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The role of animation in decision-making

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Abstract

Animation can be an integral part of the simulation analysis process by communicating problem areas to decision makers and suggesting alternative designs or control strategies. Animation can be used in conjunction with typical simulation output measures to provide a comprehensive analysis package. The major contribution of animation to the process is its ability to provide a means to view the dynamics of system component interactions. How animation was used during analysis in three projects is presented in this paper.

1. Introduction

Animation capabilities are an important issue and are often the deciding factor in the purchase of simulation software. The level of effort required to generate an animation, graphics capabilities, and software cost are the factors in selecting an animation package.

There is very little argument that animation is useful, maybe imperative, in selling the idea of simulation. Simulationists may be required to use animation to justify their existence to "non-believers" (non-simulation types). There is no doubt that animation is a powerful communication vehicle. As simplistic as it may be, people like to see their systems "come to life". They are often more comfortable making decisions based on a simulation that they have seen graphically.

Some argue that the usefulness of animation is in the debugging, verification, and validation stages of a simulation project. This is a philosophical and practical question that must be answered by the individual. Can an animation be built and used to debug, verify, and validate a model in less time than it would take to perform the same tasks without animation? Does a visual representation of the system being modeled give more, less tangible, benefits than simply a validated model? In some cases the answer is undeniably "yes". The question to animate or not to animate is dependent upon the simulation software being used (how easy animations are built, how easy plots are generated, and the comprehensibility of the summary statistics), project time constraints, and the level of experience and enthusiasm of the analyst.

Animation also has a niche in the analysis of system performance using simulation. This paper addresses animation's role in the analysis phase of a simulation project. We will discuss how we have found it to be useful in this phase and summarize several projects in which animation has helped with the analysis.

2. Animation in the Analysis Phase of a Simulation Project

Given a set of objectives for a simulation project, analysts will design experiments to accomplish the stated goals. Results of the simulation model runs will determine how to direct further experiments. Typically, this is done by analyzing statistics. Depending upon the simulation software being employed, graphics, in the form of plots and charts, may also be used. Charts and histograms offer a visual representation of numbers that can be read from a textual report. They do not usually give the analyst a good feel for the dynamic nature of the system over time. Plots of statistics over time more effectively portray the dynamics of the system.

Animation provides the decision maker with a better feel for the dynamics of the system. Analysts can simply watch the system operate and see if a bad decision has been made and what effect that decision had on other components of the system. Schruben (1987) brings up several good points about animation. He says that "under no circumstances should animations be used in solving problems" because: (1) simulation runs with animations are too short to evaluate a system properly and (2) the analyst tends to concentrate only on unusual behavior. Eyecatching events may cause designs to be ruled out before they are fully developed. He claims that by changing a few parameter values designs may really be feasible. We agree with these points but do not feel that they are grounds for totally dismissing animation as an effective analysis tool.

Our experience with animation has convinced us that it can be used to direct simulation experiments. For example, one can view control logic in action. Poor decisions that may otherwise be concealed in results generated by a simulation model become obvious when viewed graphically. By witnessing a poor decision the analyst may get a better feel for how control strategies can be modified to improve system performance. Following are descriptions of three projects in which animation has been used to supplement the analysis.

3. Example 1: Transportation System

In a project for a steel company, we modeled the hot metal delivery system between iron and steel operations. Iron- and steel-making are separated by a body of water as well as a distance of several miles. Hot metal is transported by railroad in rail cars (hereafter referred to as bottles). Once bottles are filled with hot metal, they have a limited amount of time before they "freeze" (become solid). The objective of the system is to service iron-making with enough empty bottles so that a metal producing schedule can be maintained as well as providing steel operations with enough metal to maintain a steel producing schedule. The system is complicated by several factors: (1) only one locomotive is available to transport bottles on a full-time basis, (2) there is a limited amount of space at steel-making for full bottles, (3) a delay at iron-making due to a lack of empty bottles has serious consequences, and (4) a delay at steel-making due to lack of metal could cause the shutdown of the continuous caster, which translates into thousands of pounds of lost steel production. A diagram of the facility is shown in Figure 1.

Decision rules were built into the model to determine when the locomotive should make a trip. The rules were parameterized so they could be easily altered. In this system, each decision made by the locomotive operator was critical in avoiding delays. In addition to statistical averages computed over the length of the simulation, the effects of each decision were important. It would have been difficult to document each decision and describe the effect of each in a textual report or a set of plots. The logical choice was to animate the system. The observer could see the status of the system change, observe the conditions causing a decision to be made, and see the effect that the decision had on the system.

Along with decision rules governing the movement of bottles between iron- and steel-making, the study examined the effect of information flow to the locomotive operator. The locomotive operator may be aware of the need to cast (pour hot metal into bottles) and the completion of a cast some time before the events actually occur. This "cast start and completion window" was built into the model. The baseline scenario included notification of each event 30 minutes before it would occur. When the window was reduced to zero minutes, statistics showed that a decrease in production resulted. A dramatic increase in the number of delays incurred at both iron- and steel-making was observed. This was to be expected when the locomotive operator could not anticipate events that dictated the transfer of full and empty bottles. When notification

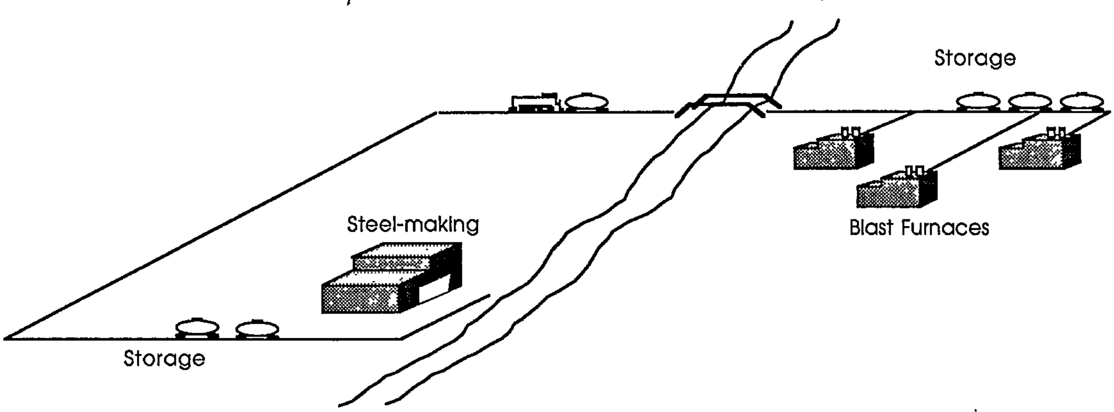

Figure 1. Hot Metal Delivery System

was given 60 minutes before cast start and completion, production was below the level observed in the baseline scenario and the number of trips made by the locomotive operator increased significantly. One would have expected that advanced knowledge would allow for more efficient use of the locomotive. In viewing the animated system the problem was identified: the locomotive made unnecessary moves. The logic governing the movement of bottles caused trips to be made in anticipation of upcoming events. For example, if the locomotive was at steel-making when notification of the start of a cast was received, the operator would take the available empty bottles and move to iron-making. Meanwhile, notification of the start of a cast at another blast furnace was received. The locomotive was not pulling enough bottles to satisfy both blast furnaces, so, upon arrival at iron-making, the operator had to return to steel-making to retrieve additional empties. The operator could have waited at steel-making for enough empty bottles to satisfy casting at both blast furnaces without causing any delays at iron-making. Animation of the system exposed this unwise decision and directed improvements to the company's existing decision logic.

4. Example 2: Manufacturing System

A simulation model was built for a residential furnace manufacturer. The system includes a series of assembly stations along a power-and-free conveyor. A power-and-free conveyor system is one in which parts are stopped while operations are being performed. Upon completion, the part is released and proceeds to its next operation. The system contains conveyor stops to avoid collisions in high traffic areas. Furnace assemblies stop at each station along the conveyor where components are added. After furnaces are assembled they move to a test area where all units are checked electronically. The test area consists of a bank of six test stations, all of which perform the same tests. An operator is required to hook the furnace to the test machine and to release the furnace when testing has been completed. After being tested, furnaces visit several more stations where they are packaged, sealed, and sent to shipping. The system is illustrated in Figure 2.

An animation of this facility allowed us to pinpoint problem areas quickly. It was easy to determine if backup on the conveyor was due to: (1) long cycle time at an assembly station, (2) absence of subassemblies at a given station, (3) unavailable operator(s) in the test area, (4) long test and repair cycles, or (5) lack of pallets. With interactive control of the model while running an animation, a user can see how each of these situations affects congestion in the system.

Animation of the system showed that congestion was occurring in the test area. Upon inspection of summary reports, one could identify the bottleneck. The next step was to look for high test station utilizations. In this case the utilizations were not excessively high. The animation showed that the bottleneck was caused by the conveyor servicing the test stations. Furnaces were stopped before they reached the bank of test stations. Only one furnace was allowed to travel along the conveyor servicing the stations. Once a furnace had reached its test station another could be released along the conveyor. The animation showed that test stations were available but that furnaces were waiting for previous units to reach their destinations. Travel time along this conveyor

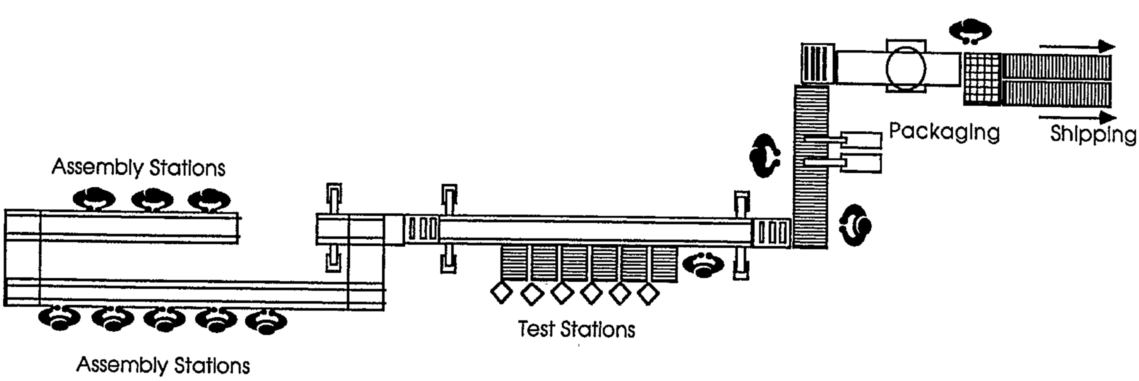

Figure 2. Furnace Assembly System

segment proved to be the bottleneck. Once the cause of the bottleneck was determined, possible solutions could be examined. One possible solution was to allow furnaces to follow one another along the conveyor segment. This would eliminate time spent waiting for previous units to reach their destinations. Another possible alternative was to put three test stations on each side of the conveyor to reduce the length of the conveyor segment and the travel time to test stations. The animation saved valuable analysis time by identifying this situation quickly.

5. Example 3: Automated Palletizing System

Our third example of how animation was used to direct analysis is an automated palletizing system for a foods producer. The objectives of the project were to model a proposed system, evaluate the system's ability to service the design load, and to fine-tune the design in terms of: robot cycle times, conveyor accumulation size, and strategy used to assign pallet positions to product types.

Cases of product enter the warehouse on an accumulating conveyor. Many different products can be palletized in the system at any given time. After traveling along the accumulating conveyor, cases are moved to the appropriate locations to be palletized. Cases are diverted from the conveyor onto input spurs at the cell where the product is being palletized. If space is not available on the input spur, the case is sent around a conveyor loop and attempts to move onto the spur when it passes by again. Each cell is responsible for palletizing a variable number of case types. Palletizing is performed by robots in two cells and by an operator in the third cell. Once a pallet has been filled it is removed by fork truck and moved into storage. A diagram of the system is shown in Figure 3.

Animation of this system provided a common sense approach to correcting design flaws. Buildup on an input spur causing cases to bypass is a sign that the the robot and/or operator cycle times are too long to meet the design load, the fork truck cannot regenerate empty pallets quickly enough, or that products are not evenly distributed between the cells. The animation showed a buildup of cases on an input spur at a robotic cell and cases bypassing the cell while the other two cells appeared to be underutilized. By distributing the palletizing load more evenly between the cells the number of bypasses was reduced. It was determined that the robots, the operator, and the fork truck could support the design load if pallet assignments were made wisely. The animation pointed out the case buildup problem quickly and saved hours of valuable analysis time.

6. Summary

Our experience has indicated that animation can help provide direction to simulation analysis. It can point out problem areas and give an intuitive feel for possible

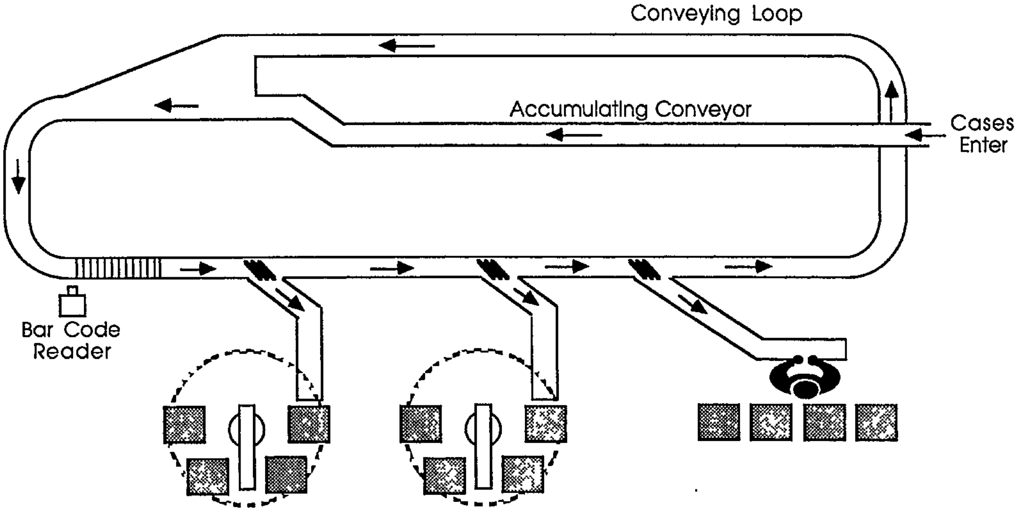

Figure 3. Automated Palletizing System

improvements in system performance. Schruben's points are well taken. It does not make sense to sit in front of a screen for hours viewing entire simulation runs. Decisions should not be made after viewing an animation of a single simulation run for a small slice of time. System designs should not be discarded because of an unusual event observed during such a viewing. We do claim, however, that animation has a niche in the analysis process. Summary reports, plots, and charts should be the focus of the analysis, but animation can be utilized as an integral part of the analysis package for certain purposes. Seeing a system come to life under different scenarios, we can get a "feel" for how decisions might be better made. Our claim is that animation can be our common sense guide in directing experiments with a simulation model. We have shown three examples of how animation successfully supplemented the typical simulation analysis procedure. In each case some aspect of the system or component relationship could not have been understood as quickly without animation.

References

Gilman, A., "Interactive Control of the Model: A Natural Companion to Animated Graphics". *Proceedings of the 1985 Winter Simulation Conference* (D. Gantz, G. Blais, S. Solomon, eds.), pp. 196-198.

Schruben, L., "Using Simulation to Solve Problems: A Tutorial on the Analysis of Simulation Output", *Proceedings of the 1987 Winter Simulation Conference* (A. Thesen, H. Grant, W. David Kelton, eds.), pp. 40-42.

Standridge, C., "Animating Simulations Using TESS", *Computer and Industrial Engineering,* vol. 10, no. 2, pp. 121-134, 1986.

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