CS 550

Intro To Computer Graphics

Paper Project Analysis

Topic: Style Compatibility of 3D Furniture Models

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- **What is the general theme of the paper you read? What does the title mean? What are they trying to do? Why are they trying to do it? (I.e., what problem are they trying to solve?)**

"Style Compatibility for 3D Furniture Models," by Tianqiang Liu, Aaron Hertzmann, Wilmot Li, and Thomas Funkhouser, suggests a method for discovering a metric for the stylistic compatibility of furniture in a scenario.

Style compatibility refers to the ability of various objects to work nicely together. Therefore, the main topic of this essay is, how to make 3D furniture models work together seamlessly.

The most popular tasks in graphics is modeling 3D scenes, and there are sizable online repositories of 3D models that are made available to amateurs or automated systems to generate scenarios.

When building a 3D environment, several of the currently available tools can assist users in choosing the proper object categories and placements; nevertheless, the majority of them overlook style compatibility, resulting in an unbalanced arrangement of the objects.

Therefore, the goal of this study is to create a mathematical model of style object compatibility which may be utilized to better direct 3- Dimensional modeling scene software. This study focuses more on how the 3 Dimensional geometric models affects their stylistic compatibility than other model characteristics like color, material, etc.

- **Who are the authors? Where are they from? What positions do they hold? Can you find out something about their backgrounds?**

In all, there were 4 authors in this research namely, Tianqiang Liu, Aaron Hertzmann, Wilmot Li, and Thomas Funkhouser. Thomas Funkhouser and Tianqiang Liu were employed by Princeton University, while Wilmot Li and Aaron Hertzmann were hired from Adobe Research.

Tianqiang Liu, a former Princeton University PhD student and research assistant, is currently employed at Google as a computer engineer.

Tianqiang Liu excels in machine learning, computer graphics, and computer vision. He concentrated on the algorithm that parses 3D scenes using a syntax that is learned through examples. In addition, he worked as a research intern with Adobe for 7 months; the paper he wrote during that time is what he researched.

The third author in our research, the Principal Scientist at Adobe Research, Aaron Hertzmann specializes in computer graphics and computer vision.

From Rice University, Aaron Hertzmann earned a BA in computer science and art and art history in 1996. From New York University, he earned a PhD in computer science in 2001.

For ten years, he taught at the University of Toronto.

He is a Distinguished Scientist with the ACM, an IEEE Senior Member, and he has honorary faculty positions at the Universities of Toronto and Washington.

Like Aaron Hertzmann, Wilmot Li, a senior research scientist, works for Adobe Research.

Thomas Funkhouser received his PhD from the University of Washington, where he had previously worked as a research assistant.

Professor Thomas Funkhouser, who also serves as the department's director for graduate studies in computer science at Princeton University, has received numerous awards for his work with the Princeton Computer Graphics Group, including the 2014 ACM SIGGRAPH Computer Graphics Achievement Award, the 2001 E. Lawrence Keyes Faculty Advancement Award from Emerson Electric, the 2000 National Science Foundation Career Award, and the 2000 Alfred P. Sloan Research Fellowship (1999).

All of them are specialists in computer graphics and have spent a lot of time researching 3D modeling.

- **What did the authors do?**

The research was conducted using a crowdsourcing model where data points were collected for object compatibility. They collected compatibility preferences in place of similarity preferences which were of form(A, B, C) or triplets where each data point (for example object A) was compared to be compatible with which other data point (object B or object C) using the human evaluation. They employ Wilber's grid technique to collect triplets effectively. For each task, the 6 target objects were evaluated by rater along with object A as reference. From

a grid of six images, they then let each response be converted into eight triplets, each consisting of the reference object, the selected object, and the two of the target objects which were mostly compatible to A.
It was a more effective way rather than having participants choose between two options. In their trials, they gathered their 3D dining and living room furniture models and several related things. They then randomly produced some questions of various types and divided the questions into two Human Intelligence Tasks. Each of the HIT scenario was tested by 50 different participating individuals. This data was analyzed, and a strongly compatible and strongly incompatible impressions were derived.

The second thing they did was define a vector x which was of geometric characteristics indicating the style of an object. They must find a solution to this difficult challenge since various objects in the same class may also have minor variations from a consistent overall shape. They developed a method where each item is represented by feature vectors which are concatenated for all its parts and its complete shape after computing a segmentation of most of the items inside the existing class, computing geometric characteristics for each portion independently.
They used Kim's "Learning part-based templates from vast collections of 3d forms" approach to build this reliable segmentation technique. For all models, this algorithm can generate a consistent segmentation and labeling.

The above procedure was then continued as the authors discussed a measurement of compatibility between a model pair from object of different classes. The authors propose to use a diagonal matrix which would represent Euclidean distance between feature vectors which is scaled, and to learn a separate embedding matrix Wc for each class c. They tested their algorithm in Python and the results showed that their method was better than training on a subset of the triplets. Finally, they discussed the utility of their compatibility metric in applications such as shape retrieval, scene building, and furniture suggestion.

- **What conclusions did the paper draw?**

The researchers were able to draw the conclusion that the research was successful, and Their research demonstrate that the learnt measure can be utilized successfully to promote higher style compatibility within apps, and their quantitative results demonstrate that it is possible to learn a compatibility metric for furniture of different classes from these triplets.

In addition, the authors noted significant restrictions on their study.

They cannot recognize fine-grained stylistic changes, such as different kinds of ornamentation, because they only consider a limited collection of geometrical elements.

Second, they solely focus on geometrical characteristics, ignoring materials, colors, construction techniques, affordances, and other 3D model characteristics that are crucial for style compatibility.

This technique is crucial for further research in certain other 3D modeling systems because it is only focused on furniture which is with respect to interior environments, for which styles have a great history history but potentially unique qualities that do not generalize to other item and scene kinds.

Therefore, further research on these three aspects of the difficulties would be beneficial in the future.

- **What insights did you get from the paper that you didn't already know?**

This paper gave me a great knowledge about the crowdsource data collection and using data triplets to eliminate the need of asking each participant individually and using grid technique for this. For me, the most important part of the study was the part where we calculated the compatibility between pair of models and the usage of mass functions. Moreover, I got to know that the use of Machine learning model is very significant in these type of studies as the trained machine learning algorithms can be better at providing compatibilities.

- **Did you see any flaws or short-sightedness in the paper's methods or conclusions?**

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This technique is crucial for further research in certain other 3D modeling systems because it is only focused on furniture within interior environments, whose styles have a rich history but potentially unique qualities that do not generalize to other item and scene kinds.

Therefore, further research on these three aspects of the difficulties would be beneficial in the future. In addition to the three issues they identified, I believe this study is quite significant for 3D modeling research.

If I was a researcher, I'd like to begin looking into the color compatibility of styles and merge these two research.

It is a good idea to break the problem into manageable bits and then put them all together to address the larger issue.

- **If you were these researchers, what would you do next in this line of research?**

As there were some limitations to the above study, further research on these topics would be great and the part about color compatibility of these different styles whereas merging these two researches would be also a great approach. Furthermore, breaking the problem into smaller parts and then putting them together to address a much greater issue would be also great.