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Subjective Evaluation on Quality of 3D MonsterModeling

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Abstract

Due to advances in computing techniques, graphics hardware, as well as networks, there has been an increase in the application of 3D across various domains. Given the difficulty in evaluating the graphical elements without a proper guideline, this paper aims to (1) Investigate and highlight the different methods used in evaluating 3D monster modeling, freeform modeling and intuitive modeling based on the literature review, (2) Develop a set of subjective questionnaires, criteria as well as procedures on the evaluation of 3D monster modeling and (3) carry out experimental and reliability testing based on some novel sample models as a step towards evaluating monster modeling.

Keywords*: Subjective Evaluation, Benchmark, 3D Modeling, Monster Creation*

Introduction

Li, Lee, Zhang, and Jiang (2016) stated that given the fact there has been an increase in the use of 3D objects across various domains, understanding the design as well as evaluation of 3D models becomes even more imperative. Creation of monsters in 3D modeling dictates that there ought to be evaluation or assessment so as to ensure the envisioned model meets the quality standards expected by end users. Given that the current literature lacks a standardized evaluation method for the development of 3D monster models, the importance of this paper could not be emphasized enough. The contribution of this paper is to come up with a proper and structured set of questionnaires that can be used as aguidanceand subsequent benchmarkfor future graphic designersas it would help them in terms of evaluating the quality of their 3D monster models.
The rest of this paper is organized in this order; First, the related work is briefly introduced, then, the proposed set of evaluation questions are elaborated, consequently the experimental results are presented followed by its subsequent analysis. Finally, this paper concludes by summing up the main arguments put forth in this paper and provides suggestions for future research in this subject area.

Related Work

Guo, Lin, Xu, and Jin, (2014)presented an inspiration-oriented procedural method to support artists in their quests of creating different sets of monsters from normal creatures. To assess the monster design samples produced by the proposed system, the chosen respondents subjectively evaluated the structural diversity of the monster set utilizing hierarchy diversity metric (HDM). On the other hand, Aoki, Mitani,Kanamori, and Fukui (2015)proposed a novel Augmented Reality (AR) 3D modeling framework for signifying designed models in such a way that the model is guaranteed to be a complete solid character. In order to evaluate this framework, student respondents filled in a free response questionnaire to determine the ease of work of the framework in terms of creating 3D objects from scratch.

Contrastingly. Su, Chen, Fu and Fu(2016) proposed a novel method to make 3D shapes through re-combination of cross-classification object parts from a current database of various model families. In their methodology, Su et al.(2016), a reference shape containing multi-functional constituent parts is pre-specified by clients, and its structure style is then reprocessed to control the creation procedure. Subsequently, every participant was asked to blindly assess the rationality both in appearance and

structure of the results using the proposed method compared to the human-designed results (excluding the composite models designed by this participant), and to give a score in the range of 0 (poorest) to 100 (best).

Furthermore, Edelsbrunner, Havemann, Sourin and Fellner, (2017)presented an approach that set up various coordinate systems in shape of grammars while Gonen and Akleman (2012) also presented a basic method for drawing 3D models in arbitrary topology. The developed system converted silhouette sketches to 3D meshes that for the most parts comprised of quadrilaterals and 4-valent vertices. A simple sketch-based modeling system was also developed to show the feasibility of their method by typically utilizing 2D-cones with an angle of □/4 and 2 passes of Laplacian smoothing in their implementation. Li et al. (2016) also presented an efficient outline alignment technique for sketch-based 3D modeling utilizing automatically extracted image features. It was expected to structure a 3D model with an irregular shape. To evaluate the accuracy and efficiency of the proposed technique, an experiment was conducted to apply the proposed technique to various images.

Nealen, Pett, Alexa and Igarashi, (2009)also displayed an algorithm for meshing closed sketched curves using a triangle grid. To evaluate the quality of the triangulation model generated by their proposed algorithm, Fiber Mesh was initialized to their proposed algorithm using exactly the same, sketched curve. The outcome demonstrated the previous approach results in more irregular mesh vertices, not only on the boundary but also in its vicinity. Their proposed algorithm provides a fast, robust and general method for meshing closed curves, including curves with a fixed number of vertices. In addition, Wang, Zheng and Seah,(2010)presented a sketch-based modeling system with auxiliary planes as references for 3D freeform shape design. To evaluate the proposed sketch-based modeling system, several 3D freeform models werecreated. The created tool also provided the freedom of sketching in 3D space, which is different from other systems that only enable the drawing on the 2D screen and thus, the modeling became much more intuitive and flexible.

All the aforementioned 3D modeling designs were evaluated based evaluation that was user-centered, there is no one-guideline or standard procedure in deriving the set of questionnaires. In this paper, we proposed a set of questionnaires in guiding the evaluation of the modeling, believability, acceptability as well as reliability for monster creation.

Recommendations on Evaluation Criteria

Framework for Evaluation of Quality of 3D Modeling of Monster

In the top-down approach, expertsare expected to comment on the quality of creative 3D modeling of monster as stated in every quality criterion (Wang et al., 2010). The analysis of multiple criteria decision analysis methodsis executed by external experts and the first step typically involves the development of a quality model (e.g. set of quality criteria) of the creative 3D modeling environment against which the evaluation is to be executed. A similar quality model should be used while assessing/evaluating the 3D modeling of monster. Since 3D modeling is a computer technology that develop representation of inanimate or living objects, shape, abstract shape, meta-part, super-part, allelic super-part, shape structure, regular structure and abnormal structure, the quality criteria modelshould at least include the modeling itself, believability, acceptability and reliability. After the assessment is completed as per the top-down approach, results should be compared, and where they are found to be similar, one could consider that the evaluation results are precise and authentic.

Evaluation Criteria

In order to evaluate the effectiveness of the 3D monster models, the following criteriais applied. Modeling is referred to as the creation of a reconstructed Three Dimensional (3D) virtual resemblance of a physical object by using data from images (Birbara, Otton, and Pather, 2017), while believability is a criterionthat represents the appearance of the 3D monster model in relation to the concept of a monster (Kosinski, Cymerman, Feder, Kurowski, SasinandBujnicki, 2003). The notion of acceptability is the criterion that has to do with the adaption and subsequent use of the 3D monster modeling by users. Reliability in this research has to do with the testing of the validity of the principles and methods as an overall agreement of measuring the monster creation over time. To determine the stability, atest is repeated on the same set of questionnaires but with different samples

to have the consistency of scores or performing descriptive analysis over time in tracing the similar pattern of the comments given by the respondents.

Procedures Tested With Proposed Samples

To evaluate the effectiveness of our 3D monster modeling, 75 respondents where used. These were students taking computer graphics coursefor the current semester. The respondentswere reminded to judge each question independently. Each student was expected to answer the same set ofquestionnaires five (5) times. Each time students watch one video, they had to answer the same set of questions. Thereafter, they were given 20 minutes to reflect on the video as they complete the evaluation questionnaire regarding the 3D monster modeling. Each video had four (4) sections namely; modeling, UV mapping, texture mapping as well as postures and positions. The average video length for the aforementioned videos wasabout 3 minutes as shown in Figure 1. Students had to watch all these videos regarding the developing of our 3D monster modeling. The evaluation took one hour and 25 minutes to complete with five rounds of similar evaluation. Lastly, the evaluation sheetswere collected and the data was compiled for analysis.

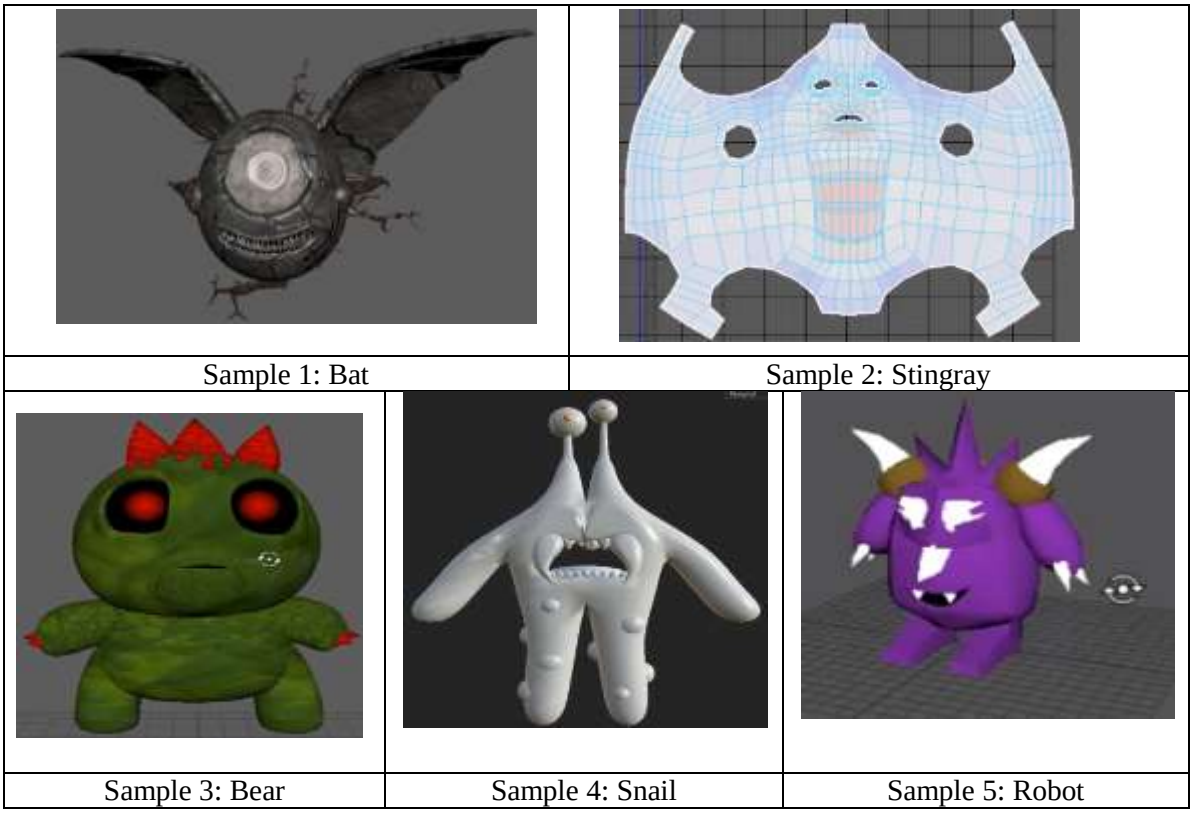

Figure 1: Several Regular Shapes from Different Categories (with Regular Structure) that are Evaluated by the students

Results and Discussions

This section outlines the findings according to the research objectives as reiterated herein, descriptive analysis was conducted towards the overall data. The section begins with the findings of the users' limitations and ends with the findings regarding the future recommendations to improve the proposed evaluation method.For the purposes of quantitative analysis of the research, respondents were given five alternative answers using the Likert measurement scalewith the score range of 1 to 5 wherein, scale 1 for strongly agree to 5 for strongly disagree. The first 13 questions were Likert scale survey questions that were aimed at soliciting information on the scale at which respondents understood the concepts of modeling, believability and acceptability in 3D monster evaluation as alluded to earlier on in the first section. Strongly agree is correlated with the evaluation method being suitable for usage in

assessing quality and personalization of creative 3D modeling of monsters, the same holds true for the opposite scenario. The next 6 questions were open-ended questions were the repeated pattern on the opinion given were traced and compiled. Discussion of the 19open and closed ended questions are shown in Table 1.

Table 1: Question Set

ID	Characteristic	Question
C1-1	Modeling	Is the evolvement of the shapes based on own creativity or preference?
C1-2		Is the UV map effectively represented in the model?
C1-3		Does the texture mapping on the monster bring out the characters of the model efficiently?
C1-4		Is the appropriate text mapping used to ensure the results of monster modeling are more accurate?
C1-5		Does the monster model features efficient multi-resolution representation?
C1-6		Does the posture of the 3D monster reflect its characteristics?
C1-7		Does the position of the 3D monster reflect its characteristics?
C2-1	Believability	Are the shapes generated/modelled by the 3D artists based on monsters?
C2-1		Are the shapes unexpected, especially in terms of the abnormal structures?
C2-3		Does discretization portray based on the polygon count?
C2-4		Generally, does the quality refer to low poly count and high believability?
C3-1	Acceptability	Do the shapes (monster) generated give you inspiration to do abstract modeling?
C3-2		Do you want to apply our model in the conceptual design stage of monster modeling in the future for video gaming?
C4-1	Reliability (Open-ended)	What are some other concerns you have when it comes to doing monster modeling?
C4-2		Suggest ways to improve our evaluation method to be unbiased?
C4-3		In order to achieve accurate monster modeling, suggest methods that can be utilized to advance sketching monster models?
C4-4		Suggest ways to improve the modeling of monsters in order to make them more realistic?
C4-5		What are the effects of using automated proceduralmodeling for 3D object variations to produce monster modeling?
C4-6		Suggest ways to ensure that the monster models created are of good quality that can be use in a movie or game.

Subjective Evaluation Analysis

This section was made up of sixsubjective questions that were aimed at soliciting information at which respondents understood the issues, challenges and effectiveness of the proposed evaluation method. When asked about concerns when it comes monster modeling, majority of the respondents indicated that creating 3D monsters that are realistic is a concern. The other concerns were the lightening, rendering and ignoring file resolution. The UV mapping, design, sketching the model, and animating for movement of the creatures are also some other concerns. Moreover, the textures and postures of the 3D monster modeling affect the character or behavior of the monster. When asked to suggest ways to improve our proposed evaluation method to be unbiased, majority of the respondents indicated that the proposed evaluation method couldinclude the animation and texturing. The texture or the color on each pixel can be evaluated to improve the viewpoint from all sides. Moreover, as per respondents, good position and texture are the best ways to improve the enhancement of the real monster.

In order to achieve accurate monster modeling, respondents were asked to suggest methods that can be utilized to advance sketching monster models.Majority of the respondents indicated the need to use UV mapping, texturing, positioning, rendering and rigging methods. Refining was proven to be the most important stage in creating 3D monster modelingin providing advance effect on the monster.One of the methods that can be utilized to advance sketching monster models was through the use ofimplicit techniques as it allows for a more realistic sketching.Besides, respondents were also asked to suggest ways to improve the modeling of monsters in order to make them more realistic. Majority of the respondents indicated that the emphasis technique such as point to point or edge modeling which aremeantto add more geometry onto existing polygons by extruding or stringing together

pointswas crucial. The respondents also added that to learn both methods, and learn how to do them well. Moreover, the use of auxiliary application and right wireframe, add more texture in UV mapping, use the right and suitable lighting and rendering could advance the modeling of 3D monsters.

The question about effects of using automated procedural modeling for 3D object variations to produce monster modeling, the majority of the respondents indicated that monsters became more realistic when the usual procedure modelingwas used. Automated procedure gives good effects to produce a monster model. Most importantly, automated procedural modeling for 3D object has reduced a large number of human errors when creating the monster for the large file size.The time consumed for rendering process using automated procedural modeling for 3D object variations also reduced tremendously.One of the effects of using automated procedure is that the resolution could be optimized (Bibara et al., 2017). Finally, the respondents were asked to suggest ways to ensure that the monster models created are of good quality that can be used in a movie or game.Majority of the respondents indicated the need for following guidelines and rules of thumbs for movie and game.One way is to ensure thatthe monster is in the form of 3D and has multi-resolutions to ensure good quality in the 3D model. The quality refers to low poly count and high reliability. The graphics designers must also use a proper technique and focus on the resolution while reducing the polygon count.

Reliability Test

The Cronbach's alpha for this data set was 0.940 as shown in Table 3 (Left), indicates a high level of internal consistency for our scale with this specific sample.The reliability test is carried out to determine the consistency of measuring tools. An instrument is considered reliable if the instrument can be trusted as a measurement of research data (Wang, 2010). In this research, reliability test was executed by utilizing Cronbach's Alpha value. This reliability test is executed by entering the appropriate responses of each of the 13 valid questions and yielding Cronbach's Alpha value of0.940. Based on the reliability level of Cronbach's Alpha, the value of 0.940 is in the scope of $0.80 < \alpha \leq 1.00$ which means that the outcomeof the test demonstratedhigh dependability of the questionnaire. So, the elements of questions and answers can be said to be reliable in order for further data processing of the questionnaire to take place. The standard deviation is carried out to determine the variability of a set of data values as shown in Figure 3 (Right). 337 observations were accounted for because 67 students evaluated each of the above monster models, hence 5 * 67 = 337.

Table 3: Reliability Statistics (Left) and Standard Deviation (Right)

Reliability Statistics

Cronbach's Alpha	.940
Cronbach's Alpha Based on Standardized Items	.940
N of Items	13

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Modelling	337	1	5	2.02	1.087
Modelling	337	1	5	1.96	1.082
Modelling	337	1	5	1.91	1.065
Modelling	337	1	5	2.12	1.059
Modelling	337	1	5	2.10	.996
Modelling	337	1	5	1.95	1.061
Modelling	337	1	5	2.02	1.098
Believability	337	1	5	1.93	1.037
Believability	337	1	5	2.28	1.143
Believability	337	1	5	2.23	.951
Believability	337	1	5	2.20	.965
Acceptability	337	1	5	1.95	1.015
Acceptability	337	1	5	2.02	1.091
Valid N (listwise)	337				

Conclusion

The present study presented a set of subjective evaluation questionnaire for creative modeling of 3D monsters. The core of the proposed set of evaluation questionnairewasto provide for a standardized method of evaluating the quality and personalization of creative 3D freeform modeling, sketch-based and intuitive modeling. Although the initial results are encouraging, there is still a room to improve

the accuracy of research findings by assessing the proposed set of evaluation questions with other case studies. The imprecision in data extraction and biasness in the selection of primary studies are some limitations that might have impacted the outcome of this paper. Future work may also investigate and highlightthe problem in subjective assessment methods used in computer graphics.

References

1. Aoki, H., Mitani, J., Kanamori, Y., & Fukui, Y. (2015). AR based ornament design system for 3D printing. Journal of Computational Design and Engineering, 2(1), 47-54.
2. Birbara, N. S., Otton, J. M., & Pather, N. (2017). 3D modelling and printing technology to produce patient-specific 3D models. Heart, Lung and Circulation.
3. Edelsbrunner, J., Havemann, S., Sourin, A., &Fellner, D. W. (2017). Procedural modeling of architecture with round geometry. Computers & graphics, 64, 14-25.
4. Gonen, O., &Akleman, E. (2012). Sketch based 3D modeling with curvature classification. Computers & Graphics, 36(5), 521-525.
5. Guo, X., Lin, J., Xu, K., & Jin, X. (2014). Creature grammar for creative modeling of 3D monsters. Graphical Models, 76(5), 376-389.
6. Kosinski, J., Cymerman, I. A., Feder, M., Kurowski, M. A., Sasin, J. M., &Bujnicki, J. M. (2003). A "FRankenstein's monster" approach to comparative modeling: Merging the finest fragments of Fold Recognition models and iterative model refinement aided by 3D structure evaluation. Proteins: Structure, Function, and Bioinformatics, 53(S6), 369-379.
7. Li, C., Lee, H., Zhang, D., & Jiang, H. (2016). Sketch-based 3D modeling by aligning outlines of an image. Journal of Computational Design and Engineering, 3(3), 286-294.
8. Nealen, A., Pett, J., Alexa, M., & Igarashi, T. (2009). GridMesh: Fast and high quality 2D mesh generation for interactive 3D shape modeling. In 2009 IEEE International Conference on Shape Modeling and Applications (pp. 155-162). IEEE.
9. Su, X., Chen, X., Fu, Q., & Fu, H. (2016). Cross-class 3D object synthesis guided by reference examples. Computers & Graphics, 54, 145-153.
10. Wang, K., Zheng, J., &Seah, H. S. (2010). Reference Plane assisted sketching interface for 3d freeform shape design. In 2010 International Conference on Cyberworlds (pp. 105-112). IEEE.