

### THE IMPORTANCE OF COMPUTATION, MODELING AND SIMULATION IN MEDICAL

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#### Abstract

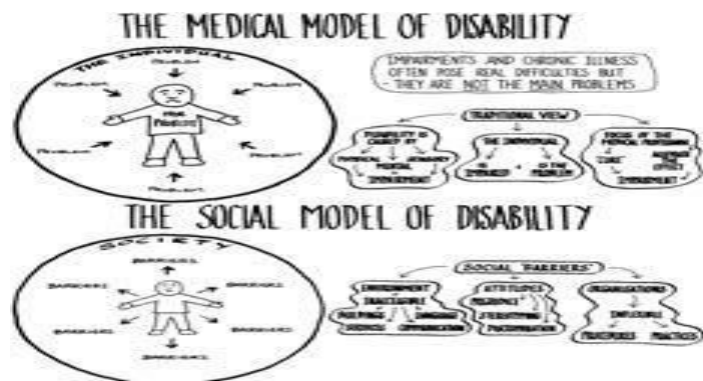
Computation, Modeling and Simulation refers to the procedure of erecting and operating computer-based mathematical problems in our daily routine. Simulation modelling in healthcare is the interrelationship between human-made and framework-oriented variables in complex systems of systems (SOS), and to explore scenarios of decision-making from different collaborators or practitioners.

#### HISTORY:-

**Simulation** - The history of computer simulation dates back to World War II when two mathematicians John Von Neumann and Stanislaw Ulam were faced with the puzzling problem of behaviour of neutrons. They introduced the game theory.

**Modeling** - Psychiatrist R.D. Laing coined the term “ medical model” in The Politics of the Family and Other Essays (1971). A medical model is a biopsychosocial model assessing a patient's problems, it shows the disease and it is detected and identified through a systematic process of observation, description, and differentiation, in accordance with standard accepted plans of action, such as medical examinations, tests, or a set of symptom descriptions.

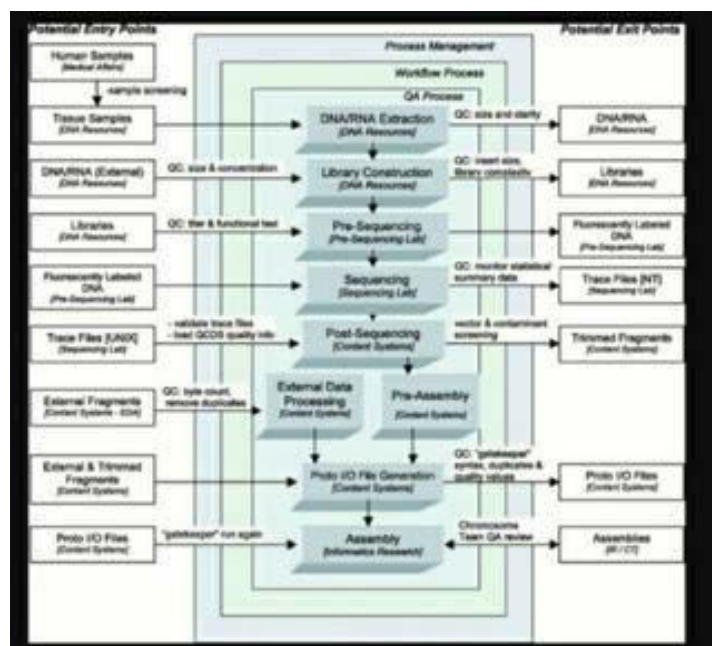
1- Image Medical model



**Computation** - Dr. Michael Waterman is known as the father of computational biology. In 1988, Dr. Michael Waterman and Eric Lander published a landmark paper describing a mathematical model for fingerprint mapping. His work formed one of the theoretical foundation for many

DNA mapping and sequencing projects, including the Human Genome Project, and has been used in some of the most commonly used tools in this medical field. Dr. Michael Waterman was a lecturer and his lectures were about the technologies and computational methods used to determine DNasequences of the genomes of organisms.

Image 2- *Sequence of Human Genome*

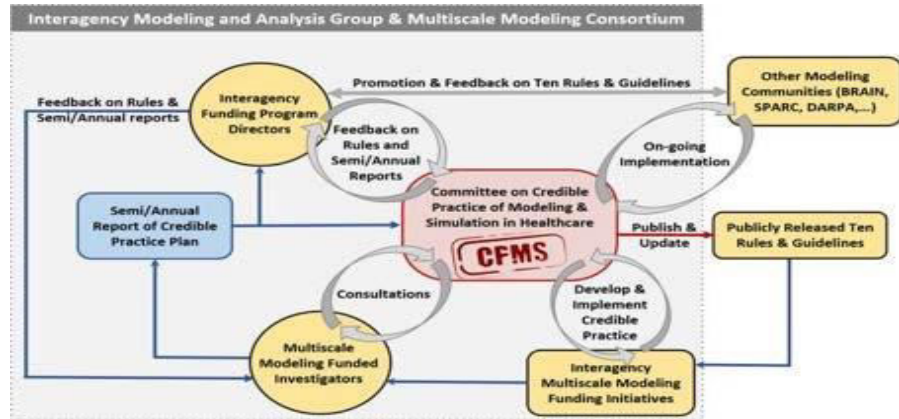


### Computational models :-

### Working:-

A computational model contains a number of variables that distinguishes the system being studied. Simulation is done by adjusting the variables alone or in groups and observing the outcomes. Simulation models consist of system entities, input variables, performance measures, and functional relationships. Data collected from these simulated experiments can be then used to identify which experiments can solve a particular problem. Computational modeling is used in many different scientific research including drug discovery, weather forecasting, flight simulation, and medical care research. Computer modeling allows scientists to conduct thousands of simulated experiments by computer.

Image 3- *Working*



### Features :-

- Time used in simulation is an indexing variable
- One of the main ways that we can save time in medical device development is through virtual prototyping
- It helps to perform a sensitivity analysis, helps to track complexity and identify the main design inputs that drive the critical result for the patient.
- It allows product development teams to run more scenarios than could be examined through the traditional methods of building prototypes and running physical tests.
- Computational, modeling and simulation consequences in making devices that are safer, more effective, more precise and with less risk.
- Provides new chances to medical device companies.
- The lower development cost also opens new markets that may not have been commercially viable in the past.
- Track transmissible diseases using Computed Tomography Scan (CT Scan), Magnetic Resonance Imaging (MRI), etc.
- Anticipating the adverse side-effect of drugs – Accurate data provided by modeling helps to develop safe and effective medications.
- Solve medical-related problems

### Types:- (Based on their functions)

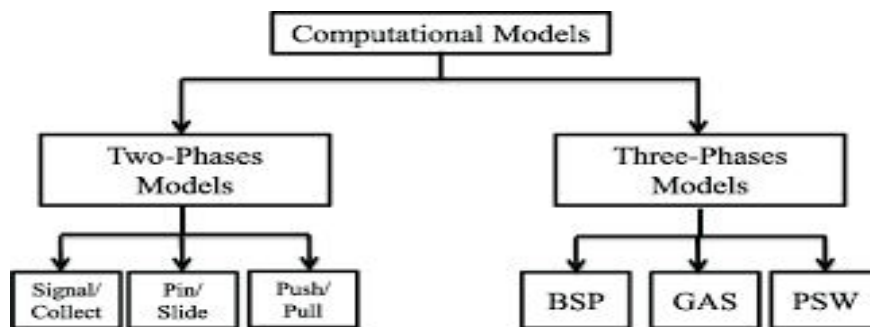
**Sequential Models :-** Sequential models a type of models in which healthcare consumption of services or supplies is seen as a sequences of consultations. They are the machine learning models that input or output sequences of data. Sequential data includes text streams, audio and video clips, time-series data and etc. Recurrent Neural Networks (RNN) is a popular

algorithm used in sequence models. Applications of Sequence Models. They are used for sequences like DNA sequences, Prognostic assessment of patients, sequential neural networks produce more accurate predictions for survival than standard neural networks, etc.

**Functional Models :-** Functional models are integrated models of healthcare which are an individualized, patient-led, science-based approach that asks how and why illness occurs and practitioners work together to address the underlying causes of disease and promote optimal wellness. They use a multi-disciplinary approach to treatment They focus on chronic conditions and alternative medicines or treatments. Examples of functional medicine are acupuncture, naturopathy, massage, chiropractic medicine, osteopathic medicine, body movement therapies, tai chi, and yoga.

**Concurrent Models :-** Concurrent models are also called as Parallel working models. Within this models the various activities of software development happen at the same time, for faster development and a better outcome. This model is applicable to all types of software development operations. It is simple for understanding and use. It gives immediate feedback from testing. It provides an precised picture of the current state of a project. The concurrent process model is often used as the prototype for the development of client/server applications. A client/server system is composed of a set of functional components. When applied to client/server, the concurrent process model defines activities in two dimensions a system dimension and component dimension.

**Types:- (Based on their phases)**



**Signal/Collect Model** - Signal/Collect programming model is that computations are executed on a graph, where the vertices are the computational units that interconnect by the means of signals that flow along the edges. All computations in the vertices are accomplished by collecting the incoming signals and then plotting the neighbours in the graph.

**Pin/Slide Model** – It is a model having a pin and a slide which are used in computational purposes.

**Push/Pull Model** – By name, it suggests that it is a model which is based on pushing and pulling which helps doing its work.



**BSP Model** - The bulk synchronous parallel (BSP) abstract computer is a bridging model for designing parallel algorithms. It is alike to the parallel random access machine (PRAM) model, but unlike PRAM, BSP does not take communication and synchronization for granted.

**GAS Model** – They are used for gas exchange in human lungs. It transports gas in the lungs by heterogeneous lung ventilation during the breath.

**PSW Model** - The program status word (PSW) is a register that performs the function of a status register and program counter, and sometimes more.

### COMPUTATIONAL BIOLOGY:-

Computational biology is a branch of biology that involves the applications of computers and computer science to the understanding and modeling of the structures and processes of life.

Computational biology involves the development and application of data-analytical and theoretical methods, mathematical modeling and computational simulation techniques to the study of biological, ecological, behavioural, and social systems. The field is broadly defined and includes foundations in biology, applied mathematics, statistics, biochemistry, chemistry, genetics, genomics, computer science, ecology, evolution, etc, but it is most commonly used as the intersection of computer science, biology, and big data. Bioinformatics began to develop in the early 1970s. A few years back, it was known for the science of analysing informatics processes of various biological systems but now it is all about research in artificial intelligence using networking models by the help of human brain in order to generate new algorithms. Biological data is used to develop other fields, biological researchers visit the idea by using computers to evaluate and compare large data sets. By 1982, information was being shared among researchers by using punch of cards. The amount of data being shared began to grow rapidly by the end of the 1980s. This required the development of new computational methods in order to quickly analyse and interpret relevant information. The Human Genome Project, began officially in 1990 and was technically completed by 2003. Since the late 1990s, computational biology has become an essential part of developing emerging technologies for the field of biology, leading to the development of a number of subfields. As of today, the International Society for Computational Biology (ISCB) recognizes 21 different Communities of Special Interest (COSIs), each of these represents a larger field of computational biology. In addition to helping sequence the human genome, computational biology has helped and continues to help create accurate models of the human brain, map the 3D structures of genomes and assist in modeling biological systems.

Computational biology is much vast and it is divided in several fields:-

- Anatomy - It focuses on the anatomical structures being imaged.
- Bioinformatics - Computational bioinformatics consists of developing and creating databases or other methods of storing, retrieving, and analysing biological data through various mathematical and computing algorithms. Usually, this process involves genetics and analysing genes.
- Biomodeling - Computational biomodeling aims to develop and use visual simulations in order to assess the complexity of biological systems.
- Ecology
- Evolutionary Biology





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- Gene Ontology – It's about understanding how individual genes contribute to the biology of an organism at the molecular, cellular, and organism levels
- Genomics - Computational genomics is a field within genomics which studies the genomes of cells and organisms.
- 3D Genomics - 3D Genomics is a subsection in computational biology that focuses on the organization and interaction of genes within a Eukaryotic Cell.
- Mathematical Biology – It is a field that uses mathematical models, analyses, and representations of living organisms to examine the systems that govern structure, development, and behaviour of and within biological systems.
- Neuropsychiatry - Computational neuropsychiatry is the emerging field that uses mathematical and computer-assisted modeling of brain mechanisms involved in mental disorders.
- Neuroscience - It is the study of brain function in terms of the information processing properties of the structures that make up the nervous system.
- Oncology – It is also called as Cancer Computational Biology. It aims to determine the future mutations in cancer through an algorithmic approach to analysing data.
- Pharmacology – It is the study of the effects of genomic data to find links between specific genotypes and diseases and then screening drug data.
- Sequence Alignment – It is the process of comparing and detecting similarities between biological sequences or genes.
- Systems Biology – It consists of computing the interactions between various biological systems ranging from the cellular level to entire populations with the goal of discovering emergent properties.

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