Physics of the Digital World

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Abstract

Jumping, friction, gravity, inertia, and other concepts are things we're used to experiencing in real life, so we assumed that it's normal to have them in video games as well. However, it took developers decades and billions of dollars to develop these concepts with such resemblance to our current world. As a result, physics became an important part in enhancing the gaming industry and propelling it to the top of the increasing worldwide market, making physics a critical pillar in any upcoming game. In fact, several games, such as *Portal* and *TABS*, rely on physics as their primary gameplay style. In this paper, we will examine the history of game physics, some of its divisions, and the method of integrating it in a game using a few examples.

1 Introduction: History of Game Physics

1.1 The Origin

The beginning was with a black screen containing two white rectangles and a circle: *Pong*. built and released in 1972, *Pong* was a digital form of ping-pong that is believed to be the game that inaugurated the video game era, but it was also the first to implement **physics**. The calculations in *Pong* are simple: limited, in fact, to determining the direction at which the projectile should bounce given its arriving direction using a set of rules that only loosely approximate the actual physics involved. Speed is not even a consideration because it is increased independently throughout a match to boost intensity and difficulty.[Mel].

1.2 Adding Physics to Objects

Fast-forward to 1998, and game physics took another groundbreaking step, under the name of *Jurassic Park: Trespasser*. Although that game was not a huge hit, it was a significant contributor to game physics. For example, the irritating stuck-to-the-ground barrels in *Jurassic Park: Trespasser* were given physical attributes that allowed players to move, knock, or throw them like real-life barrels. More interestingly, that game was the originator of the now-famous **Ragdoll** principle: make animations depicting a character's death or when a character picks up a limp object[Bro09]. It also contained a gaming engine that could detect weight, gravity, direction of impact, and other characteristics and use them to simulate the physics of an object.

1.3 Interactions with the Environment

In 2001, games started responding to players demands and send interaction with the environment on a whole new level. *Red Faction* gave players the ability to demolish walls, dig tunnels with C4, and destroy a whole building. Then came *Far Cry* in 2003 to continue where *Red Faction* stopped. It made the players use fragile ceilings and explosive barrels to defeat enemy camps.

1.4 Further Improvements

More game companies and developers started to focus more on physics and developing game engines that analyze various variables and calculations in the process of simulating physics. *Half Life 2*, for example, was influenced by *Trespasser* project and added provided more physics by taking speed and density in account and designing physics for water and floating objects. Other games added trees, physics to car body and tires, and tearable cloths.

2 Implementations

2.1 By Game Engines

First, game developers don't usually write complex physics formulas in their games. They rely on pre-made physics engines, or extensions, for the software package that they are using, to supply the physics for the game. An engine or extension is essentially a library of commands and functions that a developer adds to the software to accomplish different kinds of action. One of these pre-made physics laws is **Real-time Light**. Players can look at an object from multiple angles, and more will often be performing all sorts of different actions. Next to that, direct and indirect light - light reflected from other objects - should be put in consideration. To generate dynamic lighting, create realistic shadows, and properly lit environment props, the game engine calculates all the light vectors and the effect of the mentioned variables on them during the gameplay[Wri].

2.2 By Developers

In some games that uses physics as a main aspect of the gameplay or add more complicated principles to improve the players' experience, game developers start adding mathematical formulas and laws to simulate their goal. However, in this process, game developers tend to use the pre-made physics by the engine in their calculations to make the process easier and faster. To illustrate, let's look at *Portal*, a game in which you play as a test subject that uses a portal gun to solve puzzles and advance to the next levels. From the known moves in this game is to make a portal on the ground and another on the wall, so, once you jump in the first portal, your velocity due to gravity becomes horizontal and give you a boost[Bri18], figure 1 visualize the move.

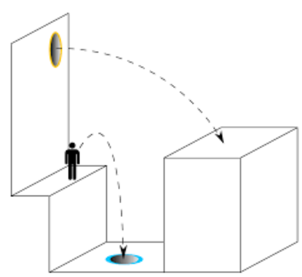

Figure 1: Demonstration of the physics of jumping from one portal into another

This is simply done by calculating the velocity of the player in the negative Y-axis due to gravity, which is pre-made by the engine, and then swap it with the positive Z-axis so that the speed becomes horizontal and shoots the player forward. The player will not keep this going for long, however, as the previously mentioned world gravity will slowly accelerate the player towards the ground again. This is also where the air resistance comes into play. As the player flies forwards through the air, they will slowly start to lose their forward momentum.

3 Physics in Animations and Simulations

Other than video games, physics played additional roles in the digital world. One of these positions is in animation, which is a lot like video games. In animations, physics is utilized to mimic the unexpected motion of objects or motion that would be hard for developers to animate accurately. Most water surfaces, for example, were developed with physics that included waves, reactions for outside interactions, and density to float/sink items, making them nearly equal to their real-life counterparts. Projectiles are another example. Because measuring the impact force, direction, and point of contact for each object that was near an explosion, for example, will be difficult and time-consuming. Furthermore, virtual physics opens up a great educational approach. It has the potential to transform lecture-based classrooms into more enjoyable, interactive experiences that facilitate understanding of complex subjects and push students to study and explore. Developers can use virtual physics to create simulations of aerodynamics, gravitational forces between planets, or black holes, as well as variables that students can change and study the consequences on the simulation. Such simulations and animations will be crucial for education in schools and regions with limited access to visual demonstration technologies. They will also aid in the understanding of phenomena that cannot be seen with human eyes, and as virtual and augment realities advance, Mixed Reality (a blend of physical and digital worlds, unlocking natural and intuitive 3D human, computer, and environmental interactions.) will make invaluable contributions to STEM fields[Mil95].

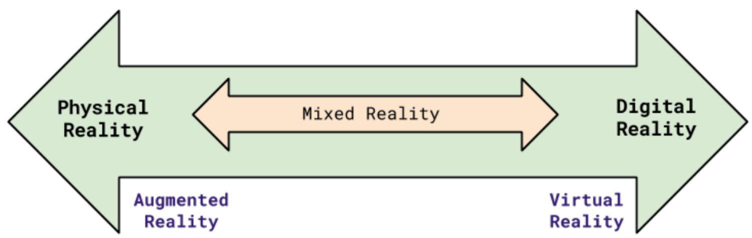

Figure 2: Visualization of the Mixed Reality concept

Mixed reality has promising potential since it enables the creation of three-dimensional (3D) interactive learning environments that allow users to interact with and alter the virtual environment. Traveling to space and studying galaxies can be a common daily-activity in physics classes.

4 Conclusion

In conclusion, from the few angle calculations in *Pong*to the creation of dynamic light or portal effects, digital world physics has continued to improve and become nearly as realistic as real world physics. Whether handled by gaming engines or developers, physics became a crucial foundation with varied contributions that drove it to the next level. Using it in association with video games and Mixed Reality will also be a game changer for Stem disciplines, as it will aid in training young scientists while also assisting adult researchers in their study by anticipating data and displaying phenomena.

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