

Importance of Simulation and Modality in Modern Computer Science Technology

Dr. Divanshu Dixit

Abstract:

Computer system users, administrators, and designers usually have a goal of highest performance at lowest cost. Modeling and simulation of system design trade off is good preparation for design and engineering decisions in real world jobs.

The scenario described above is but one situation where computer simulation can be effectively used. In addition to its use as a tool to better understand and optimize performance and/or reliability of systems, simulation is also extensively used to verify the correctness of designs. Most if not all digital integrated circuits manufactured today are first extensively simulated before they are manufactured to identify and correct design errors. Simulation early in the design cycle is important because the cost to repair mistakes increases dramatically the later in the product life cycle that the error is detected. Another important application of simulation is in developing "virtual environments", e.g., for training. Analogous to the holodeck in the popular science-fiction television program Star Trek, simulations generate dynamic environments with which users can interact "as if they were really there." Such simulations are used extensively today to train military personnel for battlefield situations, at a fraction of the cost of running exercises involving real tanks, aircraft, etc.

Dynamic modeling in organizations is the collective ability to understand the implications of change over time. This skill lies at the heart of successful strategic decision process. The availability of effective visual modeling and simulation enables the analyst and the decision-maker to boost their dynamic decision by rehearsing strategy to avoid hidden pitfalls.

Key-Words: ENIAC, CSSL,SCS,SaaS.

Introduction:

Computer simulation modeling is a discipline gaining popularity in both government and industry. Computer simulation modeling can assist in the design, creation, and evaluation of complex systems. Designers, program managers, analysts, and engineers use computer simulation modeling to understand and evaluate 'what if' case scenarios. It can model a real or proposed system using computer software and is useful when changes to the actual system are

difficult to implement, involve high costs, or are impractical. Some examples of computer simulation modeling familiar to most of us include: weather forecasting, flight simulators used for training pilots, and car crash modeling.

Benefits:

- Gain greater understanding of a process
- Identify problem areas or bottlenecks in processes
- Evaluate effect of systems or process changes such as demand, resources, supply, and constraints
- Identify actions needed upstream or downstream relative to a given operation, organization, or activity to either improve or mitigate processes or events
- Evaluate impact of changes in policy prior to implementation

Types of Simulation Models:

- Discrete Models – Changes to the system occur at specific times
 - Division of Property Management trouble calls
 - Acquisition or construction business processes
 - A manufacturing system with parts entering and leaving at specific times
- Continuous Models – The state of the system changes continuously over time
 - A reservoir as water flows in and out
 - Chilled water or steam distribution
- Mixed Models – Contains both discrete and continuous elements
 - A refinery with continuously changing pressure inside vessels and discretely occurring shutdowns
 - Chilled water distribution including plant shutdowns

Types of Data/Information Needed to Develop a Simulation Model:

- The overall process flow and its associated resources
- What is being produced, served, or acted upon by the process (entities)
- Frequency at which the entities arrive in the process
- How long do individual steps in the process take

- Probability distributions that characterize real life uncertainties and variations in the process

Role of Computer Simulation Technology in Modern Engineering:

Computer simulation technology has developed in close relation with both the computer industry and engineering processes. Associated with the process manufacturing industries, simulation has been customarily used as a tool to increase the production capacity.

In the early stages, computer simulation was not very accessible; a lengthy process, the ambiguity of resulting models, and a large number of required specialists resulted in prohibitively expensive associated costs. Until the wide-scale adoption of computing algorithms in 1970's, industrial engineers learn about computer simulation models in schools but rarely apply them.

Development in computing, modern programming language, visualization tools, and graphics have had a huge impact on the evolution of simulation technology.

Main History Milestones

1943 – ENIAC (Electronic Numerical Integrator and Computer) was the first digital machinery construction and started in secret at the Moore School of Electrical Engineering, University of Pennsylvania. Its main goal was ballistic trajectory calculation [1];

1945 – Jon Von Neumann developed the “merge sort” algorithm, which was integrated with one of the first computer simulation programs running on the DVAC (Electronic Discrete Variable Automatic Computer) [2];

1952 – John McLeod, a pioneer in modern simulation, founded the first Simulation Council, known today as Society for Computer Simulation (SCS) [3];

1961 – IBM presented the “Gordon Simulator” to Norden (systems design company), which comprised a tool used to design a system to distribute weather information to general aviation [4];

1964 – CACI Products Company released SIMSCRIPT, a powerful free-form simulation language designed to simplify writing programs for simulation models, used especially in inventory simulations [3];

1967 – Norwegian Computer Center developed the language Simula67 [3];

1967 – Continuous System Simulation Language (CSSL) was developed by the Society for Computer Simulation [3];

1979 – Alan Pritsker developed the first version of SLAM, a FORTRAN based computer simulation language;

1998 – Micro Saint v2.0 for Windows 95 provided automatic data collection, optimization, and a new Windows interface, without any programming language requirement;

2008 – NASA released the Standard for Development of Models and Simulations;

2012 – Barna Szabo and Ricardo Actis introduced simulation governance as a technical requirement for mechanical design [5];

2013 – SimScale officially released the world's first and only 100% web-based engineering simulation platform [6];

What is Computer Simulation Technology Offering Today?

Today's modern versions of simulation technology regularly provide a set of features:

- A uniquely structured environment that facilitates models with rapid geometry setup function
- Automatically details generation, windows interfaces, and pop-up menus
- Easy and quick to use, with lower risks of errors
- Built-in material handling patterns and templates
- Product design verified and tested faster, offering 3D views alternatives

- 3D graphics automatically created as the user enters data
- Simulations results can be instantly viewed in 3D animation [3]

Real-time simulation technology is used today in various industrial applications in the fields of manufacturing, energy and power systems, industrial equipment, valves, pumps, automotive, and airplane engines. The key challenges in the industrial simulation are digital model integration, reducing time to market, computational processing power, energy efficiency, and the associated cost reduction.

The first step in the simplification of the simulation process was the separation from traditionally designed applications, achieved by the universal recognition of major project files with standard extensions. This offered total independence between product design and the simulation process.

The migration of computer simulation software into the Cloud has made a massive impact on product cost reduction, quality improvement, and market-ready effectiveness. All major CAE providers have started offering alternative services to the traditional on-premises simulation software, but not covering all benefits Cloud has to offer.

What is Next in Engineering Simulation?

Some industry analysis trends emerged at the last edition of the NAFEMS World Congress— (International Association for the Engineering Modelling, Analysis, and Simulation Community established in 1983)[6].

- Design-centric workflow – already adopted in digital industry models
- Ease of use and/or usability – applications should be friendly, for large numbers of users
- Analysis and simulation of CAD – as part of modern digital processes
- The impact of the Web, Cloud, and mobile devices – opening access and communication facilities
- Capturing and reuse of knowledge – by embedding digital data science models
- Systems approach to combining heterogeneous models – multiphysics simulations

- Speed and model fidelity – improved by Cloud infinite computational power
- Unattractive technical issues – limited by opening access to knowledge
- Changes to licensing models – due to essential differences offered by Cloud subscription Software as a Service (SaaS) models
- Nano simulations – finite element analysis and simulation at the nanoscale opens up a vast applicability in the field of biological engineering

These trends are linked to a major initiative to expand the use and benefit of engineering simulation to larger user categories, “The goal is to gain better advantage and growth of CAE software given the business drivers that push the need for more innovation and creative competitiveness”, says Joe Walsh, CEO of IntrinSIM [6].

Experts appreciate that the simulation democratization process has currently three obstacles: software costs, hardware expenses, and expertise training. The Cloud models offer a solution for first two of these stumbling blocks, opening the doors to vendors which offer freemium versions of simulation analysis on a pay-by-use model. “We need to reduce the level of expertise required to do simulation,” says Walsh in an interview for Engineering.com [6]. “This is referred to as design-centric workflow rather than simulation-centric. This way simulation is used to derive and drive design decisions as opposed to just using it to do an analysis.”

“The Next” is here, with Reliable Alternatives

With its web-based engineering simulation platform, SimScale offers real answers to all three major obstacles in the computer-aided engineering (CAE) democratization process. SimScale has created a completely new approach to how CAE technology can be used, by making it accessible, cost-efficient, and easy-to-learn and use.

Accessibility – any user has access to necessary powerful computer simulation technology running in a simple web browser, without any supplementary hardware, software or maintenance resources;

Cost-efficiency – using SimScale, users pay only for what they use, achieving the best cost/performance in the engineering process;

Simulation in education and training:

Simulation is extensively used for educational purposes.^[21] It is used for cases where it is prohibitively expensive or simply too dangerous to allow trainees to use the real equipment in the real world. In such situations they will spend time learning valuable lessons in a "safe" virtual environment yet living a lifelike experience (or at least it is the goal). Often the convenience is to permit mistakes during training for a safety-critical system.

Simulations in education are somewhat like training simulations. They focus on specific tasks. The term 'microworld' is used to refer to educational simulations which model some abstract concept rather than simulating a realistic object or environment, or in some cases model a real-world environment in a simplistic way so as to help a learner develop an understanding of the key concepts. Normally, a user can create some sort of construction within the microworld that will behave in a way consistent with the concepts being modeled. Seymour Papert was one of the first to advocate the value of microworlds, and the Logo programming environment developed by Papert is one of the most well-known microworlds.

Project management simulation is increasingly used to train students and professionals in the art and science of project management. Using simulation for project management training improves learning retention and enhances the learning process.

Social simulations may be used in social science classrooms to illustrate social and political processes in anthropology, economics, history, political science, or sociology courses, typically at the high school or university level. These may, for example, take the form of civics simulations, in which participants assume roles in a simulated society, or international relations simulations in which participants engage in negotiations, alliance formation, trade, diplomacy, and the use of force. Such simulations might be based on fictitious political systems, or be based on current or historical events. An example of the latter would be Barnard College's *Reacting to the Past* series of historical educational games. The National Science Foundation has also supported the creation of reacting games that address science and math education. In social media simulations, participants train communication with critics and other stakeholders in a private environment.

In recent years, there has been increasing use of social simulations for staff training in aid and development agencies. The Carana simulation, for example, was first developed by the United Nations Development Programme, and is now used in a very revised form by the World Bank for training staff to deal with fragile and conflict-affected countries.

Military uses for simulation often involve aircraft or armoured fighting vehicles, but can also target small arms and other weapon systems training. Specifically, virtual firearms ranges have become the norm in most military training processes and there is a significant amount of data to suggest this is a useful tool for armed professionals.

Virtual simulation

Virtual simulation is a category of simulation that uses simulation equipment to create a **simulated world** for the user. Virtual simulations allow users to interact with a virtual world. Virtual worlds operate on platforms of integrated software and hardware components. In this manner, the system can accept input from the user (e.g., body tracking, voice/sound recognition, physical controllers) and produce output to the user (e.g., visual display, aural display, haptic display). Virtual simulations use the aforementioned modes of interaction to produce a sense of immersion for the user.

Virtual simulation input hardware

There is a wide variety of input hardware available to accept user input for virtual simulations. The following list briefly describes several of them:

- *Body tracking*: The motion capture method is often used to record the user's movements and translate the captured data into inputs for the virtual simulation. For example, if a user physically turns their head, the motion would be captured by the simulation hardware in some way and translated to a corresponding shift in view within the simulation.
 - Capture suits and/or gloves may be used to capture movements of user's body parts. The systems may have sensors incorporated inside them to sense movements of different body parts (e.g., fingers). Alternatively, these systems may have exterior tracking

devices or marks that can be detected by external ultrasound, optical receivers or electromagnetic sensors. Internal inertial sensors are also available on some systems. The units may transmit data either wirelessly or through cables.

- Eye trackers can also be used to detect eye movements so that the system can determine precisely where a user is looking at any given instant.
- *Physical controllers*: Physical controllers provide input to the simulation only through direct manipulation by the user. In virtual simulations, tactile feedback from physical controllers is highly desirable in a number of simulation environments.
 - Omni directional treadmills can be used to capture the users locomotion as they walk or run.
 - High fidelity instrumentation such as instrument panels in virtual aircraft cockpits provides users with actual controls to raise the level of immersion. For example, pilots can use the actual global positioning system controls from the real device in a simulated cockpit to help them practice procedures with the actual device in the context of the integrated cockpit system.
- *Voice/sound recognition*: This form of interaction may be used either to interact with agents within the simulation (e.g., virtual people) or to manipulate objects in the simulation (e.g., information). Voice interaction presumably increases the level of immersion for the user.
 - Users may use headsets with boom microphones, lapel microphones or the room may be equipped with strategically located microphones.

Virtual simulation output hardware

There is a wide variety of output hardware available to deliver a stimulus to users in virtual simulations. The following list briefly describes several of them:

- *Visual display*: Visual displays provide the visual stimulus to the user.
 - Stationary displays can vary from a conventional desktop display to 360-degree wrap-around screens to stereo three-dimensional screens. Conventional desktop displays can

vary in size from 15 to 60 inches (380 to 1,520 mm). Wrap around screens is typically used in what is known as a cave automatic virtual environment (CAVE). Stereo three-dimensional screens produce three-dimensional images either with or without special glasses—depending on the design.

- Head-mounted displays (HMDs) have small displays that are mounted on headgear worn by the user. These systems are connected directly into the virtual simulation to provide the user with a more immersive experience. Weight, update rates and field of view are some of the key variables that differentiate HMDs. Naturally, heavier HMDs are undesirable as they cause fatigue over time. If the update rate is too slow, the system is unable to update the displays fast enough to correspond with a quick head turn by the user. Slower update rates tend to cause simulation sickness and disrupt the sense of immersion. Field of view or the angular extent of the world that is seen at a given moment field of view can vary from system to system and has been found to affect the user's sense of immersion.
- *Aural display*: Several different types of audio systems exist to help the user hear and localize sounds spatially. Special software can be used to produce 3D audio effects 3D audio to create the illusion that sound sources are placed within a defined three-dimensional space around the user.
 - Stationary conventional speaker systems may be used to provide dual or multi-channel surround sound. However, external speakers are not as effective as headphones in producing 3D audio effects.
 - Conventional headphones offer a portable alternative to stationary speakers. They also have the added advantages of masking real-world noise and facilitate more effective 3D audio sound effects.
- *Haptic display*: These displays provide a sense of touch to the user (haptic technology). This type of output is sometimes referred to as force feedback.
 - Tactile tile displays use different types of actuators such as inflatable bladders, vibrators, low-frequency sub-woofers, pin actuators and/or thermo-actuators to produce sensations for the user.

- End effector displays can respond to users inputs with resistance and force. These systems are often used in medical applications for remote surgeries that employ robotic instruments.
- *Vestibular display*: These displays provide a sense of motion to the user (motion simulator). They often manifest as motion bases for virtual vehicle simulation such as driving simulators or flight simulators. Motion bases are fixed in place but use actuators to move the simulator in ways that can produce the sensations pitching, yawing or rolling. The simulators can also move in such a way as to produce a sense of acceleration on all axes (e.g., the motion base can produce the sensation of falling).

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