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Development of Emulator for CSS3 Extension to Represent Web Contents on Stereo Device

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Abstract

In this paper, we extend CSS specifications which are needed to reconstruct standard-based 2D web contents in 3D space using CSS stylesheet, and we implement an emulator to confirm the result of representing written sample contents 3D-stereoscopically on a stereo device. First, a new profile which is needed to set the view volume and layout web contents out in 3D space is proposed by extending CSS3 specifications. Then, the user freely reconstructs the web contents from the browser in 3D space using the nwly extended CSS3 specifications and writes sample contents of various kinds. In sequence, the sample contents which were written through preprocessing process using the extended specifications are converted to original CSS code, so that it is executable in webkit-based browsers. Lastly, in system rendering engine emulator, stereo view volume is automatically created, and the user can verify the result of 3D-stereoscopic representation by emulating the final stereo image files, which can be obtained from virtual left and right cameras, on stereo device.

Keywords: *3D, Web contents, Stereoscopic, Emulator, HTML5, CSS3*

1. Introduction

Recently, demand for web contents application in fields of smart TV and data broadcasts is increasing, as smart devices which support 3D stereo function such as smartphone, smart TV are surging. Also, standardization of TV platform based on HTML5, web's standard technology, is domestically in progress. In W3C(World Wide Web Consortium) accordingly, study on 3D stereo display and its standardization is going on actively, and in terms of hybrid broadcast, study on representing data using browser-based declarative contents is being progressed. As for browser-based declarative contents, XML(Extensible Markup Language), HTML(Hypertext Markup Language), CSS(Cascading Style Sheet) and more were applied, and it has become possible to describe contents independently of platform or device using these web standards. As for browser-based declarative contents technology which is becoming spotlighted recently, there are HTML5 and CSS. HTML5 is the next-generation web standard which is being established in W3C, the ISO (International Organization for Standardization) for web standards, and it extensively defines various tags. CSS is a W3C standard which was established with the purpose to separate and describe the logical structure of a web page and the presentation on screen, and it defines several levels and profiles to support various styles based on media type. In CSS particularly, many profiles are being supported with the purpose to consider various device environments. Out of them, CSS TV profile is a profile which was defined considering the requirements and conditions of a TV

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device, and it is applied when representing browser-based contents in TV. However, the current CSS TV profile standard was defined before the appearance of CSS3, hence not including the concept of three-dimensional space. Also, standards for HTML5 or CSS which are already developed or being developed, do not contain specification of methods to place contents in three-dimensional space or to represent it as stereo solid image.

Thus, in this paper, we extend current CSS specifications to represent web contents written in HTML5 in stereo space, under web environment. In addition, we implement an emulator to verify the result of representing written sample contents 3D-stereoscopically on a stereo device.

2. Related Technology

2.1. 3D Representation Techniques and Extension for Stereoscopic 3D

As 3D data applications in webpages increase, 3D representation-related study on the webpage is being progressed [1]. Currently, 3D modeling representation is available on WebGL and Web3D, but it focuses entirely on 3D objects in 3D space. Also, related studies on representation for the stereoscopic 3D web are being progressed in W3C [2]. It extends CSS specification to represent 3D-stereoscopically on the web as shown in Table 1.

Table 1. CSS Specification Extension for Representing Stereoscopic 3D

Composition	CSS property
Extended CSS 3D property	perspective-baseline
Stereo properties to specify stereo 3D contents	stereo-content, stereo-render-option, stereo, stereo-size-type, stereo-order-type, stereo-format
Media type ‘3D-display' for Media Query	non-normative
Display Interface (Device API for stereo rendering)	non-normative

In particular, browser-based content of TV can be represented using CSS TV Profile 1.0[3], which is defined considering requirements and constraints of TV device as shown in Table 2. Other than shown in the table, specifications which are related to mouse event and conditional search, such as Speech module, Template Layout module, Fragmentation module and more, were excluded from the TV profile. Above this, existing broadcast contents which enable 3D image data to be sent to the user’s device beforehand by downloading in real-time using broadcast network or IP network, and hybrid network-based 3DTV service technology which can provide 3DTV service at optional time using synchronous or non-synchronous methods, are being studied.

Table 2. CSS TV Profile 1.0 Specification

Related modules	Excluded specification from current CSS
Backgrounds and Borders module Level 3	background-attachment, border-collapse, border-spacing
Positioned Layout module Level 3	none

Font module Level 3	font-size-adjust, font-stretch
Text Level 3	text-shadow, word-spacing, white-space
Lists and Counters module Level 3	none
Basic UI module Level 3	cursor

2.3. CSS3 Modules in W3C

In W3C, the characteristics of CSS2 which define the layout of webpage and its style were extended. The most recent CSS3 module extended the characteristics of CSS2 which effectively assigns the style of a web page document, and adopted the concept of modules such as text, font color, background & border, transform, transition, animation and more [4]. Thus, it has become possible to create code in module units, load only the CSS modules that are needed in sorts of browsers or devices, and rapidly update only the necessary module. Of the three CSS3 modules related to this study, CSS3 Fragmentation Module is a module which divides the formation of a page, and it can split a page in various sizes and directions. CSS3 Positioned Layout Module [5] is mostly used when placing elements, and it enables assigning the order when the positions of elements overlap. CSS3 3D Transform Module [6] is used when placing elements in 2D/3D space, editing web contents or defining spaces of 3D form. CSS3 3D Transform Module is only concerned in 3D transformation (T, R, S) of the objects in 2D space, but there are no attributes to lay objects out in 3D space.

3. Objective of Research

We extend CSS specifications which are needed to reconstruct 2D web contents in 3D space using CSS, and we implement an emulator to confirm the result of representing written sample contents 3D-stereoscopically on a stereo device, as shown in Figure 1.

Process of this system is composed of user's 3D-stereoscopic representation using extended CSS3 specifications and emulation in system rendering engine emulator. First, the user separates a web page consisted of various 2D-based multimedia contents into various forms using current CSS properties. Then, a new profile which is needed to set the view volume and layout web contents out in 3D space is proposed by extending CSS3 specifications. After that, the user freely reconstructs the web contents from the browser in 3D space using the newly extended CSS3 specifications and writes sample contents of various kinds. In sequence, the sample contents which were written through preprocessing process using the extended specifications are converted to original CSS code, so that it is executable in webkit-based browsers. Lastly, in system rendering engine emulator, stereo view volume is automatically created, and the user can verify the result of 3D-stereoscopic representation by emulating the final stereo image files, which can be obtained from virtual left and right cameras, on stereo device.

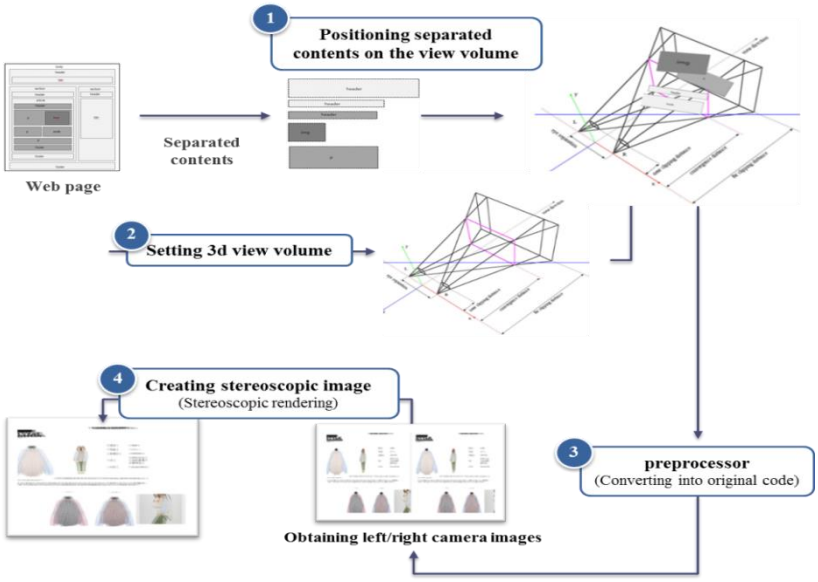


Figure 1. Process of 3D Stereo Representation from 2D Web Content

4. CSS3 Stylesheet Extension for Representing 3D Layout of Web Content

There is no solution to fill in overall information which is needed to set the view volume in graphics using current CSS specifications. Like this, setting view volume using CSS cannot have abundant composition like view volume in graphics, so it is necessary to define new CSS profile by extending CSS specifications, which is needed when setting view volume.

The profile we are proposing was newly defined by extending CSS specifications in order to enable representing 3D-stereoscopically on various stereo devices by reconstructing 2D web contents in 3D space. Later on, it will be consisting of contents showing CSS specification extension and contents of CSS TV Profile 1.0, which is the CSS profile related to TV devices. While sequentially progressing steps of view volume settings, contents layout in view volume, and projection mode settings in order to place the objects separated from web page on three-dimensional space, we examined nodes, properties and property values which are needed in each step and defined other necessary factors.

4.1. 3D View Volume Setup

In order to place multimedia objects comprising the web content into 3D space, 3D view volume must be set. 3D view volume of 3D graphics information includes various properties; *e.g.*, viewpoint, view direction, up-vector, view angle, near/far clipping distance, convergence distance. So, camera, lens, clipping and other setting information are required by default.

Currently, there is no way to set all the information to set the rich view volume using CSS. We can set the view volume by using following three properties; perspective, perspective-origin, transform-style of the CSS 3D Transform module. It cannot represent all the information of 3D view volume setting on graphics. It can only set viewpoint and convergence distance. Table 4 summarizes default information required to set the 3D view volume and the properties of view volume setting in existing CSS [7].

Table 4. 3D View Volume Setting Information and Related Property of CSS

Category	3D view-volume set-up information	Related attribute of CSS
viewpoint setup	viewpoint(x, y, z)	perspective-origin: x, y
	up-vector(x, y, z)	fixed(0, 1, 0)
	view direction(x, y, z)	fixed(0, 0, 1)
view space setup	view angle($\propto_w$, $\propto_h$)	fixed(Screen size)
	near, far clipping distance(d_n, d_f)	none
	convergence distance(d_c)	perspective
projection setup	projection mode setup	transform-style : ‘flat | preserve-3d’
placement of web content	none	z-index: <element>

Therefore, we need to extend CSS specification for 3D layout of web content as shown in Table 5. Users could set camera position which determines a viewpoint by using 'perspective-origin' property of CSS 3D Transform module, but it can only be set vertically or horizontally of the camera position as the input values of the property only have x, y coordinates. The additional '-3dLayout-perspective-origin' property accepts input of x, y, coordinates of camera position with z-value additionally, which is the distance from camera to convergence plane. Absolute length units such as %, mm, and em could be used as input units. In current CSS, there is no property to set view-direction, which enables setting the direction of convergence plane to perpendicular. Therefore, we suggest extension of specifications for the users to freely look at the object from the various points including the front, back, left, right, up, down, and more, so that the user could set from at which point they are looking at convergence plane using CSS. Also, there is no property to set the up-vector in current CSS, as the direction of y axis is fixed towards the form. Therefore, we extend the specification for setting up camera freely in the direction to the left, right, up, down direction with x, y positioning values. This allows defining the rotation of camera by setting which direction shows ‘an upward direction’ of the display.

'-3dLayout-PerspectiveVolume' property consists of four parameters (<fovy>, <aspect>, <near>, <far>) for setting the view space which helps to set up the view volume. <fovy> is the user's field of view, <aspect> is projection surface of the horizontal / vertical scaling, <near>, <far> tells the distance of near and far clipping plane on z axis. Therefore, these allow the user to set how closely they could see the object and towards which point they could see. Through 'transform-style' property of CSS, user could set how to render object in 3D space. We added the '3dstereo' property value for specifying the projection mode with forms of layout in 3D space.

Table 5. CSS Specification Extension for 3D Layout of Web Content

Category	CSS specification extension
viewpoint setup	**•-3dLayout-perspective-origin : x y z;** : extend ‘perspective-origin : x y;’ property **•-3dLayout-view-direction : x, y, z;** **:** suggest new **•-3dLayout-up-vector : x, y;** **:** suggest new

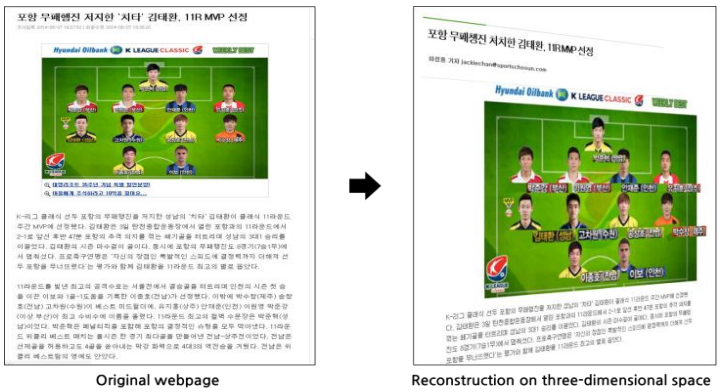
view space setup	**•-3dLayout-perspectiveVolume : <fovy> <aspect> <near> <far>;** : extend 'perspective : <length>;' property
projection setup	**•transform-style : '3dstereo';** : add property value to 'transform-style : flat | preserve-3d' property of current CSS

4.2. Object Layout in the View Volume

Currently, there is no way to input z-value for each content directly. Now, 'z-index' of CSS3 Positioned Layout module determines arrangement of elements. It only determines arrangement of elements within the same plane, so it cannot compose 3D space. Therefore, we suggest extending CSS specification to place web content in view volume as shown in Table 6. '-3dLayout-positioning' and '-3dLayout-relative-positioning' property inputs horizontal, vertical positions and z-coordinate concurrently for each object 'depth' and 'z-depth' property input the form of 'real value + unit'. If users arrange objects in the relative coordinates, they have to set a base layer position by using '3dLayout-SetbasePosition (<x position>, <y position>, <z position>)' property. These properties enable each object to include Z value and express information of relative depth. In order to confirm the result of placing 2D content in 3D space in document, the result was rotated by a predetermined angle as shown in Figure 2.

Table 6. CSS Specification Extension for Layout of Web Content in View Volume

Category	CSS specification extension
Absolute positioning	**•-3dLayout-depth : <length>;** : suggest new property **•-3dLayout-positioning : <x position> <y position> <z position>;** : suggest new property
Relative positioning	**•-3dLayout-z-depth : <length>;** : suggest new property **•-3dLayout-relative-positioning : <x position> <y position> <z position>;** : suggest new property. Input '3dLayout-SetbasePosition : x y z;' property to set a position of based layer



Original webpage　　Reconstruction on three-dimensional space

Figure 2. Placement of Web Content in View Volume

4. Rendering Engine Emulator and Results

In advance, we proposed methods to setup the View Volume which is necessary when reconstructing HTML-based webpage in 3D space using CSS3. However, the extended CSS3 specifications proposed in this study are not W3C standards, and cannot be represented on current browsers. Therefore, it is necessary to enable contents written in extended CSS3 specifications to be represented on webkit-based browsers, and web contents to be represented stereoscopically on stereo devices, with the extended CSS3 specifications.

Accordingly, the system process must be largely composed of preprocessing process and emulation process of the rendering engine emulator which provides output of left/right eye image as shown in Figure 3. Above all, the preprocessing process must be progressed in order to make web browser-mounted contents written in CSS3 specifications, extended to represent web contents 3D-stereoscopically, be representable on webkit-based browsers. The preprocessed contents are outputted after being converted into original code, and afterwards, the rendering engine emulator outputs images from virtual left/right eye cameras respectively by automatically creating stereo view volume. The final result of 3D-stereoscopically represented stereo image file can be verified through emulation on stereo device.

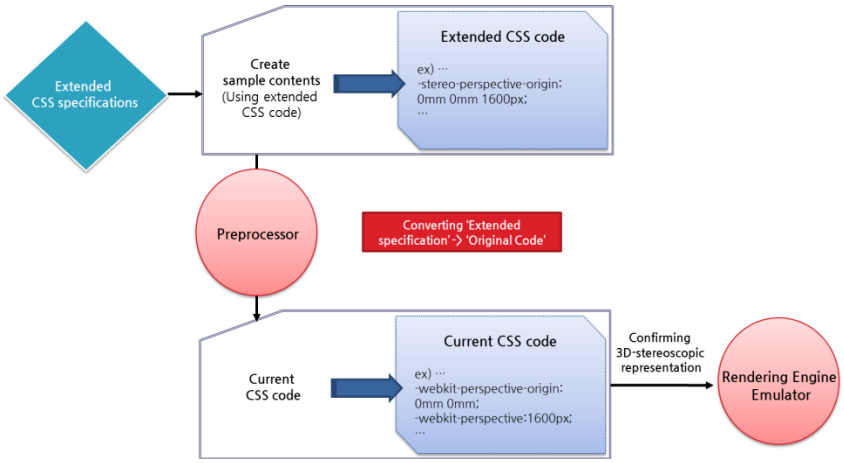


Figure 3. System Procedure [8]

4.1 Preprocessor

System preprocessor was implemented using Javascript, and it converts written extended code into current CSS code to enable web browser-based declarative contents, written in extended CSS specifications, to be executable on webkit-based browsers. The preprocessor is largely divided into steps of file-reading, converting extended specifications, and creating new files by outputting converted values. It shows the output forms of preprocessing specifications, which were additionally extended in process of view point/volume settings, contents layout and projection mode settings. In addition, in order to make CSS code executable on the rendering engine emulator which will be run by webkit-based browser afterwards, CSS hack '-webkit-'must be requisitely used.

4.2 Rendering Engine Emulator

This section describes the operations in rendering engine emulator, the last process. The emulator automatically creates stereo view volume on the basis of user-set mono view

volume. Then, left/right eye images are obtained from virtual left/right eye cameras, and the final stereo images are emulated on a stereo device according to display properties.

4.2.1 Automatic Formation of Stereo View Volume: At the position of previously set view point, default mono view volume is set. This project is based on the assumption that the position of view point of the mono view volume, set in this study, is placed in the middle of user's left and right eyes. In this regard, the rendering engine emulator automatically sets two view volumes of virtual left/right eyes, which have distance of 65mm, the standard distance of left/right eyes of an adult. Then the emulator applies camera position-setting CSS extended specification property '-3dLayout-perspective-origin' to obtain information about view point position at left/right eye, by equally moving the x-coordinate of mono view volume's view point position by 32.5mm in left/right directions. In this way, the emulator automatically creates the stereo view volume, and we can construct stereo view volumes of diverse forms, depending on the position of focus point. There are two methods of creating stereo view volume, which are defining the focus point as infinity and positioning the focus point on projection plane as shown in Figure 4.

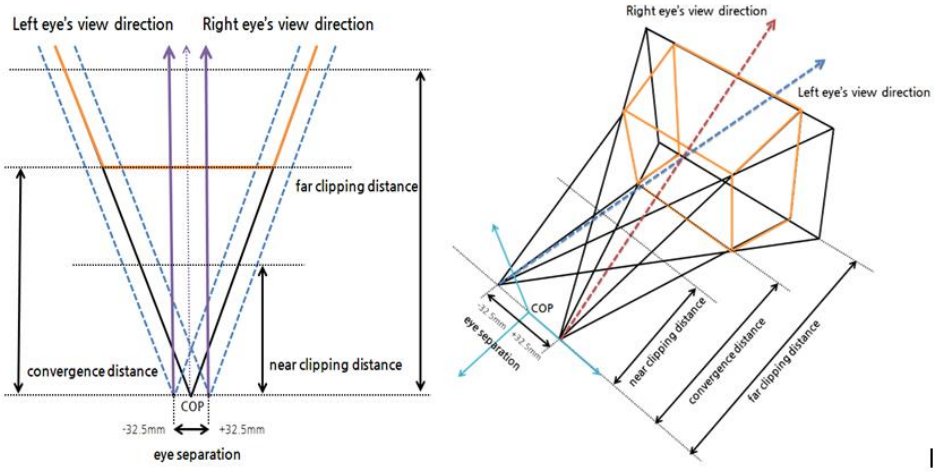


Figure 4. Automatic Formation of Stereo View Volume

4.2.2 Obtaining Left/Right Eye Images: Left/right eye images can be obtained from the emulator, using either of two methods of setting the stereo view volume. By making the view direction of left/right eye cameras of previously created stereo view volume regularly perpendicular to projection plane, the focus point is set as infinity, and the stereo view volume is created. As shown in Figure 4, the focal distance is automatically set as infinity in a stereo view volume space which is set using the original CSS, since when setting the view volume, the view direction toward view plane is fixed perpendicularly in default. However, if extended CSS specifications are applied, it is possible to adjust the view direction or view angle of left/right eye cameras in previously created stereo view volume. Therefore, stereo view volume can be formed by positioning the focal distance on projection plane, as shown in Figure 4. Accordingly, the viewing volumes at left/right eyes respectively are constructed diversely, based on the amount of left/right movement of viewpoint's x-coordinate. From these newly created left/right cameras, images for left/right eye images can be obtained.

4.2.3 Creating Stereo Image: Following is the description of creating final stereo image file by composing the same-sized left/right images. In the process of setting the stereo view

volume, we can obtain left/right eye images by defining the depth value of separated declarative contents or coordinates in 3D space and finally positioning the objects in stereo view volume. In order to emulate in adequate forms for stereo devices, which are output devices, images obtained respectively from left/right binocular view volumes are outputted in equal sizes and finally created as a stereo image file.

Rendering engine emulator, which is executable on webkit-based browsers, was built to display two left/right eye images respectively on assigned fields, and results of representing final 3D-stereo sample contents 3D-stereoscopically can be verified through the emulator. In default, webpage screen in mono view volume, which has the user-set viewpoint position information, is outputted on the two assigned fields. Images which are to be outputted in corresponding frames are set to match the output device. Then, the sizes of left/right images to be outputted in two fields in accordance with horizontal to vertical ratio of the two initially defined fields are automatically adjusted. Operation process of the emulator is shown in Figure 6, and the result of representing the final stereo image file 3D-stereoscopically was verified by emulating on final stereo device in adequate forms as shown in Figure 7.

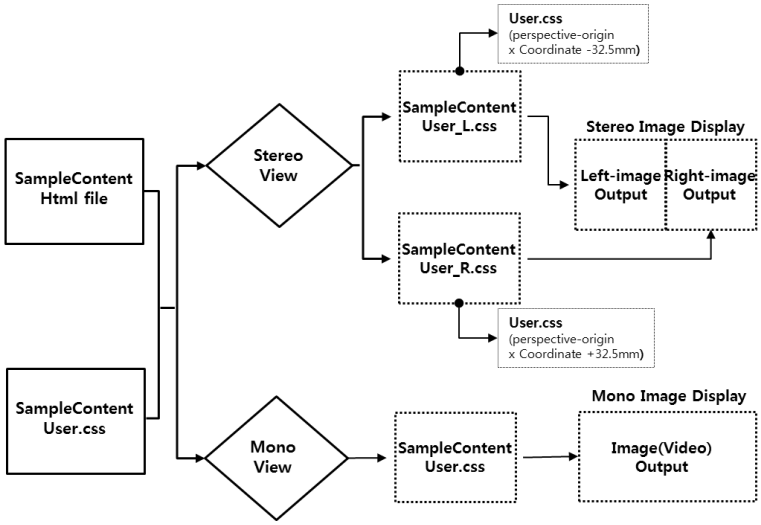


Figure 6. Procedure of Rendering Engine Emulator [8]

Figure 7. Final Result of 3D Stereo Sample Content in Stereo Device

5. Conclusion

Various stereo devices such as 3DTV support HTML5-based standard web browsers, and therefore, it is meaningful that web contents which were mostly written in HTML were represented in 3D-stereoscopic space, using web standard CSS instead of 3D graphic language. In this paper, webpages written in HTML5 were represented in three-dimensional space 3D-stereoscopically. First, we proposed a new CSS profile by extending CSS specifications, which are necessary in order to set view volume and place web contents in three-dimensional space. Also, using this profile, we implemented an emulator so that the sample contents, created by reconstructing browser-based declarative contents on webpage written in HTML5 in three-dimensional space, can be represented in stereo solid image.

Webpages which consist of various 2D-based multimedia contents were reconstructed in a three-dimensional space and represented 3D-stereoscopically using CSS. With this study, we could represent construction and manipulate 2D-based web contents freely in three-dimensional space. Thus, we will be able to represent interactive web content easily in free style in 3D space. Also, by applying the camera conception, it will be possible to manipulate view volume in various forms in 3D space, and to enable users to approach content from various viewpoints. By developing with HTML5 and CSS this way, we will be able to contribute to developing web standards. Also, studies to implement construction tools for 3D stereo representation of web content and other necessary technologies should be done in future.

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