Developing Web-Based Online Advertisement Targeting System for 3D Models

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Abstract – The paper presents a strategy for implementing a hybrid recommender system to a 3D online marketplace to realize a more efficient funneling of 3D models recommendations. The 3D models’ marketplace is an ever-growing medium which supplies to movies, commercial or video games, production quality finished assets ready to be included in their project. A robust targeted advertising mechanism leads to a better browsing experience for the end user and a more efficient monetization campaign. The following research also reveals a strategy for elevating the user experience for visualizing 3D models in an online marketplace. The targeted approach proposes the implementation of a web-based engine which allows full interaction with the 3D model, rather than browsing a series of renders or scrolling a through a 360 animation, the standard approach used by current marketplaces. The system will contain an extra layer of recommendations targeting the vendors, and presents a strategy to dynamically adjust the prices of the 3D models existing in the online marketplace based on prediction algorithms.

Keywords – Online Advertising, CG Graphics, Regression Statistics, 3D Online Marketplace, Unity Engine.

I. INTRODUCTION

Recommender systems have been developed to overcome the problem of information overload for online applications such as e-commerce, e-learning, and social networks. Their ultimate goal is to create meaningful recommendations to the end user for items that might be of interest to him.

The main advantages when someone exploiting this technology includes [1]:

- **The number of sold products / services will be increased.** This is the main goal, where the number of sold items with recommendation is larger than that without recommendations. The goal is established because recommended items are more likely meet the user’s needs, thus increasing the odds of making a purchase.

- **User satisfaction will be increased.** The system with effective recommender can help in improving the user experience with the web application. Incorporating accurate and effective recommendations in a clear interface will increase the user’s subjective evaluation of the system. Hence, the system usage will increase and also the chances for successful recommendations will rise.

- **Increase user fidelity.** A user should be loyal to a platform. When the customer returns, the system will recognize and treat him as a valued visitor. The user appreciates the recommendations tailored to its taste; hence, when the user interacted longer with the system, the user model will be refined more with more recommender output can be effectively customized to match the user’s interesting.

Categories of the recommender systems are as follows, taking into account upon what the recommendations will be given [2]:

- Content-based recommendations – the user receives recommendations similar to the items that he had prefer-
-red in the past.

- Collaborative recommendations – the user receives recommended items that people with similar preferences had liked in the past.

- Hybrid approaches – these methods combine content-based and collaborative methods.

The standard format for 3D objects is .OBJ, a geometry definition file format developed by Wave front Technologies. In addition .MTL file format is usually a companion which describes the surface shading properties of objects in .OBJ files. An .OBJ file may reference one or more .MTL files depending on its complexity.

The OBJ file format will be used for representing the position of each vertex, the UV position of each texture coordinate vertex, vertex normal, and the faces which used for declaring each polygon as a list of vertices and texture vertices.

CG for Graphics (CG) is open-source and considered as high-level shading language running cross-API (OpenGL & DirectX) and cross-platform (Windows, Linux, Mac OS), CG usually used to control the appearance of objects which had been drawn by programmable graphics hardware.

Data mining is defined as extracting patterns from large data sets by using statistical algorithms. It helps business analysts to generate hypotheses, but it does not validate the hypotheses [4].

For prediction analysis, linear regression models commonly used are known to outperform fancier nonlinear models in situations with small numbers of training cases, low signal-to-noise ratio or sparse data [5].

Classical assumptions for regression analysis imply that [6]:

- The sample must be representative of the population for the inference prediction.
- The error is assumed to be a random variable with a mean of zero conditional on the explanatory variables.

- The predictors must be linearly independent (i.e. it must not be possible to express any predictor as a linear combination of others).

- The variance of the error is constant across observations.

**Regression Statistics.**

The quality of a regression model will be evaluated by statistics the Root Mean Squared Error and the Mean Absolute Error [7].

- **Root Mean Squared Error**

  The RMSE is the square root of the average squared distance of a data point from the fitted line.

  \[
  \text{RMSE} = \sqrt{\frac{1}{n} \sum_{j=1}^{n} (y_j - \hat{y}_j)^2}
  \]  

- **Mean Absolute Error**

  The average of the absolute value of residuals will be represented by MAE.

  \[
  \text{MAE} = \frac{1}{n} \sum_{j=1}^{n} |y_j - \hat{y}_j|
  \]  

**II. STATE OF THE ART**

The apex of the 3D online marketplace is represented by Turbosquid, an online platform that allows artists to display their work and sell them to potential buyers.

A 3D model is sold along with a specific agreement towards the royalty rights. Standard agreements include: Royalty Free License, Corporate License, and New Uses.

![Fig. 2. Turbosquid Website.](image)

Current advertising solutions include recommendations depending on the current product being visualized such as products from the same category and other models from the same publisher.

Special features for Turbosquid include CheckMate Pro Certificates for 3D models if, upon request, the object is found compliant with the current standards and Squid Guild membership which allows its members in exchange for their exclusivity to the platform to receive better royalty rates [8].
Another platform that promotes the selling of assets for computer generated productions is 3D Ocean. It part of the Envato network which comprises the entire Tuts+ Empire and has reached more than 1.4 million registered members.

![3D Ocean Website](image)

Turbosquid, the benchmark in for 3D models’ marketplace typically offers a series of beauty renders and wireframe views, pre-uploaded by the user on the system upon publishing. The potential buyer can form an erroneous opinion on the model based only on the 2D representations.

![Turbosquid Model Presentation](image)

Sketchfab introduced the concept of visualizing 3D models in a browser based environment at a production quality standard. It is used by artists to share their models with the community to receive feedback without sharing the actual files leading to potential copyright infringements.
Sketchfab allows users to publish and find 3D content and also share it on other platforms like Tumblr, WordPress, Behance, Facebook by using the embed functionality.

The online marketplaces offer the liberty to users to charge their desired price for their products.

In a highly dynamic market, a system should be devised where the buyers are also notified about the market trends and they receive recommendations regarding their prices.

### III. Material and Methods

The system proposes a solution involving a hybrid recommendation technique using both content-based and collaborative filtering with a mixed hybridization technique for channeling advertisements of recommended 3D models.

**Collaborative Filtering.**

A user is able to rate a 3D model after a purchase was made, to express his satisfaction level from 1 to 5. High rates increase the reliability of the quality of the 3D model, hence the reputation of its publisher [9].

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 1</td>
<td>5</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>User 2</td>
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<tr>
<td>User 3</td>
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<td>3</td>
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<td>5</td>
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<tr>
<td>User 4</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>User 5</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

In order to best match a product to its potential clients, the *Pearson Correlation Coefficient* is used.

\[
r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2} \sqrt{\sum(y_i - \bar{y})^2}}
\] (1)
Table 2. User Similarity [9].

<table>
<thead>
<tr>
<th></th>
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<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 1</td>
<td>-</td>
<td>-0.6035</td>
<td>0.1323</td>
<td>0.6816</td>
<td>-0.0273</td>
</tr>
<tr>
<td>User 2</td>
<td>-0.6035</td>
<td>-</td>
<td>-0.5791</td>
<td>-0.4015</td>
<td>-0.5393</td>
</tr>
<tr>
<td>User 3</td>
<td>0.1323</td>
<td>-0.5791</td>
<td>-</td>
<td>-0.1635</td>
<td>0.7163</td>
</tr>
<tr>
<td>User 4</td>
<td>0.6816</td>
<td>-0.4015</td>
<td>-0.1635</td>
<td>-</td>
<td>0.2587</td>
</tr>
<tr>
<td>User 5</td>
<td>-0.0273</td>
<td>-0.5393</td>
<td>0.7163</td>
<td>0.2587</td>
<td>-</td>
</tr>
</tbody>
</table>

The system selects the users which score a positive correlation coefficient and recommends the models rated above average that was not visualized by the targeted user.

For example, User 4 has similar tastes with User 1 and User 5. Hence, the system recommends Model 2 (from User 1) and Model 5 (from User 5).

**Content-Based Filtering.**

Our content-based filtering algorithm matches the 3D model’s keywords to the user profile. The user profile is constructed based on his previous purchases, respectively on their descriptive tags.

In order to have a 3D model published on the platform, the author has to complete its descriptive profile. It includes the following features:-

- Price
- Format (.max, .obj, .fbx)
- Category (sports, characters, vehicles, architecture)
- Tags
- Description
- Specifications (number of polygons, number of vertices, textures yes/no, materials yes/no, rigged yes/no, animated yes/no, UV mapped yes/no).

To compute the degree of similarity between the 3D model’s profile and the keywords in the user’s profile, we use the Szymkiewicz-Simpson Coefficient.

\[
\text{Overlap}(X, Y) = \frac{|X \cap Y|}{\min(|X|, |Y|)}
\]  

(2)

Everything above a certain threshold will be recommended to the end user.

**Hybrid Recommender.**

Multiple recommender approaches are combined with a mixed hybridization method to obtain better recommendations, to enhance the marketplace profitability. Hybridization can diminish some of the problems associated with collaborative filtering, content-based filtering and other recommendation techniques [10].

**User Experience.**

The system proposes, for enhancing the user experience, the development of a real-time interactive 3D model
viewer. The current workflow adopted by online marketplaces requires a tedious process for the user which has to render different views of the models as well as wireframe shots. Moreover, to increase the credibility one can realize a 360 animation of the model. From the publisher’s point of view it is extra work which is time consuming and does not reflect 100% their models. From the buyer’s point of view, he can make the decision of purchasing only by browsing the predefined views, not very comprehensive for a model which may be viewed from any angle in a game engine or a movie shot [11].

By repurposing the Unity engine, generally used for creating video games, and developing custom shaders, setting a studio lighting setup, input controllers and adding functionalities to load the objects and materials on runtime one can obtain a model viewer that can be easily embedded into a web page.

![Unity Engine](image)

**Fig. 6. Unity Engine.**

The engine should allow the visualization of 3D models without a polygon number limit and supporting texture maps such as diffuse, specular and normal:

- Diffuse map: contains the color information; it usually contains the ambient occlusion baked into it.
- Normal map: contains information about the surface normal; which used for adding details without more polygons to the geometry.
- Specular map: represents the amount of light reflectivity a surface has.

![Model asset workflow](image)

**Fig. 7. Model asset workflow [12].**

The custom shader is developed in Unity using CG (C for Graphics). For programming vertex and pixel shaders, a high-level shading language had been developed by both NVIDIA and Microsoft.

If a texture of a model determines what is drawn on a surface, the shader is what determines how it is drawn [12].
The custom shader has integrated the following properties:

- _Color – Sets the color tint of the model in RGBA space.
- _MainTex – Accepts a 2D Texture and sets the color information to the model based on its UV mapping.
- _BumpMap – Accepts a 2D Texture and sets how the surface reacts to light to fake additional details in the mesh.
- _BumpDepth – A float value representing the intensity of the bump effect.
- _SpecColor – Sets the color of the reflected light in RGBA space.
- _Shininess – A float value representing how sharp the specular reflections are.
- _RimColor – Sets the color of a falloff effect in RGBA space.
- _RimPower – Sets the spread of a falloff effect.

The interaction with the model viewer will allow the following operations: zooming, rotating the object, switching between textured and wireframe views. These operations are available on by using mouse events on desktops and by using touch inputs on mobile devices.

IV. RESULTS

Data Mining:

Linear regression is a prediction technique used when the class and all its attributes are numeric.

![Supply and Demand](Fig. 8. Supply and Demand [10].)

In an online market where the main commodities are 3D models, the supply is infinite. Hence the price variation will only depend on the demand fluctuation.

The system will provide two layers of recommendations:

1. Per Product Recommendation

For each product the system will retrieve its sales count during the last seven days and will predict how many units will be sold in the current day.
Regression Statistics.

The system approximated the regression line having the equation of $12.36 \times X - 9.14$, and gave the prediction that in the 8th day the sales will increase to a number of 89.7142.

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<tbody>
<tr>
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</tr>
<tr>
<td>Slope</td>
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</tr>
<tr>
<td>$R^2$</td>
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</tr>
<tr>
<td>Intercept SE</td>
<td>14.6962</td>
</tr>
<tr>
<td>Slope SE</td>
<td>3.2861</td>
</tr>
</tbody>
</table>

To impose a unit-elastic demand, the system will also recommend a new price for the product. Unit elastic describes a demand curve which is perfectly responsive to changes in price. That is, the quantity demanded changes according to the same percentage as the change in price.
In our case, the system will recommend a drop in price to a value of 91.4013.

2. Recommendations Regarding General Tendencies

For each product category the system will retrieve its sales count during the last seven days and will predict which category will have an increase in popularity and the users will be endorsed to create 3D models for that category [14].

The system approximated the regression line having the equation of 29.96 * X – 55.14, which have a positive slope of 29.9642. If the system finds a slope greater than 0 (stagnation) then it recommends the category as popular.

Regression Statistics

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<tbody>
<tr>
<td>Intercept</td>
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</tr>
<tr>
<td>Slop</td>
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</tr>
<tr>
<td>R²</td>
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</tr>
<tr>
<td>Intercept Standard Error</td>
<td>39.1907</td>
</tr>
<tr>
<td>Slop Standard Error</td>
<td>8.7633</td>
</tr>
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</table>

V. Conclusions

For improving recommendation performance and preventing the ramp-up problem, a hybrid recommendation system has been generated by mean of combining both content-based methods with collaborative filtering method which is considered as the most common recommendation method. Collaborative Filtering has been performed by allowing users to rate a 3d model after purchasing it. However, the function of the proposed content-based filtering algorithm will depend on matching both 3D models keywords and user profile (3D model’s keywords will be provided when an author create his own descriptive profile, while the profile of a user is constructed based on his previous purchases, respectively on their descriptive tags). Unity engine had been used for enhancing user experience and providing a real-time interactive 3D model viewer, where the users can zoom/rotate objects and switch between texture and wireframe views. All their operation will be accomplished.
by using either mouse events on a personal computer or touch inputs on handheld devices. Linear regression as prediction technique had been used for providing two layers of recommendations: per product recommendation (for predicting the number of units may be sold today) and recommendations based on general tendencies (for predicting the product with the highest popularity of each category).

REFERENCES


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