Clinical Healthcare Simulators

- **Objectives of Developing Medical simulators:**
  1. Teaching diagnostic procedures as well as medical concepts and decision making to personnel in the health professions.
  2. Prototyping new devices for biomedical engineering problems.

Clinical Healthcare Simulators (cont.)

- **Forms of Medical Simulators:**
  1. A computer connected to a plastic simulation of the relevant anatomy.
    - Sophisticated simulators of this type employ a life size mannequin that responds to injected drugs and can be programmed to create simulations of life-threatening emergencies.
2. Visual components of the procedure are reproduced by computer graphics techniques, while touch-based components are reproduced by haptic feedback devices combined with physical simulation routines computed in response to the user's actions.

3. Medical simulations are developed to be widely distributed (such as web-enabled simulations and procedural simulations that can be viewed via standard web browsers).

Clinical Healthcare Simulators (cont.)

Improving patient safety

• Patient safety is a concern in the medical industry. Patients have been known to suffer injuries and even death due to management error, and lack of using best standards of care and training.

• Innovative simulation training solutions are now being used to train medical professionals in an attempt to reduce the number of safety concerns that have adverse effects on the patients.
Clinical Healthcare Simulators (cont.)

Improving patient safety (cont.)

• One such attempt to improve patient safety through the use of simulations training is pediatric care to deliver just-in-time service or/and just-in-place.

• This training consists of 20 minutes of simulated training just before workers report to shift. This may increase the positive and reduce the negative results that have generally been associated with the procedure.

Clinical Healthcare Simulators (cont.)

History of simulation in healthcare

• The first medical simulators were simple models of human patients.

• Models are used today to help students learn the anatomy of the musculoskeletal system and organ systems.
Clinical Healthcare Simulators (cont.)

Type of medical models

1- Active models

• Active models that attempt to reproduce living anatomy or physiology are recent developments.
• The famous “Harvey” mannequin was developed at the University of Miami and is able to recreate many of the physical findings of the cardiology examination, including palpation, auscultation, and electrocardiography.

2- Interactive models

• Interactive models have been developed that respond to actions taken by a student or physician.
• These simulation models were two dimensional computer programs that acted more like a textbook than a patient. Computer simulations have the advantage of allowing a student to make judgments, and also to make errors.
• This kind of simulations will lead to a much stronger learning environment than passive instruction.
Clinical Healthcare Simulators (cont.)

3- Computer simulators

- Simulators have been proposed as an ideal tool for assessment of students for clinical skills.
- Programmed patients and simulated clinical situations, including mock disaster drills, have been used extensively for education and evaluation. These “lifelike” simulations are expensive, and lack reproducibility.
- Alternatively, other less cost -wise simulations can be used, including:
  1. A fully functional "3Di" simulators.
  2. Gaming platforms have been applied to create these virtual medical environments to create an interactive method for learning and application of information in a clinical context.
  3. Immersive disease state simulations Using sensors and transducers symptomatic effects

Simulation in entertainment

- Simulation in entertainment encompasses many large and popular industries such as film, television, video games (including serious games) and rides in theme parks.
- Although modern simulation is thought to have its roots in training and the military, in the 20th century it also became a conduit for enterprises which were more hedonistic in nature.
Simulation in entertainment (cont.)

• History of Simulation in entertainment

1- Early history (1940’s and 50’s)
   • The first simulation game may have been created as early as 1947 by Thomas T. Goldsmith Jr. and Estle Ray Mann. This was a straightforward game that simulated a missile being fired at a target.

   • In 1958 a computer game called “Tennis for Two” was created by Willy Higinbotham which simulated a tennis game between two players who could both play at the same time using hand controls and was displayed on an oscilloscope. This was one of the first electronic video games to use a graphical display.

Simulation in entertainment (cont.)

2- Modern simulation (1980’s-present)
   1. For Games:
      • The first video game consoles released in the 1970s and early 1980s fell prey to the industry crash in 1983, but in 1985.
      • Nintendo released the Nintendo Entertainment System (NES) which became the best-selling console in video game history.
      • In the 1990s, computer games became widely popular with the release of such game as The Sims and Command and Conquer
Simulation in entertainment (cont.)

2. For Films:
   • Computer-generated imagery was used in film to simulate objects as early as 1976, though in 1982, the film Tron was the first film to use computer-generated imagery for more than a couple of minutes.
   • In 1993, the film Jurassic Park became the first popular film to use computer-generated graphics extensively, integrating the simulated dinosaurs almost seamlessly into live action scenes.
   • In 1995, the film Toy Story was the first film to use only computer-generated images and by the new millennium computer generated graphics were the leading choice for special effects in films.

Simulation in entertainment (cont.)

3. For Theme Park rides:
   • Simulators have been used for entertainment since the Link Trainer in the 1930s.
   • The first modern simulator ride to open at a theme park was Disney’s Star Tours in 1987.
   • Universal’s the Fantastic World of Hanna-Barbera in 1990 which was the first ride to be done entirely with computer graphics.
Simulation in entertainment (cont.)

• Examples of Entertainment Simulation

1. **Computer & Video Games:** Popular simulation games include *SimCity*, *Tiger Woods PGA Tour* and *Virtonomics*.

2. **Films:** Examples of movies that use computer-generated imagery include *Finding Nemo*, *300* and *Iron Man*.

3. **Theme Park rides:** Examples of simulation rides include *Mission Space* and *The Simpsons Ride*.

Simulation and manufacturing

• Manufacturing represents one of the most important applications of Simulation.

• This technique represents a valuable tool used by engineers when evaluating the effect of capital investment in equipment and physical facilities like factory plants, warehouses, and distribution centers.

• Simulation can be used to:
  1. predict the performance of an existing or planned system and to compare alternative solutions for a particular design problem.
  2. quantify system performance.
Simulation and manufacturing

- Common measures of system performance that could be quantified by Simulators, include the following:
  1. Throughput under average and peak loads.
  2. System cycle time (how long it takes to produce one part).
  3. Utilization of resources, labor, and machines.
  4. Bottlenecks and choke points.
  5. Queuing at work locations.
  6. Queuing and delays caused by material-handling devices and systems.
  7. WIP storage needs.
  8. Staffing requirements.
  9. Effectiveness of scheduling systems.
  10. Effectiveness of control systems.

Automobile Simulator

- An automobile simulator provides an opportunity to reproduce the characteristics of real vehicles in a virtual environment.

- It replicates the external factors and conditions with which a vehicle interacts enabling a driver to feel as if they are sitting in the cab of their own vehicle.

- Scenarios and events are replicated with sufficient reality to ensure that drivers become fully immersed in the experience rather than simply viewing it as an educational experience.
Automobile Simulator (cont.)

• The simulator provides a constructive experience for each of the following:

  1. **For novice drivers**: truck simulators provide an opportunity to begin their career by applying best practice.

  2. **For mature drivers**: simulation provides the ability to enhance good driving or to detect poor practice and to suggest the necessary steps for remedial action.

  3. **For companies**: it provides an opportunity to educate staff in the driving skills that achieve reduced maintenance costs, improved productivity and, most importantly, to ensure the safety of their actions in all possible situations.

Biomechanics simulators

• An open-source simulation platform for creating dynamic mechanical models built from combinations of rigid and deformable bodies, joints, constraints, and various force actuators.

• It is specialized for creating biomechanical models of human anatomical structures, with the intention to study their function and eventually assist in the design and planning of medical treatment.

• A biomechanics simulator is used to:
  1. analyze walking dynamics.
  2. study sports performance.
  3. simulate surgical procedures.
  4. analyze joint loads.
  5. design medical devices.
  6. animate human and animal movement.
City and urban simulation

• A City simulator can be a city-building game but can also be a tool used by urban planners to understand how cities are likely to evolve in response to various policy decisions.

• AnyLogic is an example of modern, large-scale urban simulators designed for use by urban planners.

• City simulators are generally agent-based simulations with explicit representations for land use and transportation.

• UrbanSim and LEAM are examples of large-scale urban simulation models that are used by metropolitan planning agencies and military bases for land use and transportation planning.

Classroom of the future

• The "classroom of the future" will probably contain several kinds of simulators, in addition to textual and visual learning tools. This will allow students to enter the clinical years better prepared, and with a higher skill level.

• The advanced student or postgraduate will have a more concise and comprehensive method of retraining — or of incorporating new clinical procedures into their skill set — and regulatory bodies and medical institutions will find it easier to assess the proficiency and competency of individuals.
Classroom of the future (cont.)

- The classroom of the future will also form the basis of a clinical skills unit for continuing education of medical personnel; and in the same way that the use of periodic flight training assists airline pilots, this technology will assist practitioners throughout their career.

- The simulator will be more than a "living" textbook, it will become an integral a part of the practice of medicine. The simulator environment will also provide a standard platform for curriculum development in institutions of medical education.

Communication satellite simulation

- Modern satellite communications systems (SatCom) are often large and complex with many interacting parts and elements. In addition, the need for broadband connectivity on a moving vehicle has increased dramatically in the past few years for both commercial and military applications.

- To accurately predict and deliver high quality of service, SatCom system designers have to factor in terrain as well as atmospheric and meteorological conditions in their planning.
Communication satellite simulation (cont.)

• To deal with such complexity, system designers and operators increasingly turn towards computer models of their systems to simulate real world operational conditions and gain insights into usability and requirements prior to final product sign-off.

• Modeling improves the understanding of the system by enabling the SatCom system designer or planner to simulate real world performance by injecting the models with multiple hypothetical atmospheric and environmental conditions.

Equipment simulation

• Due to the dangerous and expensive nature of training on heavy equipment, simulation has become a common solution across many industries.

• Types of most commonly simulated equipment include:
  1. Cranes.
  2. Mining Reclaimers.
  3. Construction Equipment.

• Often the simulation units will include pre-built scenarios by which to teach trainees, as well as the ability to customize new scenarios. Such equipment simulators are intended to create a safe and cost effective alternative to training on live equipment.