PHYSICS SIMULATION AND IT'S IMPLEMENTATION IN VIDEO GAME ENGINE

seminar report submitted
in partial fulfillment of the requirement for award of the degree of

Bachelor of Technology
in
Computer Science and Engineering

By

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It is certified that the work contained in the project report titled ”PHYSICS SIMULATION AND IT’S IMPLEMENTATION IN VIDEO GAME ENGINE” by ”B.MANEESH KUMAR (17UECS0079), B.S.MANEESH (17UEAG0009), K.UMA SUDAN (17UECS0773)” has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

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This project report entitled (PHYSICS SIMULATION AND IT'S IMPLEMENTATION IN VIDEO GAME ENGINE) by B.MANEESH KUMAR (17UECS0079), B.S.MANEESH (17UEAG0009), K.UMA SUDAN (17UECS0773)) is approved for the degree of B.Tech in Computer Science & Engineering.

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ABSTRACT

In the current world, the development of science and technology has become a part of humanity's lifestyle and way of regular living and when it comes to recent several decades every inventions and development i.e. (Space exploration, Automobile, video games, etc.) are a resultant of accuracy and precision over the computer physics simulation which was lacking during the 90s due to absence of the computer's software. simulation can be defined as a process of mathematical modelling executed on a computer system which is intended to predict the properties, attributes,behavior of and therefore the outcome of a real-world or hypothetical systems. Due to such simulation, It was and is possible to save a large amount of money and time by pinpointing the errors, exception, and problems to have occurred during the simulation itself and sorting them out then and there itself.

Since they are able to verify reliability and efficiency of chosen mathematical models, simulations have become a necessary tool for important mathematical modeling of many natural systems in physics including fields such as astrophysics, climatology, chemistry, biology and manufacturing, also as human systems in economics, psychology, social science, health care and engineering Simulation of a system is represented because the running of the system's model. It can be used to explore and gain new insights into new technology and to estimate the performance of systems too complex for analytical solutions. This Seminar gives an brief introduction about physics simulation, How it works, basic functions and working of an game engines.

Keywords: computer physics simulation ,mathematical modeling, analytical solutions, game engines.

LIST OF FIGURES

LIST OF ACRONYM AND ABBREVIATION

2D	2nd Dimension
3D	3ed Dimension
CD	Collision Detection
FX	Effects

Contents

Chapter 1

INTRODUCTION

1.1 Introduction

Simulation is used in many contexts such as simulation of technology for performance ,optimizing,safety, testing, training, education analyzing engineering safety , and video games. often, Simulation is also used with scientific modelling of natural systems or human systems to obtain an good insight into their functioning. Simulation are often used to point out the eventual real effects of other conditions and courses of action. Simulation is also used when the important system can't be engaged, because it's going to not be accessible, or it's going to be dangerous or unacceptable to interact , or it's being designed but not yet built, or it's going to simply not exist. Key issues in simulation include the acquisition of valid source information about the relevant selection of key characteristics and behaviors, the utilization of simplifying approximations and assumptions within the simulation, and fidelity and validity of the simulation outcomes.

1.2 Aim of the Seminar

The scope of this seminar is to explain the basic functions of video game engine and it's functionality. To provide a clear understanding

of physics applied over the game objects to express it's behavior undergoing all the natural physics laws.

1.3 Scope of the Seminar

This seminar will provide an overall idea of how video game engine works with the physics engine built in it to express real life physics behavior and also will give a deeper understanding of different types of game objects .

1.4 Methodology

The game engine is the heart of a game and consists of several components. shows the common architecture of a game engine which consists of five major components: the authoring tool, the physics engine, the rendering engine, the user interface (UI), the audio engine, and the authoring tool. The physics engine, as mentioned above, is responsible for the computation of physics.It handles the mathematical functions to simulate physics; however it does not know what needs to be simulated.A typical physics engine partitions the physical simulation into two phases: collision detection and multibody dynamics. Collision detection is the process that determines contact behaviors between objects, while multibody dynamics calculates the dynamical motions of objects which are connected with each other by joints or exist independently. Both are based on mathematical methods that are derived or modified from physical laws.

1.5 Architecture of an Game engine

The game engine is the heart of a game and consists of several components. shows the common architecture of a game engine which consists of five major components: the authoring tool, the physics engine, the rendering engine, the user interface (UI), the audio engine, and the authoring tool. The physics engine, as mentioned above, is responsible for the computation of physics.It handles the mathematical functions to simulate physics; however it does not know what needs to be simulated. A typical physics engine partitions the physical simulation into two phases: collision detection and multibody dynamics. Collision detection is the process that determines contact behaviors between objects, while multibody dynamics calculates the dynamical motions of objects which are connected with each other by joints or exist independently. Both are based on mathematical methods that are derived or modified from physical laws. The goal of a rendering engine is to draw a 3D world and display it on the screen. The work of the rendering engine are often described by three main parts . The first part is to rework 3D data of game objects into 2D data in screen space, which incorporates two transformations. In the first transformation, the engine converts 3D data in the game world into 3D data in the coordinates of the view world, which is associated with the camera in the game world. It decides which view will be seen by the player on the screen. The second transformation converts 3D data of the view world into 2D data within the screen world. This process is called projection. In the projection, the 2D data is formed available to be drawn as pixels on the pc screen. The second a part of the rendering work is to exclude portions of the info which are invisible to the player. This process includes culling and clipping, which can decrease

the computational costs of a rendering engine. The third part is to draw the 2D data within the screen space onto the pc screen. This process is called rasterization, which takes up most time of the time spent in rendering. The rasterization process decides the displayed colors of the pixels through the calculation of several shading effects, including materials, textures, lighting, specular effects, transparency, ray mirror, and other special functional effects. The function of the audio engine component is to get sounds while the sport is running. Audio can be extremely important for a game's atmosphere, and can heighten player satisfaction and enhance the quality of a game. This audio can include recorded sounds, interface sounds, and sound effects . For example, voices and background music are recorded sounds, while button clicks are a kind of interface sound, and explosions and sounds of brakes are sound effects (FXs). To generate these sounds, an audio engine has got to load, edit, and blend the sound data. An audio engine is usually provided with several functions to generate game audio, such as playing, mixing, 3D sound (stereo effects), the Doppler effect and the fading-out effect. The component that represents interaction between game objects and a player is named the interface (UI) which may be separated into invisible interfaces and visual interfaces . The invisible interfaces are the UIs which have no on-screen features; for instance, control triggers using a mouse or keyboard, which can be used to select, move items, navigate in a virtual environment, operate character movements, communicate with non-player characters etc. The visible interfaces are the UIs that have on-screen features, such as selective menus, the health meter of a character, and any other on-screen information that is provided for the player. The physics engine, the rendering engine, the audio engine, and therefore the UI are the essential components required to develop a sensible physics-based simulation

or virtual environment. Some frameworks of integrated development environments (IDE), such as XNA (Microsoft, 2008), provide an integrated library for utilizing these four components to develop their simulations or games. However, these still need good programming skills and energy to create up a strong and stable simulation system. Therefore, so as to assist game designers avoid taking an excessive amount of effort and time in developing the complex foundation and structure of a game program, advanced game engines provide authoring tools. The game designers just got to load the sport content (3D models, textures, or sounds), specify parameters, and style the sport logic via this authoring tool. This allows game designers to use straightforward commands or actions to order the sport engine to execute detailed programming jobs. Thus, the game designers can spend their time on more relevant parts.

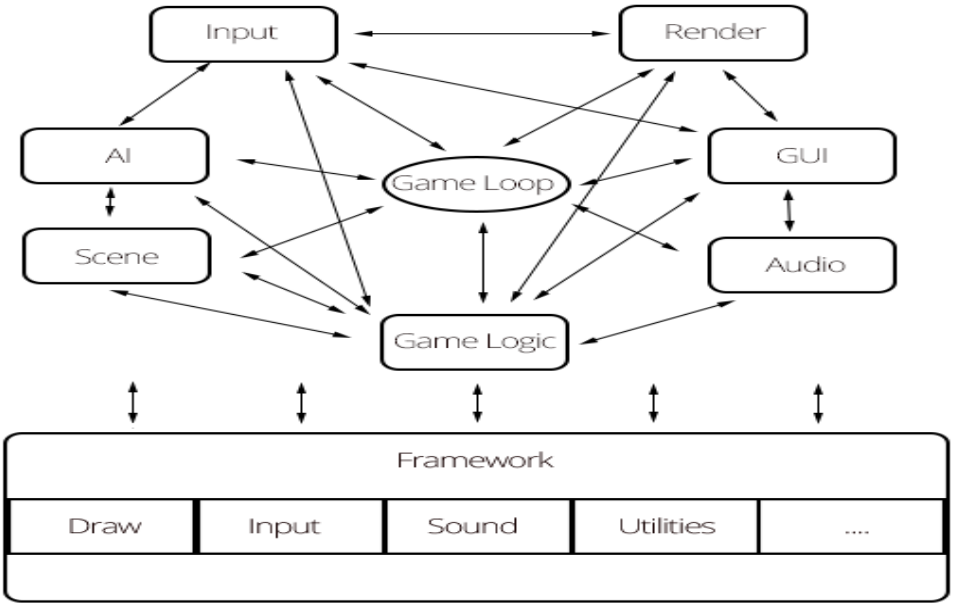

Figure 1.1: Architecture of an Game engine

Chapter 2

LITERATURE REVIEW

a)Games are Designed to Increase Students' Motivation in Learning Physics-V Tinedi1, Y Yohandri1, D Djamas1 Physics Department, Universitas Negeri Padang, Jl. Prof Dr. Hamka Air Tawar, Padang, Sumatera Barat 25131, Indonesia(2018)

As per the survey done up till now, most of the people are trying to analyse the aspects on how the Augmented reality is working and more than 47k websites are working on the updates of current situation to help everyone learn more about Augmented reality. Developers have given innovative ideas on the application of Augmented reality with multiple techniques using Video games engines, visual holograms and Native mobile Applications. With current literature on the virtual model environmental interactions analysis of Augmented reality people are headed towards the more real life applications over many cross platform executable files.

b)Game-Based Learning of Physics Content: The Effectiveness of a Physics Game for Learning Basic Physics Concepts Aroutis N. Foster foster74@msu.edu,Matthew J. Koehler mkoehler@msu.edu ,Punyashloke Mishra punya@msu.edu Learning, Technology Culture College of Education,Michigan State University(2006)

Video game industry is an great pioneer of the 20th century and an

leadin force ion the start of the twenty first century. Developers have given innovative ideas and various ways to implement virtual reality and augmented reality to enable an user interactive and competitive world. It hold great potential in future markets and is an promising field destined to revolutionise the entertainment industry into an highly innovative and competitive for the future.

c)Zhang, J., Chen, Q., Reid, D. J. (2000). Simulation-based scientific discovery learning: A research on the effects of experimental support and learners' reasoning ability.

The video games industry is one of the most successful and vibrant industry to flourish in the late 20th century. With the dawn of the 21th century video games give out new and interesting aspects of computer technology to explore and develop. One such field is Augmented reality . It provides the basis required to bring the distinct virtual and real worlds together.

Chapter 3

SEMINAR DESCRIPTION

3.1 Existing System

Physics simulation is the study of scientific problems using computational methods; it combines computer science, physics and applied mathematics to develop scientific solutions to complex problems. Physics simulation assists the areas of theory and experimentation in traditional scientific investigation. It has been successfully applied to areas such as material science, molecular modeling, protein folding, aerodynamic design atmospheric science, and testing,electronic circuit design, nanotechnology and many more. When big-shot companies and engineers put there trust excepting a perfect simulation from a computer; Applied physics plays a major role to get a precise output very much similar to real-world experimental results over the considered situation. this is possible by taking in multiple-input parameters i.e.(gravity, force, air pressure, and many other physical parameters)applying all of them over the computer simulation environment to work as it works in the real-world situation and to make the object experience as in the real world.

Advantages

Advantage is that the Physics simulation helps in computerised prototyping any simulation in free of cost and time,Many industries and company along space agency are using to test their projects.

Disadvantages

Disadvantage is that the Physics simulation are not always work with high precision its always ends up with a minimum amount of error.The complex the construction begins the higher the risk of failure and unknown error to be raised.

3.2 Feasibility Study

A physics engine is computer software that gives an approximate simulation of certain physical systems, like Rigid body dynamics, Rag doll mechanics, Soft body dynamics, Particle system, Fluid dynamics, Projectiles. It is of use in the domains of computer graphics, video games, and film. Their main uses are in video games and in 3D animation software in which case the simulations are in real-time. The term is sometimes used more generally to describe any software system for simulating physical phenomena, such as complex mathematical simulations and to enable an physical representation.Computer animation physics or game physics involves the introduction of the laws of physics into an simulation engine, particularly in 3D special effects , for the aim of creating the effects appear more realistic to the observer. An simulation can only be a close approximation to actual physics as computation is performed using discrete values and obtaining precise values is almost impossible even with our modern day

equipment. Additionally, games may intentionally deviate from actual physics for gameplay purposes; a standard example is allowing the player to double jump when there's nothing to leap off of. There are several elements that form components of simulation physics including the physics engine, program code that's wont to simulate Newtonian physics within the environment, and collision detection, used to solve the matter of determining when any two or more physical objects within the environment cross each other's path. An Physics Engine applies complex concepts abstracted in form of game physics. It is used to simulate complex scenarios to render an realistic output. The simulation is further used for making scientific products or entertainment products.

Chapter 4

METHODOLOGIES

4.1 Rigid body dynamics

Rigid-body dynamics studies the movement of systems of interconnected bodies under the action of external forces. The assumption that the bodies are rigid, which suggests that they are doing not deform under the action of applied forces. It further simplifies the analysis of the body by reducing the parameters that describe the configuration of the system to the interpretation and rotation of reference frames attached to each body and can be treated as an single cohesive body. it excludes bodies that display either fluid,elastic or plastic behaviour Rigid bodies do not really exist in the physical world as no what body is taken it can be broken down into its components with closer inspection. But while calculating with that assumption gives an almost negligible result than if you do otherwise. Rigid body Dynamics can be further derived from using laws of motion by newtons theories or Lagrangian mechanics.

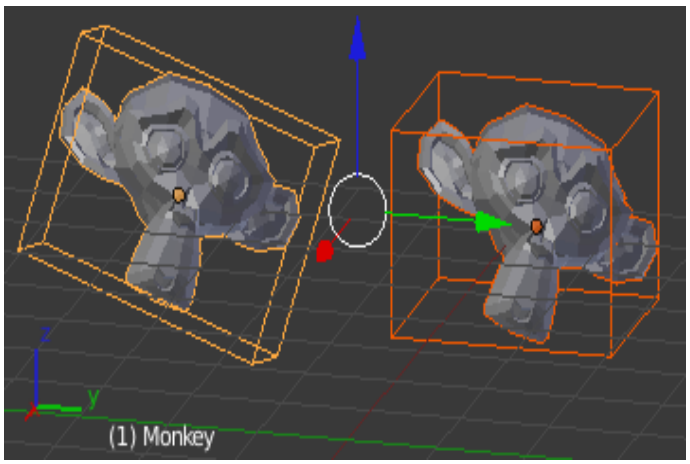

Figure 4.1: Rigid body

4.2 Soft Body Mechanics

Soft-body dynamics may be a field of graphical physics that focuses on visual simulation of the motion and properties of deformable objects. Unlike Rigid body these are too loosely bound and can not be assumed as rigid body as it would make an visible impact while representing mathematically. They are mostly used in video games and films. Unlike in simulation of rigid bodies, the form of sentimental bodies can change, meaning that the relative distance of two points on the thing isn't fixed. Although the relative distances of points are not fixed, the body is expected to retain its shape to some degree like various fluids. soft body dynamics is generally used for many purposes including simulation of soft organic materials such as muscle, fat, hair and vegetation, as well as other deformable materials such as clothing and fabric. Generally this model only provide visually plausible simulations instead of accurate scientific simulations due to the ineffeciant values taken as input.Although there is an large overlap

Figure 4.2: Soft Body

4.3 Fluid mechanics

Fluid mechanics is that the branch of physics concerned with the mechanics of fluids (liquids, gases, and plasma etc) its dynamics , its properties and therefore the forces acting upon them. Fluid mechanics is essential to understand the nature, dynamics and the forces acting upon an non solid loosely connected body. It are often divided into fluid statics the study of fluids at rest and fluid dynamics the study of the effect of forces on fluid motion. Fluid mechanics, especially fluid dynamics, is a lively field of research, typically mathematically complex. Fluid Mechanics is used to simulate the nature of various kinds of fluids like liquids , gases and even plasma.They are generally used to simulate for scientific clarity for research purposes or to create assets and its behaviour in hyper realistic games.

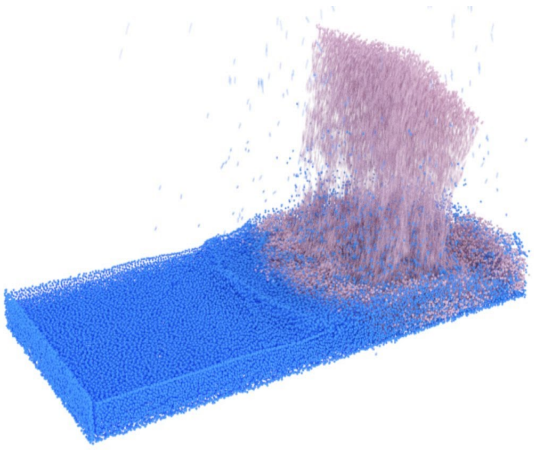

Figure 4.3: Fluid mechanics

4.4 Particle system:

A particle system is a technique in game physics and computer graphics that uses many minute sprites or 3D models to achieve what can not be done using conventional rendering. In Particle system these small models are generated simultaneously in lange quantity and are made to move is an almost chaotic way. They are generated from an single point called the emitter.typically a particle system's position and motion in 3D space are controlled by what is referred to as an emitter.The emitter acts as the source of the particles, and its coordinates determines where they are generated and where they move to. A regular mesh such as a can be used as an emitter to generation purposes. The emitter has attached to it a set of physical behavior parameters that determine the nature of the particles. The emitter further is used to generate an large number of similar objects and make them grow in indefinite ways. It is used to generate skin,muscle,hair,grass growth etc

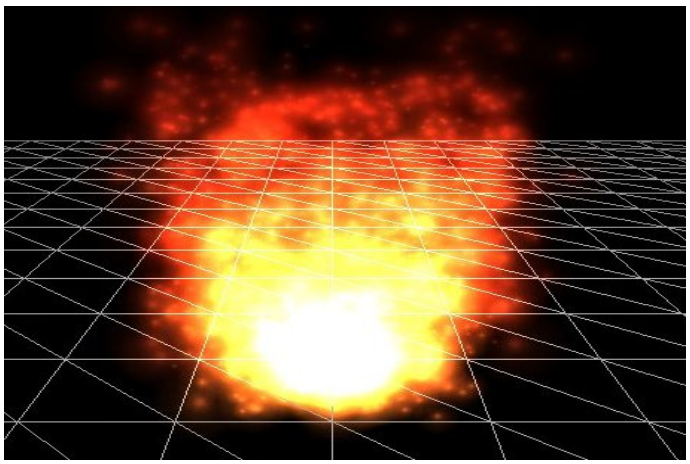

Figure 4.4: Particle system

4.5 Rag doll Mechanics

Rag doll mechanics can be described as the study and application on how physical values act on an regular ragdoll .an ragdoll is an humanoid doll and can be used within an system to simulate an human beings behaviour. An Ragdoll can be subjected to external forces such as gravity , fiction, collisions etc and also can exert internal forces to move each of its components is an desired way.Ragdolls can also be enabled to customized physics for extra features . Ragdolls can come in all shape an size and it is also possible to modify them using external skins and assets.

Figure 4.5: Rag doll Mechanics

4.6 Projectiles

A projectile is any object thrown into space by application of force .Although any object in motion through space could also be known as a projectile.An projectile is usually parabolic in shape Mathematical equations of motion are wont to analyze projectile trajectory. An projected object is observed for an angle to the horizontal has both the vertical and horizontal components of velocity. The vertical component of the velocity on the y-axis given as Vy=USin(a) while the horizontal component of the velocity Vx=UCos(a). .(a being the angle of the applied vector)

Chapter 5

RESULTS AND DISCUSSIONS

5.1 Anatomy of an Physics Engine

An Physics engine is an important component in an game engine and in other simulation software such as blender,box2d etc. The actual designs and implementations of physics engines obviously differ so it is hard to discuss them in general, but it is possible to isolate typical or most common elements which can expected to appear in contemporary solutions. In the coarsest terms, the two main modules that can be easily distinguished are those responsible for collision detection (CD) and simulation. This distinction is fairly natural if one takes into account there are standalone collision detection libraries which can be obviously used in a variety of applications but are most commonly utilized by simulation libraries. Moreover, collision detection and simulation are actually two very different subjects: the former is a purely geometric problem while the latter is concerned with mathematical modeling of motion.

5.2 Collision Detection Module

The core task of the collision detection module is to supply the information about the existence and properties of interactions between the geometric shapesdescribing the simulated objects. For the CD module to work properly, the simulation module needs to provide it with the current positions and orientations of the objects. The CD process is usually divided into phases broad phase during which bounding boxes or spheres, octrees, hierarchical hash tables and similar methods are applied to discard pairs for which the coarse-grain test is enough to authoritatively state that the objects forming it are not intersecting narrow phase during which fine-grain (and thus more computationally demanding) tests are performed but only among the pairs that have survived the broad phase Finally, CD module can provide spatial-temporal coherence analysis which isolates independent contact groups within the overall system and exploits caching which can leverage the efficiency of the CD process itself but it is also becoming more an popular to use the information inside the simulator.

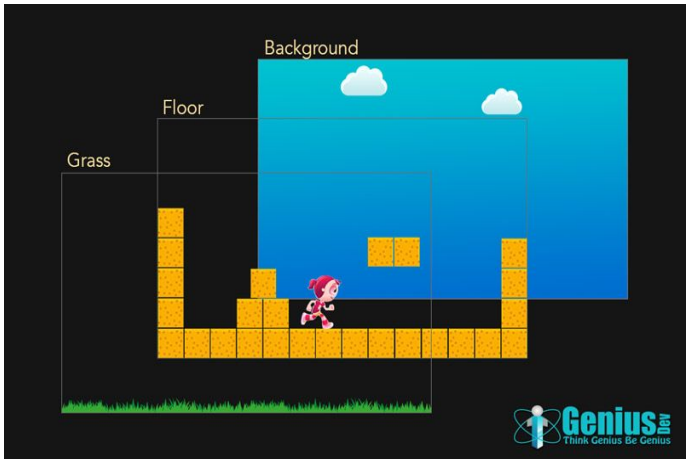

Figure 5.1: Collision Detection

5.3 Simulation Detection Module

The simulation module uses the information about the objects system such as their inertial properties, current configuration and velocity along with the information about the nature of their current interactions to step the system forward in time. Interactions between the objects make their motion inter-dependent, e.g.if the CD reports that two rigid bodies are touching, simulation module needs to restrict their motion so that they do not penetrate into each other when stepping the time forward. If such interactions are present within the system, we call it a constrained system, in their absence we say that the system is unconstrained.

Chapter 6

CONCLUSION AND FUTURE ENHANCEMENTS

6.1 Conclusion

In this seminar we have demonstrated an basic working of many fundamental concepts of physics and their implementation using an game engine. The physics engine remains to be an milestone in scientific research and is prevalent in fields such as astronomy and constructions. The future holds much more potential for simulations and for video game industry in general

6.2 Future Enhancements

Physics Simulation and mathematical modeling have been of great use for us in the past century and has enabled us to create and understand many kinds of problems. Simulations and modeling have also revolutionized the animation and video game industries. The future holds even greater usage of physics simulations in both research and consumer fields. With increase of processing power and the introduction of remote processing With the discovery of new theories simula-

tion has been an essential tool for understanding concepts of increasing complexities. simulations also play an major role in the emerging markets of augmented reality and virtual reality to make it more user interactive.

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