3D Online Parts Catalog For Quick Identification and Learning

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ARTICLE INFO	ABSTRACT
	People sometimes face challenges when they have to memorize many components or parts of a machine. Even though a complete schematic description of a machine and its parts is generally available, the large number of similar parts but have different uses is quite troublesome, especially for those who are not specifically in that field. Inventory system managers and item supply custodians must really understand the parts requested by certain customers, so as not to make mistakes in distributing the parts ordered. Identifying with the correct nomenclature or using part identification number can overcome this problem in general, but it is not without problems. Users who don't understand the code also create the potential for mistaken identification when there are similarities with different items. There are many difficulties experienced by the general public users in identifying, selecting and sourcing suitable parts from the increasingly diverse choices available from various online sources. The ongoing research is developing the concept of an integrated information system cataloging parts using 3D visualization. 3D visualization not only identifies the parts but shows them in relation to each other in a 3D view derived from a complete machine. The initial prototype was built based on the spiral evolutionary engineering method as it contained the core features with extended functionality built around them to be able to exchange data including fetching from external sources. The proposed system is intended to help users speed up learning and identifying each part, thereby reducing mistakes when they need a certain part or just to understand that part. The catalog presents various data about the spare parts down to its availability status since it can be linked directly to the inventory system of the provider or other third parties from which the parts can be purchased. Users can also utilize it to quickly learn about certain parts of the machine since it can be connected to information providers related to those parts, including through the use of AI and automated search engines to gather specific information.

1. Introduction

Searching for certain objects via search engines on the internet sometimes makes it difficult for users, especially those who don't really understand the object they are looking for. This also often happens to users who are looking for specific spare parts needed for specific machines or equipment. Mistaken purchases by users often occur, spare parts that seem to match what they need turn out not to be suitable even though they look similar. Mistakes can even still occur in those whose field of work is related to machines and often require certain spare parts. While time may improve the

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experience, there will always be new machines, new variants, new parts, and many other things that can make it overwhelming for users to keep track of everything.

Creating a list of items in catalog form is a way to make it easier to search for a particular item electronically. Certain fields such as libraries use it so that users can search for items in it online [1]. However, even in specific groups such as academics, not all of them have the ability to search for objects according to their field of work [2], so they are not always successful in finding what they are looking for. User search capabilities can vary to varying degrees, requiring adjustments in the system to make it easier to use [3].

Like the printed version, electronic catalogs are not only for finding items that users need, but can be used as a promotional tool. Electronic catalogs in the form of websites that are enriched with a variety of information and information delivery methods can further increase users' interest in looking further at what is on offer [4]. Catalogs in the form of websites are often the choice because they allow the widest range of users [5].

Even though they include image elements, most of the details are insufficient for general users, and this usually leads to misinterpretation and even wrong purchases. Catalogs for certain items such as machine spare parts generally use unique identifiers in a certain format and are arranged in a structured manner with nomenclature to facilitate identification [6], as shown in a sample of electronic catalog from a car manufacturer [7]. Although an identification number can often aid in a search, it only works for those who know it, and if the relevant information is sufficient. In many cases, users can even misunderstand an identification number simply because it looks similar, or misinterpret the accompanying information because it is incomplete. This error increasingly occurs when the spare parts sought are of the aftermarket type, because identification numbers do not always match or are not even included [8]. Some of them provide electronic catalogs which are actually softcopies of the printed version, shown in a sample of a service part catalog [9], so that the information obtained is limited to what is printed in the catalog.

Visualization of spare parts in online electronic catalogs is generally done by displaying sketch images followed by several short descriptions. Open sales sites such as marketplaces [10] or specific goods sellers [11] sometimes also display photos of the spare parts. This method allows ordinary users to know what kind of spare parts are offered, but not really know whether they suit their needs (type, variant, etc.), and various other related things that are actually important for users to know. Therefore, some suppliers or sellers sometimes include a simple schematic diagram, an exploded view version of a set of spare parts that includes these spare parts. However, most of them use low resolution graphics, and the information provided is very little. Sometimes they even use codes or abbreviations so that they are generally confusing for users who are not technicians or who have not received training on the item, as shown in search results page on a spare parts provider site [12].

In order to make the product representation looks more realistic and closer to what the user imagines, a display method based on 3D graphics is used. 3D viewing is an option because users can examine an item from all sides by navigating like in the real world. In this way, users do not need to try to imagine for themselves, as when looking at a flat schematic diagram, which sometimes leads to errors in interpretation. The use of 3D on the web requires the implementation of Web3D technology [13] which is available in various implementation formats or in the form of frameworks. Several companies have used Web3D in their promotional websites, but they are limited to displaying certain products, such as car [14-15]. The site does not integrate various functions or other information because it is only promotional in nature, however, the use of 3D graphics looks very prominent in helping users examine the physical products displayed.

In order to help users, especially to practice recognizing spare parts and related matters, a spare parts visualization method is needed which can provide a basic understanding as shown in a

schematic diagram, but is more informative and makes it easier for users to obtain further information from various sources. A better display can be obtained from the use of 3D graphics combined with other information in the form of textual, images and videos, which are well integrated in a display set. All of this is combined in an open, web-based system so that it can be utilized by many users who need it.

2. Related Research

Currently, the discussion about electronic catalogs has shifted to online sales media which has implemented all the principles of online catalogs down to the transaction function which allows users to make purchases online through various payment services. Research on electronic catalogs in online stores is still being carried out, generally focusing on user aspects [16]. The system can be in the form of a web-based online catalog or application-based for specific platforms. Currently, the majority of media for e-commerce and e-business have implemented an online catalog model to offer their merchandise with more or less similar techniques. However, there are always users who have special product needs who have difficulty finding a suitable online sales place to get the goods they are looking for [17]. There are also many users who do not have complete information regarding the items they want, so they cannot provide the right data as input to the system so that it can produce results that best suit their wishes [18].

Several parties, especially MSME business owners, have used social media as a place to sell their products [19], thus giving social media a new name, namely social commerce [20]. As with media in the form of sales sites or marketplaces, users cannot always easily find the items they need. Some marketplaces have a product search function from the catalog, but instead they produce a variety of findings that are far from what users want. The development of a more detailed search function in the marketplace based on data from its information catalog has been carried out by Ionescu *et al.,* [21] although it is only specifically for geospatial data.

Spare parts sold online are not only original products from brand holders, but can also be OEM (Original Equipment Manufacturer) or aftermarket types. Advances in 3D printing technology have made parts produced from the Additive Manufacturing (AM) process [22] increasingly popular. These service providers sell their services through orders from users, because they do not make spare parts in large quantities like factories. Products from the AM process can be an alternative for providing spare parts online which can be linked to the online catalog being developed, however there are several things that can become obstacles to the mass use of AM so that the inclusion of AM in Supply Chain Management (SCM) for spare parts is necessary considered in more depth [23].

Interactive 3D display of machines and spare parts in web-based applications can be visualized using standard or non-standard formats. The VRML standard format (ISO/IEC 14772-1:1997) [24] and its successor, X3D (ISO/IEC 19775-1:2023) [25] are the official formats of the Web3D consortium, while WebGL [26] and its successor, WebGPU [27] are some of the non-standard formats and are widely implemented with various frameworks or libraries created with JavaScript [28]. Web3D has been utilized by commercial websites [29] in various forms because it provides a different and immersive interaction experience compared to conventional 2D displays. 3D environments can also help users' understanding of certain materials [30]. However, 3D for the web is here not to replace 2D but to complement it [31]. This can be seen from the use of 3D and 2D display styles simultaneously which can improve the display quality of a web page [32].

Web3D technology has various ways of describing 3D models and environments along with their interaction methods, which can generally be seen in two main types, namely imperative/procedural and declarative [33-34]. The imperative type describes the model in a programming-like way using a

certain algorithm, followed by various parameters, variables etc. This model description technique provides high flexibility because it follows how the author coded it [35]. However, this type of description technique gives rise to high complexity in its creation, is hard to learn especially by beginners, longer to master especially for those who do not have a programming background [36], and can be more expensive to procure if it involves a third party, since the specialist providing this type of application development service generally charges a high fee.

On the other hand, the simpler declarative type can lead to easier creation and daily maintenance by average users, and it also introduces lesser codes & programming logics. The X3D format, which is a declarative type, can be easily used in web pages using the X3DOM framework [37], and can be easily inserted into page templates used by conventional web servers. This method allows web pages that comply with the HTML5 standard [38] to have the ability to display 3D models directly without requiring any plugins. X3DOM also allows 3D models to be integrated elements in web documents [39] in a simple way. This can be advantageous since users do not need to frequently switch from 3D view to 2D view or vice versa, do not need frames and do not require complicated page settings using special coding.

Although it offers many visual advantages, high detail from 3D models is not that easy to obtain, especially from objects with high shape complexity. This is because for certain objects, providing a 3D model is not easy [40]. Using 3D modeling software to create assets will take a long time, especially if there are a large number of 3D models to be created. Creating 3D models quickly can be done using photogrammetry [41] or using 3D scanning devices [42]. As the main asset in the application, acquired 3D models need to be managed so that the catalog can receive and display them correctly [43]. The catalog will accept and store many 3D models in the form of files, so settings are needed on how to store assets and the process of retrieving them before displaying them on the user's device.

Online catalogs can be integrated with various other systems or applications that have specific capabilities if they have been standardized [44]. Applications that are integrated with various other systems can provide various functionalities and are generally used to improve performance and productivity [45]. One of the required functions is data search. In a catalog, the function is only to search for information stored in the catalog itself, and the search results are directed in such a way as a recommendation for a transaction to occur [46]. However, the information in the catalog is limited and sometimes insufficient for users, so it needs to be supplemented with external information. Therefore, catalogs can be integrated with functions or systems that have advanced but specific external information search capabilities related to the content in the catalog. The use of Artificial Intelligence (AI), especially Generative AI, can improve search functionality based on certain parameters, so that users can find what they need [47].

Systems similar to the one proposed do not yet include more complete capabilities in order to be a more comprehensive solution, especially for novice users who not only need spare parts but also want to practice and learn about the machines and spare parts they are looking at. Cortona's RapidCatalog [48] was created to manage spare parts displayed in 3D, and can be used as a means to train personnel to understand spare parts and the machines that include them. However, this application is intended for internal organizational needs, and not for open sales purposes to the public. Windchill from Tristar/Wincom [49] also performs 3D visualization of parts or machines even though they do not appear detailed. Applications can be made to be accessed by the public with various features including transactions, even though they are actually intended as Product Lifecycle Management (PLM) type applications which are generally used internally and are not open to the public. However, all data and modules have to be formed into extensions, just like plugins, and this can make updating applications and contents take a long time.

Door2Solution's Spare Parts Catalog [50] can also be made into an open system for public access. This application, known as Spare Parts Management (SPM), can be expanded in function so that it can be used as an online shop or portal for users related to similar products. Having a 3D display accompanied by quite detailed information, the application does not provide an external search system function and connectivity to AI to help search for information. HOOPS Software Development Kit (SDK) from Tech Soft 3D [51] which is said to be a PLM and Product Data Management (PDM) type, was built to produce an online catalog which can also be used to display 3D models along with various other functions to complement them. The resulting system can be made open but only to certain groups of users, and not for carrying out transactions.

3. Methodology

Due to the large number of cases of wrong purchases or wrong selections, an online electronic catalog system is needed that allows users to minimize the possibility of wrong purchases. The catalog must be accessible online and open with a system that is commonly used by users. Its capabilities include helping users learn various things about the spare parts they are looking for, including getting detailed information about usage and various other related matters from various sources such as the user community. The system must also be able to inform merchants who provide items, including alternative replacement parts or aftermarket type items, or even utilize AM service providers if genuine/factory-made, Original Equipment Manufacturer (OEM), or aftermarket parts can no longer be found and have appropriate specifications. In this way, the system can help train users to recognize appropriate items, find out their relationship to larger parts or the machine as a whole, or select and purchase the right items according to the specifications of the machine required.

The system is not built as a large application that includes many specific functions that vary according to the type of function. The system developed is an online catalog that can be integrated into other systems, both existing ones and those that will be developed separately in the future. Systems can be built using tools, standards and technologies that are widely used today, on the frontend and backend, thus the development process becomes easier because users do not have to master anything special. Other functionalities i.e. transactions and inventory are not built together in the main system, namely the catalog, but use a shared database. This will make it easier in further system development, and if additional functionality is available previously then the catalog that is built later can use the existing database, so that there is compatibility with the existing system so that they can collaborate well. Special search system is built with two functions, i.e. search for internal data and external information.

An overview of the proposed system based on the above description is illustrated in Figure 1, which shows the position of the catalog with the ability to display spare parts in 3D as the main system which will later be connected to various other systems. An important part of the catalog is the data wrapping subsystem, which summarizes information from the catalog for exchange with other systems, and allows the catalog to retrieve data from or send data to other connected systems. This section makes the information obtained from the catalog usable for further purposes, e.g. proceed to the transaction system so that users can make purchases. Or it can also be in a round-trip scenario, where the catalog supplies data about spare parts, then sent as key word information to an external search system to search for textual information, video, or as input for information searches that utilize AI assistance.
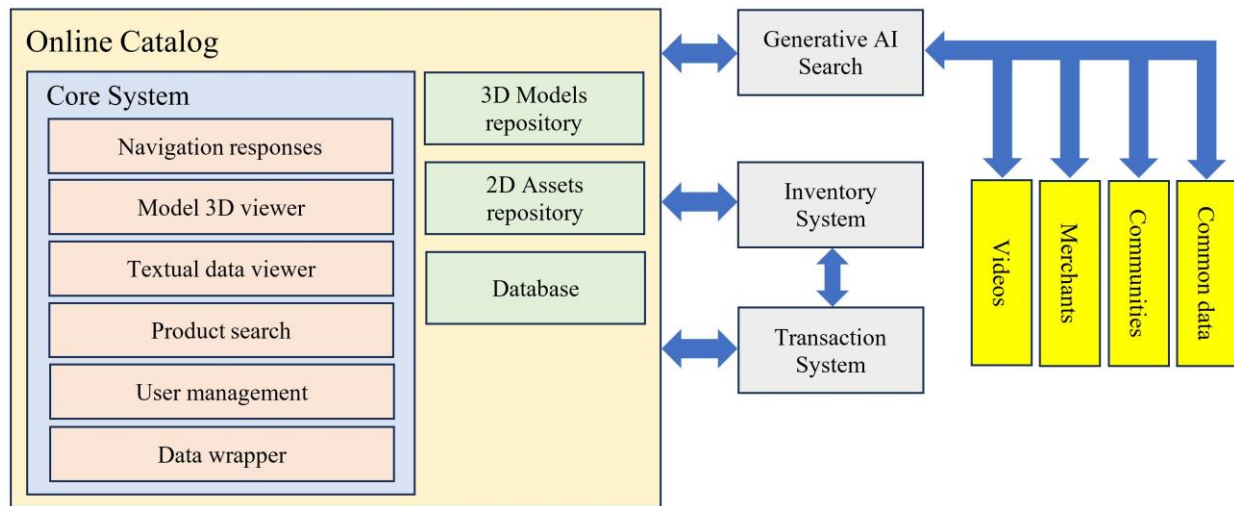
Fig. 1. Proposed system

In general, the functionality to be integrated into the online catalog system through connecting to external systems is as follows:

i. Ability to search for genuine spare parts data (from the manufacturer) or OEM, and related information such as differences in specifications, prices, providers, etc.
ii. Ability to search for seller information in one network if available, independent sellers, aftermarket product sellers, or AM type spare parts providers.
iii. Ability to search for information in the form of videos related to spare parts.
iv. Ability to search for information from online user communities.
v. Ability to receive input information from users about the spare parts they are looking for so that other users can use them, and can be made to be moderated by the catalog system manager.
vi. The ability to be able to connect to subscribed Generative AI systems to search for further information about related parts, through commands that are more human language friendly.

3D models for online catalogs are imported from documents which can come from various formats as provided by the business owner because if all 3D models have to be built from scratch it will take a very long time to prepare the data for the main display of the application. In this research, since it is not yet affiliated with any company that acts as a model provider, the 3D model sample as a product representation in the catalog was taken from the internet. One example of the 3D model used in the system prototype is shown in Figure 2 and Figure 3. Both figures display the same 3D model, the former being edited using Blender modeling software, and the latter being viewed in a 3D object viewer. The engine model has been equipped with details of the individual parts that make it up, which can later be shown in exploded view display mode.
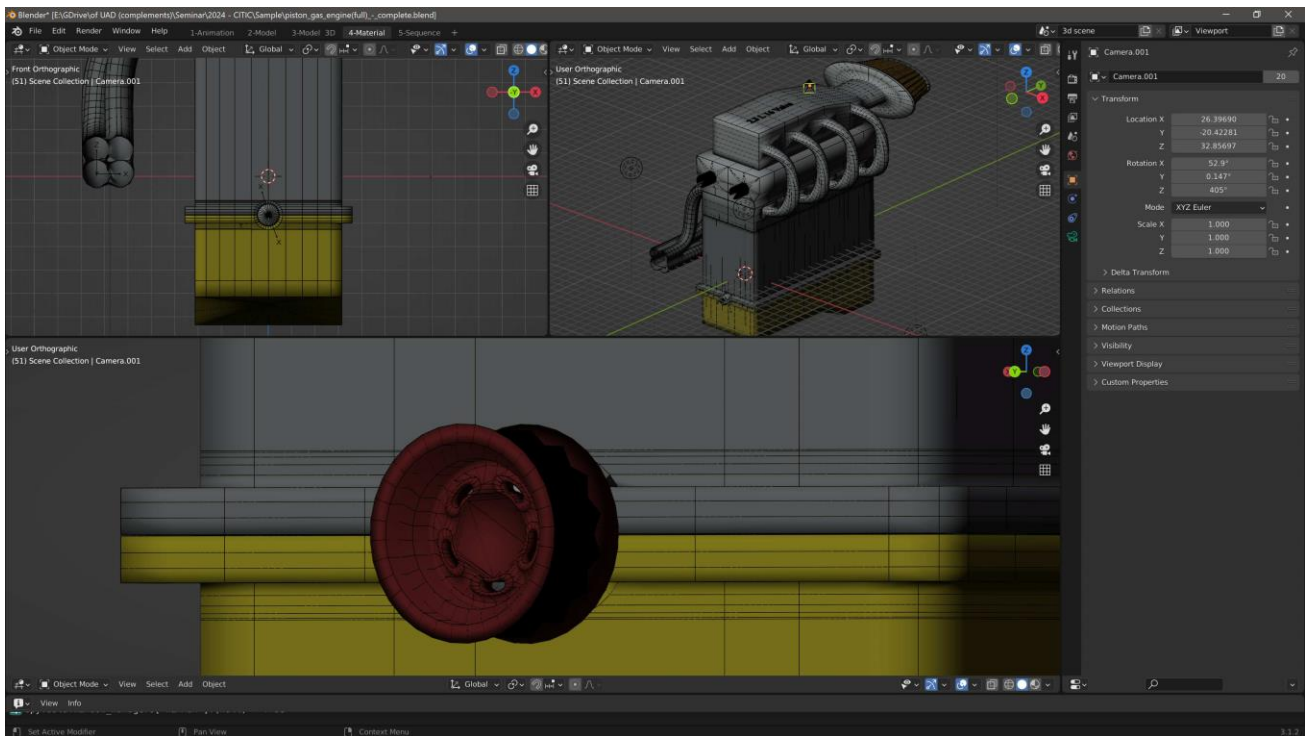
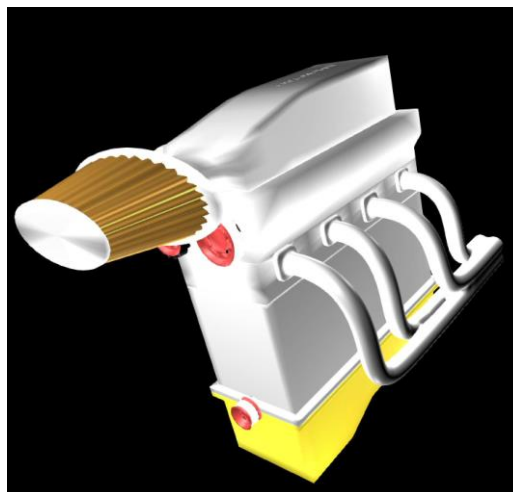**Fig. 2.** 3D model sample of a complete engine used for the prototype, edited using Blender

Fig. 3. 3D model sample of a complete engine used for the prototype, viewed in X3D viewer

If the 3D model obtained has a large file size, then optimization of the 3D model must be carried out so that the 3D model does not reduce system performance. Optimization is necessary because the 3D model description for a particular part can be complex enough that the descriptor file in the final format will be very large and unfit to be an online application element, which can result in data transfer slowdowns, occupying the user's device memory, and slowing down the 3D model rendering process to the browser. The 3D model optimization procedure is depicted simply in Figure 4.
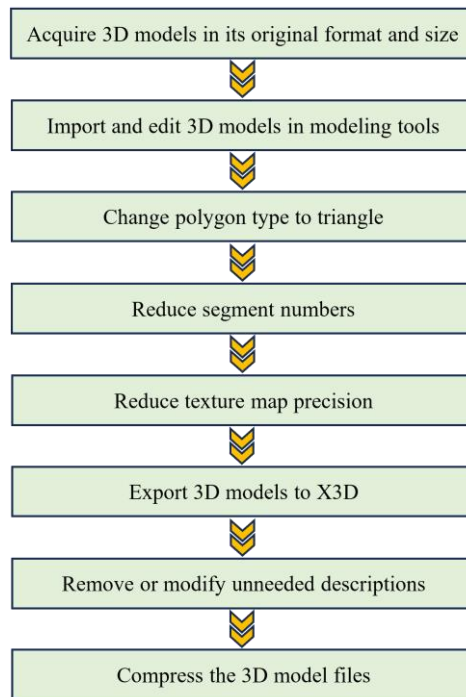
Fig. 4. Optimization procedure

The process of optimizing a 3D model is a part that requires time, because the model must appear to still have high detail while its size must be minimal. This is especially true if a 3D model of a particular part cannot be obtained so a model is scanned with a 3D scanner. If simple internal parts are scanned then optimization does not take long. However, if what is scanned is an external spare part e.g. car body parts, are large, and have surface contour patterns that are not simple, then optimization can take a long time. Scanning cannot be performed for all parts, this is because scanning only produces polygons representing the shape of the outer surface of the object, so internal details cannot be obtained. A comparison of sample 3D models for optimized and non-optimized catalogs is shown in Table 1.

Table 1
Comparison on file size and polygon numbers

3D Model	Unoptimized		Optimized	
	File size	Vertices/polygon	File size	Vertices/polygon
Engine block	3,340 KB	21,987/25,335	178 KB	2,004/2,382
Gasket	476 KB	5,238/5,284	28 KB	526/488
Crankshaft	1,318 KB	14,637/16,674	76 KB	1,367/1,395
Piston	33,153 KB	236,975/333,424	1,762 KB	22,157/26,449
Brake rotor	3,761 KB	25,576/25,584	214 KB	2,495/2,191

Optimization also impacts catalog performance because smaller 3D model file sizes help the system memory and processing devices to run faster. Although the differences of the optimization results for each individual 3D model may seem insignificant, they become apparent when the system has to load and render many models at once, and this is something catalogs will often do when displaying sets of many parts at once. Table 2 shows a comparison of the rendering speed of 3D models when navigating with examine mode in frames per second (fps), and memory usage by 3D models that have not been optimized and the ones that have been optimized. The values are the average of measurements which were conducted on the 4 PC terminals used in the experiment.

Table 2

Comparison on FPS and memory usage

3D Model	Unoptimized		Optimized	
	Frame per Second	Memory Usage	Frame per Second	Memory Usage
Engine block	41.25 fps	4.9 MB	43.51 fps	2.3 MB
Gasket	54.61 fps	2.6 MB	54.85 fps	0.9 MB
Crankshaft	45.28 fps	4.1 MB	46.17 fps	1.7 MB
Piston	31.54 fps	17.6 MB	34.33 fps	3.8 MB
Brake rotor	40.37 fps	8.7 MB	44.06 fps	3.1 MB

During the research, it was discovered that acquiring a set of 3D models along with its individual parts in modular style descriptions turned out to be more efficient than taking 3D models of individual parts one by one and then assembling them into one large part or even a whole machine. Efficiency is achieved because when using a set of 3D model, all parts are in the right location, in the right size, and in the right direction. Thus, there is no need to manually create a description of the scale, orientation, and starting point coordinates of the model which are added as `rotation`, `scale`, and `translation` parameters to the `<transform>` element since they are already available in the complete 3D model description. The manual method takes a long time and is prone to decreasing accuracy due to less precise manual descriptions. So that each component component can become an individual 3D model that allows it to be manipulated separately, the description of the related 3D model in the `<transform>` element is extracted from the complete 3D model, added with independent 3D model file compiler tags starting from the header to the closing tag `<X3D>` as well as several basic configuration attributes, then saved as a separate file. The description is then removed from the complete 3D model, replaced with an external 3D model calling tag in an `<inline>` element with a `url` parameter. `Scale`, `orientation`, and `coordinate` parameters that have been included in separate 3D model files will make them appear immediately in place as if the 3D models were unified in one description. An example of a 3D model which is a collection of several individual 3D models is shown in Figure 5. The 3D model is a combination of many separate individual 3D models i.e. cylinder, piston, piston head, crankshaft, spark plug, valve, intake/exhaust pipe, etc.
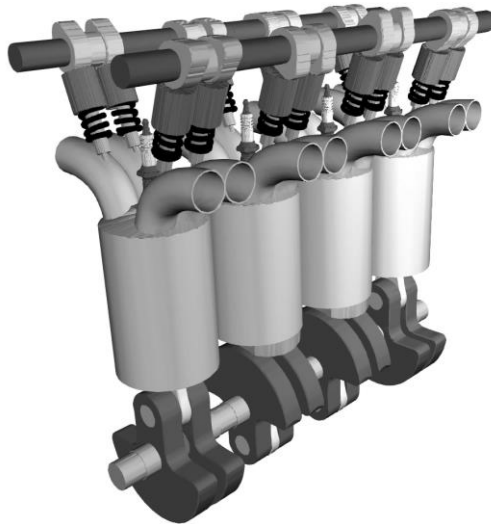
Fig. 5. An example of combined individual
3D models

This technique of breaking a single 3D model into a modular one can help optimize file size and data transfer, because if a description is used repeatedly, then `DEF` parameters can be specified followed by a variable for the referenced 3D model file, then any part of the description that requires it can use the parameters `USE` with the same variable values in the `<transform>` element so that the required 3D model will be rendered in that part. If a 3D model file is to be referenced repeatedly externally, then scale, orientation, and coordinate descriptions are not specified in separate individual 3D model files. Instead, the parameter descriptions are written in the `<transform>` element of the main file that calls the separate 3D model so that the 3D model will be in the correct place when called.

However, if the acquired full set 3D model turns out to have a monolithic style description, then additional steps need to be taken, namely cutting with a 3D modeling editor. The subtraction operation is carried out to separate the target 3D model description so that it can be separated from the main model. The separated part of the description is then named, and once exported will be identified as a description marked with `DEF` followed by a name in the `<transform>` element. Because it is a separate description, the modeling application will add `scale`, `location` and `translation` parameters along with their values. After being exported to X3D, the description can be separated from the main model file since the main 3D model file has been converted into a modular style description. The procedure to acquire specific 3D models from original single 3D models is depicted in Figure 6.
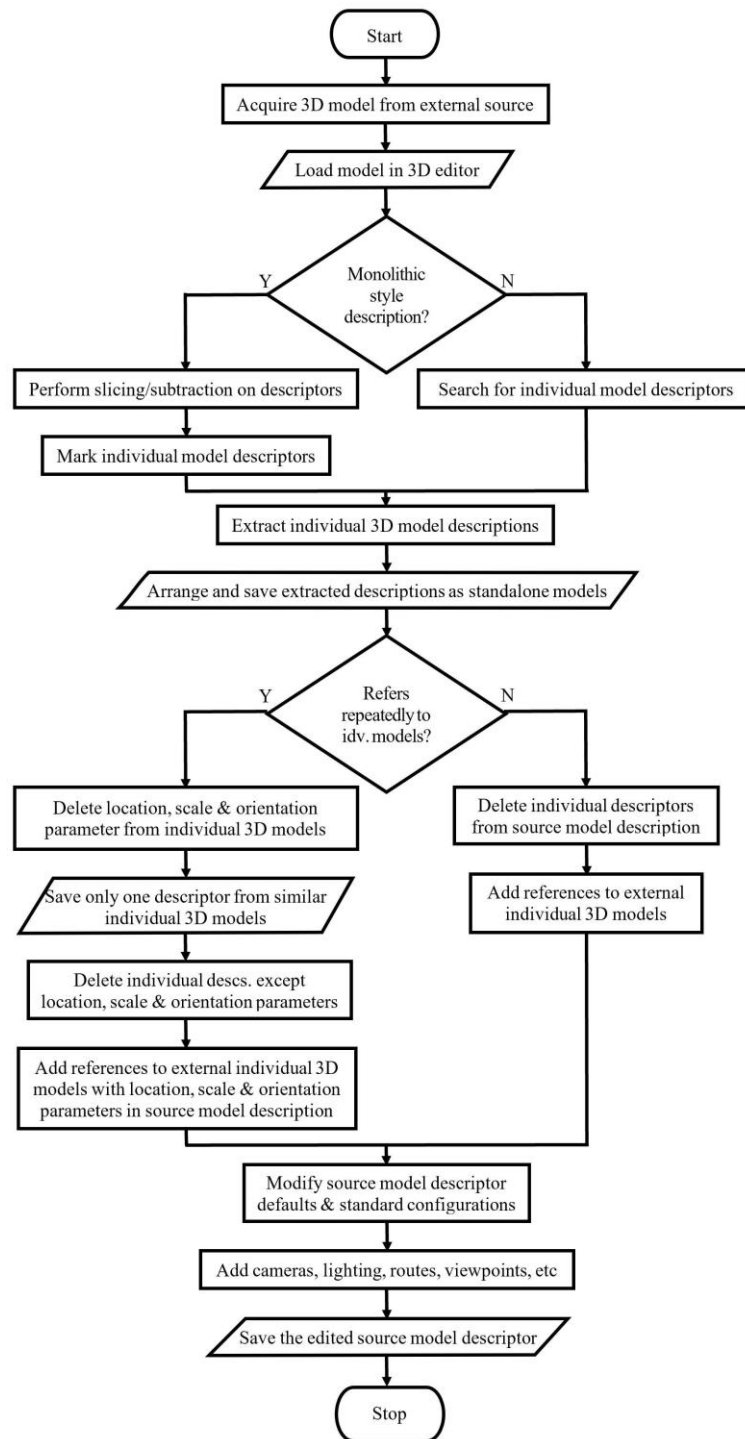
Fig. 6. Procedure to acquire 3D models from a single source model

The catalog system displays the arrangement of spare parts along with the part groups that include them. However, it allows for higher interactivity that is not found in other similar applications. The catalog will provide the option to replace certain parts in the displayed parts set, for example to indicate compatibility between certain parts. Thus, additional interaction media are needed in the 3D model viewer interface. This medium, visualized as a button assigned to each displayed 3D model, allows each individual 3D model to be hidden from the parts set viewer page. When the user replaces it with another 3D model of the part, the replacement 3D model displayed as the appropriate part option is shown. This method can be realized using the element concatenation method [52] which is

simply depicted in Figure 7. This method allows separate 3D models to be combined in one view that composes a set of parts as part of a machine or becomes the machine itself. Since each 3D model is an individual object that can be displayed separately without the presence of other parts in a set, display manipulation based on user choices can be done.
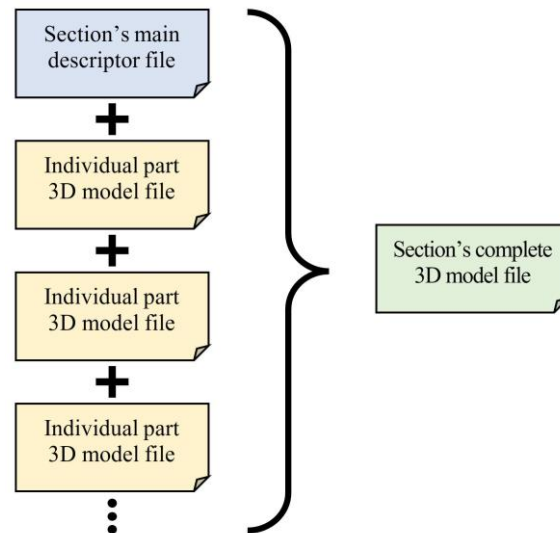

Fig. 7. Concatenation of elements to form a set of 3D models

Databases are used to store information about 3D models, however, placing 3D models directly in a database slows down the process since the steps that must be taken before the model is displayed become longer. The viewer page must also compile the model description from the database into a file before being called by the X3DOM element in the viewer page. The process can be carried out faster if the database only stores the file name of the 3D model that can be retrieved via query and then directly inserted as a variable value into the X3DOM element in the viewer page. The 3D model will still be saved as a document file according to the format used, then displayed one by one according to its set using the element concatenation method.

If one large product e.g. a car is immediately broken down into individual elements and displayed together, the appearance and the way of browsing it can make it appear too complex. Therefore, the 3D model display of spare parts is grouped hierarchically based on the highest machine part, then divided into smaller constituent parts, down to the smallest set composed of individual spare parts. For example, certain types of cars are broken down into engine, drive, electronics, A/C, multimedia, etc., then broken down again into smaller parts. Thus, the grouping of spare parts is carried out based on the part where the item is used. The hierarchical pattern of displaying the 3D model of spare parts in the catalog is exemplified in Figure 8.
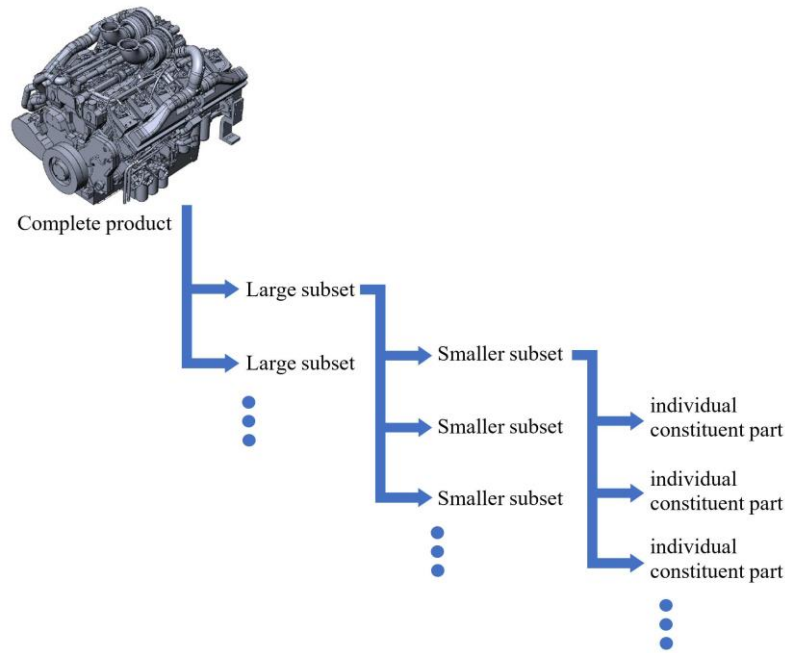
Fig. 8. Hierarchical pattern of 3D model displays

The structure of the proposed online catalog system is depicted in Figure 9. The use of X3DOM allows the use of a conventional web server together with a widely used DBMS, so that it does not require special tools or certain hosting which requires large costs. The system can also utilize popular PHP frameworks such as CodeIgniter or Laravel since inserting the X3DOM framework into templates can be done in a simple way.
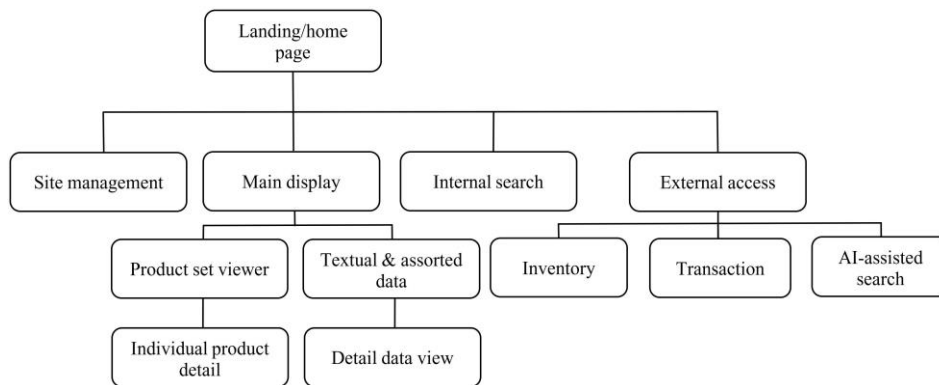

Fig. 9. General structure of the system, based on its main functionalities

The system was built using the spiral evolutionary engineering paradigm [53] as depicted in Figure 10. This method was chosen because it has suitable characteristics with online catalogs which have several basic and additional functions. In addition, this method makes it possible to prepare new features that will be added as subsequent functions to the base system even though the base system is still under development. Thus, the study in the context of creating an online catalog is limited to research into the development of a 3D model display system and basic accompanying data, to the ability to exchange data with connected external systems. The external system as depicted in the architecture will be developed in separate research. Feature development to complete the catalog is carried out iteratively according to the spiral model development method used as a reference, down to the final function that is planned to be included in the system.
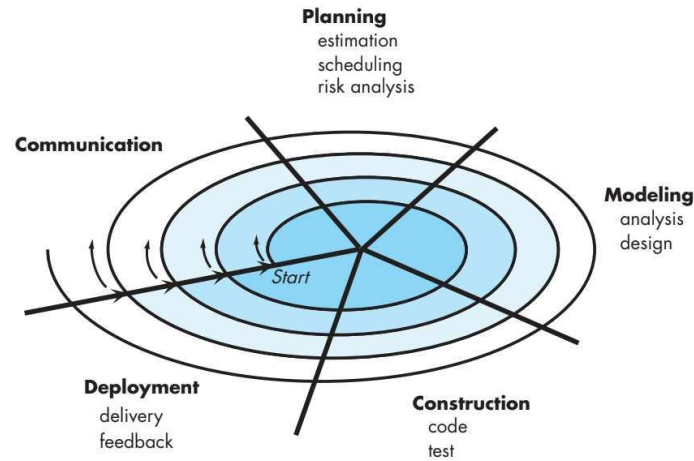
Fig. 10. Spiral model reference used to develop the system [53]

The initial iteration of development which is still ongoing is currently preparing a basic prototype of the catalogue, with the basic function i.e. the 3D model viewer in the browser already working. Other main functions and those related to external systems are still not operational because the data wrapper function for external systems is still being worked on. In this research, external systems are built as dummy systems which are both data providers and recipients of data sent by the catalog whenever there are instructions to use the functionality provided by the external system. Dummy systems do not have the basic functionality of a real system because they are only prepared to check whether data from the catalog system can be sent, and whether the catalog can retrieve data from a particular dummy system which is intended as a data feeder for the catalog.

In contrast to the other applications mentioned previously, pages that visualize 3D models will be more focused and become the main display on which all other information is based. Textual and all non-3D data is displayed in a semi-transparent layer with a maximum opacity of 20% which is placed as an overlay on top of the main display page, thus allowing the 3D model to always appear on the full screen while other information can be displayed on top of the model display or removed so that the 3D model view comes into focus. A functional preliminary prototype for design purpose only intended as the main view displaying the 3D models in the catalog is shown in Figure 11.
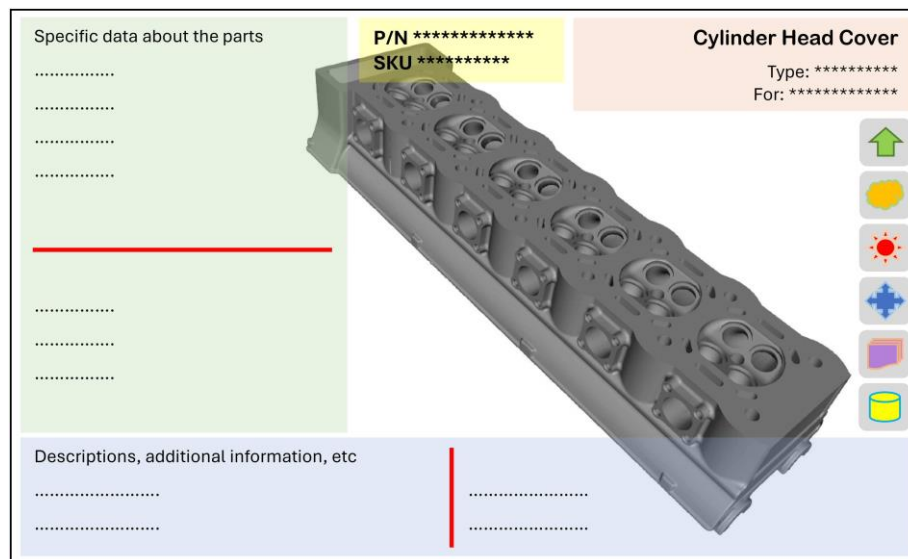

Fig. 11. Catalog main display design

4. Results

Early responses by potential users to systems currently under development appear to have a positive trend. A total of 40 people have become preliminary survey respondents to see their interest in online catalogs that can display spare parts in 3D to improve the visual aspects of products along with transaction functions and searching for related information. A mockup is provided as a sample implementation of the concept for the catalog in general, but the 3D model viewer uses a functional page which actually provides a 3D model that users can use and navigate.

In general, the majority of users agree with the specifications and design of the online catalog that has been prepared. Most respondents were not knowledgeable about machinery, but they expressed great interest because of the potential to help them deal with problems related to finding replacement parts if they needed them. It can be said in summary that the majority (each above 75%) agree on the points of the statement that the online catalog concept being developed has the potential to:

i.   Makes it easier to understand spare parts physically so that users can know their characteristics.
ii. Gives a clearer picture of the installation location.
iii. Shows visual information that helps explain part compatibility with other parts.
iv. It's easy to get specific information about the part under consideration while observing its appearance.
v.   Makes it possible to make a purchase straight away while ensuring that the part is correct, suitable and available.
vi. Allows searching for alternative sellers of similar or compatible items if the user cannot purchase genuine spare parts.
vii. Provides accompanying information from various sources that is useful and helps make part selection decisions.

However, there were two points that apparently get more negative views, namely:

i.   Get the impression of looking at actual spare parts in the real world.
ii. Allows users on any device to be able to see the display of spare parts clearly and precisely.

The first point where the majority of respondents disagree was because users sometimes find it difficult to change navigation modes when using a handheld device. The majority of respondents did inspect mockups of sample implementations of the catalog concept using handheld devices, and this limited the type of navigation mode for examining spare parts. On the second point, although only slightly more than a half, the disagreement was due to the fact that according to them the 3D model display on a handheld device was not as clear as when using a larger device such as a PC or at least a tablet. Zooming to the largest scale will force them to lower the zoom scale first before trying to do anything else, and this increases the work step when compared to using a device with a physically wider display system.

Apart from being a catalog as the main function, one of the aims of developing this online application is as a learning medium for its users. This will be possible to realize because the application does not just visualize one or a set of spare parts in 3D, but also shows the location of each spare part relative to the others interactively with various navigation methods that resemble visual observations in the real world. In addition, textual information and accompanying images will

also convey various things that can help users complete their understanding of the part. Connecting to an external search subsystem or generative AI that performs specific crawling according to the context of the parts being examined from various sources including in video form will help enrich information that can be used as learning material for users, without having to disassemble the actual machine set to see the constituent parts and the place where the spare parts are located.

As an integrated spare parts online catalog, users will be able to utilize it for various purposes and needs. The system will not only be able to be used by users who need certain spare parts for their machines, but also by users who want to learn about a specific machine and its constituent parts. This requires a lot of data related to spare parts. The data used in the main catalog system consists of:

    i.   3D Models.
    ii.   Raster images for texture maps.
    iii.   Accompanying images (graphics and photos).
    iv.   Text related to spare parts.

However, this also raises new challenges, namely the scope of the catalog's ability to show a variety of spare parts. This is because there are so many machines and spare parts from various products, versions, variants, types, etc., while preparing or procuring 3D models as the main content material requires lots of funds. A common 3D model repository and shared database for various spare parts provided by the manufacturing companies will make implementation easier, since the data can be accessed and downloaded by parties who want to build an online catalog to offer the spare parts produced by the brand owners or its subsidiaries and their OEM if there is any.

Another option is to use a dataset that contains 3D models and all accompanying files, with the condition that the models in the dataset must use the X3D format and contain spare parts models with a component set hierarchy that is specific to a particular type and brand. However, there is a possible time overhead for processing and retrieving information from the dataset when compared with direct access to the database via query. System performance on the user's side can decrease if the application has to download large datasets via the internet, compared to only fetching as much model data as is needed to be displayed at one time.

Web-based online catalogs make it possible for anyone to access them as long as they are connected to the internet. This is because every user of any type of online-enabled device and any platform has a browser so they can access the web-based system. This is one of the reasons why the proposed system is not built as an application for a specific platform which would limit the scope of its users. Almost all modern devices have browsers that are compatible with the HTML5 standard, and this complies with the framework used to display 3D models i.e. X3DOM which also uses HTML5 to adapt the X3D format without plugins. However, not all browsers have the same level of compatibility with the HTML5 standard, so potential visual problems may occur in certain browsers both when displaying 3D and non-3D content. Therefore, it is necessary to simplify the code to be as concise as possible so as to minimize the possibility of incompatibility without reducing system functionality.

5. Conclusions

Even though it is still in the early stages of development, an online catalog that can display spare parts products with a 3D display that is integrated with non-3D data and has additional functionality, especially searching for information related to spare parts from external sources, has great potential

for use by users. This is because more and more users may experience problems related to certain spare parts and they do not have knowledge about these spare parts, and they want to get additional information beyond what the technician conveys, so that it can help convince them to make a decision. The possibility of misidentification can also be minimized if users get as complete information as possible displayed in one application, thereby preventing a chain of subsequent errors that can occur if the spare part they choose turns out to be unsuitable. Apart from being a means of searching for required items, the completeness of the information provided, especially the ones obtained from the use of a search system that utilizes AI, has the potential to enable users to self-teach related parts and items.

In order to overcome problems that may arise when using handheld devices with small screens, the system is also prepared to implement responsive web design. However, due to the large number of handheld device users who generally find that customizing web displays on small devices still makes it difficult for them to interact with 3D models, it is planned to adapt the implementation using React Native once the catalog functionality can actually work according to the specifications of the analysis results.

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