The Role of Graphic Complexity in Viewer Perception of Design Ideas

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Abstract

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This study will investigate the role of visual detail and complexity in computer graphic visualizations (CGV's) with respect to perceived viewer comprehension of design intent. The emphasis is on levels of detail generated through material appearance, texture, and lighting effects in computer generated 3D models. The purpose is to determine which levels of illustrative content (in this case created from digital 3D models) are appropriate for eliciting desired viewer comprehension in design communication as well as a time value assessed efficiency model for creating CGV's.

Keywords: computer graphics, graphic visualizations, 3D modeling, presentation graphics, visual simulation, graphic complexity, viewer perception, graphic efficiency.

Introduction

This study will investigate the role of visual detail and complexity in computer graphic visualizations (CGVs) with respect to perceived viewer comprehension of design intent. The emphasis is on levels of detail generated through material appearance, texture, and lighting effects in computer generated 3D models. The purpose is to determine which levels of illustrative content (in this case created from digital 3D models) are appropriate for eliciting desired viewer comprehension in design communication as well as a time value assessed efficiency model for creating CGVs.

Background

Designers are problem solvers, and as such, their job is to envision and propose ideas (usually physical facilities) to support the desired activities of others, and to direct the process by which the design intentions become a physical reality. Figure One illustrates the generic design process that describes the sequence of actions common to most types of design endeavors where physical products are the eventual outcomes. The design process involves many participants —clients, government regulators, town board members, the local interested public, etc.—some of whom influence decisions made during the design process and many who may be disadvantaged in their understanding of what they are assessing and deciding upon. This disadvantage is often due to a lack of knowledge and conceptual training that would allow the participant to grasp the full breadth of what is being communicated. These participants are then dependant on the communication skills of the designer and the images they choose to present.

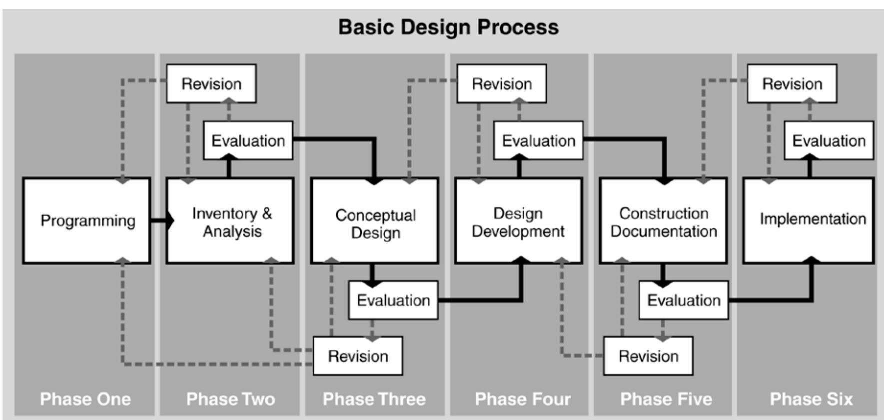

Fig. 1: The basic design process of a typical project. (Reuter 2007)

Environmental designs may be explored and communicated in many ways, but people prefer to see visualizations of how a proposed project is likely to appear in order to be able to make decisions throughout the design process. In many ways, the act of visualization is the act of making ideas more real, even to the person having the original thoughts, in order to investigate and demonstrate design components and allowing people to determine what it would feel like to be in the the proposed space. This forces designers to create a series of graphic visualizations legible to the layperson, in addition to what they might create to aid their own thought processes as the design progresses. The CGVs created for clients, public participants, and regulators are often quite different from those created for the designers themselves. Neto supports this idea by stating that "abstract representation methods are initially better for understanding the underlying spatial structure of reality and for transforming it (e.g. new buildings or urban space). ...lay people may have more difficulty in understanding more abstract or complex design issues than specialists..." (Neto 2006 pg. 350) requiring different sets of images for presentation than those for internal use.

The relationships a designer has with their clients is usually close, and much time is spent communicating ideas both verbally and graphically between the two parties. These graphics can be less formal and more along the lines of simple sketches and rough renderings in order to refine ideas. The more difficult task is preparing CGVs for persons less familiar with the intricacies of the design, and those who will be deciding on approval for the project to continue towards design development and construction. These formal presentations to local governments and town board groups can be a pivotal step in a projects timeline, and large amounts of time and money are spent in preparing CGVs to provide regulatory agencies with enough information to improve their ability to make informed decisions.

It is especially helpful to create exploratory computer graphic visualizations during the conceptual design phase of a project (Phase Three as shown in Figure One). The goal of these images is to present viewers with easily understandable options while minimizing the costs while obtaining necessary approvals. These costs can quickly add up and begin to cut into a projects profitability, as the designers time along with that of others who check and approve the work in office can become expensive.

One method of creating CGVs is by creating digital 3D models and using them to create static 2D images from various viewpoints of interest. A 3D model is made up of geometry that represents the physical elements of the proposed design; shaders are applied to the geometry to represent the appearance of materials and textures. A variety of lighting effects are then added to provide more levels of visual realism to the images being produced.

The graphics serve to communicate a projects intent while helping the project to be seen in a more positive light by participants in the public review process, helping the project gain approval. In addition, it is the designers responsibility to produce the graphics at the lowest cost possible charged to the client. The majority of the cost of producing a CGV is in the hours of labor a designer spends creating the graphic. Another time sink in CGV creation is the time it takes for a computer (or network of computers) to create a static 2D image from the digital 3D model. Greater graphic complexity means longer production and rendering time, hence greater graphic complexity means greater expense. A fundamental question of this study is, what is the minimum level of graphic complexity, and thus least costly level of graphic production, which will satisfy public review participants?

The visualizations need to be created in such a way that they keep the costs of the conceptual design phase low while still including enough detailed design information for clients and review boards to be able to make informed decisions about the project. There is a fine line between these conflicting goals; spending too much time on a model wastes money.

In order for interested parties to be able to make informed decisions pertinent to the project (during the conceptual design phase), certain pieces of information should be included into the computer generated visualizations; namely, some sort of site context, proposed changes to existing infrastructure, design intentions, and design consequences. The more successful a designer can be in displaying their intentions; the more likely they will be able to get design ideas across, increasing the chances that they will gain approval for that stage of development.

In addition to providing for decision making, designers and their visualizations often have to demonstrate design aspects that can be unpopular, but are necessary elements for the clients design, or to be environmentally responsible. The impacts of these possibly contentious areas must be shown in sufficient detail in order to alleviate the concerns of the public. Neto found that "the public were much more open to options normally considered unacceptable when they saw what these options would look like in real life" (Neto 2006 p. 348) through the display of CGVs.

The use of 2D rendered images has long been the main method of presenting design ideas to regulatory committees. As these images are static and non-interactive, the task of convincing people of the merits of a design falls to the presenter and to the images themselves, though it should be noted that "an excessive emphasis on visualization and imagery can impoverish design communication." (Neto 2006 p. 347) The purpose of presenting visualizations to a review board, government agency, or other regulatory panel is to gain approval for the project to progress to the next stage in the design process. In this vein, the goal of the visualizations themselves is to provide review board participants with enough supporting information to allow them to be satisfied that they have been given the information necessary for them to make an informed decision on the fate of the project.

Often times this can mean that a CGV will require more detail than expected in order to convince a possibly hostile party of a designs merits. There must be enough detail in an image to show the projects context in the existing landscape, major amenities and organizational elements, and any areas of conflict. A study conducted in Portugal found that "there seems to be no clear idea of what might be the common factor for the level of abstractness of representation methods to use or the level of complexity of the design issues we should describe in order to obtain an effective communication with the public." (Neto 2006 p. 350) Bishop and Rohrmann found that when comparing a presentation of a simulated environment to a walkthrough of the actual place, "most viewers accepted the presentation as reasonably valid." despite rating the "vegetation, [and] colors… …as not fully convincing." (Bishop and Rohrmann 2003 p. 275) This showed that certain features in a visualization, namely vegetation and the colors and materials used to represent a known object may require a higher level of detail than other areas of a presentation. This finding will be investigated by this study surveying multiple levels of detail.

In questioning a valid level of detail for representational computer generated visualizations, a definition of perceived realism should be shown. "The impression of realism does not necessarily require correct imagery in terms of geometric detail as long as the general behavior is reasonable; that high image complexity is primary in creating the perception of realism; that subtle shading and surface detail are key in creating the perception of realism." (Hall 1990) In contrast, Neto has shown that current computer technology limits the realism of a CGV, stating: "because it is impossible to simulate our real experience of a space thoroughly, it seems that we try to 'catch a likeness' that reveals a key aspect of a prospective design, rather than trying to simulate the whole visual experience" (Neto 2006 pg. 350)

Previous studies have demonstrated the effectiveness of using 3D models to create representational imagery, (Neto 2006) though some come to conflicting conclusions regarding the effectiveness of abstraction and increasing degrees of realism. (Bishop and Rohrmann 2003; Lange 2001) In Neto's Ribeira study, it was demonstrated that "when communicating new designs both to specialists and lay people, both realistic and abstract representations should be used. Nevertheless, to achieve effective communication, special care must be taken to avoid form taking precedence over content." (Neto 2006 p. 347)

3D models are scale-less and the restrictions in detail limited to the width of a pencil or shades of a marker do not apply to a digital model as a designer can move in close to an object they are working on to refine detail, and create objects to precise measurements and constraints. The components of a digital 3D model can be easily linked throughout an office, allowing changes to be made in real time as multiple people work on the files that comprise a digital project. For example, one person can develop the architecture on a site, while another works on the landscape, and a third person sets up the lighting and environment. These pieces can be merged together to create the final computer generated model. Easy integration with CAD drafting applications also can speed the modeling process as information created for contract or construction documents can be reused to create the digital model.

The value of a 3D model over conventional perspective drawing and rendering techniques lies in the computer software's ability to edit (see Figure 2 on page 5), allowing fast and seamless changes to be made, especially in later stages of the project. As a digital model is a 3D representation of a space, a single model can be used to create multiple rendered images, and any edits made will be visible from any number of vantage points, saving a designer's time in recreating rendered images. While it takes time for a computer to create an image from the 3D data, sometimes hours per image; it does not require a person to be physically present while the computer is working. The computer can

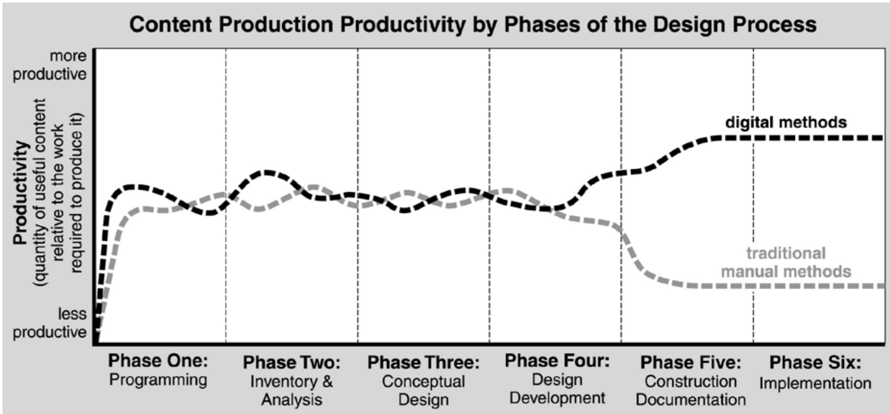

Fig. 2: Productivity differences between digital and traditional hand drawn methods. (Reuter 2007)

work while no one is in the office, or while a person is working on other things. The software can be set to notify the designer through e-mail when the image or images are done. A knowledgeable computer user can set-up and create an image digitally in roughly the same time as it would take to create an accurate image by hand, and as shown by the graphic in Figure 2, there is no clear winner in productivity throughout the initial project stages as base information becomes .

There are some repercussions to working digitally, though the positives greatly outweigh the negatives. Computer hardware, and especially software, is expensive and as technology improves, programs require regular hardware upgrades. Software is continually upgraded to newer versions, sometimes making previous versions incompatible or obsolete altogether. These costs are offset by the benefits of the digital environment. The previously mentioned ability to edit and reuse previously created content saves large amounts of not only the designer's time, but also consultants time as well. If one office has already created a drawing, its content can be integrated into other offices work.

In the digital world, there are a number of software options, each having its own distinct benefits and drawbacks. This can create issues in interoperability between consultants, where one person might not be able to use the file format created by another. Many software programs though, are able to export their content to a format that most programs can read, if not open directly (.pdf, .3ds, .dwf, etc.) While the imported content may not include all of the native options of the original software, the content should be usable and fully detailed.

It is often assumed that people lacking technical training in design disciplines have difficulty understanding what is being proposed when projects entailing land development are presented in public meetings. There may be little designers or planners can do about people who attend such meetings with their minds already made up regarding the desirability of a proposed project. However, design and planning professionals have an ethical responsibility to insure that all process participants were given a fair chance to understand the design intent of the proposed project. It should also be mentioned that the designer has the additional responsibility of pushing their clients agenda while remaining ethically and environmentally sensitive to the project as well.

Measuring whether people actually understand the intent of a proposed project is beyond the scope of this study, but determining if members of a target audience believe that they have received fair treatment regarding communication of a designs intent would answer the question as to whether the designer has met their professional obligations with respect to the review process.

This study expects that laypeople without design training will be willing to accept a moderate level of detail in digitally produced graphic visualizations in order to make informed decisions regarding project approval.

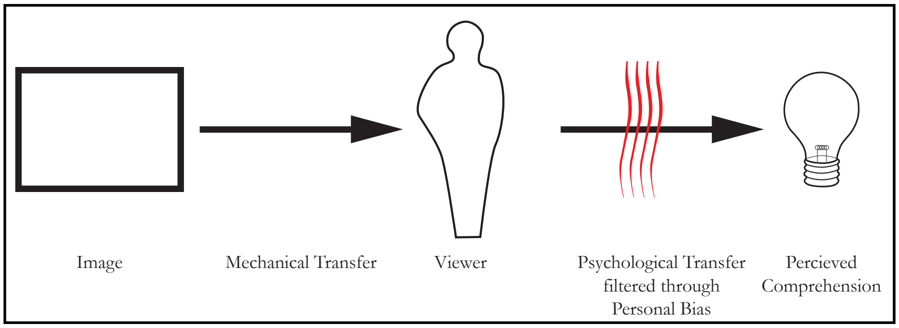

Fig. 3: A diagram describing the communication steps this study will undertake.

This study will focus on analyzing a social constructionist response to a simple mechanistic transfer of ideas from the computer generated visualizations to the study subjects. While the purpose of the CGVs are to inform the audience (in this case, a public design review board) of a projects intent, the designer is usually present to address questions and concerns raised by meeting attendees, and to help the proposal gain approval for their client. For this study, graphical content will be used without benefit of additional explanation from a presenter. Subjects will be asked to rate their responses to the content displayed in the CGVs without intervention from the presenter. The computer generated visualizations will inform the subjects of perceived meaning, and the subjects will respond to survey questions as a means of measuring viewer satisfaction with the communication value of the media. The communication process will be a linear one, from the CGV—to the respondent—to the survey, with no interaction or bias given from the presenter.

Study Objectives

The goal of this study is to determine if a relationship exists between levels of detail in digitally produced graphic visualizations and viewer perceptions of adequacy in the communication value of the graphic content. It will focus on people who are lacking in technical training in design or planning disciplines and who might be participants in local government public meetings where land development projects are under review for approval. The purpose is to determine what levels of graphic detail are likely to be perceived as adequate for computer generated visualizations of conceptual design content being communicated to a mixed audience in a public review meeting. The study will also determine an optimum cost efficiency for computer generated visualizations.

In order to meet these goals, this study will pursue the following objectives:

- Record the hours of labor used in creating the computer generated visualizations for this study.
- Create an imaginary project site to avoid any bias from survey participants that a real site might have from affecting the study.
- Create 3 digital 3D models with enough variations in visual detail and complexity that the differences are significant.
- Create rendered 2D CGV's from viewpoints similar to those that would normally be shown in a review board presentation.
- Locate potential survey participants who are either attendees of review board meetings, or who are sufficiently similar so that comparison to the target population is reasonable.
- Sample the study participants in such a way that they are unaware of what is actually being measured.
- Quantify relationships between perceived viewer comprehension, visualization effectiveness, and time invested.

Significance of the study

This study will provide an understanding of what type of computer graphic visualizations are expected by public participants and which are most efficient to produce while still providing enough detail to foster informed decision making. This information can then be used to provide a designers clients with better service by not overworking the graphics and wasting the clients money, or by not providing enough detail for informed decision making, which can lead to project delays, unnecessary revisions, and even rejections.

Methods

This study will create a digital model of a typical commercial project along a village downtown street and render 2D static images with the following levels of detail:

1. Low detail "massing model" – All design elements are represented by basic geometry with minimal modeled detail. Colors will be applied to objects to represent construction materials without any texture mapping. A single light will provide all of the illumination for the scene.

2. Mid-detail model – Design elements will be recognizable with basic detail modeled into buildings, curbs, etc. Objects will have image based textures applied to them to represent their materials and trees will be represented by mid-resolution (150 ppi) image maps. A single light will act as the sun and less intense "fill lights" will be included to improve the quality of the scene.

3. High detail model – Design elements will be modeled to their actual intent and the best ability of the author. Objects will have image based textures, bump maps, and other custom maps (specular, reflection/refraction, etc.) to represent the designed intent. A sunlight system will be used with global illumination (GI) enabled to simulate real world conditions.

Key viewpoints will be chosen and shared throughout each level of detail for the creation of static 2D rendered images. The multiple viewpoints chosen will serve to display the project areas in contention; the areas that a review board would ask to see in order to approve a typical project. The time spent performing each task of the modeling, texturing, and rendering process will be recorded individually for later analysis.

This study will survey a sample group that approximates participants in an average town board meeting, namely people with little or no training in design. Due to scheduling constraints, access to actual town board meetings may not be possible so the study will seek to survey a random sample of adults that can be compared to typical public review meeting attendees.

Respondents will be asked to view one set of images from a single level of detail in order to avoid a preference bias between the 3 levels of detail. Images will be printed on an 11"x17" piece of paper, one image per sheet, and will be loosely bound with binder clips to allow a person to organize and compare the images as they wish. A cover page will be included showing small "thumbnails" of the proceeding images, along with instructions for completing the survey. Though the surveyor will be available to answer questions, respondents will be encouraged to complete the survey on their own.

Respondents will be able to sit down at a table and will be given 15 minutes for them to analyze the images and complete the survey. The survey will be conducted in a controlled room where lighting levels remain constant and distractions are at a minimum.

The survey will seek to measure whether respondents believed that they were able to understand the design intent displayed in the visualizations and whether they found the images themselves to be an acceptable communication device. The survey will consist of both qualitative and quantitative questions in order to obtain a measurable scale of acceptance of each level of detail, as well as more open ended answers that should elaborate on what respondents believed was effective or lacking in their set of images. In addition to survey questions that will be used for this study, other questions typical to those that might be asked in a public review meeting will be included. These questions will be integrated with those specific to the study in order to closely approximate a public review meetings agenda, while attempting to keep survey respondents from guessing the intent of the survey and influencing the data.

Survey responses will be compared to determine the level of acceptance and perceived understanding of the survey respondents, organized by detail group. This data will be used to determine which level of detail people with little or no design training find acceptable in order to make informed decisions in regards to graphic visualization of design intent. This will be cross referenced with the amount of time spent creating the images to determine a balance between time invested and perceived comprehension gained.

Schedule

	August		September				October			
Task	8/23	8/30	9/6	9/13	9/20	9/27	10/4	10/11	10/18	10/25
Proposal Drafts	■	■	■							
Proposal Approval				■						
Survey Drafts				■	■	■				
3D Model Creation					■	■	■	■		
-Modeling					■	■	■			
-Texturing						■	■			
-Lighting								■		
-Viewpoint Selection							■	■		
2D Image Rendering								■		
-Post-Processing								■	■	
Data Collection										■
Data Analysis										
Final Document Production										
Interim Writing Reviews		■	■	■	■	■	■	■	■	■
Presentation Production										
Thesis Defense										

	November					December		
Task	11/1	11/8	11/15	11/22	11/29	12/6	12/13	12/20
Proposal Drafts								
Proposal Approval								
Survey Drafts								
3D Model Creation								
-Modeling								
-Texturing								
-Lighting								
-Viewpoint Selection								
2D Image Rendering								
-Post-Processing								
Data Collection	■							
Data Analysis	■	■						
Final Document Production	■	■	■	■				
Interim Writing Reviews	■	■	■					
Presentation Production				■	■			
Thesis Defense					■			

Fig. 4: Thesis Schedule

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