View-Dependent Character Animation

Parag Chaudhuri, Prem Kalra
and Subhashis Banerjee

View-Dependent Character Animation

Springer

Parag Chaudhuri
Prem Kalra
Subhashis Banerjee
Department of Computer Science and Engineering
Indian Institute of Technology Delhi
New Delhi, India

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Control Number: 2006934623

ISBN-10: 1-84628-591-7 eISBN-10: 1-84628-762-6
ISBN-13: 978-1-84628-591-2 eISBN-13: 978-1-84628-762-6

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

Acknowledgments

The authors want to thank Ashwani Jindal for being an extremely helpful collaborator. A special thanks to Vaishali Paithankar for helping with generation of a video used as an example in this book. The authors have also benefited from comments and suggestions received from the following people: Professor Sharat Chandran, Professor Karan Singh, Subhajit Sanyal, and Ayesha Choudhary.

The authors are also thankful to the extremely enthusiastic, helpful, and cooperative staff of Springer, particularly Helen Desmond, Beverley Ford, and Alfred Hofmann.

The authors wish to acknowledge the support of Mr. K. R. Kaushik in making the Vision and Graphics Lab a fantastic place for doing research. The authors want to thank the faculty, staff, and their many friends from the Department of Computer Science and Engineering for their help and support.

Finally, the authors wish to express their gratitude to their family members for their constant encouragement and patience.

Indian Institue of Technology Delhi,
India

Parag Chaudhuri
Prem Kalra
Subhashis Banerjee

Preface

Animation has grown immensely over the years to become a mainstream art form in the hugely active industries of motion films, television, and advertising. A few basic rules and principles about how to harness the technology that gives the illusion of life to still drawings or objects and how to string together individual shots and scenes to tell a story or create a homogeneous, meaningful sequence or mood govern the fundamental aspects of creating an animation.

Computer animation builds upon these fundamentals and uses computer - generated imagery (CGI) to weave magic on the screen. In spite of the fact that the technology employed in creating animation has advanced by leaps and bounds over the years, animation remains a very labourious process, involving a lot of skill and often many iterations, before the magic looks just right. This is the reason why computer animation remains a very active area for research.

Animations where the character and the rendering camera both move are known as *moving-camera character animations*. The sheer number of parameters the animator has to control, in order to get the desired action shot from the intended camera position, is overwhelming. We present, in this book, view-dependent animation as a solution to the challenges encountered during the creation of moving-camera character animations.

Creation of 3D character animations in which the viewpoint changes in every frame is a challenging problem because it demands a definite relation to be preserved between the character and the camera, in order to achieve clarity in staging. We present view-dependent animation as a solution to this arduous problem. In view-dependent animation, the character's pose *depends* on the view. The camera and character pose association, once specified by the animator, is maintained automatically throughout such an animation. We design a general framework to create view-dependent animations.

We formulate the concept of a view space of key views and associated key character poses. The view space representation captures all the information contained in a camera matrix, i.e., the position of the camera center, the direction of viewing, and the focal length of the camera, concisely and elegantly. Any camera path traced on the envelope of this view space generates a view-dependent animation. This facilitates fast and easy exploration of the view space in terms of the view-dependent animations it can generate.

We present a pipeline to create the view space from sketches and a base three-dimensional (3D) mesh model of the character to be animated. Robust computer vision techniques are used to recover the camera from the sketches. We present two novel view-dependent algorithms, which allow us to embed a multilayered deformation system into a view-dependent setting and integrate it with computer vision techniques. These algorithms match the pose of the 3D character to the sketched pose. The recovered camera and pose form the key views and key character poses and create a view space that can be used to generate a view-dependent animation by tracing paths on it.

We then analyze the problem of authoring view-dependent animations from multimodal inputs. We demonstrate that we can extract the relevant information about the cameras and character poses from a video sequence and create a view space. The view space serves as a common representation for all the information contained in different input types like sketches, video, and motion capture. Hence, it is used to integrate all these inputs together. We show that we can use this combined information to generate a view-dependent animation in real time as the animator traces a path on the view space.

We introduce the concept of *stylistic reuse* and formulate it in terms of our framework. We present three techniques for reusing camera-controlled pose variations to animate multiple view-dependent instances of the same character, a group of distinct characters, or the body parts of the same character.

The book is addressed to a broad audience. It should be of great value to both practitioners and researchers in the area of computer animation. We also cover all the prior work relevant to the topics presented in this book so that there is no specific prerequisite. A basic familiarity with the area of computer animation and computer graphics should be sufficient. The book has a lot of figures to help understand all the concepts introduced in it. We have included an example animation for every facet of view-dependent character animation we have explored in this book. All the example animations are available at http://www.cse.iitd.ernet.in/~parag/vdabook.

We would very much appreciate receiving comments and suggestions from the readers.

Indian Institute of Technology Delhi,
India

Parag Chaudhuri
Prem Kalra
Subhashis Banerjee

Contents

1

Introduction

The word *animate* literally means "*to give life to*." Animation can be thought of as the process of making objects move and creating an *illusion of life* [124]. The animator is the person who directs and composes this movement. Since movements of objects and creatures in an animation are generally inspired by how they move in real life, animation is easy, in principle. But as the famous Disney animator Bill Tytla once said, "There is no particular mystery in animation... it's really very simple, and like anything that is simple, it is about the hardest thing in the world to do."

Traditionally, animation began with each frame being painted by hand and then filmed. Over the course of many years animators perfected the ability to impart unique, endearing personalities to their characters. Many technical developments including the introduction of colour and sound, the use of translucent cels (short for celluloid) in compositing multiple layers of drawings into a final image, and the Disney multiplane camera [124] helped animation mature into a rich and complex art form.

Computer animation is the modern day avatar of animation where the computer is used to draw (or render) the moving images. With the advent of the computer, animation has gradually moved into the realm of three dimensions. The computer is primarily used as a tool to interact with the characters in 3D in order to define and control their movement. Today, animated characters span across a diverse spectrum ranging from cartoonlike humans (*The Incredibles* [15]) to fantasy characters (*Shrek* [1]) and from animals (*Madagascar* [35]) to photorealistic humans (*Final Fantasy: The Spirits Within* [114]). The need to animate such diverse characters has caused character animation to become an extensively researched area.

Coordinating and presenting the character's movement in three dimensions to convey a specific idea to the audience, however, still remains an arduous challenge. The animator has to employ a lot of artistic and technical skill, and often a labourious iterative trial-and-error process to achieve a desired combination of the character's action and the point of view from which it is shown. Since in computer animation, values of many parameters that govern the appearance and the movement of the character, can be varied, the animator has an overwhelming number of things to control. It is especially difficult for the animator to generate the character's action if the point of view (i.e., the rendering camera) is also moving. This book deals specifically with the problem of creating moving-camera character animations using a technique called *view-dependent character animation.*

Creating moving-camera character animations in three dimensions is a multifaceted computer graphics and computer vision problem. It warrants a formal representation of the moving camera and efficient algorithms to help author the multitude of character poses required for the animation. One also has to deal with issues pertaining to camera, character pose interpolation, and visualization of the association between the two. Therefore, the solution to this problem, on one hand, has to be efficient and elegant from the perspective of a computer scientist. On the other hand, the solution must make sense and be intuitive to use for the animator. We develop and demonstrate a framework in an endeavour to find such a solution.

To set the context for developing a framework for moving-camera character animation, it is important to understand the fundamental principles behind animation. This chapter discusses the animation pipeline and draws inspiration from well established animation practices to introduce the idea of view-dependent character animation.

1.1 Principles of Animation

The primary aim of animation is to infuse life into characters. This required the early practitioners of animation to experiment with a plethora of methods for depicting movement on paper. In order to perfect this art, early animators who made sketches of moving human figures and animals, studied models in motion as well as live action film, playing certain actions over and over. The analysis of action became important to the development of animation. The animators continually searched for better ways to communicate the lessons they learned. Gradually, procedures were isolated and named, analyzed and perfected, and new artists were taught these practices as rules of the trade. These came to be known as the *principles of animation* [124]. These principles are

1. *Squash and stretch* – Defining the rigidity and mass of an object by distorting its shape during an action.
2. *Timing* – The spacing of actions in time to define the weight and size of objects, and the personality of characters.
3. *Anticipation* – The preparation for an upcoming action so that the audience knows it (or something) is coming.
4. *Staging* – The idea of presenting an action so that it is unmistakably clear and is not missed by the audience.
5. *Follow through and overlapping action* – Guiding the termination of an action and establishing its relationship to the next action. Actions should flow into one another to make the entire scene flow together.
6. *Straight ahead versus pose-to-pose action* – Two contrasting approaches to the creation of movement. *Straight ahead* refers to progressing from a starting point

and developing the motion as you go. *Pose-to-pose* refers to the approach of identifying key frames and then interpolating intermediate frames between them.

7. *Slow in and out* – The spacing of the in-between frames to achieve subtlety of timing and movement. This is based on the observation that characters usually ease into and ease out of actions.
8. *Arcs* – Since things in nature don't usually move in straight lines, this helps in defining the visual path of action for natural movement.
9. *Exaggeration* – Accentuating the essence of an idea via design and action.
10. *Secondary action* – The action of an object resulting from another action. These support the main action, possibly supplying physically based reactions to the previous action.
11. *Appeal* – Creating a design or an action that the audience enjoys watching.

These principles were adapted for computer animation by Lasseter [86]. Squash and stretch, timing, slow in and out, arcs, and secondary actions deal with how the *physics* of the character (like its weight, size, and speed) is presented in relation to its environment. Exaggeration, appeal, follow through, and overlapping action are the principles that address the design of an action sequence. Straight ahead and pose-to-pose are concerned with contrasting production techniques for animation. Anticipation and staging define how an action is presented to the audience,

Animators developed the animation pipeline based on these principles. An animation develops as an amalgamation of ideas: the story, the characters, the continuity, and the relationships between scenes. The animation pipeline is a sequence of several steps that converts a story to a final animation.

1.2 The Animation Pipeline

First, a preliminary storyline is decided upon along with a script. Next, a *storyboard* that lays out the action scenes by sketching representative frames is developed. The story sketch shows character, attitude, expressions, type of action, as well as the sequence of events. In a preliminary storyboard, however, only the sequence of actions of the various characters are planned. The characters are not fully developed. The look and feel of a character is developed by sketching the character in various poses in a *model sheet*. The appearance of the character is documented from all directions and is used as a reference while actually animating the character. The *exposure sheet* records information for each frame such as sound track cues, camera moves, and compositing elements. Often the storyboard is transferred to film with the accompanying sound track and a story reel or an *animatic* is created to get a feel of the visual dynamics of the animation. Once the storyboard is fixed, a *detailed story* is worked out. *Key frames* (also known as *extremes*) are then identified and produced by master animators. Assistant animators are responsible for producing the frames between the keys; this is called *in-betweening*. *Test shots*, short sequences rendered in full colour, are used to test the rendering. The penciled frames are transferred to cels and painted. These cels are then composited together and filmed to get the final animation.

Computer animation production has borrowed most of the ideas from the conventional animation pipeline. The storyboard still holds the same functional place in the animation process, as does the model sheet. However, after the planning phase, computer animation often makes the transition into 3D. The character models and the world which they inhabit have to be handcrafted. Controls are provided that allow movements of various parts of the character. Then the animation staging is done in 3D, in which the camera positioning and movement for each shot is decided. This is followed by shading and lighting the animation and finally rendering the frames. As mentioned earlier, this sequence of steps is extremely tedious and time-consuming. It involves a lot of skill and a trial-and-error, iterative process wherein performing one task may require redoing one or more previously completed tasks.

We are now ready to examine moving-camera character animations and the challenges the animator has to face while creating them.

1.3 Moving-Camera Character Animation

Fig. 1.1. A preliminary storyboard (see top to bottom, left to right).

We explain the creation of a moving-camera character animation using an example, *Hugo's High Jump*. Hugo [17] is the name of the character in the animation. We start with a preliminary storyboard (see Fig. 1.1) for this animation. Once the basic action has been planned and the character's look has been decided upon, we get the final or detailed storyboard, as shown in Fig. 1.2.

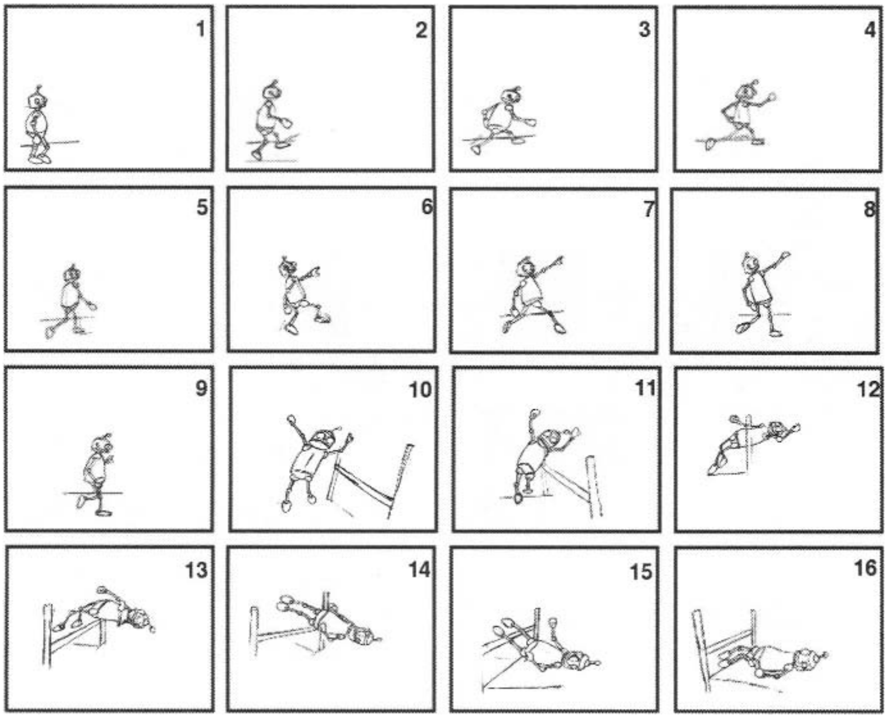

Fig. 1.2. The final storyboard for *Hugo's High Jump*.

Then the layout of the scenes is planned. Among other things, the layout also indicates the camera position for each frame. The layout is guided by the principle of staging and has to clearly portray where the viewer is supposed to be while observing the situation. Figure 1.3 is a time-lapse sketch for the animation sequence storyboarded in Figures 1.1 and 1.2. A time-lapse sketch shows the position of the character at different times in a single sketch.

This animation has a moving camera, i.e., the viewpoint is changing in each frame. The layout helps plan these camera moves. Figure 1.4 shows how the framing of the shots change as the camera moves through frames 1, 9, 11, and 15. When the character is seen from the camera position for that particular frame number, the scene looks like the corresponding thumbnail on the storyboard. The movement of the camera center is drawn in red across all the frames in Fig. 1.5. It is clearly seen that in order to achieve clarity in staging the animator has to create a very definite relation between the pose of the character and the camera position. Every shot is

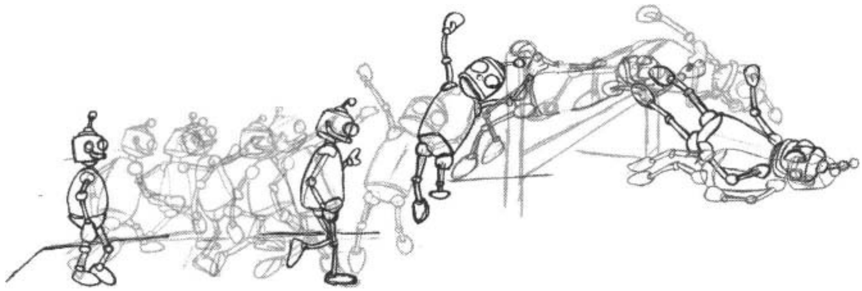

Fig. 1.3. A time-lapse sketch of *Hugo's High Jump*.

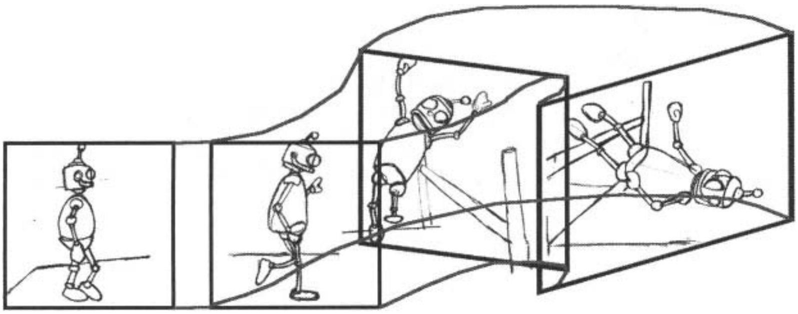

Fig. 1.4. The moving-camera frame (see colour insert).

drawn from the viewpoint of the audience, implicitly establishing a camera from which the action is understood clearly.

Thus, the camera–character relationship plays a pivotal role from a very early stage in the animation creation process. This combination of the camera or the *view* and the character's pose or movement is maintained throughout the creation of the animation, even when the character is transferred from two dimensions to three dimensions.

Translating the planned camera and character moves to 3D is an extremely difficult task. In this book we develop a framework to alleviate this problem. In order to illustrate the primary difficulty in creating moving-camera character animations, we evaluate the challenges involved in the process and suggest our alternative methodology.