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# 3D Online Parts Catalogue for Quick Identification and Learning

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**ABSTRACT**

People sometimes face challenges when they have to memorize many components or parts of a machine. Although a complete schematic description of a machine and its parts is generally available, many similar parts with different uses can be troublesome, especially for those not specifically in that field. Inventory system managers and item supply custodians must thoroughly understand the parts requested by specific customers, so as not to make mistakes in distributing the ordered parts. 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 between different items. The general public users experience many difficulties 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 catalogueing parts using 3D visualization. 3D visualization identifies the parts and 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 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 specific part or to understand it. The catalogue presents various data about spare parts, including their availability status, since it can be linked directly to the provider's inventory system 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 particular objects *via* search engines on the internet sometimes makes it difficult for users, especially those who don't understand the object they are looking for. This also often happens to users looking for spare parts needed for specific machines or equipment. Mistaken purchases by users frequently occur, and spare parts that seem to match what they need are

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unsuitable, even though they look similar. Mistakes can still happen in those whose work is related to machines and often requires certain spare parts. While time may improve the experience, there will always be new machines, variants, parts, and many other things that can make it overwhelming for users to keep track of everything.

Creating a list of items in catalogue 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 catalogues are not only for finding items that users need, but can be used as a promotional tool. Electronic catalogues in the form of websites enriched with various information and information delivery methods can further increase users' interest in looking further at what is on offer [4]. Catalogues in the form of websites are often the choice because they allow the broadest range of users [5].

Even though they include image elements, most details are insufficient for general users, leading to misinterpretation and even wrong purchases. Catalogues for certain items, such as machine spare parts, generally use unique identifiers in a specific format and are arranged in a structured manner with nomenclature to facilitate identification [6], as shown in a sample of an electronic catalogue 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 catalogues, which are soft copies of the printed version, shown in a sample of a service part catalogue [9], so the information obtained is limited to what is printed in the catalogue.

Visualization of spare parts in online electronic catalogues is generally done by displaying sketch images followed by several short descriptions. Open sales sites such as marketplaces or specific goods sellers sometimes display photos of spare parts [10,11]. 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 other important things 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 consists of these spare parts. However, most of them use low-resolution graphics, and the information provided is very limited. Sometimes, they even use codes or abbreviations, so they are generally confusing for non-technicians or those who have not received training on the item, as shown in the search results page on a spare parts provider site [12].

To make the product representation look 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 as 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. 3D on the web requires Web3D technology [13], available in various implementation formats or frameworks. Several companies have used Web3D in their promotional websites, but are limited in displaying certain products, such as cars [14,15]. The site does not integrate various functions or other information because it is only promotional in nature. However, using 3D graphics looks very prominent in helping users examine the physical products displayed.

A spare parts visualization method is needed to help users, especially to practice recognizing spare parts and related matters, to provide a basic understanding, as shown in a schematic diagram. It is more informative and makes it easier for users to obtain further information from various sources. A better display can be obtained using 3D graphics combined with other information in text, 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 catalogues has shifted to online sales media, which has implemented all the principles of online catalogues down to the transaction function, allowing users to make purchases online through various payment services. Research on electronic catalogues 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 catalogue or an application-based for specific platforms. The majority of media for e-commerce and e-business have implemented an online catalogue model to offer their merchandise with more or less similar techniques. However, users with special product needs often have difficulty finding a suitable online sales place to get the goods they seek [17]. Many users do not have complete information regarding the items they want, so they cannot provide the correct data as input to the system so that it can produce results that best suit their wishes [18].

Several parties, especially Micro, Small and Medium Enterprises (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 catalogue. Nevertheless, 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 catalogue has been carried out by Ionescu *et al.,* [21] although it is only specifically for geospatial data.

Spare parts sold online are original products from brand holders and can also be Original Equipment Manufacturer (OEM) or aftermarket types. Advances in 3D printing technology have made parts produced from the Additive Manufacturing (AM) process increasingly popular [22]. These service providers sell their services through user orders, 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 catalogue being developed, however several things 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].

An 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) and its successor, X3D (ISO/IEC 19775-1:2023) are the official formats of the Web3D consortium, while WebGL and its successor, WebGPU are some of the non-standard formats and are widely implemented with various frameworks or libraries created with JavaScript [24-28]. Web3D has been utilized by commercial websites 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 [29,30]. However, 3D for the web is here not to replace 2D but to complement it [31]. This can be seen from using 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, generally seen in two main types, imperative/procedural and declarative

[33,34]. The imperative type describes the model in a programming-like way using a particular 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 fewer 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 to display 3D models directly without requiring plugins [38]. X3DOM also enables 3D models to be integrated as elements of web documents in a simple way [39]. This can be advantageous since users do not need to frequently switch from 3D view to 2D view or *vice versa*, as they do not need frames and do not require complicated page settings using special coding.

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

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

Systems similar to the one proposed do not yet include more complete capabilities to be a more comprehensive solution, especially for novice users who need spare parts and want to practice and learn about the machines and spare parts they are looking at. Cortona's RapidCatalogue 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 [48]. However, this application is intended for internal organizational needs, and not for open sales purposes to the public. Windchill from Tristar/Wincom also performs 3D visualization of parts or machines, even though they do not appear detailed [49]. 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 must be formed into extensions, just like plugins, which can take a long time to update applications and content.

Door2Solution's Spare Parts Catalogue can also be made into an open system for public access [50]. This application, known as Spare Parts Management (SPM), can be expanded to be used as an online shop or portal for users related to similar products. With a 3D display accompanied by 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 catalogue that 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 specific 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 catalogue system is needed that allows users to minimize the possibility of incorrect purchases. The catalogue must be accessible online and open with a commonly used system. Its capabilities include helping users learn about the spare parts they are looking for, including getting detailed information about usage and 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, 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 an extensive application that includes many specific functions that vary according to the type of function. The system developed is an online catalogue 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 catalogue, but use a shared database. This will make it easier in further system development. If additional functionality is available previously, then the catalogue built later can use the existing database, so that there is compatibility with the existing system, and they can collaborate well. A special search system is built with two functions: 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 catalogue 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 catalogue is the data wrapping subsystem, which summarizes information from the catalogue for exchange with other systems, and allows the catalogue to retrieve data from or send data to other connected systems. This section makes the information obtained from the catalogue 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 catalogue supplies data about spare parts, then sent as keyword information to an external search system to search for textual information, video, or as input for information searches that utilize AI assistance.

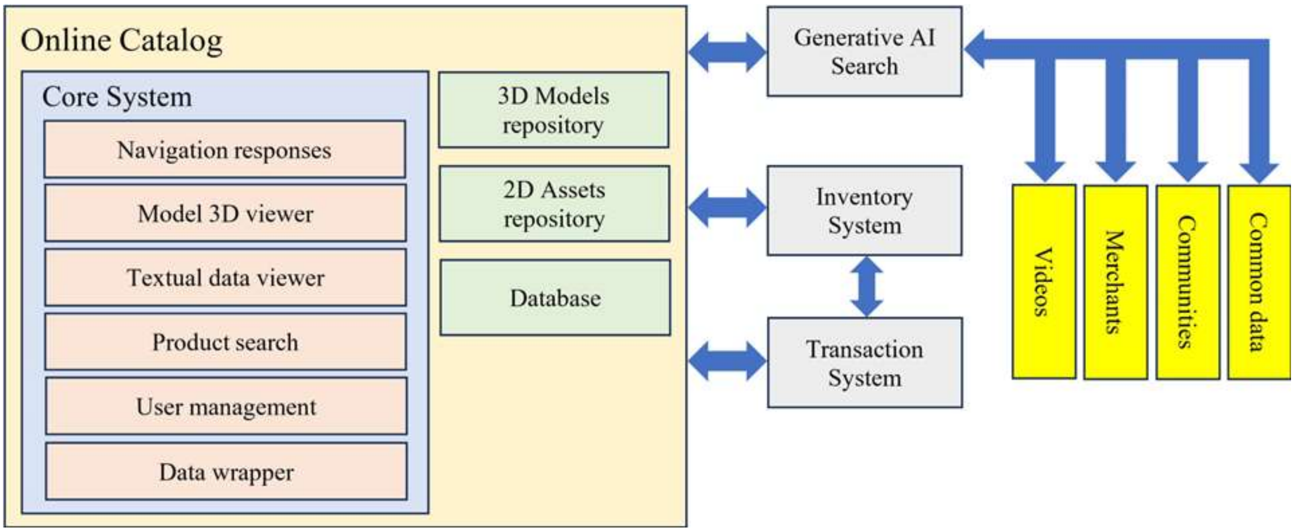


**Fig. 1.** Proposed system

In general, the functionality to be integrated into the online catalogue 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 moderated by the catalogue system manager.
vi. The ability 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 catalogues 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 catalogue was taken from the internet. One example of the 3D model used in the system prototype is shown in Figures 2 and 3. Both figures display the same 3D model, the former being edited using Blender modelling 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.

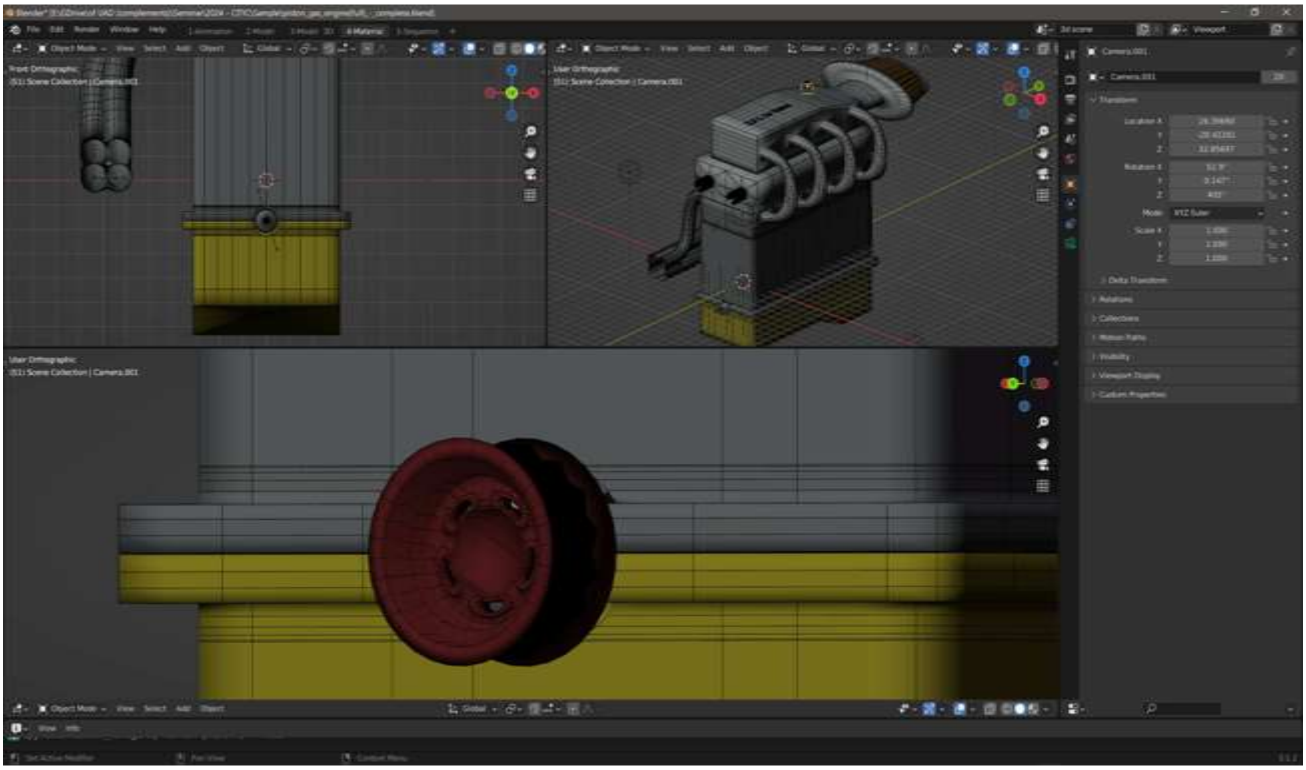

**Fig. 2.** 3D model sample of a complete engine used for the prototype, edited using Blender

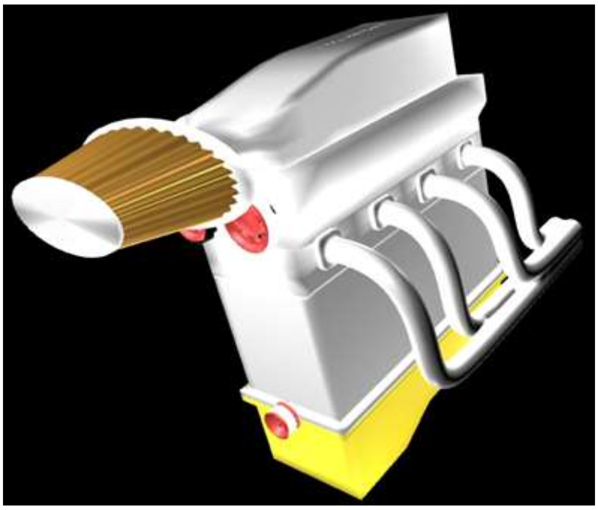

**Fig. 3.** 3D model sample of a complete engine used for the prototype, viewed in X3D viewer

If the 3D model obtained has a large file size, then the 3D model must be optimized 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.

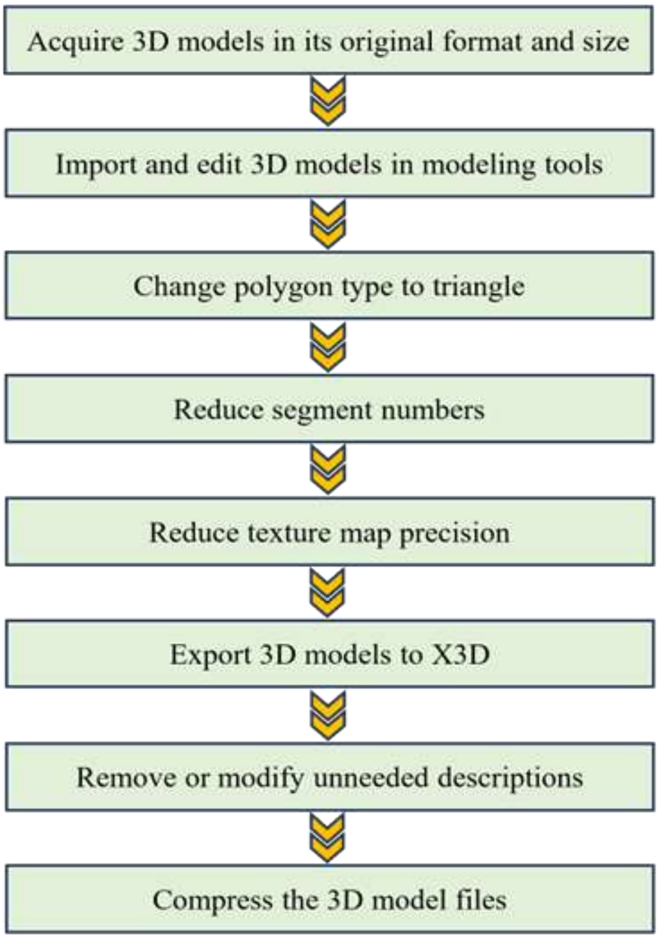


**Fig. 4.** Optimization procedure

The process of optimizing a 3D model is a part that requires time because the model must still appear to 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, that 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, because scanning only produces polygons representing the shape of the object's outer surface, so internal details cannot be obtained. A comparison of sample 3D models for optimized and non-optimized catalogues is shown in Table 1.

Optimization also impacts catalogue 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, which catalogues will often do when displaying sets of many parts at once. Table 2 compares 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 those that have been optimized. The values are the average of measurements that were conducted on the 4 PC terminals used in the experiment.

**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 |

**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 models, all parts are in the right location, size, and 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 combines many individual 3D models, i.e., cylinder, piston, piston head, crankshaft, spark plug, valve, intake/exhaust pipe, etc.

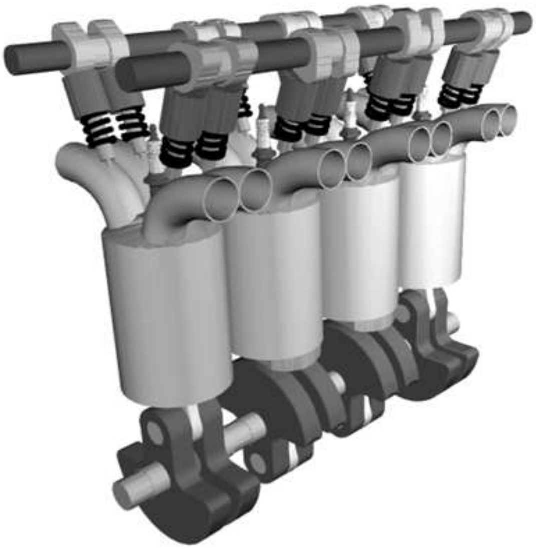

**Fig. 5.** An example of combined individual 3D models

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. Any part of the description that requires it can use the parameters `USE` with the same variable values in the `<transform>` element, so 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 complete set of 3D models turns out to have a monolithic style description, 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.

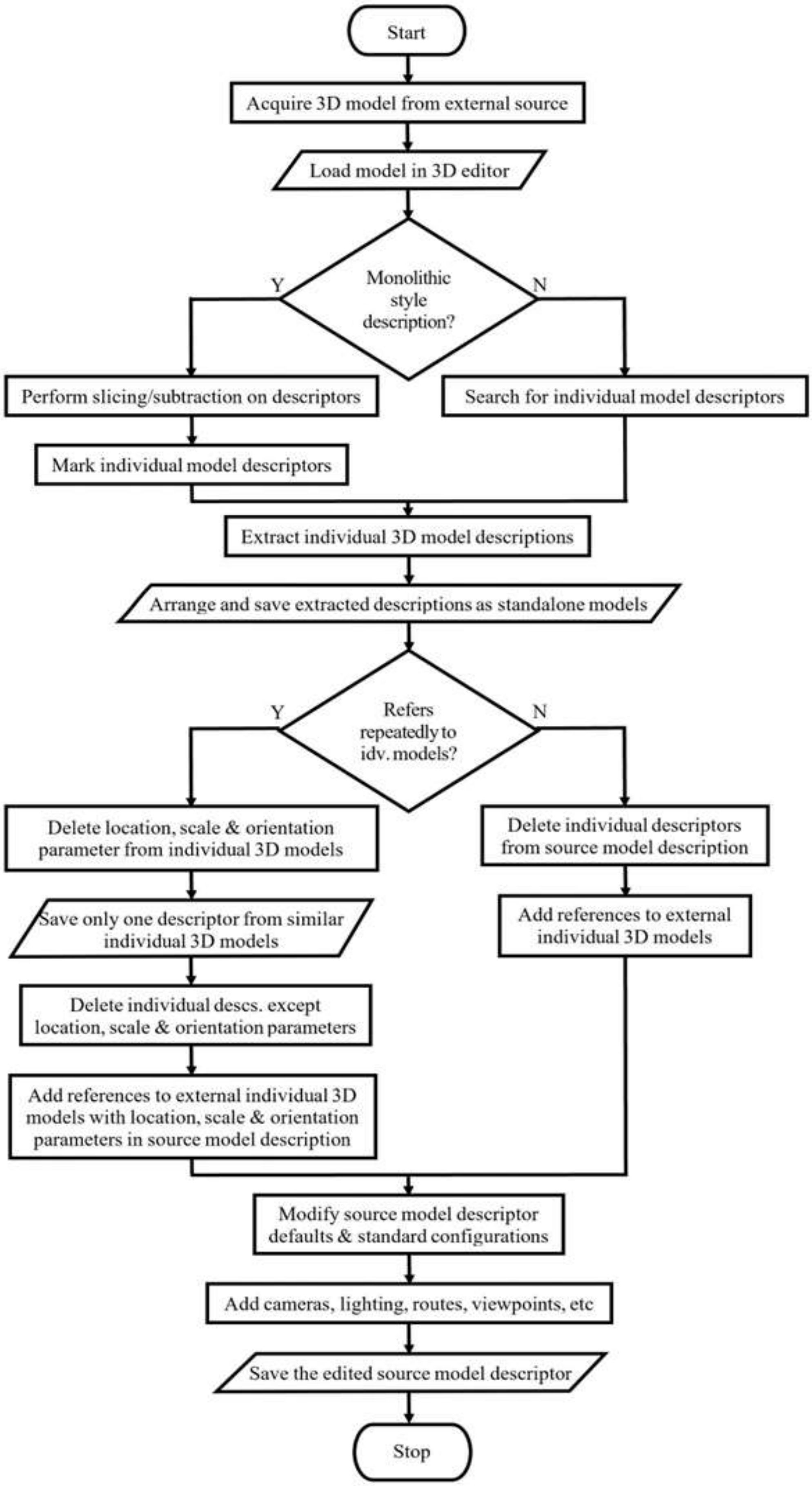


**Fig. 6.** Procedure to acquire 3D models from a single source model

The catalogue 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 similar applications. The catalogue 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 is displayed as the appropriate part option. 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.

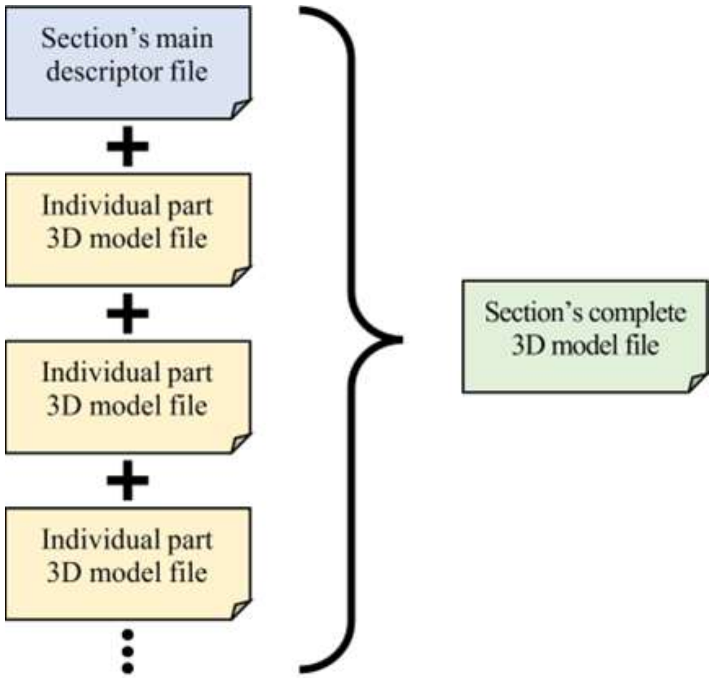


**Fig. 7.** Concatenation of elements to form a set of 3D models

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.

Suppose one large product, e.g., a car, is immediately broken down into individual elements and displayed together. In that case, 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 into smaller parts. Thus, spare parts are grouped based on the part where the item is used. The hierarchical pattern of displaying the 3D model of spare parts in the catalogue is exemplified in Figure 8.

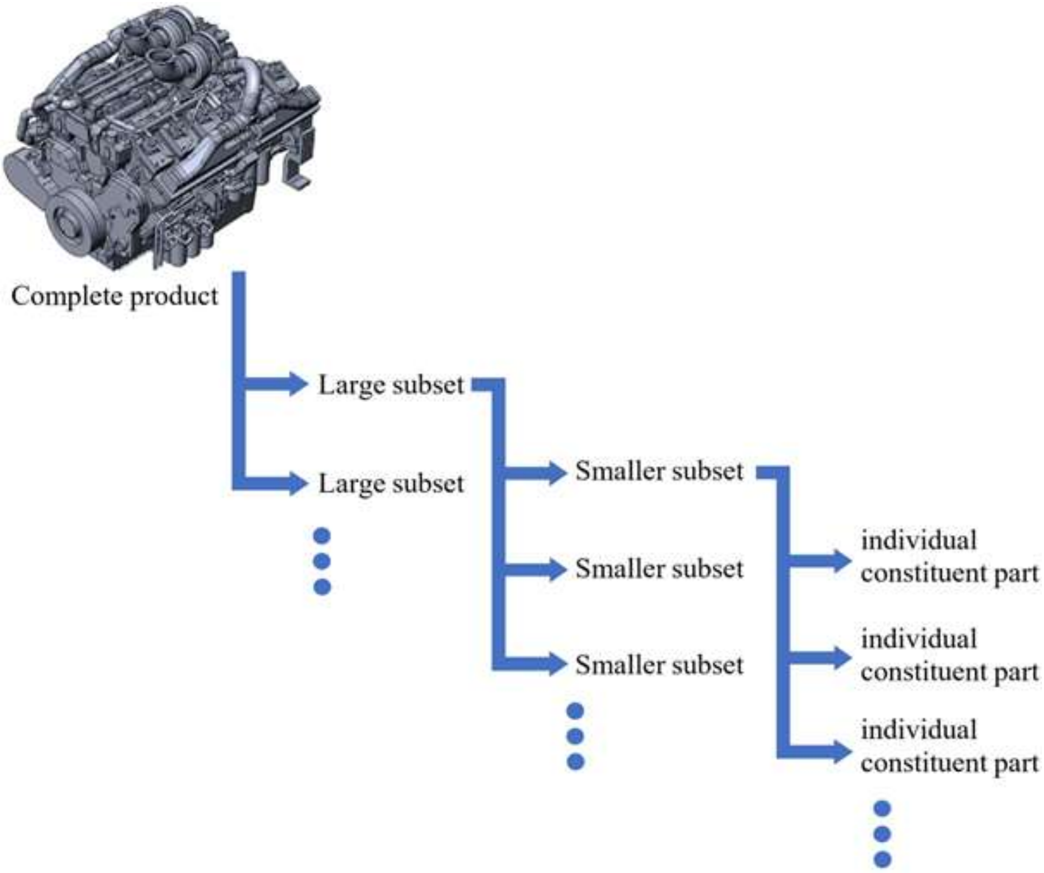


**Fig. 8.** Hierarchical pattern of 3D model displays

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

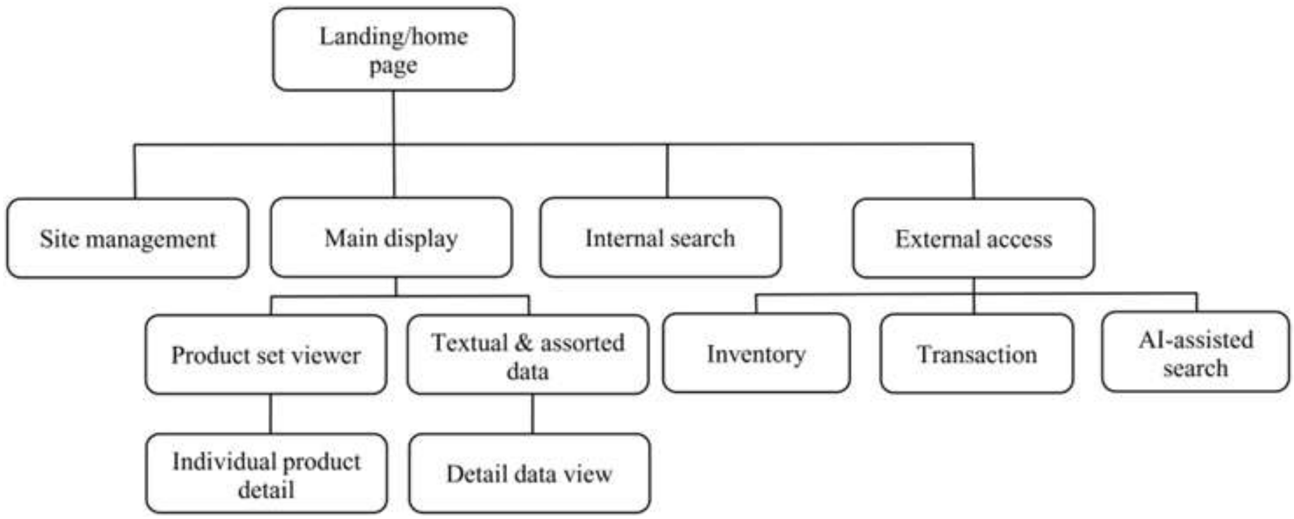


**Fig. 9.** General structure of the system, based on its main functionalities

The system was built using the spiral evolutionary engineering paradigm as depicted in Figure 10 [53]. This method was chosen because it has suitable characteristics for online catalogues with 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 catalogue is limited to research into the development of a 3D model display system and basic accompanying data, as well as 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 catalogue is carried out iteratively according to the spiral model development method used as a reference, down to the final function planned to be included in the system.

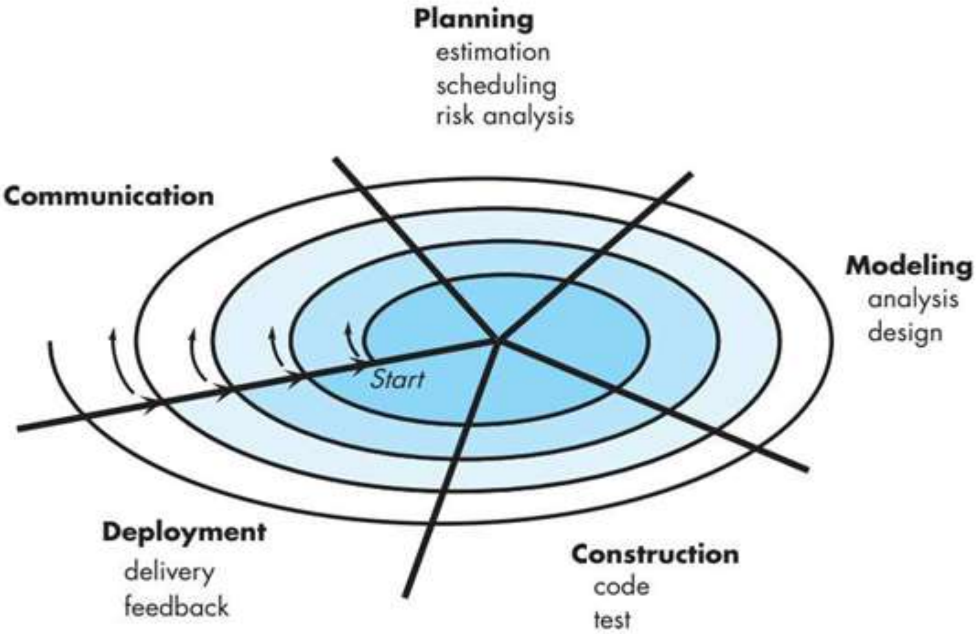


**Fig. 10.** Spiral model reference used to develop the system [53]

The initial iteration of development, which is still ongoing, is preparing a basic prototype of the catalogueue, 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 that are both data providers and recipients of data sent by the catalogue 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 catalogue system can be sent, and whether the catalogue can retrieve data from a particular dummy system intended as a data feeder for the catalogue.

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. In contrast, 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 purposes only, intended as the main view displaying the 3D models in the catalogue, is shown in Figure 11.

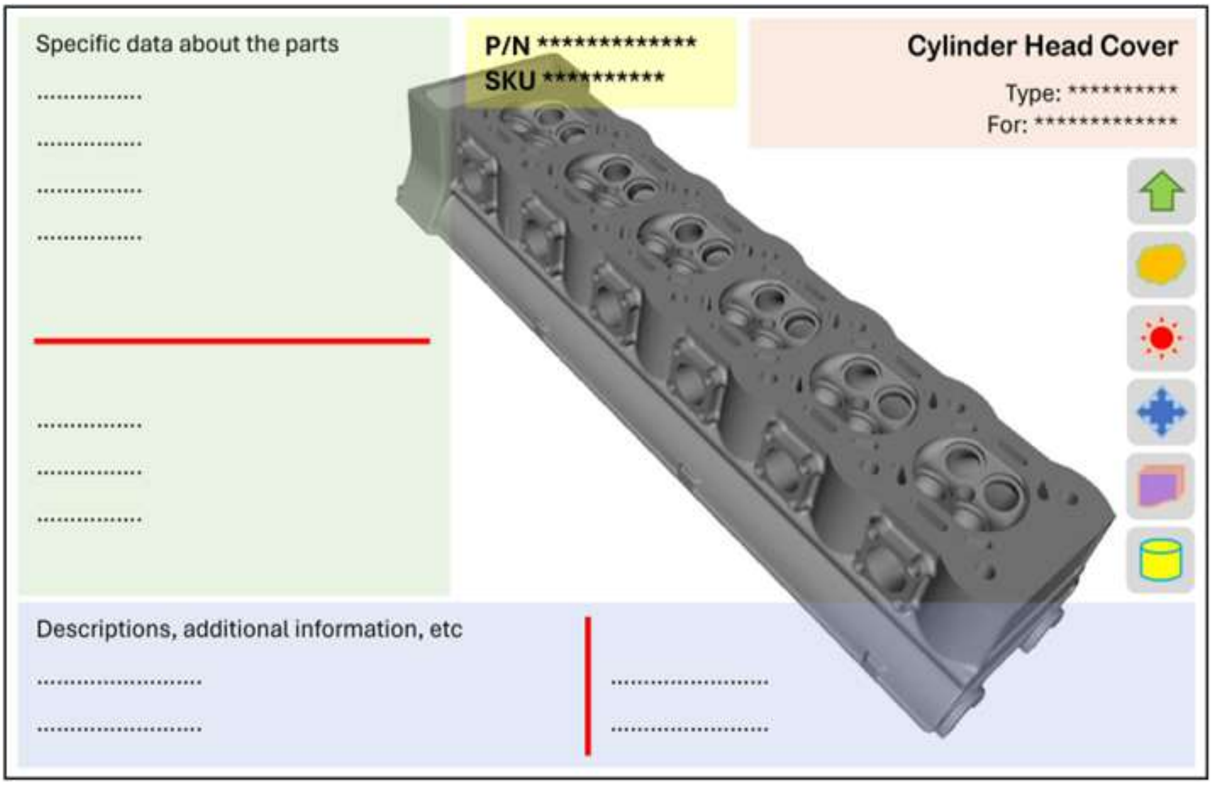


**Fig. 11.** Catalogue main display design

## 4. Results and Discussion

Early responses by potential users to systems currently under development appear to have a positive trend. A total of 40 people has become preliminary survey respondents to see their interest in online catalogues 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 catalogue in general. Still, the 3D model viewer uses a functional page that 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 catalogue that has been prepared. Most respondents were not knowledgeable about machinery but expressed great interest because of the potential to help them deal with problems related to finding replacement parts if needed. It can be said in summary that the majority (each above 75%) agree on the points of the statement that the online catalogue concept being developed has the potential to:

i. Makes it easier to understand spare parts physically so that users can understand 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. It makes it possible to make a purchase immediately while ensuring that the part is correct, suitable, and available
vi. It allows users to search for alternative sellers of similar or compatible items if they 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 received 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 see the display of spare parts clearly and precisely

The first point where most respondents disagree is that users sometimes find it challenging to change navigation modes when using a handheld device. Most respondents inspected mockups of sample implementations of the catalogue concept using handheld devices, which limited the type of navigation mode for examining spare parts. On the second point, although only slightly more than half, the disagreement was since, according to them, the 3D model displayed 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 steps compared to using a device with a physically wider display system.

Apart from being a catalogue as the main function, one of the aims of developing this online application is to serve as a learning medium for its users. This will be possible 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 a system that can be used for the learning needs of its users, the system can be part of an effort to realize online education by including various factors as mentioned in previous research [54].

As an integrated spare parts online catalogue, users can 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 catalogue 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 catalogue's ability to show various 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 catalogue 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 containing 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 specific to a particular type and brand. However, there is a possible time overhead for processing and retrieving information from the dataset compared to direct access to the database *via* query. System performance on the user's side can decrease if the application downloads large datasets via the internet, compared to only fetching as much model data as needed to be displayed simultaneously.

Since it can be connected and take data input from third parties who have detailed information about the spare parts, an instant manufacturing subsystem using 3D printers can be integrated to provide spare parts on demand. Detailed material information can also be used to set printing parameters to produce the spare parts that are considered the best [55].

Web-based online catalogues 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 platform has a browser to 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 compatible with the HTML5 standard, which 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 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 catalogue 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. They want to get additional information beyond what the technician conveys, so 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 information obtained from a search system that utilizes AI, can enable users to self-teach related parts and items.

The system is also prepared to implement responsive web design to overcome problems that may arise when using handheld devices with small screens. 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 catalogue functionality can actually work according to the specifications of the analysis results.

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