

INTELLIGENT REAL-TIME 3D CONFIGURATION PLATFORM FOR CUSTOMIZING E-COMMERCE PRODUCTS

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ABSTRACT

In this paper is designed and realized a 3D web configurator platform able to optimize the creation of 3D objects for sale on multi e-commerce platform. The user can select online the preferred object by learning the configurator to optimize the 3D object features. A Support Vector Machine -SVM- algorithm adopting XGBoost approach, improved affect computing, user navigation experience and Visual Merchandising – VM- approach, all elements which support the creation of new object having the best effective features. The intelligent self-learning platform is designed for the real time construction of 3D CAD objects and integrates different user facilities such as augmented reality, web plugin, and WebGL graphical libraries. The proposed work follows the research and development -R&D- guidelines of 'Frascati' manual concerning new search engine as research topic and summarize the result of an industry research project.

KEYWORDS

New Search Engine, Support Vector Machine, E-Commerce, Augmented Reality, Affective Computing, User Experience, Frascati R&D, XGBoost, WebGL.

1. INTRODUCTION: BASIC STATE OF THE ART DEFINING INITIAL PROJECT SPECIFICATIONS

In this section is discussed the state of the art of basic concepts adopted for the formulation of the preliminary information system architecture of the proposed case of study. Some authors have studied the performance of some 3D graphics APIs for the Web systems, by comparing the processing times of desktop PCs with mobile technology [1]. These studies have shown that, especially in the mobile case, the choice of appropriate APIs is of significant importance to avoid the "bottleneck" effect of the web. In the literature have been analyzed several reference architectures, useful for understanding the mechanisms for creating and displaying 3D contents on the Web, and highlighting the main phases that characterize a web configurator such as [2][3]:

- data model;
- web service;
- 3D representation;
- visualization.

Other studies have shown the timing of communication processes related to the exchange of data between client and server [4], thus enhancing the importance to design an efficient system architecture managing the web accesses. A technology that can be used for the development of a three-dimensional 3D configurator could adopt the Web-based Graphics Library –WebGL-. Some examples of WebGL platforms are reported in [5] and in [6], which clearly show how the user can act dynamically, for example by clicking with the mouse in the 3D object or by rotating it in real time processing. Other researchers have analyzed some solutions where the user can insert an object by giving specific coordinates in 3D space [7] thus introducing interactivity. The tool "3D Buffer" of ArcGIS, allows instead to create 3D objects starting from elementary elements [8]. Other tools allow the intersection of 3D objects [9], performing logical union and difference operations. Concerning 3D configurator design, the use case diagrams represent an important tool for the graphic representation of the design system and is usually implemented using Unified Modeling Language –UML- [10], a tool that can be used in the final design of the project idea. Currently for the development of 3D content by WebGL technology, there are several useful guides such as those shown in [11] and [12], useful for the development phase of a project based on the creation of a 3D configurator. Some studies have instead combined the WebGL technology with the concept of "Affective Computing" [13], thus improving intelligence to a platform to develop, an intelligence that, to date, has not yet been implemented in commercial cases WebGL associated with E-commerce platforms [14]. The concept of Affective Computing concerns precisely the emotional state of a person [15]. This state can be integrated in some way for the creation of dynamic 3D objects, where the user can customize the products for sale in real time, according to his own mood or preferences (which could be evaluated a priori through a special process of profiling). Tools for the recognition of the emotional state can be face emotion recognition [16]-[17] (detection of emotions from facial expressions), or the interpretation of the reading of audio tracks of the voice [16], or the recognition of the person's profile by text interpretation [18]. Another approached which can be adopted to analyze preference and humor online [19] is the user experience enabling online interaction, including augmented reality –AR- [20]. Following the state of the art analysis are defined the preliminary project specifications. The project is characterized by the choice of a series of innovative technological elements that cannot be found in the current market about E-commerce configurators, thus orienting the research on a competitive advantage: specifically the current solutions mostly provide a 2D and few 3D configuration, but not real-time 3D facilities linked to a multi E-commerce platform. Following this direction, the work aims to develop a configurator that, in addition to 2D, offers a real-time 3D viewer that can be used on the most common web browsers available on modern devices including PCs, smartphones and tablets introducing innovative element such as automatism in the creation of 3D CAD object by means of Support Vector Machine –SVM- algorithms and Visual Merchandising –VM- approach. Below are summarized the preliminary specifications of the research project.

Real-Time 3D Technology

WebGL technology will support the real-time 3D technology in the web environment allowing the E-commerce platform development embedding a configurator able to personalize objects for sale. A critical aspect will mainly concern the computational cost involving for example mobile device thus suggesting the cloud computing as an alternative solution. The research in this topic will aim to define a reference model for the creation of customizable contents by implementing innovative methods that allow the use of real-time 3D rendering even on devices without high computational capabilities.

API And Plug-Ins

The framework of the state of the art shows a fragmented offer of different plug-ins developed for specific E-commerce platforms. The configurator object of the current work is equipped with a plug-in and an API system allowing integration with any ecommerce platform.

Affective Computing (System Intelligence)

The paper includes the development of innovative techniques of recognition of emotional states to improve interaction with the user. The aim is to introduce intelligence into the software system so that the user is profiled based on the emotional states detected during navigation which represents an important phase of the system training (Support Vector Machine –SVM- learning model). When the user is profiled, the system will be able to suggest the most interesting graphic elements also considering Visual Merchandising –VM- impact. In the world of configurators, the use of these techniques is innovative.

Cloud Computing

The configurator object works as a Software as a Service –SaaS- on the cloud platform. From the technological point of view, the cloud represents a real revolution, changing the development paradigm and providing the opportunity to obtain applications characterized by high levels of performance, scalability and reliability.

Cloud Database

The prototype will allow users to use a cloud-based database system. Traditional databases provide full transactional support but present a major limitation for horizontal scalability (on multiple servers), making it necessary to use oversized servers to cope with peak usage. They also do not allow to support geographically distributed users. The NoSQL databases (Big Data Systems) offer excellent scalability but could be instable and do not support the SQL standard useful for common web applications. The answer to this type of problem is coming from the development of new databases, which promise continuous availability, full support for Atomicity, Consistency, Isolation, Durability –ACID- transactions and the SQL language, with the possibility of scaling multiple machines on multiple data centers. Equipping a SaaS solution with a transactional SQL database that can elastically scale over different data centers represents a significant evolutionary step in the field of cloud data storage and a clear competitive technological advantage.

Virtual Mirror With 3D Composer

For products that use a modular architecture, the virtual mirror allows to choose the variable parts (modules), in order to create a customized object. The study of AR technologies could be a solution to show how the user could interact with the object by adopting a composer 3D.

The listed specifications are embedded into the functional scheme of Fig. 1, where the 3D web configurator platform to implement is interconnected with different E-commerce (multi E-commerce platform).

According with the listed specifications and with the preliminary state of the art, the main goal of the work is the “design and implementation of a new search engine based on original technologies”, representing a concept of R&D software of ‘Frascati’ guidelines [21].

In Fig. 1 is illustrated the functional scheme of the proposed work where are summarized the previous specifications.

The paper is structured as follows:

- is described by UML and flow chart diagrams the 3D web configurator design;
- is illustrated and commented the frameworks of the prototype configurator platform by showing some examples of most important scripts improving Affective Computing;
- are commented the prototype platform tests;
- are provided in Appendix other scripts adopted for the development of the prototype platform.

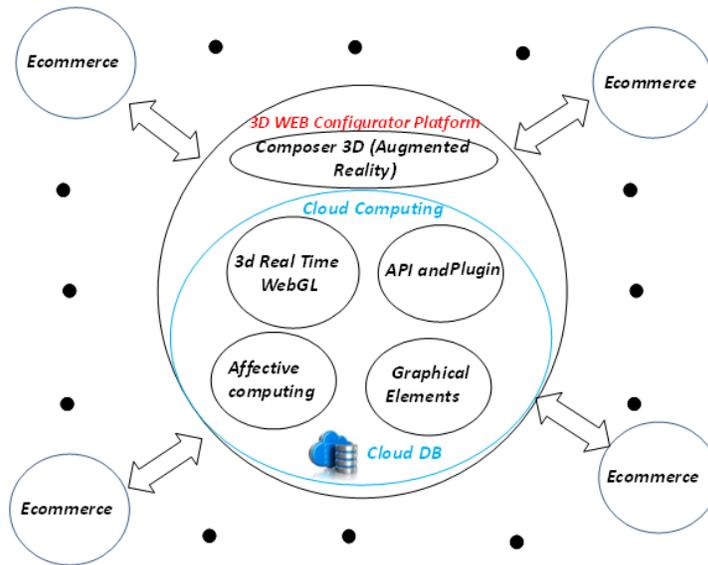


Figure 1. 3D web platform configurator architecture.

2. PLATFORM DESIGN

The design of the 3D platform is represented by the UML diagram (UML2 language) of Fig.2 indicating the following main actors of the prototype system:

- the E-commerce Administrator (E-commerce Admin) having the function to insert new 3D objects for sale through the use of a template, and to manage the service subscription;
- the System Administrator (System Admin) having the function to overview the cloud system resources, to guarantee the system backup, to establish the price of services, and to manage user services;
- the User navigating on the multi E-commerce platform thus providing important data concerning user experience and affective computing;
- the 3D Configurator able to optimize by SVM algorithms the features of the 3D object for sale in the multi E-Commerce platform.

In Fig. 3 (a) is illustrated the relationship between SVM algorithms and the user navigating on the Web E-commerce platform: the SVM algorithms analyzes the frequency of objects observed on

line in order to combine the user profiling together with the Affective Computing characteristics and user experience which can be improved also by means of AR content of the 3D (object to visualize on the user mobile phone). In Fig. 3 (b) is shown the whole process involving 3D object design optimization and customer loyalty: the SVM algorithm provides a score about frequency observation of an object online exposed and visualized thus allowing the optimization of the 3D object features design: the new object will be constructed adopting the features of main visible impact according to the Visual Merchandising –VM- approaches adopted mainly in the retail industry of developing store layouts and three-dimensional displays (virtual store) in order to maximize sales. In the case of study the VM approach has been applied specifically for online sales [22]-[23]. The VM methodologies to apply are consequence of the Affective Computing analysis. In fact according with [23] important elements influencing online visual merchandising are product demonstration, web graphics and web navigation. The optimization of all of these elements can be performed by analyzing in detail the navigation user experience, the Affective Computing evaluation and the effectiveness of AR contents (virtual product demonstration). Furthermore the innovative platform could be linked directly to a Customer Relationship Management –CRM- tool suitable for planning intelligent promotions for different typologies of customer clustering. The customer segmentation can be studied by applying data mining algorithms such as K-Means one [24].

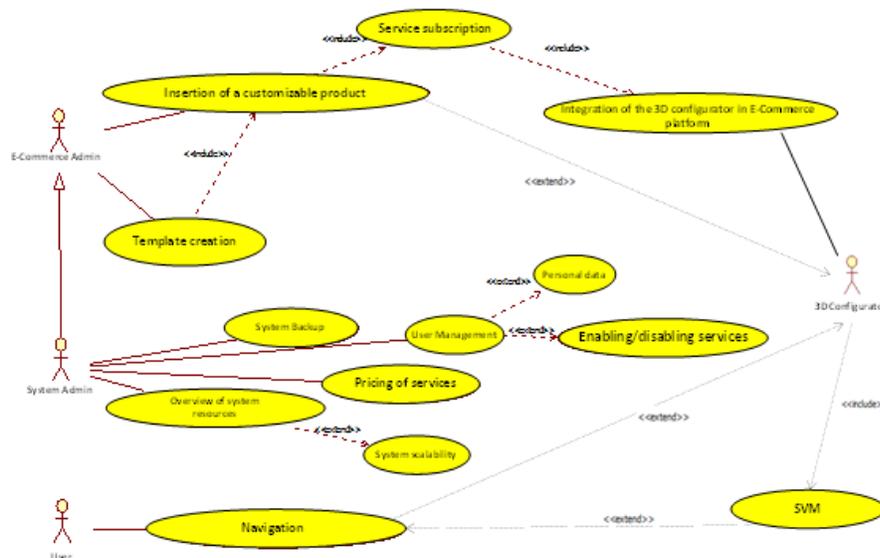


Figure 2. UML2 case uses diagram.

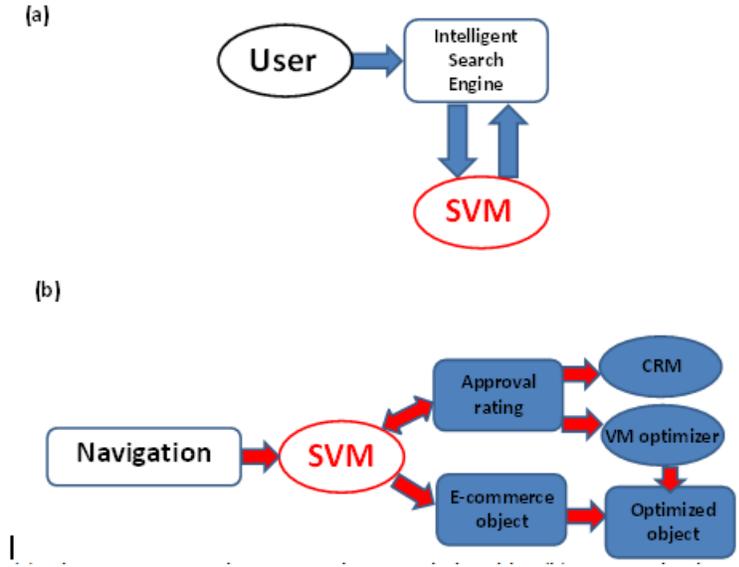


Figure 3. (a) Diagram representing user and SVM relationship; (b) user navigation experience improving object optimization design.

3. PLATFORM PROTOTYPE FRAMEWORKS AND CONFIGURATOR IMPLEMENTATION

The 3D Configurator prototype has been implemented by adopting a Magento framework and WebGL graphical libraries (javascript library providing API for internet browsers) based on OpenGL ES 2.0 and HTML5 Canvas (CreateJS libraries) technologies. The adopted tool includes the following functions:

- render engines (Canvas, WebGL, and SVG);
- scenes (scene can be changed at run time, imported, and exported);
- rooms (perspective and orthogonal);
- lights (point, point, directional and environment; objects can cast / receive shadows);
- textures and materials (Lambert, Phong, etc., including support for bump maps and mirror maps);
- geometries (including lines, planes, cubes, spheres, polyhedra, cylinders, particle systems, and 3D text);
- export utility compatible with JSON files from 3D modeling software (such as Blender, 3ds Max, or Maya) and importing files (such as Wavefront .obj format or Collada .dae format) directly into a scene;
- shaders (provides access to the OpenGL Shading Language for more direct control of the graphics pipeline);
- a library of post-processing shaders (including bloom, blur, edge detection, Fresnel, etc.);
- a library of stereoscopic effects (anaglyph, Parallax / Cross-eyed, and Oculus Rift).

For the integration of the 3D configurator into an E-commerce framework has been adopted the open source Magento tool allowing the integration of the following facilities:

- Advanced warehouse management;
- Creation of product categories;
- Digitization of logistics;
- Integration with Customer Relationship Management –CRM- and Enterprise Resources Planning -ERP- management software;
- Integration with the main marketplaces orienting the platform on a multi e-commerce system (such as Amazon, Ebay);
- Accounting and administration functions;
- Autonomy in content uploading;
- Multilingual store;
- Secure payment system.

Figure 4 (a) shows an example of a 3D object created in the prototype configurator using the above listed facilities and Blender tool for the creation of the raw 3D CAD object (example of skateboard design). In Fig. 4 (b) is illustrated a screenshot of the adopted Magento framework used for the texture configuration of the same object optimizing the impact by the red colour (see Fig. 5).

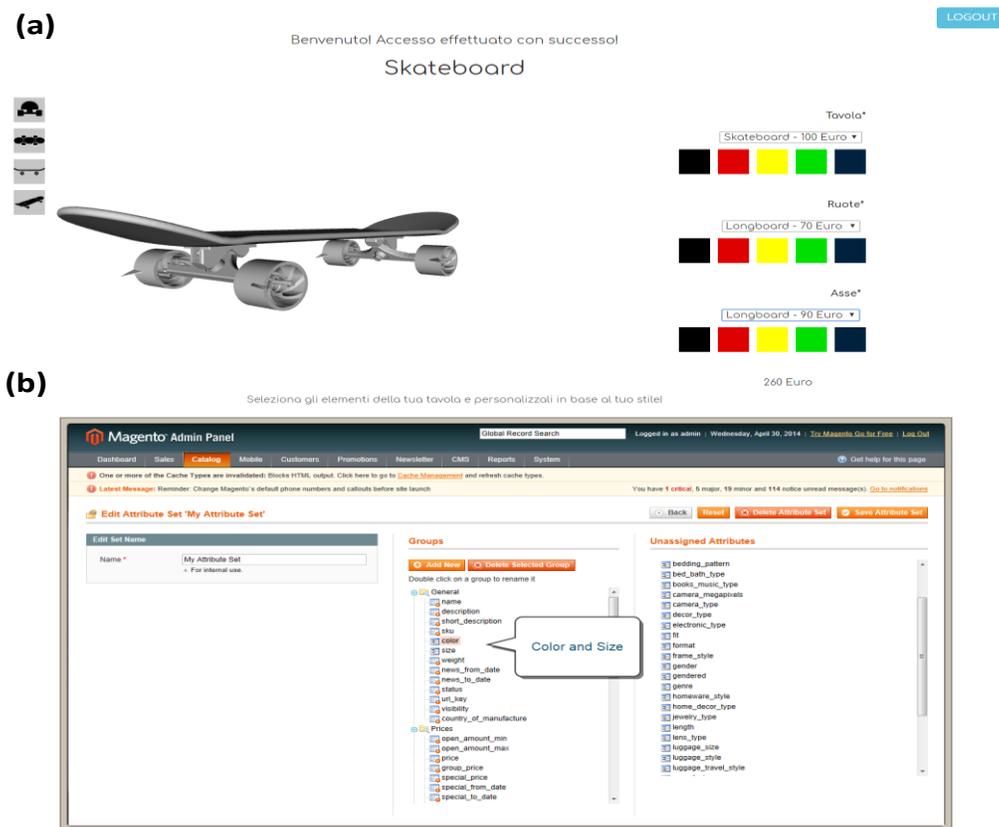


Figure 4. (a) 3D configurator prototype showing a 3D object for sale; (b) Magento framework adopted for the 3D configurator.

Skateboard



Figure 5. 3D object characterized by red colour.

To access the customization platform described above, has been implemented a login and registration form for the user through PHP and HTML scripts enabling server connection. In the case of study a local server was implemented through the use of a tool called WAMP. WAMP is an acronym that indicates a web / database development software platform that takes its name from the initials of the software components with which it is made listed below:

- Windows (operating system that must already be installed on the PC);
- Apache (Web server);
- MySQL (database management system (or database server) with SQLite and related graphical toolkits);
- PHP, Perl and / or Python (scripting languages).

Through WAMP tool it is possible to create a MySQL database through the phpMyAdmin graphic platform. Before accessing the 3D configurator, the user is directed to the search page, which uses the Google API to search within various E-commerce providing as result a JSON output file (Log file of containing user experience information). By navigating on the implemented page of Fig. 6 it is possible to search a product using 3 search bars (multi E-commerce searching). In particular the first search bar from left allows (via Google API) to search Amazon.it. This is possible through a JAVASCRIPT script allowing to make a request to Google. The second bar is related to the search engine of the 3D configurator. The third search bar uses the same API to search within another E-commerce sites. In order to customize the APIs and then allow you to search on one or more E-commerce, Google provides the Google Developer Console: through this platform it is possible to easily access the Custom Search API and view the metrics of requests made to Google servers. Through Google's Custom Search Engine (CSE) it is also possible to create customized search engines through a simple graphical interface. In Fig. 6 is also reported the HTML response of a defined request.

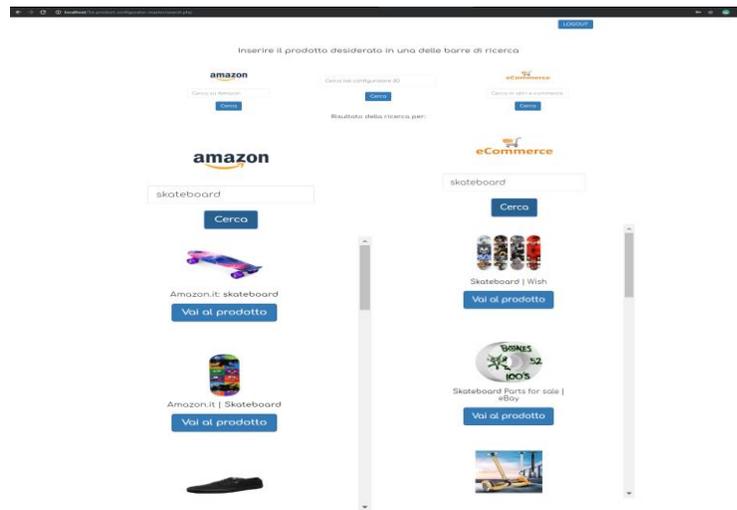


Figure 6. Interface of product request and related html outputs.

For data collection has been designed a cloud database system. A cloud database is a collection of structured, unstructured or informative content residing on a private, public or hybrid cloud computing infrastructure platform. There are two models of cloud database environment: traditional and as a DataBase as a Service service (DBaaS). In the case of study has been used the traditional database through a virtual machine in which the database resides. Once the connection is established, the full package project is inserted inside the server through a client interface such as FileZilla, allowing the passage of files. After configuring these first settings it will be possible to use the project as if it were local and use the MySQL instance directly from the browser to be able to use, or modify the database.

3.1. 3D Configurator Intelligence

For the Affective Computing [25] module a study was carried out to obtain reliable results without the use of cameras that visualize facial expressions for the sentiment detection. Consequently, everything was based on the user interaction with the site and on the choice done during the navigation. The proposed platform elaborates the logs that are created and inserted into the database by associating the user which have generated them. The logs are then classified into record tables containing the description of the system log (Log_Type) and the linking with the user: the SVM algorithm will assign to each individual log a weight which is a function of browsing frequency on a determinate platform page. In particular the implemented algorithm is the Extreme Gradient Boosting with XGBoost classifier [26] able to allocate values to every single log. XGBoost [27] is an open-source software library which provides a gradient boosting framework for C++, Java, Python, R, and Julia.

To train the machine learning algorithm, a python script was created, which automatically generates system logs representing the user navigation behaviour (analysis of sequential logs patterns). A value is assigned to each log based on the approach of the user to use the 3D configurator and on his actions executed within it. Below is reported the script adopted for the XGBoost classifier implementation adopting Pandas libraries:

```
from xgboost import XGBClassifier
import numpy as np
import pandas
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score

#loading data
dataset = pandas.read_csv('C:/wamp64/www/3d-product-configurator-master/dataset_log.csv',
sep=',', header=None)

X = dataset[3]
y = dataset[4]

X = X.values
y = y.values

X = np.column_stack((X, X))

seed = 42
test_size = 0.1
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=test_size, random_state=seed)

model = XGBClassifier()
model.fit(X=X_train, y=y_train)

from joblib import dump
dump(model, 'predict_model.joblib')
```

In Fig. 7 is illustrated an example of affective computing response performed by applying the XGBoost algorithm. In appendix A, Appenix B and Appendix C are listed the other scripts enabling the affective computing evaluation.

Affective Computing: Modellatore 3D

Erika Rossi 99.34%
Mario De Gialli 99.58%
Erika De Gialli 99.56%
Michele Verdi 99.72%

Figure 7. Example of the affective computing analysis.

4. CONCLUSION

The goal of the paper is to show results of a case of study regarding research and development - R&D- of new search engine based on original technologies applied to multi e-commerce platform. The goal of the proposed paper is to show how starting with traditional tools of a 3D configurator it is possible to create an intelligent platform oriented on the optimization of object features for inline sale. The paper enhances the possibility to improve a self learning approach for the optimization of object design adopting support vector machine algorithms. In particular has been applied the XGBoost classifier for the implementation of the affective computing function based on user experience. The user experience is improved by analysing user navigation data and by visual merchandising method. The paper shows different open source tools which can be adopted to develop an innovative search engine E-commerce platform. In table are summarized all the limits and the advantages of the main elements discussed in the work.

Table 1. Limits and advantages of technologies and elements considered into the work.

Technology/elements	Limits	Advantages
Multi E-Commerce platform searching function	A product is searched using different search engines containing a single photo (low visual impact).	The 3D Configurator provides an alternative way to observe an object to buy having preferred features (high visual impact).
WebGL	Complex objects could require an high computational cost for the visualization.	The cloud computing is suitable for a certain online interactivity with the object.
SVM algorithm	The XGBoost algorithm needs of training dataset with a lot number of sample (navigation	The XGBoost automatizes the self-learning model (self-learning <i>Affective Computing</i>) during the
	log).	user navigation time.
VM	The VM results could be correlated with the user segmentation in order to perform a correct analysis.	The VM approach is useful for the design of AR object characterized by a good visual impact.
AR	The construction of AR content requires a lot of time.	AR objects visualized by mobile phone could increase the online sales probabilities.

APPENDIX A

Below is reported the script allowing percentage calculus of the affective computing (file Affective calculator.py).

```
import sys, json, base64
from datetime import datetime, timedelta
array_log = json.loads(base64.b64decode(sys.argv[1]))
somma_iter = 0
somma_valori = 0
max = 0
for el in array_log:
    somma_iter = somma_iter + int(el["iterazioni_giornaliere"])
    somma_valori = somma_valori + int(el["score_giornaliere"])
    calc = somma_valori / somma_iter
    if calc > max :
        max = calc

media_iter = somma_iter/array_log.__len__()
media_valori = somma_valori/array_log.__len__()
valore = int((media_valori/media_iter) / max * 10000) / 100
valore = str(valore)+'%'
print(valore)
```

APPENDIX B

Below is reported the code able to train di machine learning algorithm generating affective computing weights:

```
from xgboost import XGBClassifier
import numpy as np
import pandas
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score

#loading data
dataset = pandas.read_csv('C:/wamp64/www/3d-product-configurator-master/dataset_log.csv', sep=',',
header=None)

X = dataset[3]
y = dataset[4]

X = X.values
y = y.values

X = np.column_stack((X, X))

seed = 42
test_size = 0.1
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=test_size, random_state=seed)

model = XGBClassifier()
model.fit(X=X_train, y=y_train)
```

```
from joblib import dump
dump(model, 'predict_model.joblib')
```

APPENDIX C

Below is reported the php script executing affective computing algorithm returning the affective computing value (Affective_computing.php):

```
<?php
session_start();

require 'setup.php';

date_default_timezone_set('Europe/Vatican');

?>
<!DOCTYPE html>
<html>
<head>
    <title>Affective Computing Calculator</title>
    <link rel="stylesheet" href="https://use.fontawesome.com/releases/v5.8.1/css/all.css"
integrity="sha384-
50oBUHEmvpQ+1IW4y57PTFmhCaXp0ML5d60M1M7uH2+nqUivzIebhndOJK28anvf"
crossorigin="anonymous">
    <link rel="stylesheet" href="css/style.css">
    <link href="https://fonts.googleapis.com/css?family=Comfortaa:400,700" rel="stylesheet">
    <link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.7/css/bootstrap.min.css"
integrity="sha384-
BVYiSIFeK1dGmJRAkycuHAHRg32OmUcww7on3RYdg4Va+PmSTsz/K68vbdEjh4u"
crossorigin="anonymous">
    <link rel="stylesheet" href="css/style_login.css">
    <link rel="stylesheet" href="http://fonts.googleapis.com/css?family=Open+Sans+Condensed:700"
/>
    <!--[if lt IE 9]>
        <script src="http://html5shiv.googlecode.com/svn/trunk/html5.js"></script>
    <![endif]-->
    <script src="js/jquery.js"></script>
    <script src="js/three.js"></script>
    <script src="js/ColladaLoader.js"></script>
    <script src="js/OrbitalControls.js"></script>
    <script src="js/scene.js"></script>
</head>
<body>
    <div class="container">
        <h1 style="margin-top: 1em;">Affective Computing: Modellatore 3D</h1>
        <h3 style="margin-top: 1em;">Risultato elaborato in data: <?php echo date('Y-m-d
H:i:s');?> in base al numero di utenti e ai log creati all'interno del sito fino a questo momento.</h3>
    </div>
    <div class="card" style="margin-top: 2em">
        <div class="card-body">
            <?php
                $num_usr_qry = $conn->prepare('SELECT nome, cognome, id_utente
FROM utente');
                $num_usr_qry->execute();
```

```

$num_usr = $num_usr_qry->fetchAll(PDO::FETCH_ASSOC);
foreach ($num_usr as $val){
    $id_utente = $val["id_utente"];
    $log_utente_qry = $conn->prepare('SELECT COUNT(id) as
iterazioni_giornaliere, SUM(valore_log) as score_giornaliero FROM log WHERE cod_utente =
'.$id_utente.' GROUP by DAY(data_ora)');
    $log_utente_qry->execute();
    $log_utente = $log_utente_qry-
>fetchAll(PDO::FETCH_ASSOC);

    $affective_value = shell_exec('C:\Python\python.exe
affective_calculator.py '.base64_encode(json_encode($log_utente)));
    echo "<div class='row'><h1 class='display-
4'>".$val["nome"]." ".$val["cognome"]." ".$affective_value."</h1></div>";
    }
?>
</div>
</div>
</body>
</html>

```

ACKNOWLEDGEMENTS

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