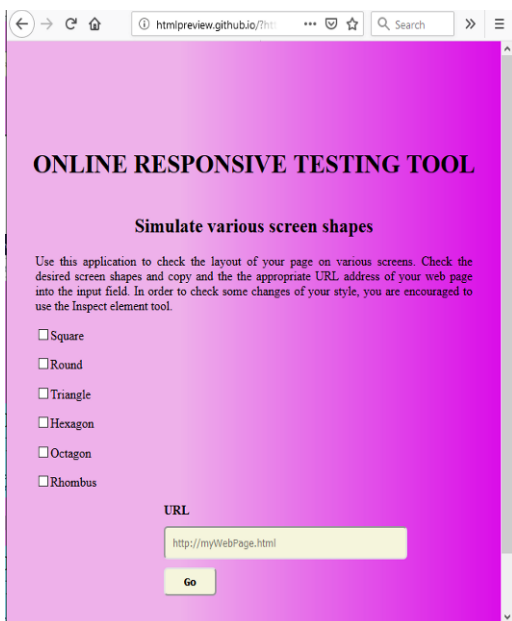


Figure 3. The online responsive testing tool.

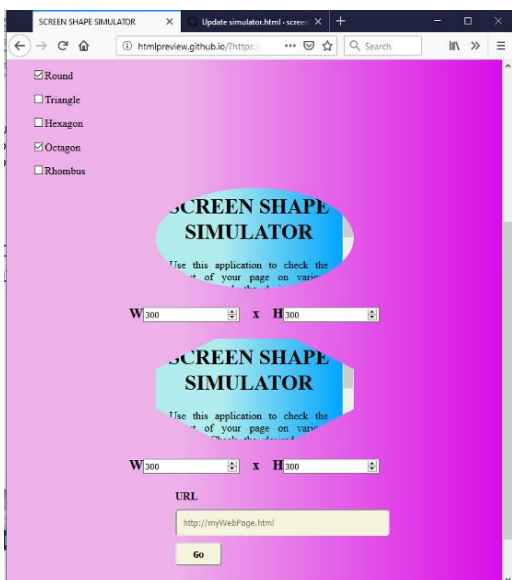


Figure 4

Figure 4. Round and Octagon shaped screens.

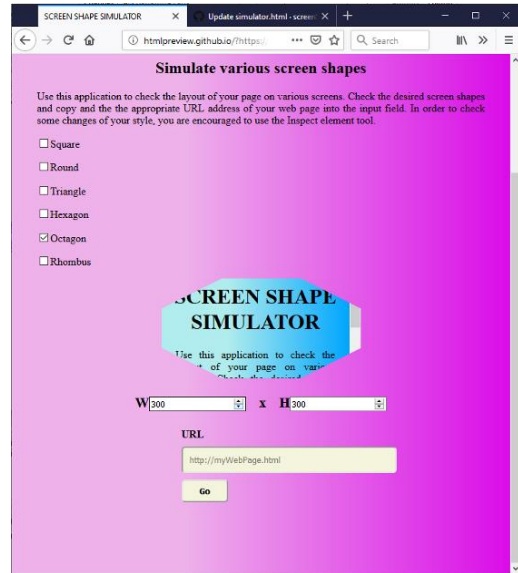


Figure 5. The round shape is unchecked now.

Figure 4. shows two iframes simulating a round shaped and an octagon shaped screen which appear on the page after checking the appropriate checkboxes. All added iframes load a test page.

As one can see at Figure 5. if we uncheck the round shaped checkbox, the appropriate iframe will disappear from the page.

In order to allow testing the entire web page, all iframes are scrolling enabled, see Figure 6. Thus, the user can turn on and off the visibility of each frame as needed, in order to have better overview.

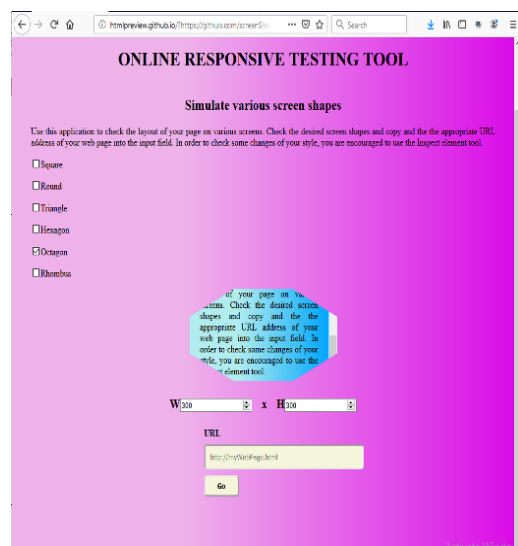


Figure 6. The iframe is scrolling enabled.

Below each iframe, there also appear two menus for selecting the width and height of the iframe. Figure 7. shows the enlarged iframe (400 x 400px).

On the bottom of the page there is an input field where one can input the URL address of the web page to be tested. For example, let us check the Infotech-Jahorina symposium website ([44]) layout, Figure 8. As one can see, the page is not

displayed correctly. There are many problems with the layout. For example, the conference logo is cropped.

To find out what changes in the style are needed to display the page elements correctly, one can right click at the page element and to start the Inspect Element tool (see [45] for a detailed description of the usage of this tool).

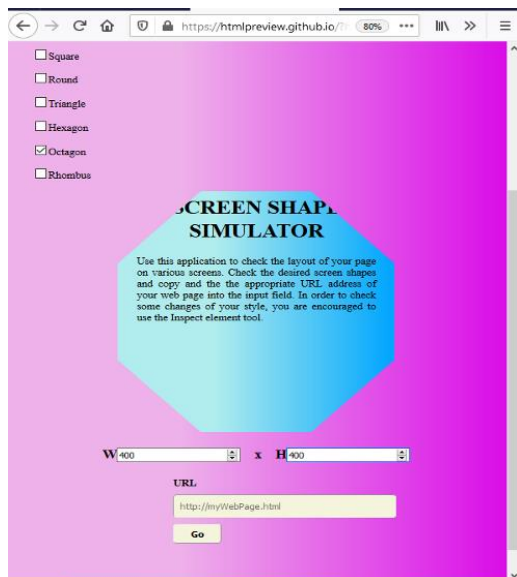


Figure 7. The dimensions of the screen are changed.

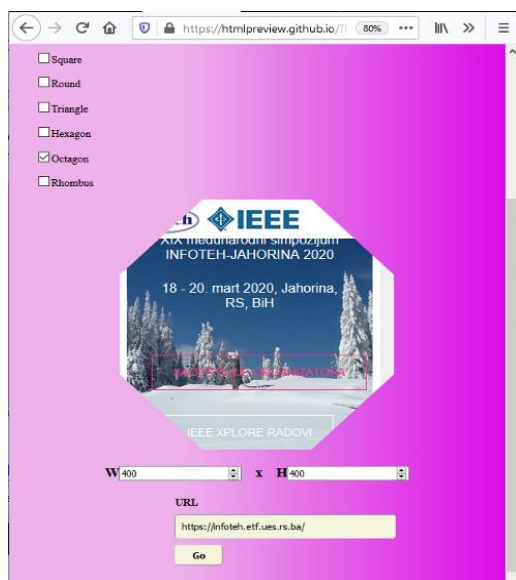


Figure 8. A new page is loaded in the frame.

By using the Inspect Element tool one can see the source code of the web page, and the appropriate CSS style. The user can change the style in order to have a preview on the intended changes. In our case, there are a several issues in the style to be changed in order to display the page correctly. First, due to the shape of the screen, there is not enough place for all the elements appearing in the header: The IEEE logo, the Infotech-Jahorina symposium logo and the hamburger menu. This is why we have to increase the header height first. Then the two logos and the hamburger menu should change their positions by adding them some margins. Besides, scaling them helps to get more place, too. As one can conclude from the source code

of the page, the page heading is placed in a divider with a jumbotron class. Since it is cropped, we need to increase its top margin. For practical purpose, we will show only a few of these steps on Figure 9. - Figure 11.

Figure 9. shows scaling and positioning the IEEE logo. Figure 10. shows positioning and scaling the hamburger menu, whereas Figure 11. shows increasing the top margin of the divider with the jumbotron class containing the page heading. After one finishes trying out the needed changes of the page style in the Inspect element tool, it remains to copy and paste them into



Figure 9. Changing the position and scaling the IEEE logo.

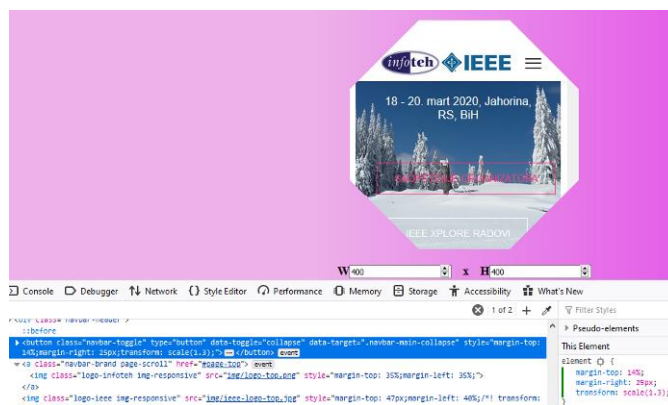


Figure 10. Changing the position and scaling the hamburger menu

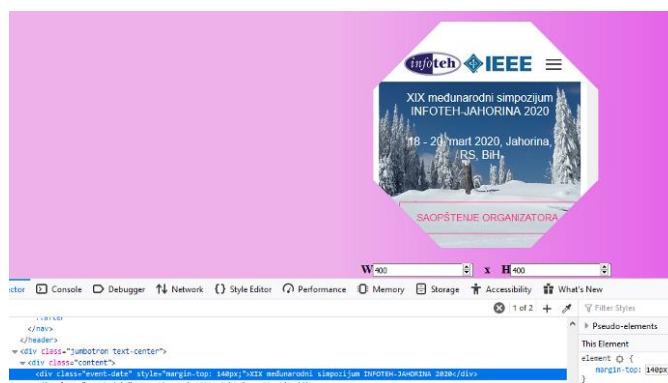


Figure 11. Increasing the top margin of the heading in the jumbotron class.

the source code of our web site. Then the layout of the page is suitable to be displayed on an octagon shaped display of dimensions 400x400px.

VI. COMPARISON OF THE DEVELOPED RESPONSIVE WEB DESIGN TESTING TOOL WITH SIMILAR TOOLS

As already mentioned, there are a lot of responsive testing tools available on the web, but they are all created in order to check the responsiveness of web pages to be displayed on rectangular screens only. The majority of such tools are limited to a specific set of screen dimensions which are most common for PC, tablet and mobile phones. This is due to the reason that smart watches with web browsers are a novelty by now. The mobile testing add-on for Google Chrome called Mobile/Responsive web design tester [46] and the Multi screen test *What is my screen resolution*, [47] are an exception, they allow the users to choose their own dimensions of the screen (besides a set of common dimensions). So, we can compare a web page layout on rectangular screens obtained using our testing tool with the ones obtained using the Google Chrome responsive add-one and the Multi screen test.

Our aim is to analyze issues in finding the proper style of the web page of the International Symposium Infotech-Jahorina

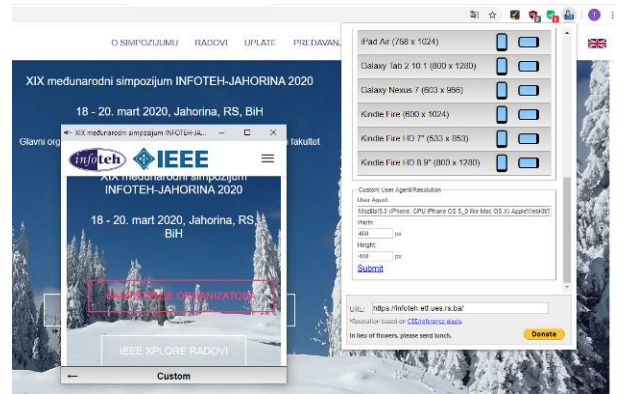


Figure 13. Infotech-Jahorina symposium web site layout on Mobile/responsive web design tester, [46] with screen dimesions 400x400px.

displayed on various screen shapes by using our responsive testing tool in the next section. Figure 12. shows the layout of the Infotech-Jahorina Symposium website on all screen shapes available on our responsive testing tool with dimensions 400x400px. Let us compare the layout of the page on a square screen (Figure 12. a)) using our repsonive testing tool with the layouts of the same page one gets using the Google Chrome add-on (Figure 13. and the Multi screen test (Figure 14. for the

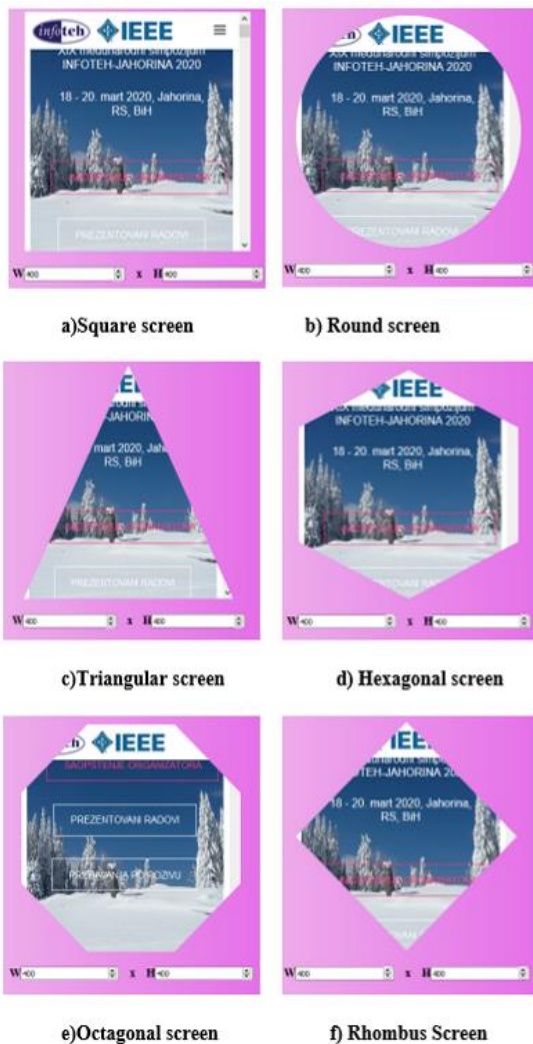


Figure 12. Infotech-Jahorina Symposium website layout on various screen shapes with screen dimensions 400x400px.

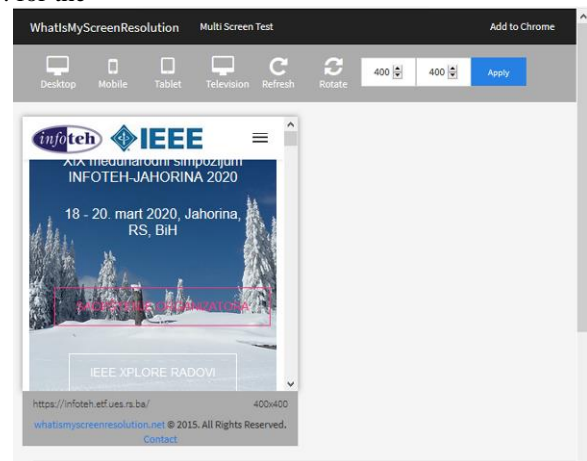


Figure 14. Infotech-Jahorina symposium web site layout using Multi screen test *What is my screen resolution*, [47] with screen dimensions 400x400px.

same screen dimensions. As we can see, the results are the same.

VII. ADAPTING THE LAYOUT OF WEB CONTENT TO VARIOUS SCREEN SHAPES

The work with the new responsive testing tool was illustrated in Section five. This section is devoted to the issues of styling a web page to be displayed correctly on various screen shapes. Let us try to explain some of these issues considering the layout of the Infotech-Jahorina Symposium website. To be more precise, we are going to find a proper style for the header elements like logo and navigation menu. The chosen screen dimensions are 400x400px.

Let us first comment the layout of the page on square, round, triangular, hexagonal, octagon and rhombus shaped screens shown on Figure 12. As one can easily check by analyzing the source code, the Infotech-Jahorina symposium

website is created using the Bootstrap framework, so it is responsive in the classical sense, i.e. for square shaped screens. So there is only one lack on this layout: The heading of the page is not completely visible, Figure 12. a). The same appears as a problem on all the other screen shapes, as well. On the other side, the web page layouts on all screen shapes, except the square one, have an additional problem: The header including the Symposium logo, the IEEE logo and the hamburger menu button are not correctly displayed. Hence, there is a set of corrections in the style to be performed in order to display the page correctly on those screen shapes, as can be seen from TABLE I.

As already mentioned, in the case of the square screen shape, there is only one correction needed, i.e. one has to increase the margin-top to the jumbotron class with heading of the web page. Besides that, for the round, hexagonal and octagonal screen shapes, we need to increase the header height in order to make place for the header elements, to change the position of the IEEE and the Infoteh-Jahorina symposium logo and the hamburger menu. In addition, the triangular and rhombus screen shapes indicate a pretty large increasing of the header height, so the sticky navigation menu does not make any sense, and we should unstick it. According to the needed changes in the page style, we can group the available screen shapes into three groups, see TABLE II.

TABLE I. CHANGES IN STYLE NEEDED ON VARIOUS SCREEN SHAPES

Issue to be corrected	Screen shape					
	Square	Round	Triangular	Hexagonal	Octagonal	Rhombus
Increase jumbotron margin-top	✓	✓	✓	✓	✓	✓
Change the header height	✗	✓	✓	✓	✓	✓
Change IEEE- logo position	✗	✓	✓	✓	✓	✓
Change Infoteh – Jahorina logo position	✗	✓	✓	✓	✓	✓
Change Hamburger menu button position	✗	✓	✓	✓	✓	✓
Scale the IEEE - logo	✗	✗	✓	✓	✓	✓
Scale the Infoteh-Jahorina logo	✗	✗	✓	✓	✓	✓
Scale the Hamburger menu button	✗	✓	✓	✓	✓	✓

Unstick the navigation menu	✗	✗	✓	✗	✗	✓
-----------------------------	---	---	---	---	---	---

TABLE II. SCREEN SHAPE GROUPS ACCORDING TO STYLING ISSUES

Styling group	Screen shape
I	Square
II	Round, Hexagonal, Octagonal
III	Triangular, Rhombus

We can conclude that due to the different shape issues, it is almost impossible to seek for a unique design that fits all screen shapes. By now, one could create separate web pages for each group of screen shapes, but this would be a big step backwards in responsive web design. That is why we are awaiting the development of media queries, not only for round



Figure 15. The corrected layout of the Infoteh – Jahorina symposium web page using the responsive testing tool

and rectangular screen shapes, but for a larger set of shapes. Figure 15. shows the corrected layout of the Infoteh-Jahorina symposium website using the responsive web design tool with the screen shapes simulator.

VIII. CONCLUSIONS

Herein a responsive web design testing tool for different screen shapes is presented. This tool presents a small step in dealing with an upcoming issue in the field of responsive web design: Adapting web content to different screen shapes. The responsive web design testing tool contains a screen shape simulator which enables the user to choose various screen shapes for which the layout of the web page is intended to be adapted. The Infoteh-Jahorina symposium web site is taken as an example to illustrate the use of the tool and to realize the issues of styling a web page to be displayed correctly on various screen shapes. Considering the obtained results, one can conclude that the best solution for this problem could be the development of CSS media queries for various screen shapes. This would enable to use various styles for the same web page when displayed on devices with various screen shapes. But, since we still don't have those media queries to distinguish various screen shapes, the only way to adapt the layout on various screen shapes is to group several similar screen shapes and create separate web sites for them. However, this is not a sustainable solution, since this causes several other problems like duplicate content treatment by Google crawlers and updating information on several websites on the same time which can be quite uncomfortable and time wasting.

The screen shape simulator is limited for now, since it offers only a few different screen shapes (square, round, triangular, hexagonal octagonal and rhombus). But the list of shapes can be easily extended. Another limitation is that the screen shapes which are available for testing are regular geometric shapes. On the other hand, there are no limitations for LED displays to be produced in irregular geometric shapes. Creating a modification of this testing tool which allows defining irregular geometric screen shapes could be created in JavaScript as well. It could be based on transforming the regular geometric shape by dragging its nodes and obtaining the parameters of the clip-path accordingly. This will remain for the author's further investigations.

REFERENCES

- [1] T. Krunić, A responsive web design testing tool using a simulator of different screen shapes built in JavaScript, 19th International Symposium INFOTEH-JAHORINA, 19-21 March, 2020, pp. 139-140, <https://infoteh.etf.ues.rs.ba/zbornik/2020/radovi/P-3/P-3-4.pdf>
- [2] S. Kemp, Digital 2019: Global internet use accelerates, 2019, <https://wearesocial.com/blog/2019/01/digital-2019-global-internet-use-accelerates>
- [3] Smart device, Technopedia, 2020, <https://www.techopedia.com/definition/31463/smart-device>
- [4] Smart devices, Arm glossary, 2020, <https://www.arm.com/glossary/smart-devices>
- [5] T. Lacom, What is a smart display?, Smart home, 2018, <https://www.digitaltrends.com/home/what-is-a-smart-display/>
- [6] Popularity of outdoor LED displays in different countries, DAKCO, 2019, <https://www.dakcoled.com/blog/popularity-of-outdoor-led-displays.html>
- [7] M. Federed, Why LED display solution are must have for business, 2109, <https://www.digitalsignageconnection.com/why-led-display-solutions-are-a-must-have-for-your-business>
- [8] History of monitors, 2020, <https://www.absolutelegends.net/history-of-monitors/>
- [9] J. Bort, The history of the tablet, an idea Steve Jobs stole and turned into a game-changer, 2013, <https://www.businessinsider.com/history-of-the-tablet-2013-5>
- [10] K. Jackson, A brief history of the smartphone, Sience node, 2018, <https://sciencenode.org/feature/How%20did%20smartphones%20evolve.php>
- [11] Web browser for wear OS (android wear), Google play, 2020, <https://play.google.com/store/apps/details?id=com.appfour.wearbrowser&hl=fr>
- [12] J. Edelblut, Hexagon wearable, 2020, <https://www.behance.net/gallery/30412423/Hexagon-Wearable>,
- [13] Visual Power, Creative LED display, P3 Hexagon shape led display, <http://www.avledscreen.com/productn.asp?ArticleID=2004>
- [14] Creative led display, Apexls, <https://www.kszled.com/creative-led-display/triangular-led-display.html>
- [15] Heart shape flex LED panel, 2020, <http://www.ledadvertising-display.com/sale-11770649-heart-shape-flex-led-panel-ultra-thin-flexible-display-screen-1000nits.html>
- [16] Round flexible LED display for shopping center, 2020, <http://www.ledadvertising-display.com/sale-11770642-1500-nits-round-flexible-led-display-for-shopping-center-concert-room.html>
- [17] I. Fried, That triangle-shaped tablet from "The Office" — One Guy Wants to Build It, 2011, <http://allthingsd.com/20111222/that-triangle-shaped-tablet-from-the-office-one-guy-wants-to-build-it/>
- [18] K. Cyr, M.dot vs. responsive vs. progressive: What's the right solution for your company?, <https://www.mobify.com/insights/m-dot-responsive-progressive-whats-the-right-solution/>, 2015
- [19] B. Wright, Standalone mobile site vs mobile responsive site, <https://todaylocalmedia.com/standalone-mobile-site-vs-mobile-responsive-site/>, 2020
- [20] Responsive web design vs. standalone mobile site: Which is better for SEO?, <https://www.flightpath.com/blog/2014/05/responsive-web-design-vs-standalone-mobile-site-better-seo/>, Flyingpath, 2014
- [21] C. Holst, Account creation, standalone mobile websites, and dealing with non-UX designers, Smashing magazine, <https://www.smashingmagazine.com/2013/02/account-creation-standalone-mobile-sites/>, 2013
- [22] J. Looper, Responsive design vs. 'm' sites, <https://www.sitepoint.com/responsive-design-vs-m-sites/>, 2014
- [23] The evolution of responsive web design: A very brief history, 2020, <https://www.1digitalagency.com/the-evolution-of-responsive-web-design-a-very-brief-history/>
- [24] Responsive web design – what it is and how to use it, 2011, Smashing magazine, <https://www.smashingmagazine.com/2011/01/guidelines-for-responsive-web-design/>
- [25] A. Pillon, What is responsive web design, Small business trends, 2018, <https://smallbiztrends.com/2013/05/what-is-responsive-web-design.html>
- [26] Using media queries, MDN web docs, 2020, https://developer.mozilla.org/en-US/docs/Web/CSS/Media_Queries/Using_media_queries
- [27] Grid system, Bootstrap, 2020, <https://getbootstrap.com/docs/4.0/layout/grid/>
- [28] K. Sherwin, 2014, Beware horizontal scrolling and mimicking swipe on desktop, 2014, <https://www.nngroup.com/articles/horizontal-scrolling/>
- [29] See your site responsive, 2020, <http://ami.responsivedesign.is/>
- [30] Responsive test tool, 2020, <http://responsivetesttool.com/>
- [31] How responsive is your web design?, Responsive web design checker, 2020, <https://responsivedesignchecker.com/>
- [32] P. Lamkin, Smartwatch timeline, The devices that paved the way for the Apple watch, 2015, <https://www.wearable.com/smartwatches/smartwatch-timeline-history-watches>
- [33] CSS round display level 1, CSS working draft, 2016, <https://www.w3.org/TR/css-round-display-1/>
- [34] T. Krunić, D. Krstić, A simple responsive web design simulator for round screen devices built in JavaScript, XVLI International symposium on operational research, Kladovo, Serbia, 2019, ISBN: 978-86-768-363-7, pp. 209 – 214, <http://symopsis2019.fon.bg.ac.rs/download/SYM-OP-IS%202019%20Proceedings.pdf>
- [35] Responsive web design, AIDAH creative enterprise, 2019, <https://www.aidah.co.za/responsive-design.html>

- [36] S. Perry, Bruce Lee may have invented responsive web design, Posts – Steve Perry Creative, <https://steveperrycreative.com/post/bruce-lee-may-have-invented-responsive-web-design>, 2019
- [37] A. McPeack, How responsive web design will change in 2019 and beyond, 2019, <https://crossbrowsertesting.com/blog/development/future-responsive-design-2019/>
- [38] What is the HTML DOM?, https://www.w3schools.com/whatis/whatis_html5dom.asp
- [39] Introduction to the DOM, MDN web docs, https://developer.mozilla.org/en-US/docs/Web/API/Document_Object_Model/Introduction
- [40] The advantages and disadvantages of Javascript, <https://www.freecodecamp.org/news/the-advantages-and-disadvantages-of-javascript/>, Free code camp, 2019
- [41] CSS clip-path property, https://www.w3schools.com/cssref/css3_pr_clip-path.asp, 2020
- [42] GitHub, <https://github.com/>
- [43] GitHub & BitBucket HTML preview, <https://htmlpreview.github.io/>
- [44] International Symposium INFOTEH-JAHORINA, <https://infoteh.etf.ues.rs.ba/> 2020
- [45] A. Pope, Inspect Element: How to temporarily edit any web page, 2018, <https://zapier.com/blog/inspect-element-tutorial>
- [46] Mobile/Responsive web design tester, <https://chrome.google.com/webstore/detail/mobileresponsive-web-desi/elmekokodcohlommfikpmojhegnbelo?hl=en>, 2020
- [47] What is my screen resolution, Multi screen test, <http://whatismyscreenresolution.net/>, 2020



Tanja Krunić was born in Langen, Germany, in 1974. She received a BSc, MSc and PhD degree in Mathematics from the Faculty of Natural Sciences, University of Novi Sad, Serbia.

She teaches subjects connected with web design, web development and Search engine optimization at the Higher Education Technical School of Professional Studies in Novi Sad, Serbia.

Her basic field of interest is also Mathematical analysis, especially partial differential equations