PERFORMANCE OF TIME BASED ANIMATION
ON PHYSIC MOTION

Loh Ngiiik Hoon

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PERFORMANCE OF TIME BASED ANIMATION ON PHYSIC MOTION

LOH NGIIK HOON

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with regulations of Universiti Malaysia Sarawak. It is original and is the result of my work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted at Universiti Malaysia Sarawak or to any other academic institution or non-academic institution for any other degree or qualification.

Name of Student : LOH NGIIK HOON
Student ID No : 10021674
Programme Degree : MASTER OF ARTS (ANIMATION)
Faculty : FACULTY OF APPLIED AND CREATIVE ARTS
Thesis Title : PERFORMANCE OF TIME BASED ANIMATION ON PHYSIC MOTION

Signature of Student : 
Date : 5.2.2013
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TABLE OF CONTENT

CONTENT | PAGES
---|---
AUTHOR'S DECLARATION | ii
ACKNOWLEDGEMENT | iii
TABLE OF CONTENTS | iv
LIST OF TABLES | ix
LIST OF FIGURES | x
ABSTRACT | xv
ABSTRAK | xvi

CHAPTER 1: INTRODUCTION

1.0 Overview | 1
1.1 Background of Research | 1
1.2 Problem Statement | 8
1.3 Research Questions | 10
1.4 Research Objectives | 10
1.5 Hypothesis | 11
1.6 Research Scope | 11
1.7 Significance of Study | 12
1.8 Limitations | 13
CHAPTER 2: LITERATURE REVIEW

2.0 Overview

2.1 Literature Review

2.1.1 Realistic Animation

2.1.1.1 Summary of the Principles and Factors for Generating Realistic Animation

2.1.2 Concept of Physically based Animation

2.1.2.1 Summary of the Concept of Physically Based Animation and the Methods, Models and Techniques used in Physically Based Animation

2.1.3 Bouncing Ball Animation

2.1.3.1 Concept of Bouncing Ball Animation

2.1.3.2 Application of Concept Bouncing Ball

2.1.3.3 Techniques on Drawing Bouncing Ball

2.1.3.4 Physics Motion for Bouncing Ball

2.1.4 Real Time

2.1.5 Algorithm Animation

2.2 Conceptual Framework

2.3 Summary
CHAPTER 3: METHODOLOGY

3.0 Overview

3.1 Primary Data

3.1.1 Observation

3.1.1.1 Non-participant observation on undergraduate animation students

3.1.1.2 Participant observation in the field of Information technology (IT) Company

3.1.2 Interview

3.1.3 Video Observation Study

3.1.4 Experiments

3.1.5 Validation

3.2 Secondary Data

3.3 Research Process

3.4 Summary

CHAPTER 4: FINDINGS AND DISCUSSION

4.0 Overview

4.1 Physic Animation Development Process

4.1.1 Real World

4.1.1.1 Video Observation on Bouncing Ball Animation
4.1.1.1 Publication of TV Commercial Animation Cartoons
4.1.1.1.2 Standard Bouncing Ball Animations Done By Undergraduate Student
4.1.1.2 Video Observation on Real Motion of Bouncing Ball
4.1.1.3 Comparison of Animation and Real Motion on Bouncing Ball’s Dynamics
4.1.2 Summary of Video Analysis
4.1.3 Physics Motion model
4.1.4 Summary of Physics Motion Model Analysis
4.1.5 Physics Motion Solution
4.1.6 Final motion
4.1.7 Summary of Final Motion
4.2 Software Development Process
4.2.1 Model World
4.2.2 Autodesk Maya
4.3 Application and Evaluation
4.4 Summary

CHAPTER 5: CONCLUSION
5.0 Overview
5.1 Finding Model
5.2 Summary of Research
5.3 Contribution of Research
5.4 Recommendations for Future Research

REFERENCES
APPENDIX A
APPENDIX B
APPENDIX C
APPENDIX D
APPENDIX E
APPENDIX F
APPENDIX G
APPENDIX H
### LIST OF TABLES

<table>
<thead>
<tr>
<th>CONTENT</th>
<th>PAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHAPTER 2: LITERATURE REVIEW</strong></td>
<td></td>
</tr>
<tr>
<td>Table 2.1: Summary of the Principles and Factors for Generating Realistic Animation</td>
<td>17</td>
</tr>
<tr>
<td>Table 2.2: Summary of the Concept of Physically Based Animation</td>
<td>26</td>
</tr>
<tr>
<td>Table 2.3: Summary of the Methods, Models and Techniques used in Physically Based Animation</td>
<td>28</td>
</tr>
<tr>
<td><strong>CHAPTER 4: FINDINGS AND DISCUSSION</strong></td>
<td></td>
</tr>
<tr>
<td>Table 4.1: Summary of Dynamic Bouncing Ball Animation</td>
<td>78</td>
</tr>
<tr>
<td>Table 4.2: Summary of Physics Motion Model for Dynamic Bouncing Ball</td>
<td>86</td>
</tr>
<tr>
<td>Table 4.3: Summary of Physics Motion Model for Measuring Realistic Bouncing Ball’s Dynamic</td>
<td>99</td>
</tr>
<tr>
<td>Table 4.4: Comparison between Model World and Real World</td>
<td>107</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

## CONTENT

<table>
<thead>
<tr>
<th>CHAPTER 1: INTRODUCTION</th>
<th>PAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.1: The Two Basic Elements of Animation by Williams (2001)</td>
<td>5</td>
</tr>
<tr>
<td>Figure 1.2: Timing throughout a Bounce by Webster (2005)</td>
<td>6</td>
</tr>
<tr>
<td>Figure 1.3: Screen shot of setting keyframe in Autodesk MAYA software</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER 2: LITERATURE REVIEW</th>
<th>PAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 2.1: Outline of the motion-transformation process created by Popovic (2000)</td>
<td>20</td>
</tr>
<tr>
<td>Figure 2.2: A time-lapsed animation of a vertically bouncing ball produced by Chenney, Pingel, Iverson and Szymanski (2002)</td>
<td>23</td>
</tr>
<tr>
<td>Figure 2.3: The Concept of Bouncing Ball by Chris Webster (2005)</td>
<td>31</td>
</tr>
<tr>
<td>Figure 2.4: The Concept of Bouncing Ball by Whitaker and Halas (2002)</td>
<td>31</td>
</tr>
<tr>
<td>Figure 2.5: Character bounces by Whitaker and Halas (2002)</td>
<td>32</td>
</tr>
<tr>
<td>Figure 2.6: Bouncing Ball and Character Motion Path by Preston Blair (1994)</td>
<td>34</td>
</tr>
</tbody>
</table>
Figure 2.7: A Scene of Character Motion Path from Cartoon Aladdin by Walt Disney (1992) 34
Figure 2.8: Techniques Chart and Breakdown Drawing for Bouncing Ball simulation by Tony White (2009) 35
Figure 2.9: Breakdown Drawing by Tony White (2009) 35
Figure 2.10: Bouncing Ball illustration by Richard Williams (2002) 36
Figure 2.11: Bouncing Ball illustration by Chris Webster (2005) 36
Figure 2.12: The standard full Bouncing Ball illustration by Tony White (2006) 37
Figure 2.13: The Effects of Air Resistance on Projectiles by James Shipman, Jerry D. Wilson and Aaron Todd (2007) 43
Figure 2.14: Conceptual Framework 47

CHAPTER 3: METHODOLOGY

Figure 3.1: Research Process Diagram 58

CHAPTER 4: FINDINGS AND DISCUSSION

Figure 4.1: Model of Physic Animation Development Process 62
Figure 4.2: Screen shot of 2D Bouncing Tennis Ball from Disney Goofy Animation 63
Figure 4.3: Screen shot of 3D Bouncing Basketball from Speculative Golden Grahams TV commercial 65

Figure 4.4: Screen shot of 2D Bouncy Rubber ball by Undergraduate 1st Year Student 67

Figure 4.5: Screen shot of 3D Bouncy Rubber ball by Undergraduate 2nd Year Student 68

Figure 4.6: Type of Balls used in Experiment 71

Figure 4.7: Type of Floors used in Experiment 71

Figure 4.8: Screen shot of Progress Measurement on Bouncing Ball Experiment 72

Figure 4.9: The Results of Dynamic Bouncing Ball Bounce on Different Floors 73

Figure 4.10: The Results of different types of balls bounce on the same Floor 75

Figure 4.11: Comparison of frames between the real motion and animation on the bouncing ball’s deformation 77

Figure 4.12: The Ball in Vertically Downward Freefall 80

Figure 4.13: The Ball Begins to Make Contact with the Surface 80

Figure 4.14: The Ball Touches floor surface and is preparing to rebounce 81

Figure 4.15: The Ball is in the Rebounding Stage 81

Figure 4.16: The Ball Fully Rebounded and Lifted Off from the Surface 82
Figure 4.17: The Dynamics of Bouncing Ball Model

Figure 4.18: Process of Measuring and Experimenting on the Physics Motion

Figure 4.19: Measurement on the Height of Dynamic Bouncing Ball

Figure 4.20: Measurement on the Timing and Height of Dynamic Bouncing Ball

Figure 4.21: Measurement on the Timing, Height and Coefficient Bounce Height of dynamic bouncing ball

Figure 4.22: Measurement on the Timing, Height and Coefficient Bounce Height of dynamic bouncing ball

Figure 4.23: Measurement on the Timing, Height and Coefficient of Restitution of dynamic bouncing ball

Figure 4.24: Comparison of Physics Formula Data and Real Data on Bouncing Ball

Figure 4.25: Comparison of Physics Formula Data and Real Data on Different Types of Bouncing Ball

Figure 4.26: Physics factors of Dynamic Bouncing Ball

Figure 4.27: Layout of Autodesk Maya 2011 Running MEL Script

Figure 4.28: Layout of Python Script Running Physics Formula

Figure 4.29: Layout of Python Script Running Physics Formula
Figure 4.30: “Realistic Bouncing Ball” Menu Tab Created In Autodesk Maya 2011 104
Figure 4.31: Layout of Key-frames Tools in Autodesk Maya 2011 105
Figure 4.32: Process of Simulating Realistic Time Based Bouncing Ball Physics Motion 105
Figure 4.33: Simulating Physic Time Based Basketball through Created System 105
Figure 4.34: Realistic Time based Bouncing Basketball through Created System 106
Figure 4.35: System Evaluation and Validation through Student Professionals 117
Figure 4.36: System Evaluation and Validation through Professionals 117
Figure 4.37: Means of System Evaluation 118
Figure 4.38: System Validation on ‘Application’ 120
Figure 4.39: System Validation on ‘Development’ 121
Figure 4.40: System Validation on ‘Performance’ 122
Figure 4.41: System Validation on ‘Visual’ 123
Figure 4.42: System Validation on ‘Interactive’ 124
Figure 4.43: Summary of the System Evaluation 125

CHAPTER 5: CONCLUSION

Figure 5.1: Finding Model 128
ABSTRACT

This study investigates the use of physics formula in achieving realistic time-based animation. The need for physics animation was to produce more realistic animations adhering to the basic laws of physics. According to the research, timing was an extremely important principle in animation. Timing gave meaning to the movement. To elaborate, the speed of an action defines how well the idea behind the action reads to an audience. It could even bring to light the emotions hidden within the scene. From the study, it seemed that creating realistic timing simulation in animation was significantly difficult particularly in setting keyframes. It was comprehensible that setting the value of keyframes was unambiguous while specifying the timing for keyframe was a harder task and often time consuming. The case study of bouncing balls' simulation was carried out and an algorithm was presented to produce physics-based real-time simulation. Experiments had been carried out on different materials of the bouncing ball and different floor types. The formula created from this study was programmed into the software development platform. The results showed that the use of algorithmic formula achieved realistic-timing animation. Animation-based physics formula provided the animator the ability to control the realism of animation without setting the keyframe manually to achieve realistic-timing simulation.
ABSTRAK

CHAPTER 1
INTRODUCTION

1.0 Overview

This research intends to study realistic time based animation through the application of physics motion. The study focuses on the real time simulation which is consistent with the physics motion to create realism in animation. In this chapter, background of the research, problem statement, research questions, objectives, hypothesis, and scope of the research would be listed in details.

1.1 Background of Research

The concept of physically based animation has been long established by Disney artists through “The Twelve Basic Principles of Animation”. They emphasize on the principles include squash and stretch, timing, anticipation, staging, arcs, exaggeration, follow through and overlapping action, straight ahead and pose to pose action, secondary action, slow in and slow out, solid drawing and appeal. In the earliest form of animated cartoon, all work aspects are directly control by the animator. Motion is created by drawing objects over successive frames to be played in sequence. A prime goal of animation is the illusion of life. In order to achieve this illusion, an illusion of reality is conveyed. According to Thomas & Johnston (1981), Disney artists in particular have employed a well defined set of rules for enhancing the quality of
animations. The main purpose of the twelve basic principles was to produce more realistic animations adhering to the basic laws of physics. Lasseter (1987), explained these principles in the context of 3D computer animation. According to him, the principle of timing is extremely important because it gives meaning to a movement, and the speed of an action defines how well the idea behind the action will read to an audience. It indicates the weight and size of an object, and can even carry emotional meaning. Furthermore, he also described that the proper timing is crucial to make ideas readable. In addition, Webster (2005), stated that good timing could be said to be somewhat subjective, yet it is animation timing that makes an animation believable, funny, frightening, moving, poetically beautiful or just downright silly. To get it right, constant practice is demanded, and becoming a master of this art form is the work of a lifetime. Realistic timing is extremely important in an animation to add a life-like quality to animated objects. Motions of the animated objects are made more interesting to behold the audiences and are able to convey the message to them.

The overall aim of realism is to give the animation some real-world authority. Interestingly, realism can be described in many ways. As claimed by Hodgkinson (2009), realism animation in the past had often been presented through real-world informed movement, often stylistically exaggerated. However, with the advent of computer 3D animation, the unique qualities of this medium enable an extra layer of visually convincing realism. Else, Wong & Datta (2004), stated that a recurring goal of scientists and artists alike is to reach the point where graphics and reality become
indistinguishable. For artists and game programmers, the realism of graphics can often
determine the immersiveness of a program. On the other hand, the realism needed for
scientists is to ensure the accuracy of simulations and predictions of object behaviour.

There are many reasons for striving for realistic in animation. Consequently, animation
artists carefully study the motion of the objects by adding the quality and accuracy to
generate realistic looking animations.

The physics-based approach is a well-adapted concept in order to simulate the
realistic looking animations. Nowadays, the concept of applying the laws of physics in
animation has further gained importance with the advent of technology. According to
Garcia, Dingliana & Sullivan (2008), as the quality and accuracy of physics engines
increases, there has been some demands for going beyond just accurate physics and
incorporating artistic variations to interactive real-time simulations. Furthermore,
Robertson (1998, 1999, 2001a, 2001b), explained that to transform vision into a realistic
animation, the animator defines desired behaviour in precision and constructs motions
that appear realistic. The results of physics based simulation techniques show
excellency in generating realistic motions and the techniques have become widely
adopted in the computer animation industry lately. Hence, to generate a realistic and
accurate timing animation, there is a need of consideration of physics motion.

Physics-based animation means the laws of physics are approximated with
numerical algorithms to automatically create realistic behaviours and motions of
animated objects. According to Hahn (1998), physically based illumination models in computer graphics display algorithms, where we need to think of objects in a scene as real objects having mass, moment of inertia, elasticity and fiction. However, Glimberg & Engel (2007), stated that in the real world, moving objects are affected by a virtually unlimited number of external factors as well, including shifting winds, air humidity, different materials and attraction forces from every object. A completely realistic physical world taking all these factors into consideration would be hard to be handled in animation making. Furthermore, Popovic, Seitz, and Erdman (2003), explained that a simulated rigid-body motion depends on many parameters such as initial positions, velocities, and elasticities of each object and surface normals at each collision. Garcia, Dingliana & Sullivan (2008), also mentioned that no matter how precise our model, it will only be an approximation of the real world. Thus, physics animation remains a challenge which lies in the fact that the physical world we are attempting to model or animated is infinitely complex.

The concept of physics motion can be interpreted in relation to the principle of bouncing ball simulation. According to Heck, Ellermeijer & Kedzierska (2008), Newton’s laws of motion and concepts of gravitational energy and kinetic energy, with examples of objects dropped or thrown vertically, contain investigative activities about free-falling objects study. However, in the opinion of Williams (2001), the concept of bouncing ball is often used and it shows many different aspects of animations. The simulation of bouncing ball includes the principles of squash and stretch, arcs,
momentum, timing, key drawings, in-between drawings, weight, speed, and the substance of an object. The two basic elements of animation in bouncing ball simulation is shown as below:

![Figure 1.1: The Two Basic Elements of Animation by Williams (2001)](image)

Figure 1.1 shows two basic elements of animation which are spacing and timing. Williams (2001), explained that when a ball hits the ‘Boink’ point, that is the timing. The impacts show when the ball is hitting the ground and that is the timing of the action. On the other hand, spacing is shown when a ball overlaps itself at the slow part of its arc, but when it drops fast, it is spaced further apart. The spacing is how close or far apart those clusters are.

Bouncing ball is the most basic of all animation exercises and one of the most important. Its concept is often used and shows many different aspects of animations such as walking, running, hopping and juggling. Hence, it is critical to the animator as a
reference for doing any kind of animation. In addition, this simple action of bouncing ball simulation indicate the principles of animation such as timing, squash and stretch, arcs, volume and weight.

![Timing Throughout a Bounce](image)

Figure 1.2: Timing throughout a Bounce by Webster (2005)

From Figure 1.2, timing of the ball bounces can be noticed by the way in which there are more drawings at the peak of the arc than there are during rising or falling. This affects the speed of the ball, slow at the top and faster when up and down. But, different weights move in different routes and different way of bounces. As stated by Webster (2005), the dynamics of a thrown object are not only determined by the force applied to it to make it move in the first place, but also gravitational forces. This gives us a particularly distinctive arc. A further aspect we need to consider is that an object is a source of stored energy and that energy can be released in a number of ways. Falling objects release their energy, at least some of it, which is to say they bounce or move off in other directions. We can see clearly through examples of how the energy within a
falling object is expended. The height of a bouncing ball is determined by the height from which it is dropped. The higher the position the ball falls from, the greater the height of the bounce.

Last but not least, realistic bouncing ball simulation showed the significance in the animation that a lot of physical measurements are required. In realistic-bounce animation, however, the most important aspect of the principle is the fact that an object's volume does not change when squashed or stretched. As real objects, the realistic motion of a bouncing ball needs to be considered with the bounce characteristics, and they are mass \( (m) \), acceleration \( (a) \), velocity \( (v) \), time \( (t) \) and gravitational force \( (F) \). This can be determined by laws of motion, Newton's laws of motion, and Hooke's law. According to Ross (2006), the dynamics of a collision can be determined between a ball and another object, in principle, from the initial conditions and the functional form of the force acting on the ball. If the collision is elastic, it can be determined by Newton's laws of motion, \( F=ma \) and Hooke's law, \( F = kx \), where \( x \) is ball compression if the force acting on a ball and the collision is elastic and the springiness or rigidity of an object is \( k \). The collision of a ball always involves some loss of energy. The coefficient of restitution (COR) has been measured for many objects and surfaces on the energy loss when the force acting on a colliding ball.

Based on physical motion regarding numerical simulations, an algorithm formula for fast and physics-based accuracy simulation will be developed, in which the