

# Physically-Based Animation in Performing Accuracy Bouncing Simulation

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**Abstract**—This study investigates the use of physics formulas in achieving plausible bouncing simulation in animation. The need for physics animation was to produce visually believable animations adhering to the basic laws of physics. Based on the review, the creation of accurate timing simulation in bouncing dynamic was significantly difficult particularly in setting keyframes. It was comprehensible that setting the value of keyframes was unambiguous while specifying the timing for keyframes was a harder task and often time-consuming. The case study of bouncing balls' simulation was carried out in this research and the variables of mass, velocity, acceleration, force, and gravity are taking into consideration in the motion. However, the bouncing dynamic is a significant study in animation. It is often used and it shows many different aspects of animations, such as a falling object, walking, running, hopping, and juggling. Therefore, the physical framework was proposed in this study based on numerical simulations, as the real-time animation can be addressed for controlling the motion of bouncing dynamic object in animation. Animation based physics algorithm provided the animator the ability to control the realism of animation without setting the keyframe manually, to provide an extra layer of visually convincing simulation.

**Keywords**—Bouncing simulation; physics algorithm; physics animation; real time animation; animation

## I. INTRODUCTION

The concept of physically based in animation has been long established by Disney artists through “The Twelve Basic Principles of Animation”. The main purpose of the twelve basic principles was to produce more realistic animations adhering to the basic laws of physics [1]. In the context of 3D computer animation, realistic timing is extremely important to add a life-like quality to animate objects and give the animation some real-world authority. The proper timing is crucial to make the ideas readable. Consequently, animation artists carefully study the motion of the objects by adding quality and accuracy to generate realistic-looking animations. Thus, the concept of applying the laws of physics in animation has further gained importance to generate an accurate timing animation, and there is a need for consideration of physics motion in this field.

The concept of physics motion can be interpreted with the principle of bouncing ball simulation. The bouncing ball is the most basic and one of the most important animation exercises. Bouncing ball simulation causes the natural factors of motion, velocity, acceleration, mass, gravity, friction, elasticity, or

squash and stretch, and timing. Hence, this concept of a bouncing ball is often used in the animation as a reference because it integrates several fundamental concepts that animators apply to just about everything they animate. The author in [2] also explained, bouncing ball is a common model for numerous rhythmic tasks such as walking, running, hopping, and juggling, and it has been an extensive study which provides a theoretical basis for control of such rhythmic tasks in animation. Last but not least, realistic bouncing ball simulation showed the significance in the animation that a lot of physical measurements are required. Plus, timing an animation is often the most difficult part to set the spatial values of the keyframe in achieving realistic simulation. Most of the users are unable to imagine the timing and convey it using the provided interfaces. Therefore, the physics-based approach is a well-adapted concept to simulate believable animations. Based on the physical motion regarding numerical simulations framework, the animator is provided with the ability to control the realism motion of simulated object without setting the keyframe manually, by adding an extra layer of visually convincing animation. Hence, the different section of introduction, literature review, analysis physics motion of bouncing simulation, physics motion, real time dynamic bouncing ball, result and findings, implication, discussion, and conclusion are discussed in this paper.

## II. LITERATURE REVIEW

### A. Concept of Physically based Animation

Physically-based animation has emerged as a core area of computer graphics finding widespread application in the film and video game industries as well as in areas such as virtual surgery, virtual reality, and training simulations [3]. With the advance production technology, it allows designers to create animation by their own will with the greatest degree of freedom, but the products of the technology are not very good in terms of natural performance [4]. In order to fit into the current trend of fast increase of computer processing and user experience, physically-based animation is a well-adapted concept to simulate the realistic-looking animations with self-controllable performance. According to [5], the physics-based approach uses the law of physics to simulate motion and interaction with the environment. In his study, he pointed out a complete and effective system for animation should integrate key-framing and physics-based techniques. Key-framing allows objects or characters to perform unnatural tasks.