Methods for Overcoming Problems in Preparing 3D Models of MSME Products for Online Sales Media

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Abstract. Visualization that appears more detailed on a specific object is the reason why many parties want to use Web3D technology on their websites, including MSME entrepreneurs. However, this technology requires the availability of appropriate 3D models. For businesses, especially the MSME category, creating 3D models as one of the requirements to be able to utilize Web3D technology can provide additional burdens for daily operations. MSMEs are very limited in both human resources and financial aspects so that allocating personnel and funds becomes very difficult. They needed an acquisition mechanism that could quickly produce 3D models and be immediately publishable. Apart from being quick to obtain, 3D models must accurately provide a description of the product, be suitable for sending via the internet network, and not burden the visitor's system whatever device or platform and browser they use. Provision of models using 3D scanning devices has been taken as a suitable choice from several available methods. The experiments carried out in this study have demonstrated effectiveness of this method in preparing 3D models as the main components for websites built for MSMEs. Post-processing works were still required before the results become suitable for use to represent actual products on MSME marketing and sales websites. The method can minimize the time for preparing site assets and support the independence of MSMEs in their daily operations, and help them to get back on their feet after experienced a downturn as a result of the Covid-19 pandemic several years ago. Although the final processing results produce 3D model files with an average file size of 5.2% compared to the initial scan results, further research is needed to obtain more compact 3D models, using polygons other than triangles. This is because it was found in experiments that segment reduction with any technique resulted in deformation when the number of remaining segments approached 20%.

INTRODUCTION

The Covid-19 pandemic that occurred a few years ago has had a huge impact on many parties. One of the parties affected is the business community, especially those in the MSME category [1]. MSMEs that rely on visits from prospective buyers experienced a drastic decline in transactions due to the reduced number of visitors at business locations. MSME owners are trying to overcome this problem by innovating [2], including switching to using internet-based online media [3]. However, the online media used must look attractive and have innovation, as well as content that is always up to date because apart from limited production, MSME products are also not widely known due to minimal promotion due to lack of funds [4].

Apart from using social media in its various forms [5] as a low-cost solution for their marketing and sales purposes, a common choice for MSMEs is to place their product information on marketplaces, blogs, or specific platform applications. Due to the unique nature of the products and many of them are handmade so they cannot be obtained from mass product manufacturers, physical visualization of the product is important [6] to create the best possible picture for potential buyers who want to be absolutely sure about the product they are looking at. Online media which generally use photos and videos do not allow visitors to get a complete picture like when observing products directly at MSME locations. 3D graphics visualization become an option because they allow visitors to see with perception as if observing an object in the real world in real-time [7]. Potential consumers are generally also interested in a more realistic navigation experience, which makes them want to examine a product in more depth [8].

The use of 3D graphics through Web3D technology has been carried out in various fields [9], and can be an innovation in product visualization because of its ability to depict objects in a way that imitates the real world [10]. However, 3D graphics is not something that is easy to master, especially for MSMEs who are very limited in human resources and funds. Utilization of 3D graphics requires 3D models which are the core of Web3D implementation, and it is a big problem for MSMEs to provide them. For them, learning the tools and technologies that make it possible to independently create 3D models of their own products is quite difficult. MSMEs also cannot depend on outside parties to provide 3D models because this will require relatively large additional costs for them. The high difficulty in preparing 3D models for sites prepared to market their products can hinder the desire of MSMEs to utilize Web3D technology. The possibility of implementation will be smaller if these activities do not enable MSMEs' resilience in preparing solutions for their needs [11].

This paper discusses methods for providing 3D models for MSME products that are unique and only available for a limited time. The research aims to obtain a procedure for obtaining 3D models of MSME products that are considered economical and can be carried out in a short time. Business websites generally use 3D models that are built using modeling tools using product designs created before the product is built. This research presents novelty since the products that are to be modeled en masse to be placed on business websites have been created beforehand and without any previous digital design. Thus, the resulting complete procedure requires a 3D model acquisition mechanism starting from the digitization process until obtaining 3D models that are ready to be placed on the website server. A literature review was carried out at the beginning of the research to select a basic method for acquiring 3D models. Experiments were carried out on the selected method to determine the optimal acquisition and post-processing procedures to obtain a 3D model suitable for use on websites. Therefore, research is limited to procedures according to the chosen acquisition mechanism. The products that were the object of acquisition and post-processing experiments were handicraft bags from research partner MSMEs which were generally small in size but had high surface detail due to the materials used. Basic shading and lighting effects were used only to make the 3D model appear more realistic. In addition, post-processing experiments only use triangular polygons which are the most compact n-gons and by default are assumed to produce 3D models with the smallest file sizes but can still represent the original product with high detail. The small file size is expected to mean that site performance does not suffer much, especially when the 3D model is displayed on a portable handheld device.

RELATED RESEARCH

Web3D has the potential to help businesses with display innovations that mimic the real world. Some of them are more attractive visualizations with 3D graphics that can help users learn visual-related material better [12], help users better understand various things about the product [13], and make prospective buyers better understand the physical appearance of the product so that they can have a basis for making better decisions [14]. The ability to present a view of an object from all sides without exception provides more information about whatever the user is looking at and this makes it the preferred method.

Sites that use Web3D technology display 3D models both as the main display and as site elements. Sites can use a full Web3D display pattern where visitors will enter an environment built through the implementation of 3D graphics in their browser. Viewed from the perspective of display style and how to interact with the environment, this pattern can provide visitors with a new and enjoyable web browsing experience because it is immersive [15]. However, the creation process becomes more difficult because all objects on the site must be depicted in 3D, and making them dynamic is difficult to do so most of them tend to be static even though they are interactive. On the other hand, Web3D can be used as a component or part of a conventional site. However, if it does not use a specific framework, Web3D is not truly integrated with the content of the host site that calls it, so the 3D model cannot follow the dynamic capabilities of conventional data [16].

Specific technology is required in the form of implementation to describe 3D models in a web browser. Two of them that are widely used on the internet are WebGL [17] and X3D [18], technologies that represent the Imperative and Declarative description styles respectively [19]. The way of describing 3D models using imperative style is basically drawing 3D models procedurally like in general program coding, while the declarative style depicts 3D models based on the shape of the object.

WebGL is a framework where complex models can be built with 3D modeling tools or described through scripts for simple models. This framework can use various 3D model file formats e.g. OBJ [20], and is used on sites by referring to JavaScript-based libraries that are included as part of web-based applications so that they do not require plugins [21]. There are various JavaScript-based libraries for implementing WebGL, including SpiderGL and three.js [22]. Using WebGL on a site requires mastery of specific programming scripts, learning to master it requires additional time and human resources which are difficult for MSMEs to provide. The successor to WebGL is WebGPU [23], but at the time this research was underway, the technology was not ready for use.

On the other hand, X3D is a technology and standard format according to the Web3D consortium, is a continuation of the previous standard, namely VRML [24], and has been updated in version 4 [25]. 3D models can be directly used on sites without special programming scripts because all attributes for interaction and manipulation can be directly placed in the descriptor file. Developers don't need to learn much about coding to use on sites. However, developers need to learn coding specifically if they want to use advanced interaction features so that 3D models become more dynamic with the ability to provide more specific responses according to the details of interaction with the user. In addition, X3D is not a native format for the web, its use requires plugins which often raises compatibility problems [26].

3D models can be built with various 3D modeling tools such as 3D Studio Max, Blender and others [27]. Mastering modeling tools is difficult and takes a long time, and building a model from the ground up also takes time, especially to produce a model that looks as similar as possible to the original MSME's unique handicraft products. Alternatives for creating 3D models can be done using a 3D scanner device [28] which is available as a device for industry or personal devices, however, the results must go through post-processing first. Using a LIDAR device [29] can become another option, it is usually used to scan large objects or areas, requires high costs so it will not be affordable for MSMEs.. Some mobile phone devices even include limited area scanning capabilities [30], yet detailed results on the surface shape of the object which characterizes MSME products cannot be completely recorded well. Another option to quickly build 3D models is to use photogrammetry [31]. This technique can be an option when a 3D scanner device is not available. Photogrammetry software has been developed by several parties, including by software developers for certain cell phones, some of which can be used free of charge with limited features and require certain cell phones to be used whose prices are not cheap so they are not affordable for MSMEs.

IMPLEMENTATION PREPARATION

From a survey of MSME partners carried out in the initial stages of research, a list of basic requirements for acquiring 3D models was obtained as follows:

- Easy process to carry out.
- Can be done in a short time
- The model depicts the original product as realistically as possible
- Low costs (including application provisioning)
- No need for special human resources because they are limited
- No need for long training
- There is a practical guide that can be implemented immediately
- Easy to use within existing websites

The first problem was the need for a method to obtain 3D models of their own products. It is necessary to select the most appropriate digitizing mechanism to meet the above needs. Products from MSMEs that have unique characteristics are generally limited in quantity, and need to be sold quickly so they can make other products which are usually different because materials and funds are also limited. Thus, the 3D model is needed as soon as possible so that it can be published immediately so that potential buyers can examine it. Research partner MSMEs want to create their own 3D models using 3D modeling tools, but they experience difficulties when they have to learn modeling softwares, moreover high details of their own products are difficult to reproduce. Therefore, a comparison was carried out based on previous research, including research by Lamba and Bhalla [32], Barrile et. al. [33], Bandiera et. al. [34], as well as discourses originating from the internet. Then it is matched with the basic needs and capabilities of the partner MSMEs that will use it. Table 1 is a comparative summary of several 3D model acquisition mechanisms compared to the situation of MSME partners. Emphasis is placed on cost and time which are the main requirements for choosing an acquisition mechanism, but still prioritizes a high detailed display of results so that the visualization goals using 3D models can be achieved.

TABLE 1. Comparison of model acquisition mechanisms.

Acquisition method	Pros	Cons
3D model creation services	• Service providers are not difficult to find • The format can follow the customer's needs	• High cost per model • Cannot get results quickly • The results still have to be adjusted to resemble the original product
3D modeling tools	• Allows modification of the model according to needs so that it can look more attractive than the original • No need for a third party	• IT-specific HR must study specifically until they master it, generally MSMEs don't have it • Long manufacturing time • Need tools that can require high costs • Requires high performance computer equipment
Photogrammetry	• Various applications are available • There is a free version • Can be done quickly	• Need special equipment for certain tools • The free version is limited in features, it costs a lot of money for the paid version of the tool • Requires high performance computer equipment • The details of the resulting surface shape are not close to the original product • Requires post-processing before it can be used on the web
Laser scanning: LIDAR	• High power lasers and sensors so they are not much affected by environmental conditions • Suitable for large objects or even an environmental area	• Too expensive, completely unaffordable • Requires high performance computer equipment • Requires post-processing before it can be used on the web
Laser scanning: Portable 3D Scanner	• The resulting details are close to the original object • There are industrial and personal/home scanners • Can be done quickly	• The scanning process is not always successful immediately • Requires suitable environment due to low power sensors and lasers • Requires post-processing before it can be used on the web

The discourses obtained show that there were two main suitable options, namely photogrammetry and 3D laser scanning. Portable 3D scanners do not require much additional equipment other than scanning equipment and software for post-processing. To produce 3D models with the same quality as those produced by 3D scanners, photogrammetry requires expensive, high-end special image capture devices, highly capable computers, and software that requires high costs so that its features are not limited. Therefore, based on the summary of the comparison and discourse, 3D scanning was selected as the basic acquisition mechanism to provide 3D models of all the products that would be offered on the site. The portable 3D scanner of choice is not the industrial type of scanner which is very expensive and not affordable for MSMEs, but the personal type which is widely offered online and has quite high precision. The device is available in various shapes, specifications, and sensors, at prices that MSMEs can afford. The portable 3D scanner chosen in this research uses an Intel SR300 sensor which has a resolution of 1.5 mm, which is still suitable for displaying details on handicraft products from partner MSMEs measuring between 1 – 3 mm.

The second problem that must be resolved is determining the most appropriate technology to be applied to the site prepared to display digital representations of research partner MSME products. With the main consideration being the independence of being able to develop or update their own 3D models and sites in the future with minimal IT resources, a suitable technology is needed that can be easily applied and managed. The choice is focused on the style of describing the 3D model in the browser, namely imperative or declarative, which is directly represented by each implementation, namely WebGL and X3D. A comparison of the two technologies is shown in Table 2. These two candidate technologies were chosen because apart from being popular, they also have many communities that are expected to be able to help MSMEs if there are problems with site operations.

TABLE 2. Comparison of candidate Web3D technologies for the implementation.

Aspects	WebGL	X3D
Standard	- (not a standard)	ISO/IEC-19775-1:2013
Official support	Khronos Group	Web3D Consortium
Latest version, year	2.0, 2024	4 (ISO/IEC 19775-1:2023), 2023
Description type	Imperative	Declarative
Plugin	No (using libraries)	Yes
Supported format	.OBJ, .GITF	.X3D, .X3DB
Compressed model	Yes	Yes
Binary model support	Yes	Yes
Distributed model	No	Yes
Display medium	Canvas	Frame
Text-based external model	No	Yes
Code trait	Program/script	Element/properties
Native HTML	Yes	No
Integrated 2D/3D content	Yes	No
JavaScript Support	In page	In model

Both technologies can use models created by popular 3D modeling software thereby speeding up 3D model setup. For MSMEs, the use of 3D modeling tools is limited to modifying models, because learning to master making 3D models of their own products from scratch is not possible in terms of human resources. Their unique and specific products actually provide their own complexity if they are to be modeled using 3D modeling tools. They want technology that does not create high complexity in using it due to various limitations in their business operations.

If X3D is selected, the 3D models can be used immediately without special programming or scripting, the interaction options are more limited as far as what is described in the models. However, modeling tools allow users to add features directly to the X3D model, and these features can be used by users without having to prepare special scripts written on the model viewer page. This method makes preparing a 3D model on a page shorter, easier and simpler so that it is preferred by MSME owners. On the other hand, if WebGL is chosen, coding is required first via JavaScript to use the available models, especially so that users can interact with the models. Mastering the coding techniques to use JavaScript libraries according to the chosen implementation is the biggest barrier to taking advantage of WebGL. Although users can take advantage of ready-made libraries or frameworks to avoid coding from scratch, choosing a suitable library from among the many options [35] can be a serious challenge before starting to learn how to use it. In X3D, the user only needs to call the model, the interface for interaction is directly generated by a helper application which is generally in the form of a plugin. The need to master the code for X3D can be minimal because MSMEs only need 3D models and do not need special interaction features for models other than standard ones for visitors to scrutinize product representations provided on the website. Javascripts can be inserted into the model if necessary, or use other compatible scripts, but if the basic need is only to display 3D models and provide simple interaction to the user in the form of navigation in a 3D environment, all these additions can be omitted.

Nevertheless, implementing X3D in its original form requires a plugin which is a source of compatibility problems with browsers as well as limiting its use, especially on mobile devices. Plugins also cause the placement of components on the page to be less flexible. The existence of plugins also makes it impossible to combine HTML and X3D on one page. X3D objects must be placed in a container such as an inline frame so that they appear integrated with the HTML elements even though they are actually on a separate page. Therefore, the X3DOM framework [36] is used which refers to implementation libraries such as in WebGL instead of plugins. Unlike WebGL which has to include an implementation library along with other resources for the site on the server, the X3DOM library is available online and accessed directly to the provider so it will always use the latest libraries without having to provision or periodically update them on the server. X3DOM fixes the shortcomings of X3D since it can be integrated directly in HTML documents as long as they are compatible with the HTML5 standard [37]. X3DOM also does not require the use of specific scripts, making it easy for developers to use it as a site component along with other components. X3DOM is a bridge to use X3D directly in HTML documents and take advantage of X3D features without plugins.

X3DOM has high compatibility with all browsers that comply with the HTML5 standard, including mobile devices, so it can reach as many potential site visitors as possible. These are characteristics that are appropriate for commercial sites. Since X3DOM can be integrated directly with HTML, it is possible to modify the appearance of an X3D model through X3DOM, by assigning attributes/properties and their values as is done in WebGL by using scripts according to the framework used by the web server. However, the instructions are not in the form of a program because of their declarative nature, and this is easier than programming in WebGL which is imperative.

DISCUSSION

Following general procedures obtained from various sources on the internet including 3D scanner device manufacturers, scanning is carried out by circling the product. Apart from taking a long time for each initial scanning experiment with an average result of 3 minutes 24 seconds, scanning failure was too high, reaching 78.3% for the first 5 samples so that for all products the scanning had to be carried out repeatedly with a total of 23 scans. The difficulty in performing scanning while carrying a portable computer device around the product is also quite annoying. Based on these initial experiments, changes were made to the scanning method to use an automatic rotary table, while the scanner was installed in a fixed position using a cantilever. The subsequent scan failure rate for the 24 product samples fell to 11% with the average scan time being only 52.6 seconds and repeated scans only occurring in 16.7% of all samples, although it still required additional activity in the form of scanning the bottom of the product separately to be combined into the initial scan model.

Creating 3D models via a personal scanner does not produce objects that can be directly used on websites, further processing must be carried out since the file size is too big. Initial experiments on the scanning process took a long time because it turned out that the detailed configuration settings suitable for each scan could not always be the same, even parameters related to accuracy also had to be adjusted. The research team, which was previously unfamiliar with 3D scanners, also had difficulty defining the best practices for carrying out the scanning process at MSME locations, as well as the right environment to get the best results. The process also sometimes has to be repeated because the sensitivity of the sensor to objects with certain colors causes errors in depicting the point cloud in the model so that scanning fails or certain parts of the surface fail to be scanned, causing the final polygon to appears defective. The overall process for acquiring each 3D model until it is ready to be used as a site asset is shown in Fig. 1.

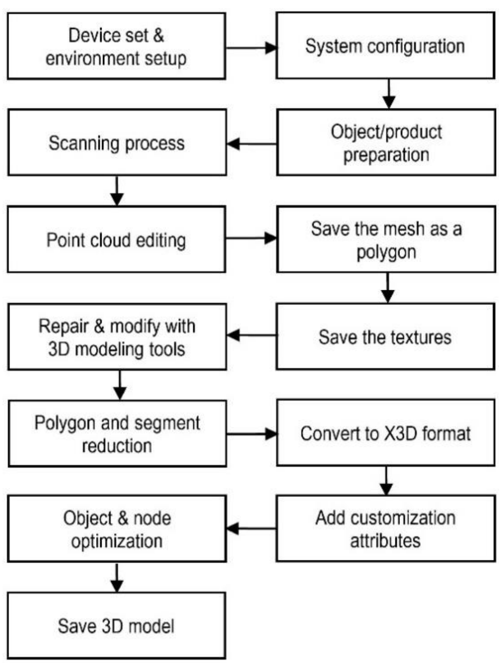


FIGURE 1. Series of process sequences for acquiring each 3D model

The experiments carried out gave rise to several findings that helped find the simplest patterns with the most optimal results in product scanning. Providing vertex color attribute information in the scanned model apparently reduces the size of the scanned file to a very small extent compared to without vertex color, but the compensation is that it does not take object surface data as a texture map placed on the surface of the model. Taking into account that the display appears to be more representative of the product even though the file size is larger in all experiments carried out, scans that map raster images of the object's surface texture were set as the basic configuration for all scanning settings. Table 3 shows a comparison of the scan file sizes for 5 product samples (hand bags) for initial experiments. The scanned file that maps the raster image of the surface of the object shown in the table has undergone a cleaning process so that its size has experienced a significant reduction, to an average of 24.1% of its original size. Figure 2 shows a comparison of the appearance of one of the initial experimental results of scanning product samples. Because it does not map the surface of the object, the polygons scanned by coloring the vertices do not produce a raster image that functions as a skin, so the appearance looks like a plain polygon. The more uniform the surface color of the original object, the lower the detail of the scan with vertex color, in contrast to scanning which produces a raster image that has high detail model even without skin. The display of the scan results also looks more realistic because the skin of the original object is mapped accurately to polygons.

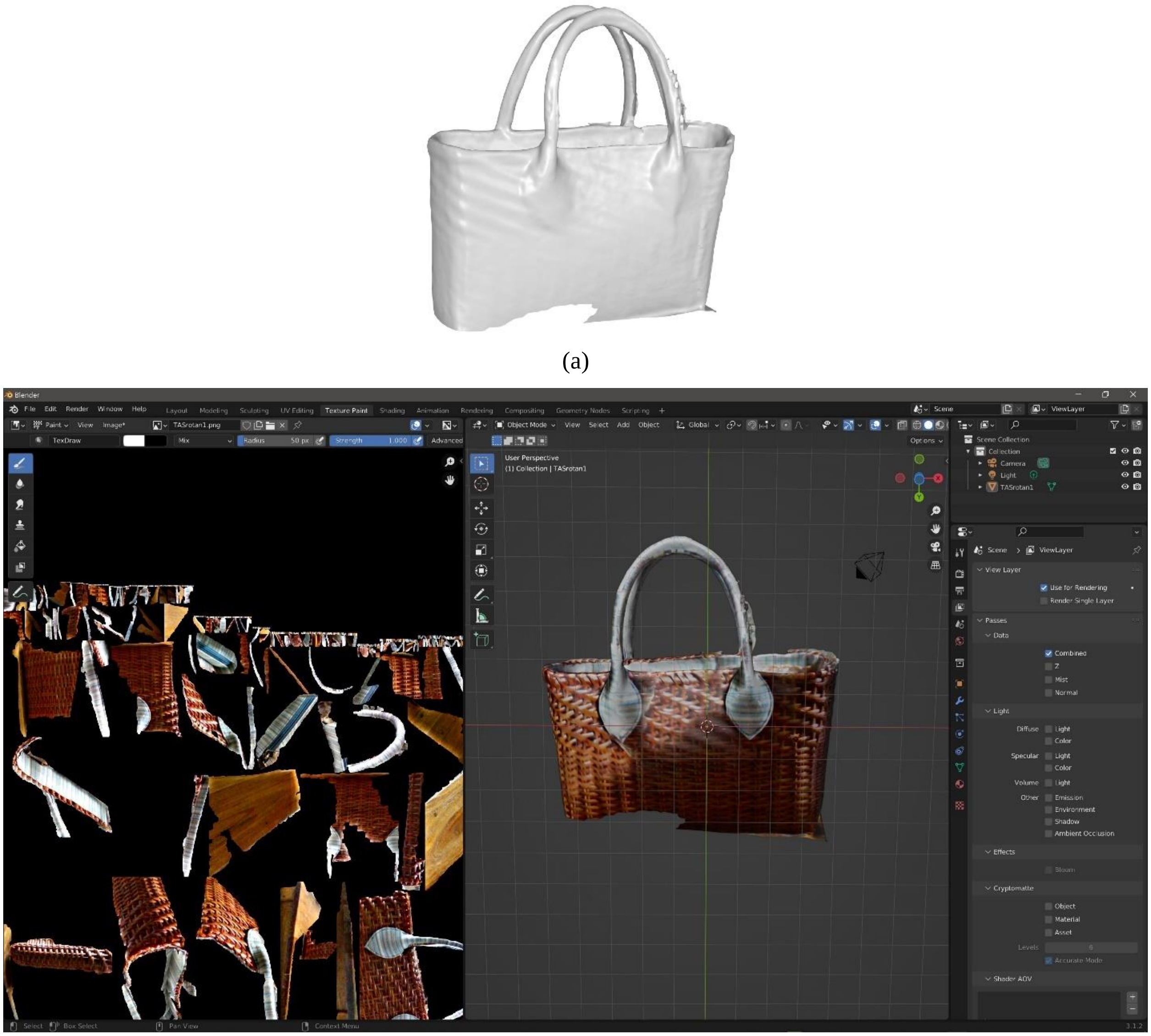
TABLE 3. Polygon file size resulting from the initial scanning experiments of 5 samples (hand bags).

Model Id.	Colored Vertices	Raster Surface
Handbag1	9,602 KB	47,256 KB
Handbag2	8,484 KB	87,986 KB
Handbag3	6,651 KB	46,024 KB
Handbag4	6,718 KB	30,368 KB
Handbag5	4,214 KB	44,396 KB

(a) (b)

FIGURE 2. Scanning results: (a) colored vertices, (b) with raster surface

In order to improve the quality of the scan results, the sensitivity of the depth sensor is then increased. The process slows down significantly with each increase in sensor sensitivity, the failure rate also increases, but the resulting polygon detail looks only slightly better. Certain areas on specific products that were previously difficult to scan with lower sensitivity can be captured even though they appear to be distorted and sometimes give rise to deformations in the model, both minor and major, accompanied by the formation of raster image patterns that look strange, requiring a lot of repairs on surfaces that do not match the original. Deformation is more difficult to repair than errors that occur because the area is not scanned completely, where the repair can be simpler because it is enough to just patch certain areas using other parts. Therefore, the scanning process using a high sensitivity depth sensor was not chosen because it requires more additional time to repeat the scanning process and to improve the scanning results. The deformation of the scan results using an increased sensitivity level of the depth sensor and the effort to repair the deformed model using a 3D modeling application are shown in Fig. 3.



(a)

(b)

FIGURE 3. (a) Object deformation resulted from higher depth sensor, (b) Repairing deformation using 3D modeling application

Based on the initial experiments, another finding was obtained: scanning was easily affected by the surrounding lighting situation, apparently because the laser intensity of the scanner device was low. When sensor sensitivity is increased, bright environments often cause the scanning process to fail or stop prematurely so that the ambient lighting must be reduced to allow scanning to be completed on a single product, resulting in texture images appearing darker and scanned colors less accurate than the original product being scanned. This is also the reason for not using a high depth sensor configuration for subsequent scans. Apart from that, the scan results with slightly lower detail do not look significantly different, the brighter texture image colors appear to give more shape to the polygons so that in general the results actually look better than polygons scanned with a high depth sensor configuration.

Even with a not very high detail configuration, the 3D model files and scanned texture maps are quite large for website assets. Apart from being burdensome in transfers on communication lines, it can also burden the user's device memory. Users of portable devices may also experience difficulties due to the use of large computing power, which in turn can accelerate battery drain. A scanned file that has not been further processed can be up to hundreds of megabytes in size, while websites that will use 3D models are designed so that they can display several 3D models at once on one page display. Some of the scan results still require repairs because sometimes segments fail to be scanned so that the surface of the model appears damaged. Repairs are also required when certain parts of the product fail to scan so the model must be modified first using 3D modeling software to make it look complete like the original product. In order to be displayed in a browser, files in OBJ format with sizes ranging from 50-150MB are converted to X3D format. The changes apparently resulted in a larger file size, ranging between 80-240MB. This size is of course not suitable for use on a website, especially one that aims to give a good impression to visitors so they want to make a purchase. Sites that become e-commerce mediums should perform as high as possible so as not to reduce users' enthusiasm for exploring the contents of the site and examining the products displayed. Table 4 shows the results of the initial scanning test experiments on some of the 23 products taken as samples in the research. The products for samples in this section are from the tote bags category.

TABLE 4. Results of initial scanning experiments for first 5 samples (tote bags).

Model Id.	Average time	Number of errors	File size (.OBJ)	File size (.PNG)	Failure
Tote1	00:11:09	2	147.9 MB	4.7 MB	Yes: failed to scan the handle
Tote2	00:15:48	4	47 MB	4.3 MB	No
Tote3	00:13:21	4	117.4 MB	5 MB	Yes: failed to scan the handle
Tote4	00:16:11	3	62.1 MB	3.4 MB	Yes: failed to scan the bottom
Tote5	00:15:05	2	109.8 MB	5.3 MB	No

All scanned 3D models use triangle type polygons. Post-processing experiments were narrowed down to 3 size reduction techniques:

- reducing the number of triangles forming the model,
- reducing the percentage of the number of meshes randomly, or
- simplifying the forming polygons by making deviations.

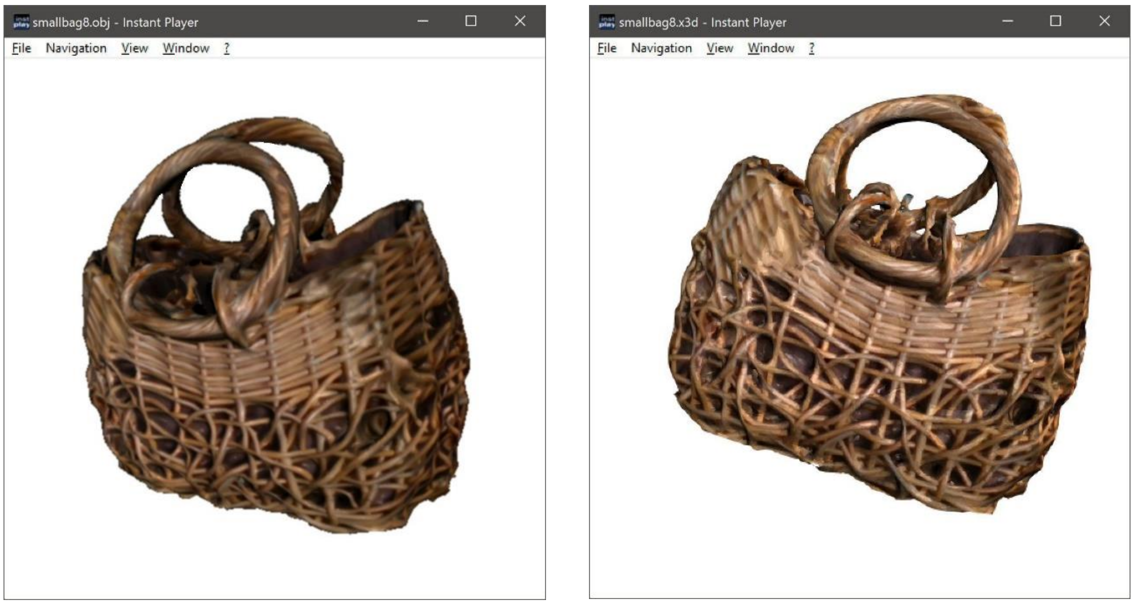
Reducing triangles can reduce the descriptor that forms a complete polygon so that it can reduce the file size, this is done by combining several triangles at once in an area. This does reduce the detail of the surface contours of the 3D model, especially when the merging is done uniformly which will unite more triangles that are considered one area for the sake of massive simplification. Because the scanning configuration also produces the texture of the original object, the use of textures can compensate for the reduced detail in the contours of the 3D model.

More or less similar results occur when subtraction is carried out based on the mesh, whereas deviating the polygons produces too large deformation on the surface so that the model looks damaged. Reducing the mesh percentage randomly generalizes the combined mesh, if it maintains the initial object shape pattern then the deformation that occurs will not be visible explicitly. The shape change pattern can be uniform, but the deformation is more obvious at the same mesh percentage. Table 5 shows the results of reduction experiments on several of all scanned file samples, with a reduction target of 10% of the vertices and triangles forming polygons. The file size units in the table are shown in KB, not MB as in the previous table, so that the difference in the reduction results can be seen. There is a significant reduction in file size but by minimizing deformation on the surface of the object so that it still appears to represent the original product.

TABLE 5. Results of reduction experiments on first 5 samples of scanned files (tote bags).

Model Id.	Reduction type	Polygon pattern	Before			After		
			Vertices	Triangles	File size	Vertices	Triangles	File size
Tote1	Triangle	Fixed	559,405	1,113,684	151,476 KB	53,067	101,008	8,483 KB
Tote2	Mesh	Fixed	182,450	362,327	48,150 KB	16,295	30,017	2,484 KB
Tote3	Triangle	Fixed	444,976	887,143	120,260 KB	41,881	80,953	6,718 KB
Tote4	Triangle	Fixed	238,604	474,657	63,566 KB	21,275	39,999	3,310 KB
Tote5	Triangle	Uniformed	416,400	830,027	112,240 KB	41,386	79,999	6,651 KB

The model file in OBJ format which has undergone a reduction process is then converted to X3D. Codes for default camera information, basic lighting and shading, default navigation mode, environment and background display, special effects including object surface brightness and contrast, and other additional attributes including those for display optimization are inserted into each model manually using a text editor. Optimization is also needed so that the model display has a uniform pattern for each product when displayed in the browser. Figure 4 shows a sample of a 3D model in OBJ format and after being converted to X3D format. The model is a digital representation of a product sample in the form of a handcrafted rattan bag with fabric lining on the inside. It has very high details so it will be difficult and takes a long time if it is made using 3D modeling software.



(a) (b)

FIGURE 4. 3D model samples in: (a) original .OBJ format, (b) converted .X3D format

Relocation of texture maps that have undergone slight changes when changing formats has also been carried out. After the modifications have been completed on the 3D model, a finalization step is carried out by compressing the descriptor file to further reduce its size. Compression is done so that the file size becomes smaller, so that the delivery time on the network can be shorter. Compression must use methods that comply with standards for 3D model formats for the results to be usable. The compression function in the 3D modeling software used in the research did not meet standards, resulting in files that could not be displayed in a browser. Therefore, the gzip utility is used which can provide results in the form of a compressed 3D model that can be displayed properly in all HTML5 compatible browsers. Table 6 shows a comparison of the sizes of several 3D model sample files taken from all the files used in the experiment, before and after compression. The samples in this comparison section are taken from the small bag category.

TABLE 6. Comparison of uncompressed and compressed file size on some model samples (small bags).

Model Id.	Uncompressed	Compressed	Reduction
Smallbag1	1,342 KB	544 KB	59.5%
Smallbag2	1,504 KB	575 KB	61.9%
Smallbag5	2,086 KB	823 KB	60.6%
Smallbag8	5,214 KB	1,909 KB	63.4%
Smallbag9	2,064 KB	829 KB	59.8%

With the same goal, the texture map image was also changed from PNG to JPEG format so that the file size is smaller. In order not to appear to cause a decrease in the quality of the texture map image, the JPEG format uses a compression factor of 20, without chroma subsampling, and with standard encoding. Table 7 shows a comparison of the file sizes of several samples of texture map images in PNG and JPEG formats used by the 3D models.

TABLE 7. Comparison of PNG and JPG file size on some texture map samples (small bags).

Texture Id.	PNG	JPG	Reduction
Smallbag1	2,859 KB	276 KB	90.4%
Smallbag2	2,834 KB	301 KB	89.4%
Smallbag5	2,276 KB	299 KB	86.9%
Smallbag8	3,401 KB	461 KB	86.5%
Smallbag9	3,608 KB	331 KB	90.8%

Figure 5 shows an example of a 3D model of the hand bag category before being compressed and using a PNG image, and after being compressed and using a JPEG image. In general, there is no visible deformation or difference in the external appearance of the model. Although it introduces the additional step of automatic decompression before displaying to the browser, the reduction in file size results in a decrease in transmission time which reduces the overall processing time for each individual model displayed, i.e. from the time the instruction to display is given by the user until the appearance of the complete display with all the page content assets.

(a) (b)

FIGURE 5. 3D model sample in: (a) original size with .PNG skin, (b) compressed state with .JPG skin

In general, the model built can perform well on all devices used for experimental testing to display results. Table 8 shows the types of devices used for testing experiments displaying pages containing 3D models of scanned results that have been processed. The experimental site which becomes a testbed for testing the results of 3D model preparation is placed on a hosting server so that the experiment is online. 3D models are displayed on category content pages as well as on product detail pages. The product detail page only contains one 3D model, while the category content page contains more than one 3D model, so it is necessary to estimate the optimal number of processed 3D models that can be installed on a page.

TABLE 8. Devices used in experiments to display 3D models.

Device type	Num. of devices	Operating system	RAM	Viewing multiple 3D models	Viewing single 3D model
PC	5	Windows	8 - 16 GB	5	5
Notebook	4	Windows	4 - 8 GB	4	4
Tablet	3	Android	512 MB - 2 GB	3	3
Smartphone	6	Android	1 GB - 6 GB	6	6

On PCs and notebooks, the average display performance were higher than 50 frames per second (fps). Even though it has been optimized, using many 3D models in one view can still reduce the display performance of related pages. This was seen on one of the tablet devices and on 2 of the smartphones used. Devices with a RAM size of 1 GB or lower seems to be the cause of decreased page display performance that displays multiple 3D models. The decrease in performance occurs in the form of increasing processing time to display all 3D models on the page. However, the navigation performance of the models was not much affected because navigation in any mode is generally only carried out on one model, and experiences a decrease in fps only on mobile devices that use older generation processors. This is also the reason why the initial plan to make all 3D models appear to rotate in the category page display was canceled because it could reduce display performance drastically. There was a proposal to replace the 3D models on category pages with a series of photo images to enable 360° animation, but this method would increase the duration of preparing the digital representation of each product on the page so this proposal was not realized. The reason why 3D models have started to be used on category pages was to arouse curiosity in visitors so that they become interested in seeing further product details when they find out that they can actually interact with the product display on the category page. Through several experiments, the 3D models displayed simultaneously on the category page were limited to a maximum of 8 since this value shows consistent display results in the form of loading all models that are always successfully displayed on the category page. Figure 6 and Figure 7 shows an example of how the 3D model appears on the category page and product detail page.

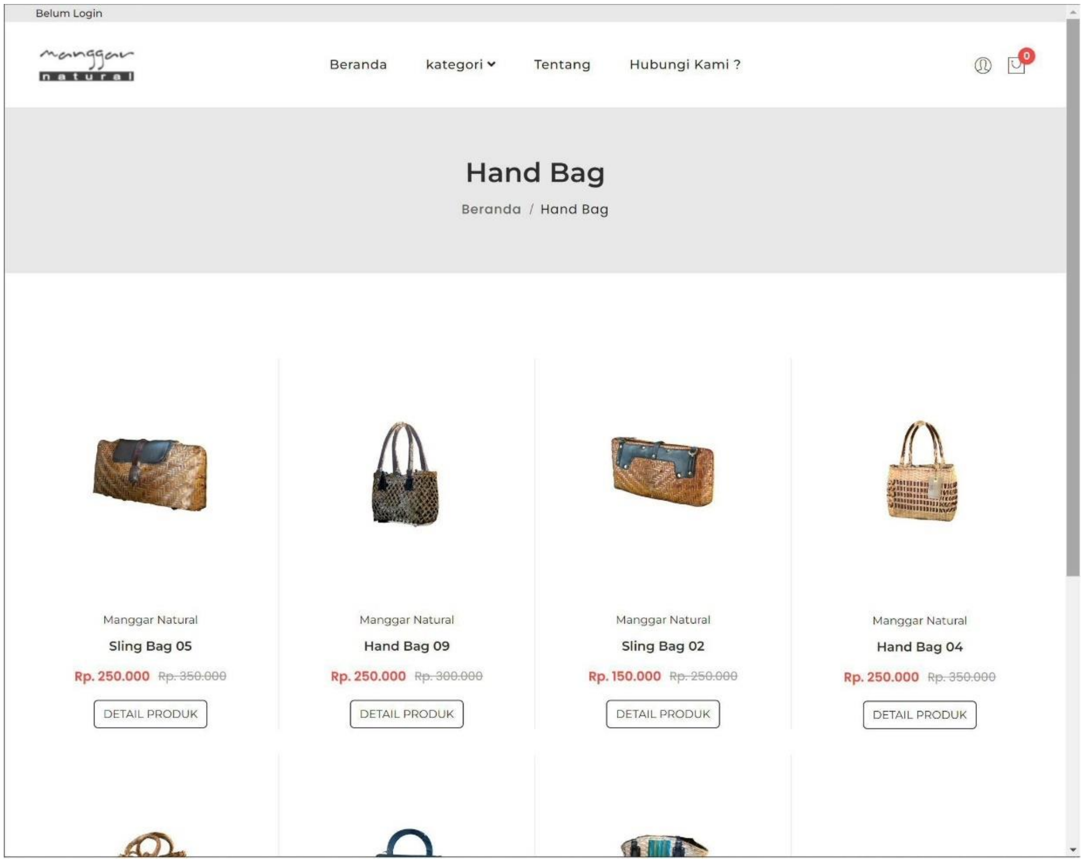


FIGURE 6. 3D model display in category page

Translations of non-English texts in Figure 6:
a. Belum Login (Not logged in)
b. Beranda (Home page)
c. Kategori (Category)
d. Tentang (About)
e. Hubungi Kami (Contact Us)
f. Detail Produk (Product Detail)

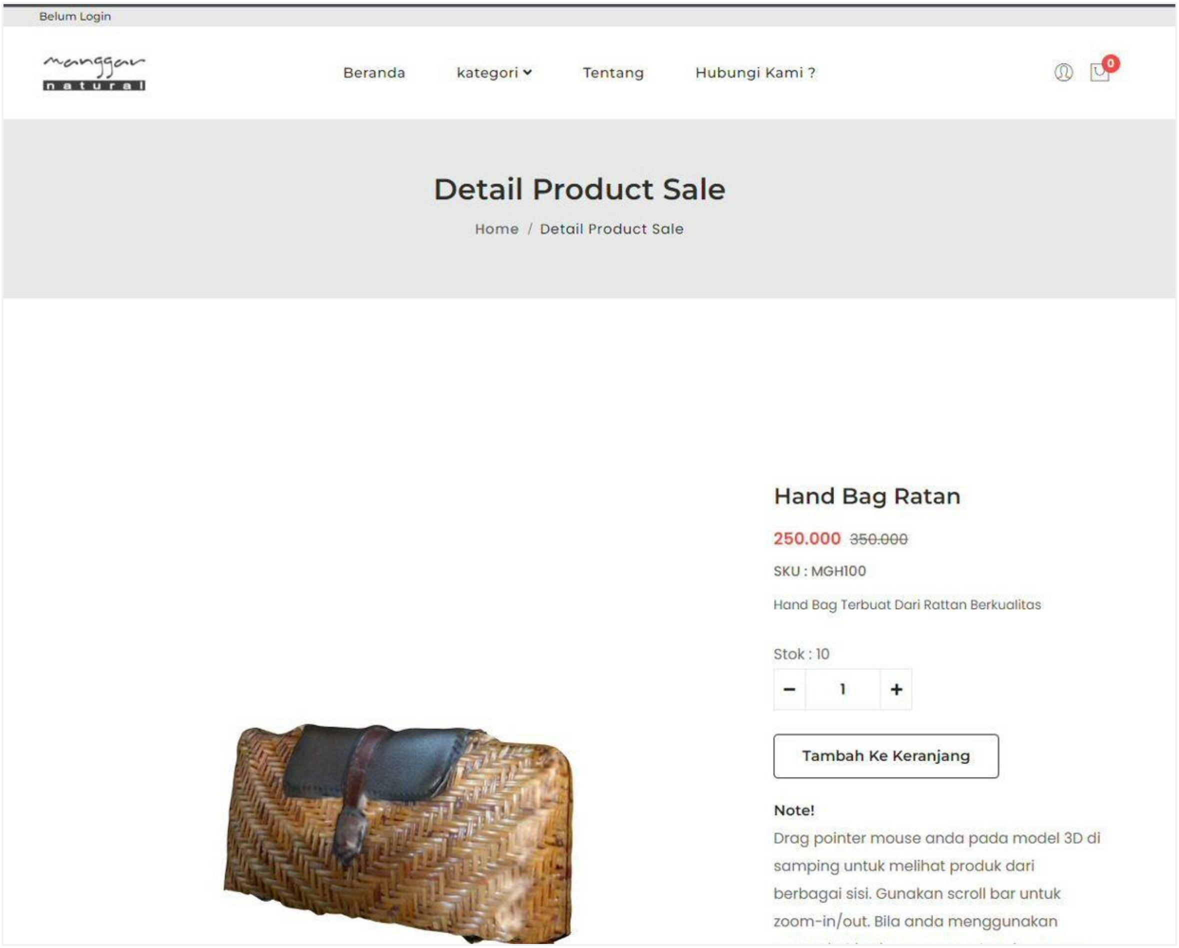


FIGURE 7. 3D model display in product detail page

Translations of non-English texts in Figure 7:
a. Belum Login (Not logged in)
b. Beranda (Home page)
c. Kategori (Category)
d. Tentang (About)
e. Hubungi Kami (Contact Us)
f. Hand Bag Ratan (Rattan Handbag)
g. Hand Bag Terbuat Dari Rattan Berkualitas (Handbag Made From Quality Rattan)
h. Stok (Stock)
i. Tambah Ke Keranjang (Add to Cart)
j. Drag pointer mouse anda pada model 3D di samping untuk melihat produk dari berbagai sisi. Gunakan scroll bar untuk zoom-in/out. Bila anda menggunakan (Drag your mouse pointer on the 3D model next to view the product from different angles. Use the scroll bar to zoom-in/out. If you are using)

All modification patterns that produce the most efficient results, and the process of acquiring the 3D models until they are ready to become assets for online media are then documented into a guideline for the steps for preparing 3D models of partner MSME products. The guideline documentation is created in the form of a sequence of procedures that includes display examples with specific tools so that MSMEs as users can replicate the process of preparing 3D models that will be used on their sites. Documentation is included with complete usage and management instructions with details of each processing step that will be included in the data and content administration section in the production version of the site. In this way, it is possible for users to later be able to obtain ready-to-use versions of scanned 3D models in a relatively quick time because they can utilize best practices resulting from experiments that have been carried out previously.

One important thing seen in the research is the difficulty of reducing the file size of 3D models through polygon reduction. A total of 9 of the 24 3D models experienced deformation when the reduction experiment had not reached 20% of the total number of polygons used in the model, so the reduction process could not continue. With a maximum reduction target of 10% to achieve a minimum file size but with a model appearance that still depicts the original product, the limitations in the reduction results give rise to 3D model files whose size can reduce application performance both during loading and rendering when the user navigates in it. Even though it also experiences deformation, the changes that occur as a result of the reduction make the original shape of the model surface change very significantly, not just disappear like the deformation resulting from scanning with high depth sensor sensitivity.

Based on observations made during the experiments, several scanned surface shape patterns experienced a shift in the initial position of the vertices of the nearest polygon when simplified, so that the simplified edges immediately changed shape. The scanned products do have very complex shapes with surfaces that are far from flat, so that when the polygons forming the model are simplified through reduction, the subsequent joining between polygons makes the model look distorted or even cut oddly. Observations in reduction experiments show that the polygon forming points have a significant impact when reducing the polygon size. Manually adding points to specific polygons can reduce deformation during reduction. However, this method is very difficult and takes a long time to carry out, especially for MSMEs, so it would be better if this could be done automatically. The most likely option is to change the base polygons that make up the 3D models to have more points, e.g. from triangle to quadrilateral or larger n-gon. However, it is necessary to consider further its use, since n-gons that are larger than triangles will theoretically take longer to process before being displayed. Additional processing time will also occur when rendering the model dynamically by visitors navigating to the model in any mode.

CONCLUSION

Providing 3D models for use in product sales media for MSMEs can be done using a 3D scanner device because the products being scanned are generally handicrafts so they are unique with high detail. Scan results require further processing to be suitable for use in online media so that they do not reduce the performance of the media that displays them. All steps in processing are then formed into a sequence of procedures that can be followed by users so that they can be used practically in order to prepare 3D models with a short duration so that they can be immediately displayed on their e-commerce website pages. It is hoped that MSMEs who are more familiar with conventional web technology can be self-sufficient in preparing 3D models for their websites in a short time. The quick availability of 3D models will enable MSMEs to utilize visualization with 3D graphics on their websites using optimal product representations for use online and can reach the widest possible number of users.

Even though triangular polygons provide the highest rendering speed due to their simplest shape, experiments show that these polygons tend to easily deform the surface of the object even though the polygon reduction has not passed 20% of the total polygon. This means that the reduced file size cannot be further reduced to make it smaller. Further experiments are needed using quadrilateral polygons and other n-gons to see their effectiveness on scanned 3D models, so that the most optimal 3D model can be obtained and make the site have higher performance when displaying the digital representations of MSME products.

ACKNOWLEDGMENTS

The authors would like to thank the management of the computer laboratory of the information systems department for allowing the use of resources during the research. We also expressed our gratitude to the Yogyakarta Public Administration of Local Government for providing the opportunity to carry out this research.

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