Simulation Visualization Rhetoric and Its Practical Implications

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ABSTRACT

Modeling and simulation has moved far beyond simple data representation into the world of visual communication over the past 15 years; ultimately, the acceptance of M&S within mainstream science and society will depend on the results that are produced visually. A simulation's function is of primary importance to its end result, but it cannot be denied that the discipline of M&S now prizes fancy graphics to communicate. Rhetorical methodological decisions have the greatest impact on the end user, and considerations that bring visual rhetoric to modeling and simulation should be examined as a necessity to application. This paper will expose the community to existing research on the rhetoric of visualization, highlights and addresses current problems with simulation visualization, and bring visualization's inherent rhetoric to the forefront of consideration and utilization.

INTRODUCTION

The considerations of the philosophical underpinnings of visualization have been left on the sidelines while researchers chase the latest technological visualization applications for modeling and simulation (M&S). Visual rhetoric in M&S is also an effect of the latest technology that deserves closer observation into its uses. Our focus in this paper is to develop the view, both now and in the future, of rhetoric's importance to simulation visualization. Visualization creates and uses images, diagrams, and/or animations to explain models, display simulations and their real-time results, and even, in some cases, for validation. When we study the epistemology of visualization, the means by which we represent data and communicate it to others is not only a matter of how relevant data is displayed but why the producer of the simulation chooses particular means of visual communication. It is rhetorical methodological decisions that have the greatest impact on the end user and there is a necessity to examine closer the considerations that bring visual rhetoric to modeling and simulation. Visualization is a serious design activity that demands deeper conceptual investigation, trumping software and programming as the initial act of the visualization process. As foundations of M&S are currently being addressed, the importance of how and why M&S is presented cannot be overlooked. A wealth of philosophical investigations exists in both arenas but joint consideration needs to be applied for a deeper understanding of current and future uses of visualization (Collins and Knowles-Ball, 2012)

M&S has moved far beyond simple data representation into the world of visual communication over the past 15 years. The advancement of technology available for conducting visualization has been expanding at the same rate as the changes of methodologies available for conducting M&S. M&S practitioners are immersed in data, algorithms, and validation, and yet these are not the impressive gaming level high definition realistic quality graphics that dazzle M&S customers; thus rhetoric emerges in the means of visual communication. Effective simulation visualization is a thing of true value, not simply eye candy or media fodder. The visual argument of data displays and statistics has been examined in the past, but the rhetorical appeals at play in M&S is uncharted territory, ripe for examination.

The need for a simulation to visually appeal and argue a directive clearly comes into play in the modern era. Consider Figure 1 for example, a red square is no longer an adequate representation of battle tank when compared to a highly rendered graphic, even though they both represent the same data. The function of simulation is of primary importance to its end result but it cannot be denied that the discipline of M&S now prizes fancy graphics to communicate. The underpinnings of visualization are deeply rooted in the power of an image to convey both quantitative and qualitative narrative structures as effectively as alphanumeric language systems. Is the visual clarity, organization, and visual understanding still secondary to the data? Are the form and the function so far removed from one another? It will be argued that the visualized form creates the narrative structure of the simulation, creating expectation and leading to bias.

Figure 1: Comparing old and new representation of a tank

This paper is designed to give a brief overview of the simulation visualization rhetoric. The following three sections give a brief overview of visualization, visual rhetoric and how they are related; this includes a discussion on some of the current problems with simulation visualization. The final sections of the paper discuss some possible solutions and conclusions are given.

VISUALIZATION BACKGROUND

Computer simulations are a construction of mathematical algorithms and data; this statement is not meant to trivialize simulation, as many modern simulation are incredibly complex and involve tens of thousands of lines of code, it is meant to explicitly point out what they are. However, most people, with the exception of the simulation developers, will see a simulation though its visualization, the graphics used to represent the inner workings of the simulation. Simulation visualizations has been defined as "a process that generates visual representation such as imagery,

graphs, and animations, of information that is otherwise more difficult to understand though other forms of representation, such as text and audio" (Sokolowski and Banks, 2010).Though this definition is not necessarily universally accepted, it acts as a working definition for the purposes of this paper.

A computer simulation could simply be presented as a series of equations and tables but, even to those trained to read such things, this can be cumbersome and difficult to follow. By representing the different elements of simulation using visualization, we are able to gain a concise clarity of the simulation's purpose and function; this clarity can thus organized in our minds to give an understanding of the simulation's purpose and results. Achieving this clarity for the viewer is no simple task and the art of visualization is discussed at length by Edward Tufte (Tufte, 2001) and William Cleveland (Cleveland, 1993).

Figure 2: Screen-shots from the computer game Doom which show the advancement of computer graphics over the last 15 years

Over fifteen years ago, the film *Jurassic Park* and the computer game *Wolfenstein 3-D* were released. The graphics used in *Jurassic Park* were so revolutionary that people in cinemas all-round the country stood up and clapped at its finish. *Wolfenstein 3-D* impressed gamers with its fast-paced 3-D gaming, the like of which had not been seen before, and it has become known as the grandfather of 3-D shooters (1UP Games, 2010). If Jurassic Park was released today, it would seem heavily dated and unlikely to receive positive reviews; similarly, *Wolfenstein 3-D* would be seen as retro gaming and would be placed in a genre of gaming where 3-D graphics are now the accepted, and expected, standard. Fifteen years has seen a dramatic change in our acceptance and expectations of visualization.

As visualization becomes more realistic and easy to integrate within a simulation, its role within the simulation process is increased. Thus what started as a simple add-on to many simulations is now an integral part of it. This means that the influence of visualization on a simulation's design and output has grown over the years to a point where people are now starting to questions its role.

Paul Roman highlighted the impact of visualization's influence in his paper: "Garbage In, Hollywood Out" (Roman, 2005). The title of the paper is a metamorphosis of the George Fuechsel's adage "Garbage In, Garbage Out" (Bulter et al, 2010), implying that bad data and design going into a simulation will result in unusable, and invalid, results being produced. Roman's play on the phase comes from the tendency of some commercial simulation vendors to mask the inadequate simulation designs behind advanced graphics. The use of visualization to express a simulation's output can be considered to be a rhetorical process.

Statistical Relationships with Visualization

The problems of information rhetoric are not M&S alone and they have been discussed extensively in other subjects, especially statistics. Statisticians have wrestled with problems of visualizations rhetoric for years. The seminal work of Darrell Huff, entitled "How to lie with Statistics," highlighted many misleading practices that are used with the graphical representations of statistics (Huff, 1954).It was suggested within the book that the cause of these misrepresentations where rhetorically, e.g., the use of cut-off graphs to exacerbate gradient changes within the data.

VISUAL RHETORIC

Many would be pleased to place rhetoric firmly in the realm of lawyers and politicians. Others may go as far as to posit it in the world of linguistics. In the past decade, rhetoric has branched out and taken a multidisciplinary approach to be applied to many aspects of the world around us. It now extends far beyond the path of verbal arguments and persuasion. As Zelizer states, "Visual *representation* gives way to visual *rhetoric* through subjectivity, voice, and contingency" (Zelizer, 2004). Meaning is visual and any visual representation is subject to having its meaning parsed for analysis and questioning.

Foss, Foss and Trapp define rhetoric quite broadly as "the unique human ability to use symbols to communicate with one another" (Foss, Foss, and Trapp, 1985). Blair opens the realm even further by stating, "Arguments in the traditional sense consists of supplying grounds for beliefs, attitudes or actions…pictures can equally be the medium for such communication" (Blair, 2004). Visual rhetoric used in visualizations does not force us to have certain interpretations as much as it creates the context for interpretive frameworks and, more importantly, shared expectations.

The basis of visual rhetoric can be found in the traditional methodologies of semiotics, or the study of signs. Semiotics is not only necessary for visual understanding, but it seeks to reveal the constructed character of meanings we use every day. As a philosophy and method of critique, it questions and investigates the coded structure and meaning of *anything* that stands for something else – what is simulation visualization if not just that? Visual systems are signs existing in semantic space. The meaning is not on the surface but arises from collaboration between signs and interpreters. Semiotics allows for a more complex, subtle, and sophisticated mode of interpreting visual rhetoric present in simulation visualization.

As rhetoric relates to the arguments and appeals found within visualization's imagery, we turn once again to Blair who provides a modern definition of rhetoric as "the best means available to make the logic of the argument persuasive to the audience." We must be open to asking how rhetorical "constraints" and "opportunities" come into play in a particular visualization, because the developers are asking "what visual imagery will the audience understand and respond to" (Blair, 2004).

A visualization simulation has both a social rhetoric factor and an aesthetic component that must be deconstructed. The social aspect asks "what does it do?" (function) while the aesthetic requirements address "how does it look" (form). As for the appeals of social rhetoric, you find the end user falling prey to the concept that a visualization must be a good simulation simply because the graphics are so impressive. The aesthetic component falls on the designer in charge of massaging rhetorical implications visually. Both have equal roles to play in regards to rhetoric being introduced into a visualization. One must suspend the idea of function of all things to understand their meaning, how they function as signs and symbols to produce layered veiled meanings, why narratives are produced and how narrative alters the meaning of the images "informing" the interpretation.

HOW RHETORIC RELATES TO M&S

M&S has been used extensively to support decision-making by giving the decision-maker new information, a different view-point or even a paradigm for framing the problem under consideration. It would be completely inappropriate to suggest that any simulation gives the "correct" answer to the problem under consideration but it does give insights into understanding some of the factors of problem. This idea is summarized by the famous quote of George Box: "All models are wrong but some are useful" (Box, 1979).Thus, as a simulation does not supply the absolute correct answer, its results are there to support the decision-maker in their decision.

Without an absolute answer to give, the M&S practitioners must decide which information, from the simulations results, to provide the decision-maker and what format this information should take: tables, dialogue or graphics. A skilled M&S practitioner will be able to select the right information and format in such a way as to increase the creditability of the simulation; this selection will be affected by the same biases that the practitioners had when developing the simulation in the first place. Thus the M&S practitioner has an opportunity to influence the decision-maker and the art of doing so is the rhetoric of M&S.

Visualization is just a small part of the M&S process; a generic overview of the whole process is given in Figure 4. Given that any visualization of the simulation results are the only thing most decision-makers will see of the simulation, there is a temptation to want to concentrate your efforts on developing the best visuals. This is not helped by the effect that visualization has on decision-makers, as highlighted by Banks and Chwif "[G]raphics can aid sales. Animated graphics seem to have a mesmerizing effect on the simulation novices" (Banks and Chwif, 2011).

This mesmerizing of simulation novices might initially seems innocent enough but it leads to a charlatan aspect of the M&S industry. Simulations, with fancy graphics, are being sold as tools for problems they are not equipped to solve. Analysis simulations with pretty front-ends but no substantial back-end are being peddled to unwary decision-maker. The results of such charlatanism might make a quick buck for some businesses but what is the effect on the industry as a whole? That decision-maker will most likely obtain bad results from the simulation and thus look unfavorably at the simulation and M&S as a whole. Is that decision-maker likely to recommend M&S to others? Quite the contrary, for a new and fledgling subject like M&S, the bad press could be devastating to its growth and, ultimately, survival.

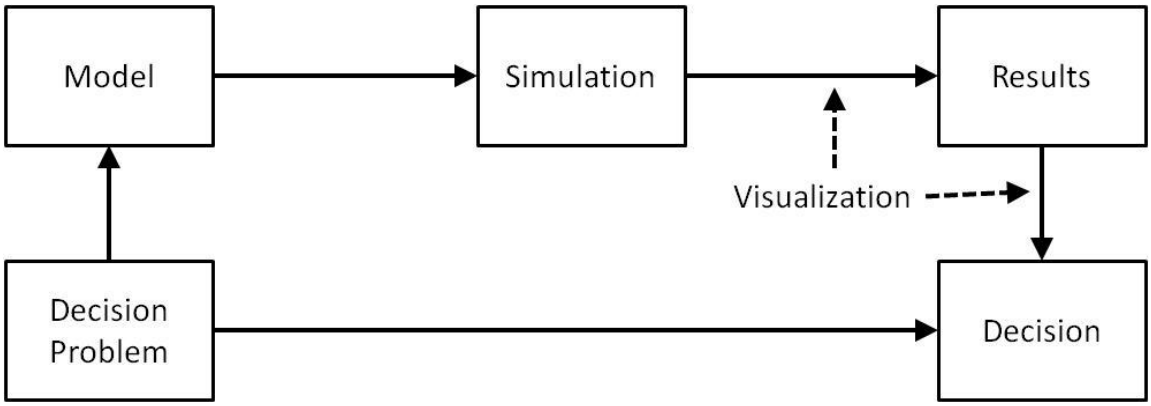

Figure 3: Generic decision-making process involving M&S

The authors would like to say that, in most cases, the addition of extra graphics within a simulation is due to an innocent wish, by the simulation developers, to make the visualizations more life-like; however, from personal and anecdotal evidence, the authors believe that there are cases of commercial simulations whose visualization is purposely designed to mislead the potential user/buyer which we have defined as the charlatan aspect of our industry. No direct examples are given here to avoid any law-suit but by walking around any large industrial M&S conferences, any M&S expert should be able to spot these charlatanism practices.

RHETORICAL VISUALIZATION – SOLUTIONS

One must ask if anything can be done to counteract bad visualization. There are different schools of thought on how this might be achieved:

Verification and Validation (V&V): Paul Roman says that the rhetorical issues with visualizations can be overcome with good V&V in his statement that "[t]he primary defen[s]e against undue influence by impressive looking outputs is validation and verification" (Roman, 2005). However, V&V is a very subjective process and there is no agreed upon standard. The process of V&V is not an instant one and it might not just be possible to apply to the simulation, this is especially true for simulation platform purchases. A simulation firm might release a limited version of the simulation platform for evaluations purposes but inadequate, or misleading, documentation of the simulations capabilities make it difficult for the simulation expert to evaluate the propriety components. Those that hold the purse-strings for purchasing simulation-platforms are not necessarily M&S experts.

Transparency: The perceptual cognitive-based school of thought argues that all data displays should be as simple, thus transparent, as possible (Kostelnick, 2008). Given the complexity of the data outputs, this is just not always feasible. To follow this school of thought would require the analyst to present the results in graphs and diagrams as simply as possible; such a display would look dated and passé to the decision-maker and ultimately affect the simulation's creditability.

Neither of the solutions presented above really give an adequate solution to the problem of misleading visualization rhetoric and the rise of simulation charlatans so what about trying to educate the populous about rhetoric instead?

Requirements may differ between the analyst and the customer, or metaphorically speaking, the car builders and the car buyers respectively. A first step towards preventing bad or unnecessary visualization would certainly be awareness of visual rhetoric's impact on visualization by both

the builder and the buyer. Primary use and clarity of form must be brought to the forefront while agendas and subjectivity take a back seat once they become apparent. With newfound awareness, the analyst must place importance once again on creditability and acceptability of a simulation to move us closer to objective communication in visualizations for analysis and training.

CONCLUSIONS

Researchers and scholars are looking into the depths of M&S but what really matters is what those outside of the M&S community see, including customers & decision-makers that "use" M&S. The considerations of visualization's rhetorical underpinnings must be brought to the forefront of M&S study in order to effect change in the application of simulation visualization. Realizing that visual rhetoric is at play in many visualizations marketed today is a first step toward requiring greater validation and transparency practices at the inception of the visualization process. Visual rhetoric in M&S, as an effect of the latest technology, deserves closer observation into its teleological uses.

To overcome the problems relating to visualization's rhetoric are non-trivial and thus could linger for a long time like those rhetorical problems of statistics. The problems cannot be ignored either, as there is a growth of charlatanism within our M&S industry which is especially due to the availability of fancy graphic for simulation purposes. Only time will tell if these problems are overcome but as the American engineered Charles F. Kettering stated "A problem well stated is a problem half solved."

Our focus in this paper was to develop the view, both now and in the future, of rhetoric's importance to simulation visualization. The importance of these epistemological investigations lies not only in thinking about visualization in a new way but also in exposing audiences to the rhetorical nature of visualization. These new connections therein expose existing problems in modeling and simulation by way of the application *and* the philosophy of visualization. Both facets must be examined at once for a true understanding of visual rhetoric's place in this field of study.

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