Tuula Rantala

ANIMATION OF A HIGH-DEFINITION 2D FIGHTING GAME CHARACTER

Thesis
Kajaani University of Applied Sciences
School of Business
Business Information Technology
Spring 2013

KAJAANIN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

OPINNÄYTETYÖ
TIIVISTELMÄ

Koulutusala Luonnontieteiden ala	Koulutusohjelma Tietojenkäsittely
Tekijä(t) Tuula Rantala	
Työn nimi Teräväpiirtoisen 2d-taistelupelihahmon animointi	
Vaihtoehtoiset ammattiopinnot Peligrafiikka	Ohjaaja(t) Nick Sweetman
	Toimeksiantaja -
Aika Kevät 2013	Sivumäärä ja liitteet 56

Tämä opinnäytetyö pyrkii erittelemään hyvän pelihahmoanimaation periaatteita ja tarkastelee eri lähestymistapoja 2d-animaation luomiseen. Perinteisen animaation periaatteet, kuten ajoitus ja liikkeen välistys, pätevät pelianimaatiossa samalla tavalla kuin elokuva-animaatiossakin. Pelien tekniset rajoitukset ja interaktiivisuus asettavat kuitenkin lisähaasteita animaatioiden toteuttamiseen tavalla, joka sekä tukee pelimekaniikkaa että on visuaalisesti kiinnostava.

Vetoava hahmoanimaatio on erityisen tärkeää taistelupeligenressä. Varhaiset taistelupelit 1990–luvun alusta käyttivät matalaresoluutioista bittikarttagrafiikkaa ja niissä oli alhainen määrä animaatiokehyksiä, mutta nykyään pelien standardit grafiikan ja animaation suhteen ovat korkealla. Viime vuosina monet pelinkehittäjät ovat siirtyneet käyttämään 2d-grafiikan sijasta 3d-grafiikkaa, koska 3d-animaation tuottaminen on monella tavalla joustavampaa. Perinteiselle 2d-grafiikalle on kuitenkin edelleen kysyntää, sillä käsin piirretyn animaation ainutlaatuista ulkoasua ei voi täysin korvata 3d-tekniikoilla. 2d-animaation luomista on pyritty tehostamaan avustavilla tekniikoilla kuten animaation jäljentämisellä 3d-animaatiosta.

Opinnäytetyön käytännön osuutena luotiin hahmoanimaatioita jotka soveltuvat teräväpiirtoiseen 2d-taistelupeliin. 2d-animoinnin apuna käytettiin 3d-animaatiota. Vaikka 3d-animaation käyttäminen mallina on hyödyllistä etenkin kokemattomalle animaattorille, liian tukeutumisen 3d-animaatioon todettiin saattavan heikentää lopullisen 2d-animaation laatua. 3d-työkalujen avustus ei korvaa hyvää 2d-perusteiden hallintaa.

Kieli	Englanti
Asiasanat	2d, 2d-animaatio, animaatio, hahmoanimaatio, taistelupelit, peligrafiikka, videopelit
Säilytyspaikka	☐ Verkkokirjasto Theseus ☐ Kajaanin ammattikorkeakoulun kirjasto

KAJAANIN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

THESIS ABSTRACT

School	Degree Programme
Business	Business Information Technology

Author(s)
Tuula Rantala

Title
Animation of a High-Definition 2d Fighting Game Character

Optional Professional Studies	Instructor(s)
Game graphics	Nick Sweetman
	Commissioned by
	-

Date	Total Number of Pages and Appendices
Spring 2013	56

This thesis aims to identify the principles of good in-game character animation and examines different approaches to creating 2d animation. Traditional animation principles, such as timing and spacing, apply to in-game animation as they do to film animation. However, due to restrictions set by the technical and interactive elements of video games, additional challenges are faced in creating animations that both support gameplay and are visually engaging.

Appealing character animation is particularly important in the fighting game genre. Early fighting games from the beginning of the 1990s used low resolution bitmap graphics with low frame counts for animation, but nowadays the standards for graphics and animation in games are high. In recent years, many game developers have shifted to using 3d graphics in place of 2d graphics, due to the more adaptive nature of 3d animation. However, there is still demand for the unique aesthetic of hand-drawn 2d, which cannot be fully replaced by 3d techniques. To make the creation process of 2d animation more efficient, supporting techniques such as tracing animation from 3d models have been employed.

As the practical part of the thesis character animations suitable for a high-definition 2d fighting game were created. To assist in the creation of 2d animation, 3d animations were used as reference. While using 3d reference is beneficial especially for less experienced animators, it was discovered that relying too heavily on 3d may compromise the quality of the final 2d animation. The assistance of 3d tools cannot substitute good 2d fundamentals.

Language of Thesis	English
Keywords	2d, 2d animation, animation, character animation, fighting games, game graphics, video games
Deposited at	☐ Electronic library Theseus ☐ Library of Kajaani University of Applied Sciences

CONTENTS

LIST OF SYMBOLS

2d graphics	Two-dimensional digital graphics.
3d graphics	Digital graphics created as a three-dimensional representation of geometric data, but displayed as a two-dimensional raster image.
Animation	A rapid display of a sequence of still images to create an illusion of movement.
Bitmap	A 2d image constructed of pixels located contiguously in a grid. A color value is allocated to each pixel in the image. Also known as raster graphics.
Color depth	The number of bits used to indicate the color value of a single pixel. Determines the amount of different color values a pixel in the image can have.
FPS	Frame rate, the amount of frames per second in animation or other video.
Frame	A single still image in an animation sequence.
High-definition	Resolutions higher than standard-definition, such as 720p (1280x720) and 1080p (1920x1080).
Pixel	The smallest component of a bitmap image.
Resolution	The number of pixels in an image, usually quoted as width x height.
Sprite	A two-dimensional graphic image, often animated, that is integrated into a larger scene.
Vector graphics	2d graphics stored as mathematical expressions which include the information about the image's attributes, such as shape, location and colors. The image is drawn and rasterized based on these instructions.

1 INTRODUCTION

High-definition 2d character animation is a relevant topic in game development today. The introduction of high-definition game platforms and displays as the standard has forced developers to raise the quality of their in-game 2d graphics. While low resolution pixel artwork may appeal to some players, it is no longer captivating to mainstream audiences. Due to rising development costs and decreasing amount of talent available, many developers have shifted to using 3d models and animation instead of hand drawn animation. The persisting supporters of 2d animation have sought ways to optimize their 2d art pipelines.

The fighting game genre is particularly interesting in regard to character animation, as it is heavily emphasized in the genre. Appealing character designs and visually impressive fighting techniques are important features in any fighting game. Especially to the casual audience, the appeal of a fighting game depends largely on the quality of its art and animation. Many of the most graphically advanced 2d games of present day are fighting games.

This thesis explores traditional animation principles and their application in in-game character animation, as well as the evolution of in-game character graphics in 2d fighting games from the early 1990s to current day. The objective of the study is to determine the quality standards of in-game character graphics in contemporary 2d fighting games and to find efficient tools and workflows for creating high-definition in-game 2d character animation. The topic is approached from the viewpoint of an inexperienced animator with limited resources at their disposal. The aim is not to revolutionize the 2d fighting game genre, but to iterate on existing processes.

As the practical part of the thesis, character animations suitable for a modern 2d fighting game were created and implemented in fighting game engine M.U.G.E.N. The thesis was conducted as a personal project with no external client. The findings of the thesis are applicable to future 2d game projects both within and outside of the fighting game genre.

2 BASICS OF ANIMATION

To create visually engaging character animation for games, it is important to understand the basic principles of animation. This chapter explains the basic terminology of animation, examines the principles of good animation and introduces different methods of 2d animation. It also includes a general overview of how animation for games differs from animation for film.

2.1 Introduction to animation

Animation is the display of images rapidly in sequence to create an illusion of movement. In traditional film animation, the frame rate is usually 24 animation frames per second. Televisions usually have a frame rate of 50 fps or 60 fps and are thus compatible with 25 or 30 animation frames per second respectively. (Roberts 2007, 2.) In traditional film animation, often only 12 unique drawings are used per second with two exposures for each drawing. Using fewer frames significantly reduces the amount of work and is sufficient for most actions. 24 individual frames are only needed for very quick or smooth movements. Whether using 12 or 24 frames is actually better for other actions is debatable. (Williams 2009, 75-79.) The frame rate used in videogames varies depending on the type of the game and the capabilities of the hardware. In modern games, the frame rate is usually between 30 and 60 frames per second. High frame rates are particularly important in fast-paced action games.

There are two main ways to animate: straight-ahead and pose-to-pose. Straight-ahead animation means drawing the action frame by frame from beginning to end. Such a method results in creative and spontaneous animation, but makes it difficult to maintain proportions and focus within a scene. In pose-to-pose animation, the animator first decides which are the most important drawings in the movement and begins by drawing them. The frames in between are drawn afterwards. This method gives complete control over the scene, and the result is clear and powerful, but lacks the spontaneity of straight ahead action. Both methods should be utilized to achieve the best possible results. (Thomas, Johnston 1981, 56-58.)

The main drawings in an animated action are the extreme positions. Often the extremes indicate a change of direction in the action. The middle position between two extremes is called a breakdown or passing position, and is crucial in defining the overall action. The remaining frames in between are called in-betweens (Figure 1). The most important drawings which actually show what is happening in the animation are called key drawings. It is useful to separate storytelling key drawings from extreme positions, but the term key is often used to refer to the extreme drawings. (Williams 2009, 47-60.)

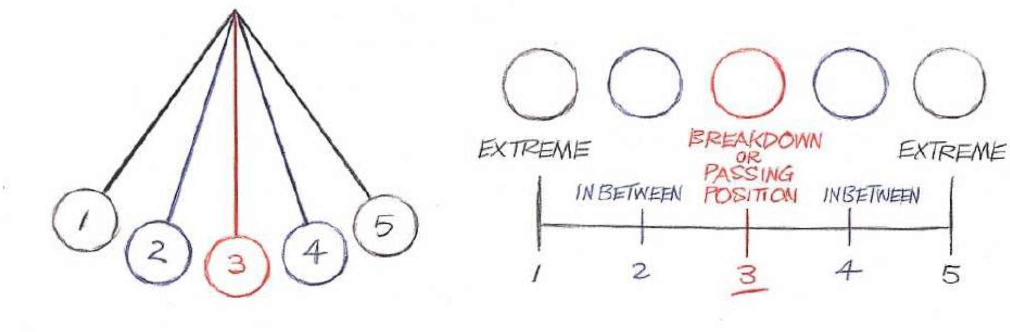

Figure 1: The extreme and in-between positions of a swinging pendulum (Williams 2009, 49).

Particularly in digital 3d or vector-based animation, the term key frame has a somewhat different meaning. Key frames are the frames where the properties of the animated object, such as location, rotation and scale, have been defined. By setting the beginning and end point of a transition, the in-between frames can be automatically generated by the software through interpolation. Usually at least the extreme and breakdown positions of an action should be set as key frames manually.

2.2 Principles of animation

To create believable character animation, a good understanding of anatomy and movement in reality is essential. However, good animation is not only an imitation of reality. To translate real life movements into convincing animation, an animator should be familiar with several principles that animators have discovered over the years. Although these principles are based on animation for film, they apply to animation for games as well.

2.2.1 Laws of motion

Movement in animation is based on movement in reality. Isaac Newton's three laws of motion are central in defining the physics of motion. Firstly, an object will retain constant velocity if no force is applied to it, or the sum of the affecting forces is zero. An object at rest will remain stationary, while a moving object will remain moving in a straight line at constant speed until an external force affects either its speed or direction. This law is the definition of inertia. Secondly, the change in velocity when an object is subjected to an external force is directly proportional to the amount of force acting on the body, and inversely proportional to the mass of the body. Thirdly, for every force, there is an equal opposite force. If a body exerts a force on another body, the second body simultaneously exerts a force of equal magnitude on the first body. (Benson 2010.)

The greater the mass of the body is, the greater is the inertia that needs to be overcome to change the motion of the body. When moving, an object generates momentum proportional to its mass and velocity. The greater the momentum, the greater is the force required to change its motion. (Webster 2005, 15-16.) Animation must suggest these forces to be convincing. To communicate weight, an appropriate amount of time must be spent on starting, stopping or changing the motion of an object. (Whitaker, Halas 2009, 31.) The behavior of an animated object and its sense of weight depend entirely on the timing and spacing of the action (Whitaker, Halas 2009, 31).

It is not necessary to work out the mathematical formulas for all movements. It is usually sufficient if the motion looks right. Sometimes, physics in animation may be intentionally bent for dramatic effect. (Whitaker, Halas 2009, 35.)

2.2.2 Timing and spacing

In animation, timing means deciding the number and spacing of the drawings in an action (Whitaker, Halas 2009, 45). The number of frames determines the amount of time an action takes. Spacing is the relative distance between the drawings in the sequence. The closer to each other the drawings are spaced, the slower the movement will appear. (Williams 2009, 35-39.) Figure 2 illustrates the movement of a coin from one side of the paper to the other.

The first example shows this movement with even spacing. The second example has the same number of frames, but uses different spacing, resulting in a notably different motion.

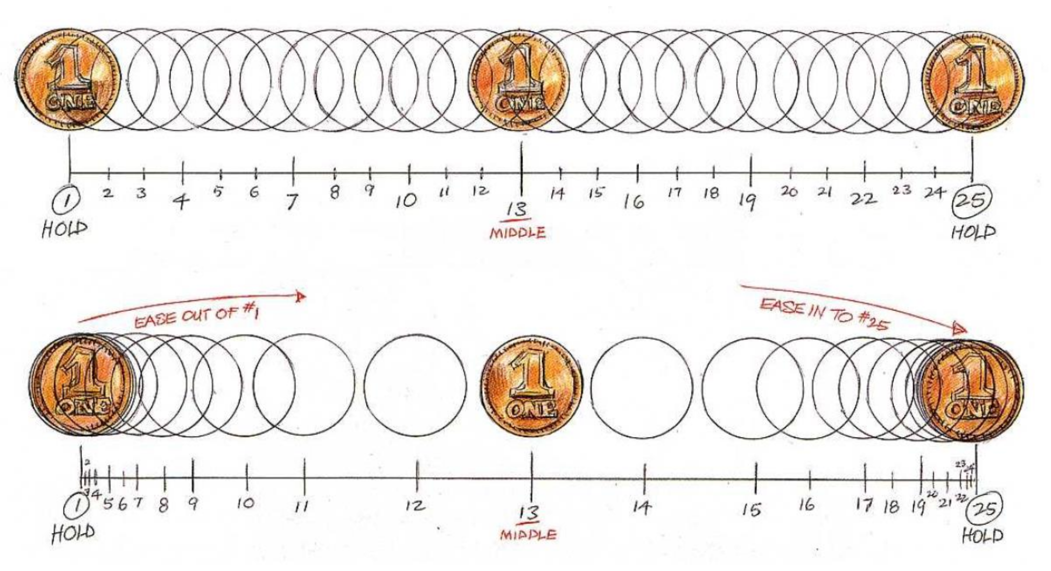

Figure 2. Timing and spacing. (Williams 2009, 38.)

Most motions include gradual acceleration or deceleration. Aside from some machines, completely evenly paced movement is unusual. (White 2006, 217.) To create variation in timing, the position of the in-betweens in relation to the keys needs to be varied. By placing more in-between frames close to the extreme positions of the motion and fewer in the middle, the motion will appear slower near these extremes. Such spacing is known as slow-in and slow-out, or in computer software often as ease-in and ease-out. (Webster 2005, 28.)

Slow-out is when the action gradually accelerates out of a key frame. Slow-out usually occurs at the beginning of a motion to suggest the inertia which the object has to overcome. The greater the inertia, the longer it takes for the object to build up momentum. Slow-in describes an action that gradually decelerates towards a key frame. Slow-in is typically used when the object slows down before coming to a stop. A light object has less momentum and thus slows down faster than a heavy object. (Webster 2005, 29.)

Timing gives meaning to movement. Objects do not move without reason - they move when forces act upon them. Animation should express this underlying cause of movement. The timing of an action depends on natural forces, particularly gravity, as well as the body's physical capabilities, but also psychological aspects of the character (Whitaker, Halas 2009, 2-3.) Altering the timing can greatly change the meaning of the action, indicating properties such as velocity and force. The speed of movement also defines a character's personality and attitude. (Thomas, Johnston 1981, 64-65.)

Timing in animation is ultimately based on timing in nature (Whitaker, Halas 2009, 2). However, it is not necessary to always use normal time when animating. Unnaturally fast timing can be humorous or frantic, while unnaturally slow timing grants elegance to the movement. Contrasting between slow and fast timing creates compelling animation. (Williams 2009, 297.) Very slow motion should be avoided, however, as in animation, closely spaced frames tend to jitter easily. (Whitaker, Halas 2009, 47).

Successful timing means that enough time is spent on preparing the audience for the action, on the action itself, and on the reaction to the action. If too much time is spent, the audience's attention will wander. If not enough time is spent, the audience may not understand the action. (Whitaker, Halas 2009, 1.) Essentially, timing is about controlling the audience's reaction to what they see (Roberts 2007, 88). Good timing fully depends on the purpose of the animation (Webster 2005, 7).

2.2.3 Anticipation, action and reaction

A movement consists of three stages: anticipation, action and reaction. Anticipation is the preparation for an action, communicating what is about to happen. Reaction is the recovery from the action, showing that the action has taken place. (Williams 2009, 273-274, 284.) The anticipation and the reaction are the extreme positions of a movement and have the most value in depicting an action (Blair 1994, 136).

Nearly all actions are preceded by some kind of anticipation. Sometimes the anticipatory move is a physical necessity for the movement. Sometimes it results from the thought process that precedes performing an action. (Webster 2005, 98-100.) In animation, proper anticipation is important to ensure that the audience can understand the animated event. To prepare the audience, each major action should be preceded with an anticipatory move that communicates what is about to happen. Such anticipation adds strength and clarity to the action. (Thomas, Johnston 1981, 51- 53.) The anticipatory movement also draws the attention of the audience to the right place on the screen. (Whitaker, Halas 2009, 56).

Anticipation is always to the opposite direction of the main action's direction: before moving forward, the character should move slightly backwards, and vice versa. (Williams 2009, 273-275.) The amount of anticipation needed depends on factors such as the amount of force behind the move, the speed of the move, and how surprising the movement is supposed to be (Roberts 2007, 91).

The faster the movement is, the more anticipation it requires for the audience to be able to follow the action. For very fast actions, showing only the anticipatory motion can be sufficient, and the action itself needs only be suggested. (Whitaker, Halas 2009, 48-49, 56.) Although usually the anticipation is slower than the action, sometimes a very fast, nearly invisible anticipatory motion can be used to give an action additional power (Williams 2009, 283-284). Occasionally, a quick move with no anticipation can be used for dramatic effect. In such a case, the end position of the movement should be held long enough that the audience has time to comprehend the action. (Whitaker, Halas 2009, 49.) It is also possible to use anticipation to lead the audience into expecting a certain action, and then surprise them with an entirely different action (Thomas, Johnston 1981, 51-53).

Too much anticipation can look artificial and unnecessarily exaggerated (Webster 2005, 98-100). The amount of anticipation should be varied to avoid repetitive and unnatural animation (Roberts 2007, 96).

2.2.4 Overlapping action

All parts of a figure should never come to a stop at the same time. A sudden complete stop looks stiff and unnatural. Instead, different parts of the body should start and stop moving at different times and move at different paces. Parts of the figure may drag behind the main movement and continue moving even after the main movement has come to a stop. Such motion is called overlapping action. (Thomas, Johnston 1981, 59-60.)

The overlapping movement can be broken down to primary, secondary and tertiary actions. The primary action is the central action. For example in a walk, the primary movement would be the movement of the hip and legs. (Webster 2005, 37-38.) Secondary actions are actions that support the primary action and make it more effective. They affect the overall movement but are not essential to it. In a walk, the movement of the arms would be a secondary action. (Webster 2005, 38-39.) Secondary actions that are not directly linked to the primary action, such as additional gestures or expressions, can be used to add richness and personality to the action. However, secondary actions should never conflict with or dominate the primary action. (Thomas, Johnston 1981, 63-64.)

Tertiary actions are actions that result from the primary and secondary actions, such as the movement of appendages and clothing attached to the main figure. Such actions have no significant effect on the main action, unless the weight and size of the appendages is notable enough to interfere with it. (Webster 2005, 39-40.)

Closely connected to overlapping action are the principles of drag and follow-through. As a figure begins to move, the inertia in its different parts is overcome at different rates. Some parts of the figure will begin to move before others. The delayed parts will begin to drag behind the primary source of motion. (Webster 2005, 35, 48.) Drag is important in giving the figure a lifelike sense of looseness and solidity (Thomas, Johnston 1981, 60). Follow-through is when appendages of the body continue moving after the main figure has stopped moving (Thomas, Johnston 1981, 59). An appendage that drags behind the primary action will do so until the primary action stops or changes direction. The appendage will then continue moving in its path until it has spent its initial force, or is interrupted by the main action. It will then change direction and again drag behind the primary action (Stanchfield 2009, 20-21.)

The nature of overlapping action depends on various factors such as the moving material's weight, flexibility, the physical forces affecting it, and how the parts of the structure are connected (Webster 2005, 36; Whitaker, Halas 2009, 59). When animating overlapping action, primary actions should be concentrated on first, before moving onto adding secondary and finally tertiary animations (Webster 2005, 39-40). Straight-ahead animation is usually the most suitable method for animating follow-through animation (Roberts 2007, 101).

2.2.5 Arcs and paths of action

Every action has an invisible line along which the action occurs, called the path of action (White 2006, 221). The path of action can be either curved or straight. If a drawing in the sequence does not fit the path, the action will not flow smoothly and there will be noticeable jitter or other unnatural movement in it. (Blair 1994, 140.)

The path of action should be logical and follow the basic laws of physics (White 2006, 345). Paths of action are most effective when they are based on arcs (Figure 3). Only machines move in an entirely straight line. (White 2006, 221). Usually the path of action is either wave-like or resembles a figure-eight (Williams 2009, 90).

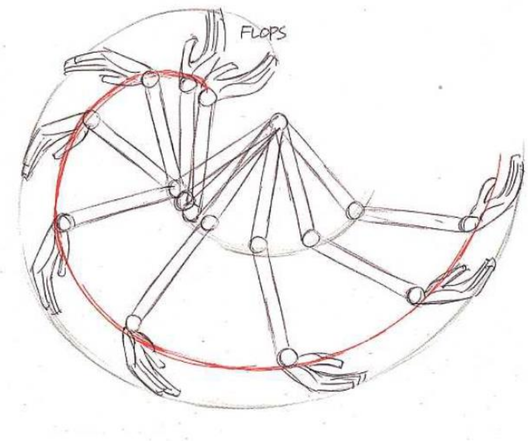

Figure 3. An example of the arc of action. (Williams 2009, 91.)

Linear motion appears mechanical. Even cartoony animation should generally conform to natural laws of motion in order to look convincing. Arcs may be ignored as a conscious stylistic choice, resulting in a powerful motion with emphasis on key drawings. This type of animation requires particularly strong key poses to work. (Webster 2005, 50-51.)

Complex animation with multiple moving components will describe several paths of action. It is useful to treat each element separately, starting animating from the primary action. (Webster 2005, 51.)

2.2.6 Squash and stretch

An organic creature should exhibit flexibility while performing an action. To avoid unnatural rigidity, the principles of squash and stretch are applied. The squashed position depicts the form either flattened or constricted, while the stretched position shows the same form in an extended condition. (Thomas, Johnston 1981, 47-48.) Squash and stretch is a process of manipulating the physical form to emphasize a specific action. For example, an object hitting the ground will flatten slightly before leaping back into air and returning to its original shape

(Figure 4). Fast-moving objects may be stretched to emphasize the speed of movement. (Webster 2005, 22.)

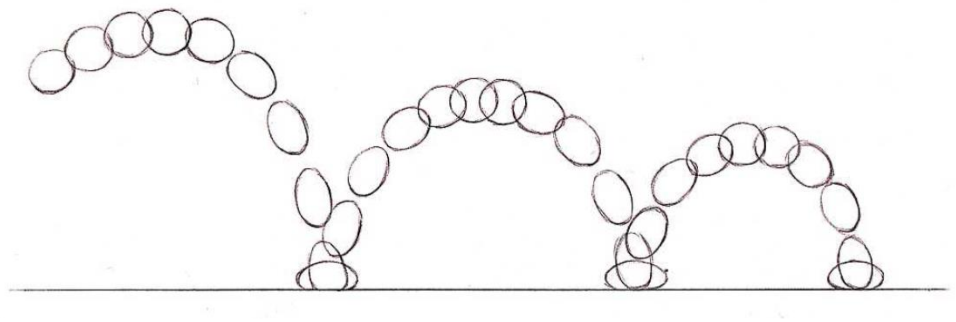

Figure 4. The bouncing ball is a classic example of squash and stretch. (Williams 2009, 39.)

Extreme squash and stretch can be used in cartoon animation for comic effect. However, when used reasonably, squash and stretch can enhance any type of animation. (Webster 2005, 18-22.) When animating realistic characters, squash and stretch must be applied within the limits of anatomy to avoid a distorted, rubber-like feel (White 2006, 372). A natural squash or stretch is achieved by extending the natural capability of the figure to a pose more extreme than the regular key pose would be. In squash, the capabilities of the body are pushed to the ultimate plausible position of squash. During stretch, the body extends itself as far as possible while avoiding unnatural distortion. After reaching the point of squash or stretch, the character should return to its normal position. (White 2006, 372-373.)

It is important that the volume of the shape remains the same between different positions. The figure should not lose or gain mass during squash or stretch. The amount of squash and stretch that should be used depends on the material of the object, particularly its weight, density and natural flexibility. (Webster 2005, 22-23.)

2.2.7 Exaggeration

Good character animation is not just an imitation of life (Whitaker, Halas 2009, 120). Movement in reality conveys more information than a drawing is able to duplicate. As result, animation traced directly from live action footage feels weightless and unbelievable. To create truly convincing animation, actions must be exaggerated. (Williams 2009, 371.)

Exaggeration does not mean violently distorting the action, but rather delving into the essence of the action and creating a caricature of it (Thomas, Johnston 1981, 65). Caricatured entities behave similarly to how they would in nature, only pushed to the extreme. Thus to create convincing animation, the subject's natural behavior must first be understood. (Whitaker, Halas 2009, 27.) After studying the mechanics of movement in reality, these mechanics can be applied to animation in a way that is not bounded by the limitations of reality (Williams 2009, 370).

Strong key poses are the key to strong animation. Pushing the dynamics of a pose results in a notably more powerful and interesting action. (White 2006, 224.) Live action can be used as reference, but it is the artists' task to emphasize what they deem important, and ignore what they do not (Williams 2009, 374-376).

2.2.8 Anatomy

Even if an animated character is caricatured, its anatomy is based on the anatomy of a real being. All the parts of the real creature should be present and operate in a believable manner. (Stanchfield 2009, 9.)

The basic shape of the human body is maintained by the skeletal system. The skeleton supports the body and produces movement through joints. Bones are curved, and long bones are cylindrical. The skeleto-muscular system consists of muscles, which operate joints, and tendons, which connect muscles to the bones (Simblet 2001, 32-34). Muscular tissue is in a constant state of tension. In exertion of force, muscles shorten and thicken, changing their shape and position. (Simblet 2001, 164.) Skin and appendages such as hair and nails form the integumentary system. The angular form of the skeleto-muscular system is softened by the fat tissue beneath the skin. (Simblet 2001, 36-38.)

The body consists of the masses of head, thorax and pelvis, which are held together by the spine. Upper and lower limbs are connected to the thorax and pelvis respectively. (Bridgman 1952, 23-25, 42.) The limbs are linked by six different types of joints, which determine how the limb can move. Most natural human movements depict arcs. (Roberts 2007, 52-54.)

Using the head as the unit of measurement, a normal human body is approximately 7 ½ heads tall. However in art, the ideal figure is 8 heads tall. In this measurement system, the legs are four heads tall, the pelvis one head tall, and the torso two heads tall. The male figure is approximately 2 1/3 heads wide while the female figure is approximately 2 heads wide. The proportions depend also on the age of the character and can be stretched further to achieve different effects. (Loomis 1943, 26-29.)

2.3 Animation techniques

The traditional approach to 2d animation is drawing each frame individually by hand using either straight-ahead or pose-to-pose techniques. However, individually drawing each animation frame requires a considerable amount of time and effort. Some techniques that can assist in creating 2d character animation more efficiently include rotoscoping, cut-out or component-based animation and skeletal animation.

Rotoscoping means tracing animation frame by frame from live action footage (Laybourne 1998, 162). While live action is good reference material, drawn animation cannot easily reproduce all the information conveyed by real life movement. Thus animation created by tracing live action footage exactly looks unconvincing and unnatural. (Williams 2009, 371-372.) The movements need to be reinterpreted and redrawn in forms suitable for animation (Johnston & Thomas, 1981, 323). Creating 2d drawings based on existing 2d or 3d animation footage may also be considered rotoscoping.

Traditional cutout animation is created by moving figures cut out of paper across a scene. Using cutouts saves work, as one drawing can be reused continuously, but also greatly restricts the movements of the characters. Cutout animation is made more flexible by jointing the character, so that certain parts, such as limbs, are individually movable. (Laybourne 1998, 60-61.) Digital cutout animation can be created with various programs that support vector-based animation. Digital cutouts can be bitmap or vector based, and can be constructed of several components that can be individually manipulated. In digital cutout animation, the in-between frames between key frames can be automatically interpolated by the software.

Skeletal animation is a computer animation technique where a set of invisible, interconnected bones is used to animate a figure. A commonly used skeletal animation technique is inverse kinematics. (Sanders c.) In inverse kinematics animation, only the beginning and ending positions of the figure's joints need to be set and the in-between frames are animated automatically (Sanders d). Skeletal animation is widely used in 3d animation, but also supported in some 2d animation programs.

2.4 Animation for games

The major difference between creating animation for movies and videogames is interactivity. In movies, the animation is meant only to be viewed passively. In games, however, every action is controlled by the user. Actions are initiated as a response to the player's commands. Objects or characters in the environment must also respond to the actions of the player with their own reactions at the proper moments. (Sanders b, 1-2.)

The main purpose of animation in games is to serve gameplay - visuals are of secondary importance (Caoili 2012). To retain a responsive feel in the controls, the animations must be adequately short and be performed instantly as the player inputs the command. Even a visually impressive animation will only frustrate the player if it takes too much time to complete. (Maestri 2001, 4.) In some games, the frame counts available for each animation are strictly specified. Compared to film animation, game animators have considerably less freedom in expressing their message. (Cartwright 2011 b.)

After control, information is the most important factor to the player. Animation is a way of communication and is useless if the player cannot see it. In games, animation needs to be staged particularly well. Feedback must be distinct, and the composition of the scene should lead the player to see what they are supposed to see. (Moleman 2009, 1-2.)

Being played in real time sets additional technical restrictions for animation in games. The capabilities of the hardware must be taken into account in determining the complexity of the animation. Most animation in a game is comprised of short cycles that are looped to create continuous movement. These cycles cover basic actions such a standing, walking and attacking. For the animation to look natural, it is essential to have a seamless transition between the cycle's last and first frame. (Maestri 2001, 1, 4-5.)

3 CHARACTER ART IN 2D FIGHTING GAMES

This section examines the evolution of character graphics in 2d fighting games from the early 1990s to current day. The purpose of this overview is to identify the usual conventions of the genre, examine what has been done before and determine what kind of standards new works should be compared to. Particular focus is given to the graphic types and the methods used in creating game character animations for 2d fighting games released within the past 5 years. This information functions as a reference point for the practical part of the thesis. The information publicly available on the subject in English is limited to a small number of online articles, interviews and developer blogs, so conclusions are drawn from a few case studies. Additional knowledge has been accumulated by personally studying a wide variety of fighting games.

3.1 Introduction to fighting games

A versus fighting game is video game where fighters of comparable strength engage in one-on-one close combat. Fighting games are a separate genre from beat 'em ups which involve one character fighting against multiple opponents simultaneously, often in a side-scrolling environment (Spencer 2008). Additionally, sports-based fighting games such as wrestling and boxing games are recognized as separate genres. (Hardcore Gaming 101 a.) These genres are not within the scope of this thesis due to their vastly different gameplay mechanics compared to conventional fighting games.

Fighting games can be categorized in several ways, but the most notable is the division between 2d and 3d fighting games. This division is based not only on graphics but also gameplay mechanics. Traditionally, 2d fighting games feature 2d graphics and gameplay on a two-dimensional plane, while 3d fighting games use real-time 3d graphics and usually allow three-dimensional movement. Some 2d fighting games have traditional 2d gameplay mechanics yet use real-time 3d graphics. Such games are sometimes referred to as 2.5d games. Although some early 3d fighting games only enabled two-dimensional movement, they are not regarded as 2.5d fighting games due to other three-dimensional gameplay elements, such as the use of 3d hit detection.

Sega's Heavyweight Champ (1976) or Vectorbeam's Warrior (1979) can be considered to be the first fighting games (Spencer 2008). However, it was Technos Japan's Karate Champ in 1984 which established the genre and standardized the side perspective typically used in fighting games. Karate Champ heavily influenced later games such as Yie Ar Kung-Fu, Street Fighter and Mortal Kombat. (Geddes & Hatfield 2007.) Konami's Yie Ar Kung-Fu (1985) was the first fighting game to feature unique characters with unique fighting styles (Fighter's Generation 2011).

Capcom's Street Fighter was released in 1987. Its sequel Street Fighter II: The World Warrior (1991) is commonly recognized to have popularized and standardized the one-on-one fighting game genre. (Hardcore Gaming 101 a.) As proof of the game's long lasting appeal, its final official arcade revision, Super Street Fighter II Turbo (1994), is still played competitively in 2013 (ST Revival 2013). This study focuses on fighting games beginning from Street Fighter II, as it established the standard mechanics that are still the basis for most new 2d fighting games. Despite technological advances, the visual layout of 2d fighting games remains largely the same after over 20 years (Figure 5).

Figure 5. The basic elements of a 2d fighting game remain unchanged after over 20 years. Left: Street Fighter 2: World Warrior (1991). Right: Street Fighter x Tekken (2012). (Svatopluk's Arcade; Shoryuken 2012.)

3.2 Low resolution bitmap graphics

Conventional 2d fighting games use bitmap assets. Due to hardware limitations, early arcade game developers had to work with a low amount of colors and low resolutions. (SNK Playmore b.) For example, Street Fighter II originally ran on Capcom's CPS-1 hardware which has a 384x224 pixel display. Fatal Fury: King of Fighters (1991) and several other SNK titles ran on the Neo Geo hardware, which has the resolution of 320x224 and is capable of displaying 4096 colors simultaneously. (Broyad 2012 a, b.)

To best utilize the limited hardware, most game art was created as 2d pixel art. Pixel art is a form of bitmap art where images are edited on the level of individual pixels. (SNK Playmore b.) Figure 6 contains a sampling of character sprites from various 2d fighting games released between 1991 and 2000. Throughout the 1990s, most fighting games used pixel art sprites with an average height of approximately 100 pixels with 4-bit color depth, meaning 16 colors in total. Some games did have higher color depths or slightly larger sprites, but it did not become the norm until the 2000s. It should be noted that low color depth is not used in pixel art only because of technical limitations, but because it makes controlling the image and handling color palettes easier with negligible impact on the final visual result.

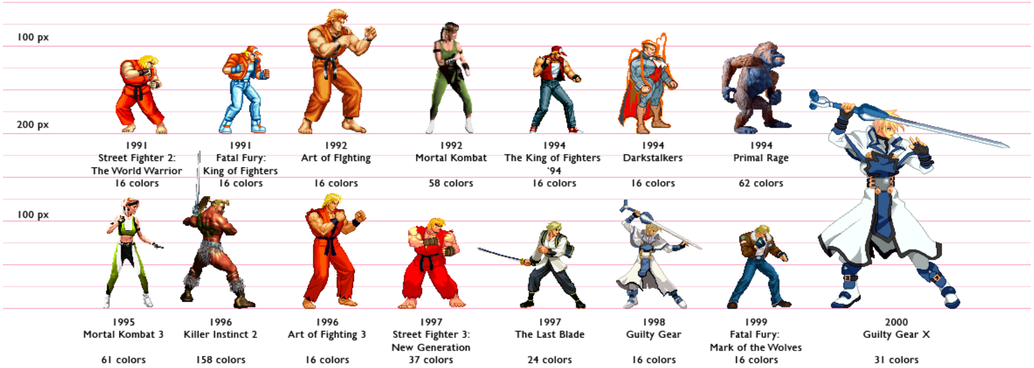

Figure 6. Character sprites from various fighting games released between 1991 and 2000. The amount of colors listed in this chart is the amount of colors in the particular sprite.

Some developers wanted to aim for a more realistic look than hand drawn pixel art. Using real time 3d graphics was not an option during the early 1990s – early examples of 3d fighting games such as Sega's Virtua Fighter (1993) feature graphics much more simplistic than their 2d counterparts. Instead techniques such as digitized photography and pre-rendered 3d were used. Midway's Mortal Kombat (1992) uses digitized footage of real life actors. The developers believed digitizing would allow for a high level of detail in a small amount of time. The approach had been used before in Atari Games' Pit-Fighter (1990). (Donovan 2010.) Atari's Primal Rage (1994) uses digitized stop motion animation created with detailed dinosaur sculptures. Earlier examples of stop motion in fighting games include Clay Fighter (1993) and Last Apostle Puppet Show (1989). (Bieniek 2011; Hardcore Gaming 101 b.) Rare's Killer Instinct (1994) uses pre-rendered 3d models instead, which means that the characters were modeled and animated in 3d and then rendered as 2d sprites. Pre-rendering allowed a greater amount of detail in the models compared to real-time 3d graphics of the time. These techniques have since become mostly outdated as graphics technology has advanced.

In addition to resolution and color depth, the quality of animation has increased over time. In Street Fighter II, Ryu's iconic Hadouken special attack is indicated with just a few unique frames. In Street Fighter III: New Generation (1997), the animation has more in-between frames and much more sophisticated follow-through animation in Ryu's clothing (Figure 7).

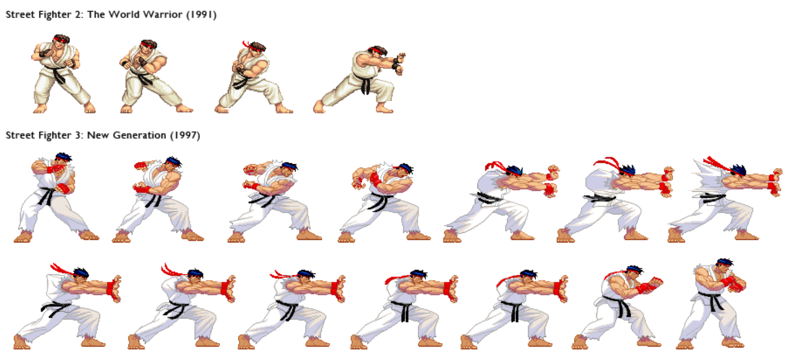

Figure 7. Hadouken!

A notable leap in sprite resolution occurred in 2000 when Arc System Works' Guilty Gear X was released, updating fighting game graphics to the standard-definition resolution 480p (640x480). Guilty Gear X sprites are approximately four times the size of traditional fighting game sprites (Figure 6). Even after Guilty Gear X, many 2d fighting games were still released using lower resolution graphics until the popularization of high-definition gaming. SNK, for example, continued using Neo Geo hardware, the last official game for the system being Samurai Shodown V Special in 2004 (Neo-Geo.com 2006).

3.3 Vector graphics and component based animation

Vector based animation refers to animation created by moving, rotating or transforming objects by controlling mathematical values (Sanders 2012 a). In vector animation, in-between frames can be interpolated mathematically, which enables creating smooth transitions quickly. This technique allows component based animation, which is similar to traditional cutout animation. Vector animation is common in Flash-based browser games but is also seen in commercial console games. Vanillaware, the company known for action role-playing games Odin Sphere (2007) and Muramasa: The Demon Blade (2009), is famous for creating beautiful 2d games using a combination of bitmap assets and vector based animation (Sheffield 2009).

In fighting games, however, vector-based animation is rare. Typically, each frame of animation in a fighting game consists of a single sprite portraying the entire character. In order to save memory, some games, such as Bandai's mecha fighting game Gundam: The Battle Master (1996), have employed component based animation, dividing the sprite into multiple separately animated parts (Hardcore Gaming 101 c). The Rumble Fish (2004) by Dimps also uses a component based sprite system, where each limb is animated separately. The animation is extremely smooth but makes the characters seem uncannily like paper dolls. (Niizumi 2004.) This is a common issue with vector-based animation and likely one of the reasons why major fighting game developers have not experimented with vector animation more, despite the benefits of automatic in-betweening.

For fan or hobbyist developers who might be willing to experiment with vector art, another issue is engine compatibility. Commonly available fighting game engines such as M.U.G.E.N and 2d Fighter Maker do not support vector art. For example, Mane6's My Little Pony - themed fighting game MLP: Fighting is Magic uses animations created in vector animation software Adobe Flash. This is a logical choice, as the game is based on a cartoon which is also animated in Flash. However, because their game engine does not support vector art, the assets must be rasterized before use in the game engine. Turning the vector sprites into palettized raster images is a complex process due to the limitations of the engine. (Wright 2012.)

3.4 3d graphics in 2d fighting games

The first fighting game to feature fully 3d polygon graphics was Sega's Virtua Fighter in 1993. Although early 3d fighting games resembled 2d fighting games in their mechanics, 3d fighting games soon started to evolve in a distinctly different direction from 2d fighting games. However, as graphics technology has advanced, using 3d graphics has become a viable option for 2d fighting game developers as well.

2d animation requires more work than 3d animation, and is less flexible and adaptable (White 2006, 296). While creating detailed 3d models is a considerable amount of work in itself, creating animations for 3d models is easier than drawing each animation frame by hand. Additionally, if changes to the character design are made mid-production, it is extremely resource-consuming to apply the changes to 2d sprites, while 3d models can easily be tweaked without needing to significantly edit the animation data. 3d graphics also make it easier to achieve a realistic look. (SNK Playmore 2009 b.)

However, the mixture of 2d gameplay and 3d graphics has often proved problematic. One of the first fighting games to incorporate completely 2d gameplay mechanics with 3d graphics successfully is Arc System Works' Battle Fantasia (2007). Battle Fantasia helped the Street Fighter IV (2008) development team realize that making a 2,5d fighting game properly was possible. (Sheffield 2008.) Since then Capcom has embraced the 2,5d style for all their new fighting games (Crecente 2010). According to Capcom, games with 2d graphics lack sales potential. Additionally, they no longer have many artists capable of doing good 2d art. (EventHubs.com 2011.)

Still, there are many who still prefer the unique, artistic feel of hand-made 2d animation over 3d animation (White 2006, 296). According to BlazBlue director Toshimichi Mori, the warmth and organic feel of traditional 2d drawing is necessary to create the best possible 2d fighting game (Stuart 2011). Similarly, the developers of The King of Fighters XII decided to use hand drawn pixel art to give the game a look and feel that no 3d game could offer. (SNK Playmore 2009 b.)

Some games, such as Battle Fantasia and several anime fighting titles, use a technique called cel-shading to make the 3d models appear more like 2d drawings. However, the technique has yet to reach the level of looking like organic hand drawn animation.

3.5 High resolution 2d graphics

While true 1080p (1920x1080) resolutions are still rare in console games, 720p (1280x720) has widely become the display standard. This switch to high-definition gaming has forced fighting game developers to increase the detail level of their character sprites (Figure 8). While pixel art is an efficient method for creating low resolution sprites, as the size of the sprite increases, painting each pixel by hand becomes increasingly time-consuming. Regardless, many Japanese fighting game developers, such as Arc System Works and SNK Playmore, continue creating their 2d assets as pixel art. Arc System Works' BlazBlue series and Persona 4 Arena use sprites similar to Guilty Gear but fit for 720p displays. SNK Playmore's The King of Fighters XII uses smaller sprites with a very detailed pixel art style. Notable examples of high-definition fighting games that do not use pixel art assets are Backbone Entertainment's Super Street Fighter II Turbo HD Remix and Reverge Labs' Skullgirls. Following is an overview of how these developers have approached the process of creating 2d character animation.

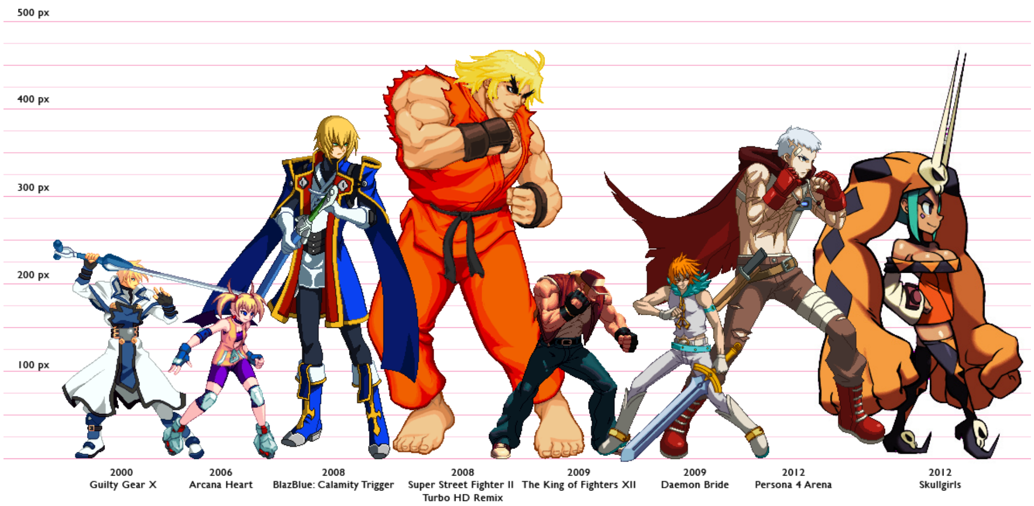

Figure 8. Examples of high resolution 2d sprites in fighting games released between 2000 and 2012.

3.5.1 BlazBlue

The BlazBlue series by Arc System Works has high resolution pixel art sprites and 3d environments in high-definition 720p resolution. The first game in the series, BlazBlue: Calamity Trigger, was released in 2008. BlazBlue's anime-influenced art and animation style is similar to that of Guilty Gear's with sprites approximately 1.5 times as tall as those in Guilty Gear.

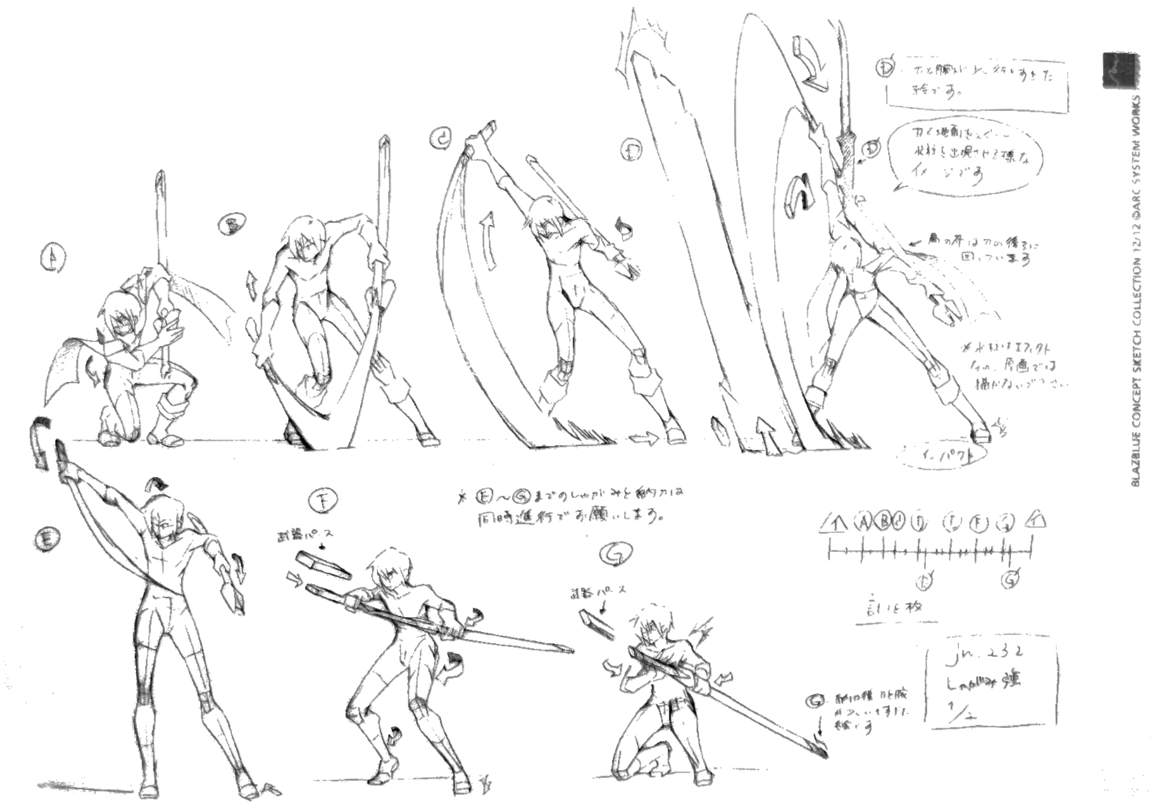

Figure 9. Concepts sketches and timing chart for key drawings (Arc System Works 2012).

The characters' animations are carefully designed by hand - 2d concepts are drawn for each animation frame (Figure 9). However, creating sprites completely by hand can cause stylistic differences when many artists work on the same character. To streamline the process, Arc System Works creates 3d models of the characters, and poses these according to the 2d frame concepts. A 2d line image is rendered from the 3d model, to which light and shadow are added by hand. The details of the sprites are then reworked to add a more organic, handmade feel (Figure 10). (Siliconera 2012.)

Figure 10. The development of a character sprite (Siliconera 2012).

Each character takes roughly 5 months to create, and has around 1000 frames of animation (Stuart 2011). Despite the high overall frame count, the frame counts for individual animations are not particularly high. The animation focuses on strong key poses rather than smooth in-betweens, as is typical for Japanese animation.

3.5.2 Super Street Fighter II Turbo HD Remix

Several fighting games from the 1990s have been re-released for modern platforms. To make the games more appealing to modern audiences, these remakes usually utilize graphical filters to smoothen the old pixel graphics. However, as these filters cannot add any detail, the results are lacking.

Super Street Fighter II Turbo HD Remix (2008) is a remake of Capcom's Super Street Fighter 2 Turbo from 1994, developed by Backbone Entertainment with artwork from comic book studio UDON Entertainment. Instead of reusing the old sprites, the development team decided to completely redraw every sprite to suit the game's new 1080p resolution. The game has hand painted sprites in approximately twenty times the resolution of the old artwork.

The developers were originally aiming for a very high detail level, which proved too ambitious during development. The quality between frames drawn by the core UDON team and artists from an outsourced company was not consistent. The shading style had to be simplified to allow more efficient animating. (Killian 2008.)

In-progress PSD-files released by the development team allow a close inspection of the creation process. The line art is drawn on top of the original sprites, closely following the original design (Figure 11). Each flat color is painted on a separate layer. Shading is not done until flat color animations have been approved through quality control (Killian 2007).

Figure 11. The new sprites closely match the proportions of the original sprites. This image is of a work in progress from before the art style was simplified.

Although impressive for having some of the first truly high-definition 2d art in fighting games, the sprite work in Super Street Fighter II Turbo HD Remix was not universally acclaimed. The frame count for animations was not increased from the original game, resulting in an outdated look. The more detailed the art is, the more the audience demands from the animation. Additionally, inspection of the animated sprites shows a considerable number of shortcuts were used in development: body parts are moved and rotated from frame to frame without completely redrawing the art. Capcom has not attempted a similar visual overhaul with their other fighting game remakes that feature much more animation frames, such as Street Fighter III: 3rd Strike Online Edition (2011), instead relying on graphical filters.

3.5.3 The King of Fighters XII

SNK initially attempted to remake their original The King of Fighters ’94 sprites in a higher resolution for the 2004 remake The King of Fighters ’94 Rebout. The new sprites were exact remakes of the original sprites and animations in four times the resolution. Due to negative fan feedback, SNK Playmore decided to redraw their sprites completely for The King of Fighters XII (2009). The new sprites are approximately the size of Guilty Gear X sprites but with extremely detailed, three-dimensional shading. On the screen the characters are upscaled to match 720p resolution.

To eliminate the style differences between different artists working on the sprites, SNK uses a method of rotoscoping 2d animations from 3d animations. Animating in 3d also saves them from having to draw 2d drafts for every animation frame. After creating initial pixel art sketches of the character, a 3d model is created. All animations are designed for this 3d model. After the 3d animations are finished, the animation frames are rendered out as 2d still frames. These frames are used as the basis to which pixel artists make adjustments and add additional details and shading by hand (Figure 12). (SNK Playmore 2009 a.)

Figure 12. Pixel sprites are created based on 3d renders. (SNK Playmore 2009 a.)

Each character has around 400 to 600 frames and takes approximately 16 months to complete (SNK Playmore 2009 a). The relatively low frame count may be explained by the limited movesets of the characters. The animations are very smooth and three-dimensional while retaining the traditional pixel art style of the series.

3.5.4 Skullgirls

The current high point in 2d fighting game character animation might be Reverge Labs' Skullgirls (2012). The game features completely hand drawn, non-pixelated high-definition sprites with 1200-1500 animation frames per character (SkullgirlsGame 2011). According to the games creators, this is the most animation frames per character in any fighting game ever (Autumn Games 2012). The game is in 720p resolution.

Skullgirls actually originated as a pixel art based game (Ahad 2009). However, the final product attempts to achieve film-like animation, combining elements of Japanese anime and western film animation. Japanese animation often focuses on key poses with follow-through animation to create movement, while western animation is more focused on the overall flow and motion of the action. The key-pose oriented approach is beneficial to fighting games, but with Skullgirls, the developers tried to find the right balance between strong poses and smooth animation. (Cartwright 2011 a.)

To maintain consistency between the works of different artists, reference sheets are created for each character, detailing aspects such as shading, color and scale. Key frame animations are then created based on rough sketches. These animations are tested in the game before proceeding to draw in-between frames. (SkullgirlsGame 2011.) At this point the linearts are still rough. After cleanup, the color map and shading are created as separate layers, which are combined programmatically to create the final image (Figure 13). (Suh 2011.) The whole process takes around 2000 man-hours per character (SkullgirlsGame 2011).

Figure 13. Process from 2d sketch to final sprite (Suh 2011).

The animation in Skullgirls is completely hand drawn with no assistance from 3d or vector tools (Cartwright 2011 a). The development team makes a point not to use any shortcuts in animating, such as cloning or rotation, as they feel it would lower the quality of the art (Cartwright 2011 b).

4 PROJECT DOCUMENTATION

As the practical part of the thesis, animated 2d character sprites suitable for a high-definition fighting game were created. Creating a fully playable character with a complete animation set would have required several months of full-time work, which could not be done within the scope of the thesis. Thus, instead of aiming for a full animation set, the focus was on creating sample animations at a high quality. The project was conducted as a personal project with no external client. The assets were incorporated in the free fighting game engine M.U.G.E.N to test how they would operate in a game environment.

The main purpose of the project was to discover an efficient workflow for creating high-definition in-game 2d character animation. Another goal was to study the application of animation principles in creating appealing in-game animations, and how these principles conflict with gameplay requirements. The findings of the project should be applicable in future 2d game projects.

On a personal level, the project was also a learning experience with the main goals of improving my art skills and gaining a better understanding of animation. I have limited previous experience in character animation, and it is mostly of vector animation in Adobe Flash.

4.1 Character design and art direction

Since the character animation was not created for an actual game in development, a game concept was created to operate as context. This concept is a 1080p high-definition 2d fighting game set in a modern, mostly realistic setting. The game has hand-drawn sprites comparable to the largest sprites that exist in modern 2d fighting games and fluent animation. To visualize the art style, a mock-up screenshot was created with background concepts and character sprite concepts (Figure 14).

Figure 14. Early mock-up of the character and environment.

The character concept used in the project is an athletic woman in her early twenties, with clothing inspired by heavy metal aesthetics and gym attire (Figure 15). The character has a fit but not extremely muscular build and is of average height. The character has an energetic personality and uses an undetermined martial arts style comprised of elements from many different styles.

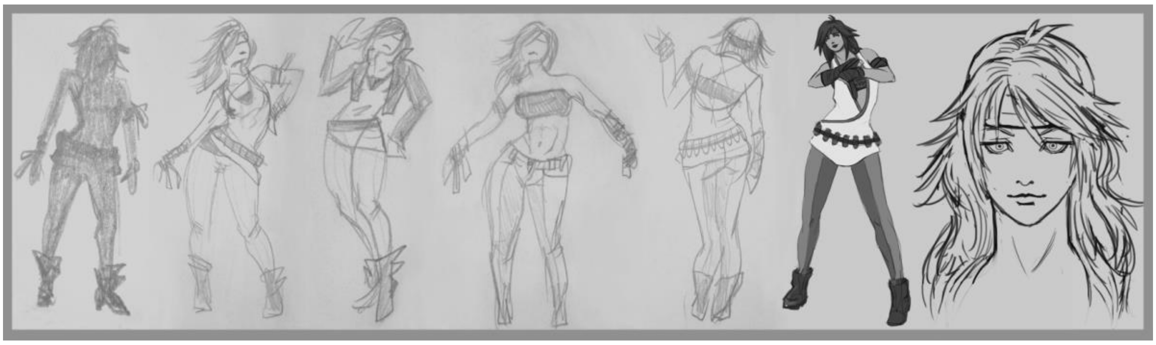

Figure 15. Rough sketches from the character design phase.

To make the character concept suitable for animation, certain restrictions needed to be taken into account. It is usually preferable to simplify and stylize an animated character. The more realistic an animated character looks, the more realistically it is expected to move, which complicates the animation process. (Roberts 2007, 55.) The character retains mostly realistic proportions, with some details such as facial features emphasized in a cartoony manner. To make the character's silhouette more interesting, the shape of the hair, the size of the boots and the hand wrappings were exaggerated. The character's default color scheme was designed to have bright colors that attract attention, with the green spot color working as a contrast for the orange pants. (Figure 16.)

Figure 16. Initial reference sheet for the character.

Having too many details on a character can be distracting and result in awkward animation. Each additional detail makes the animation process more time-consuming. (Roberts 2007, 56.) To enable the success of the project, it was important that the character design was not too intricate. However, it still needed to have some interesting details, and appendages that enable overlapping actions, such as the long flowing hair and wrappings on the arms. The most complicated aspects of the design are the pentagram logo on the top and the bullet belt. These were designed in a way that allows them to be animated separately from the main figure and also simplified if necessary. The belt in particular was expected to prove problematic, but was deemed important in conveying the feel of the character. To make it more suitable for animation, an originally realistic bullet belt design was simplified by making the individual bullets larger.

The character design has slight asymmetry, which in retrospect is not practical in 2d fighting game character animation. When the character switches from the screen's player 1 side to the player 2 side, the sprites are usually simply mirrored. If a turning around animation is created for the character, the asymmetric details will cause issues.

In designing the sprite art style, the aim was to have relatively realistic, but stylized proportions, with clean lineart, sharp details and bright colors. Reference was taken from Japanese animation, the most notable inspirations being the anime-styled pixel art sprites seen in Arc System Works games BlazBlue and Persona 4 Arena. However, it was immediately decided that pixel art would not be used in the project, as it becomes redundant and time-consuming at very high resolutions. The animation style itself was inspired by the smooth and rather realistic animation of The King of Fighters XII, as well as western animation principles.

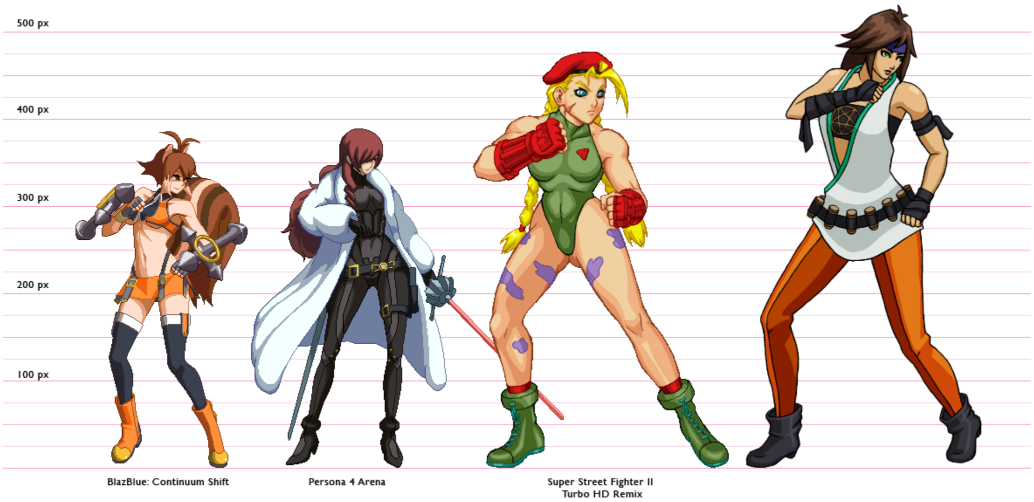

Figure 17. Comparison with similarly proportioned characters in other games.

To manage the workload, it was decided that a very simple shading style would be used, just enough to suggest three-dimensionality. Only two shades are used on most areas, with a third highlight color being reserved for particularly shiny parts such as hair, leather and skin. This is similar to the shading in BlazBlue and Persona 4 Arena, which use 2 to 3 shades for most colors, and slightly simplified compared to Super Street Fighter II Turbo HD Remix, which uses 3 to 4 shades (Figure 17). The light source is to the front and above of the character.

Due to issues with color bleed it was necessary to increase the line weight slightly from what was originally intended. However, the end result seemed appropriate for the animation style which draws more from western animation than anime (Figure 18). Using colored lineart was considered, but it was decided that the visual impact was not worth the increased amount of work.

Figure 18. From rough sprite concepts to finalized sprite.

4.2 Animation process and tools

In the early stage of the project experiments were conducted with various animation programs to determine which tools would be the most suitable. Dedicated 2d animation programs such as Pencil and Plastic Animation Paper are well suited for fully hand drawn animation. However, creating 2d animations this way requires high drawing ability, and as such may not be the most suitable option for an inexperienced animator. The other functionality of the software was also too limited for the project's needs, so it was decided that Adobe Photoshop would be used to create the 2d artwork, despite its limited animation tools.

Tests were conducted in Adobe Flash to see if vector animation mock-ups could be used as reference for the final animations, but it was quickly discovered that component-based vector animation was too limited. Implying three dimensional motions in vector animation would have required creating multiple versions of each body part at different angles, which was not considered worth the effort. Instead, it was decided that 3d animation would be used as basis for the 2d animations. Companies such as SNK Playmore and Arc System Works use 3d models as reference to eliminate inconsistency between the works of different artists. In this case, using a 3d model assisted in visualizing the animations in three dimensional space and maintaining correct proportions and anatomy.

Resources were not sufficient to create a custom 3d model of the character, so instead a pre-rigged female model was used. The proportions of the character did not fully match the 2d sprite design, but as a rough basis for the motions the 3d renders worked sufficiently. Autodesk MotionBuilder was chosen for the 3d animation mainly due to prior experience with its interface. The 3d animations were created using inverse kinematics animation with a combination of pose-to-pose and straight-ahead methods. The 3d animations were intentionally left rough, and small details such as hands were not animated.

The 3d animations were rendered out as 2d still frames and imported to Adobe Photoshop, where it was decided which frames would be used. The frame rate of the rendered 3d animations was higher than the intended frame rate of the final 2d animation, so the timing of the motions could easily be adjusted at this point. Since the animations were intended for use in a game with 60 fps frame rate, they needed to be directly compatible with this rate. After experimenting with different frame rates, it was decided that each frame would be held for 0.05 seconds or 3 frames, translating into 20 frames per second. For comparison, traditional film animation usually uses 12 frames per second for slow movements and 24 frames per second for fast movements.

Figure 19. The development phases of a single animation frame.

The 2d animation process followed the usual formula of rough animation, cleanup, flat coloring and shading (Figure 19). Generally, it is easiest to start animating with simple three dimensional shapes, and add details only after the basic movement looks right (Roberts 2007, 55). After the frames had been chosen and the 3d render adjusted to better match the character's proportions, the character's basic shapes were traced loosely over the renders. Once the basic shapes had been drawn for each frame and tested, the original renders were hidden and additional details and overlapping animations were added. Before moving onto animation cleanup, approximately every other frame was hidden, leaving only the extreme and breakdown frames, which were set to display for twice the usual length. Once the key frames had been completed, the remaining in-between frames were drawn based on the adjacent frames. Working with fewer frames at this point allowed visualizing the overall movement faster and avoiding unnecessary work should parts of the animation need corrections.

Once the line animations had been finished and tested, flat colors were added beneath the lineart. It was decided that a false color map would not be created for the sprites, and instead the intended color scheme of the character was used in order to achieve instant results. Once the flat colors were completed for each frame, shading and highlights were added. All differently colored parts were created on separate layers to make later editing easy.

4.3 Moveset design

In a proper fighting game with several playable characters, having a recognizable and unique fighting style for each character is important. However, for this project, it was decided that the character's moveset did not need to be based on one specific martial art. The focus was on appealing visuals rather than authenticity. Gameplay-wise, the character has a balanced moveset with mid-speed normal attacks.

The different actions of the character can be categorized into stances, attacks, movements and reactions. In most 2d fighting games, each action button corresponds with one normal attack. Characters usually have three sets of normal attacks: standing, crouching and aerial. Often, these moves have variations based on the distance from the enemy. In addition, characters can have various command moves, special moves and grabs. More personality can be added with flavor animations that serve no direct gameplay purpose, such as introduction and victory poses and idle animations. The full planned animation set for the character can be seen in Appendix 1.

4.3.1 Stances

In 3d fighting games, characters often have multiple stances that lead to different moves. In 2d fighting games this is uncommon. Usually, the only stances a character has are their regular standing position and a crouching stance. In many games, the crouching position is not as animated as the regular stance, as it is not seen as often. The regular stance animation, however, is extremely is important in conveying a character's personality and mood. The fighting stance's authenticity is often a secondary concern.

For this reason, the stance animation was the first to be created for the character. The stance animation has an energetic, bouncy movement. The stance was primarily inspired by other fighting game characters, but authentic martial arts poses were referenced to make it more convincing. Having three dimensional rotation in a stance animation is important to make the character seem alive, so the character's torso twists considerably during the motion. However, making this twist too extreme caused the torso to look like it is rotating independently from the lower body. Adding more rotation to the lower body motion as well might correct this issue.

Overlapping follow-through action is seen in the character's hair, hand wrappings and belt. Creating the proper sense of weight for different objects proved difficult, such as trying to retain considerable heaviness for the character's belt despite the bouncing up-and-down movement. Another problem area was the behavior of cloth on the character's overshirt.

To save some effort, the most complex parts of the animation, such as the hand wrappings, belt and shirt logo, were cloned from frame to frame with only minor edits. However, using this technique easily becomes too obvious and lowers the quality of the animation. In this animation, the use of cloning is most obvious in the linear movement of the belt that lacks three dimensional rotation.

The stance animation is 16 frames with fairly even spacing. Accentuated slow-in and slow-out might have assisted in conveying weight and effort better. To make the stance cycle more interesting, secondary actions such as hand movements could be added. Additional idle animations could also be implemented.

4.3.2 Attacks

The most important aspect about creating animation for games is that the animation must support gameplay. In fighting games, it is particularly important to take into account frame counts. Most fighting games run at 60 frames per second, and each move by a character takes a specific amount of frames to complete. These frames can be divided to startup frames, which take place before the move is capable of hitting the opponent; active frames, which mark the period of time a move is capable of hitting the opponent; and recovery frames, which finish off the animation before another command can be input. (EventHubs.com 2010.)

Each attack of a character has different properties, and the animations need to comply with their frame counts. A light jab usually has few frames, so the animation cannot have much anticipation or follow-through animation. Heavy hitting attacks are usually slower and allow for more elaborate animations. Although the games run at 60 fps, it does not necessarily mean 60 unique frames of animation per second. A single animation frame is usually held for multiple frames during a move.

In 2d fighting games, attacks are categorized to high attacks, overhead attacks and low attacks. High attacks can be blocked either standing or crouching. Overhead attacks can only be blocked standing. Low attacks can only be blocked crouching. Typically, high moves are used for quick poking while overheads and lows are used for mix-ups. Depending of which gameplay purpose a move serves, it should have an appropriate amount of anticipation. Weak moves that are not intended to be blocked on reaction should come out quickly without much anticipation. Stronger moves that are supposed to be avoidable on reaction need to be telegraphed with enough anticipation. Clear visual cues that indicate whether the move must be blocked high or low make gameplay seem intuitive.

In fighting games, key pose oriented animation style particularly valuable. When an attack hits or is blocked, the action is often frozen for a fraction of a second to create impact and give the players time to react to the situation on screen. These held poses need to look convincing. Additionally, it is worth noting that attack animations in fighting games will not always play out in their entirety. In addition to potentially being interrupted by the opponent’s moves, many fighting games involve a technique called canceling. Canceling an action essentially means omitting the recovery frames of the action in favor of playing another animation, such as another attack or a dash movement. Canceling makes focusing on strong key poses even more important (Cartwright 2011 b).

Designing the moveset of the character started from normal attacks. The game concept uses 4-button combat system with an attack button for light punch, heavy punch, light kick and heavy kick. From the perspective of animation, creating heavy attacks is more interesting than light attacks, as they can use more frames. Thus the heavy punch and heavy kick were created first. They are both high attacks.

The heavy punch is a basic hook with the rear hand. Having basic knowledge of boxing moves helped in visualizing this movement. It is important that the strength of the punch comes from the movement of the body rather that the arm. The whole body twists and moves in this movement. Both the arm and body of the character follow a curved path. (Figure 20.)

Figure 20. Hook key positions and breakdowns. Reducing an animation to silhouettes is a good way to test its readability.

Controls in a fighting game must feel responsive, so basic attacks cannot have very many startup frames, limiting the amount of anticipation that can be included. The hook has an anticipatory movement where the character's body turns briefly in the opposite direction of the movement to gather strength. The motion starts with slow-out and accelerates towards the arm's swing. Originally, the hook animation had 15 frames including several anticipatory frames, which resulted in a movement that lacks energy. Removing frames from the startup made the move appear more impactful and more suitable for gameplay purposes. The animation has fairly many recovery frames, allowing the exaggerated follow-through animation of the hair to play out.

For the heavy kick, a spin kick was chosen because it has a full circular motion. Online tutorial videos were referenced for the movement. The spin kick starts from a side stance with the character's heel and hips towards the target, which matches the character's default position. Weight is on the ball of the supporting leg. The character turns around, looks over her shoulder and raises her leg with the knee up. She then sticks the leg out and sweeps across, extending the leg before snapping it back. (Figure 21; Kwonkicker 2010.)

Figure 21. Spin kick key positions and breakdowns.

The turning around movement naturally adds anticipation frames to the animation. As with the hook animation, the spin kick originally had unnecessarily many startup frames which could be removed to improve its impact. The primary action of the animation is in the legs and body, with arm movements serving as secondary action. The hair and hand wrappings create overlapping tertiary movement.

4.3.3 Movement

In addition to standard walking forward and backward, most 2d fighting games include other types of movement such as running, dashing and different types of jumping. The standard walk is actually the slowest way to move, and in matches dashes and hops tend to be seen more often. Unlike some 3d fighting games, crouching characters usually cannot move.

Regardless, some type of walk cycle needed to be created. Instead of a standard walk, the character moves with a gallop-like sideways motion (Figure 22). It is not based on real martial arts. The intention was that the frames of the forward walking cycle could be utilized for the backward walking cycle as well, saving a considerable amount of work. Unlike the other animations, the starting position for the walk cycle is not the same as in the stance animation. This led to issues with scale and proportions, which were not fully noticed until testing the animation in the game engine.

Figure 22. Arcs of action in the walk cycle.

The walk animation was an experiment on cloning. Due to the linear nature of the motion, the character's face could be duplicated from frame to frame. For walking backwards, the frames were reversed and follow-through animations were redrawn.

4.3.4 Reactions

When a character is attacked in a fighting game, they can react primarily in two ways: by blocking the attack, or getting hit by it. Some games include other techniques such as parrying, but these are not as common. Most 2d fighting games do not have a dedicated button for guarding, so it is performed with the backward directional command instead. Because the same command is used for moving backward, the guarding stance is shown only when the other character is actually attacking.

The guarding stance is generally not animated very much, so only a few transition frames were created for the guarding animation. Some games have variations of the guarding animation depending of the strength of the blocked move, but creating individual guarding animations against all different types of moves is not practical in 2d. Thus the guarding pose was made as universal as possible with the character's arms up to protect her face. The main aim of the posture is to be easily recognizable as a guarding motion.

For getting hit, characters usually have several different reaction animations depending on the height, direction and strength of the hitting attack. Attacks that knock the character down or launch them into the air require additional animations. Usually, these animations do not have many unique frames, and instead the key position is held for the duration of the opponent's assault.

Figure 23. Reaction animation for being hit.

A generic reaction animation was created for high hitting attacks. The character is thrown off balance and leans backwards with her front foot off the ground. Her arms swing to the sides in an exaggerated motion and her fists unclench. The character was also given a painful facial expression to accentuate the reaction. (Figure 23.)

4.4 In-engine testing

The created animation assets were implemented in M.U.G.E.N to test their suitability for a game environment. M.U.G.E.N is a free fighting game engine that allows the implementation of custom characters, stages and other elements without requiring considerable programming experience. The engine allows the use of any number of sprites for a character and resolution up to 1920x1080. (Elecbyte 2011.)

The main graphical limitation of the engine is that sprites need to be in indexed color, restricting the maximum amount of colors to 256. Indexed color is a technique to manage an image's colors by not including the color information directly in the pixel data, but in a separate palette file. Each pixel in the image contains its index in the palette instead of a color value. Using indexed color sprites allows the use of multiple color palettes for the character, which are used in 2d fighting games to distinguish the characters controlled by different players.

In pixel art based games, sprites usually have a low color depth which allows easily controlling the color palette. Since the sprites in this project have a large number of colors, properly planning the palette would have been a complicated process. While not an optimal solution, it was decided that using a 256-color palette automatically generated from one of the sprites would be sufficient for testing purposes. Each frame of the character's animations was individually converted into indexed color PCX-files using the same palette. Because of the unoptimized palette, additional palettes could not be created freely and instead had to rely heavily on Photoshop's replace color and hue/saturation tools.

Figure 24. In-engine screenshot using custom character and environment assets.

To implement the sprites in the game, a character template that was provided with the engine was used. By replacing the animation assets with new sprites, the graphics could be seen in the game rather quickly (Figure 24). Most animations in games are created as cycles, which loop seamlessly from the last animation frame to the first. Ideally, all animations would flow smoothly into each other, but this is difficult to accomplish in 2d animation. During M.U.G.E.N experiments, it was noticed that most animations transitioned smoothly to and from the stance animation, as long as the starting frame for each animation was the same default position. However, the transition from the stance animation to walking animations was abrupt. The issue could be improved slightly by changing the starting frame of the stance animation to not be the first frame of the stance animation, but one of the latter frames, where the character is returning from the other extreme position. This change actually made the transitions from other moves back to the stance more natural as well, as the motion fit more naturally as a continuation of the recovery motion of the actions. This indicates that the planning of the stance animation in relation to other moves was not done as well as originally thought.

The final result of the project is a character that can move forward or backward on the screen, can attack with two different techniques and react by either blocking or getting hit by them. Additional animations or placeholder graphics can easily be implemented due to the existing character template. However, creating a truly playable character would require a considerable amount of additional tweaking, including adjusting hitboxes and other move properties. A hitbox is an invisible shape used for real-time collision detection. Ideally, the hitboxes should match the character sprites, but as they are represented with simple rectangles instead of pixel by pixel, they are not always exact. (EventHubs.com 2009.) The hitboxes or other attack properties were not edited during the project. As such, the end result is far from a playable character, but is sufficient to demonstrate the art and animation style of the project.

5 CONCLUSIONS

The objective of this thesis was to identify the principles of good in-game character animation and to explore different tools and techniques for creating 2d animation. Although other options to assist the creation of 2d animation were examined, it was quickly concluded that 3d animation is the most versatile and practical approach. Using 3d in the animation process allows visualizing motions efficiently and makes it easier to maintain correct anatomy, proportions and logical paths of action. Especially for a less experienced artist, the 3d reference is an invaluable help. However, relying too much on 3d can have negative effects. If the 2d drawings are not edited and exaggerated sufficiently, the end result will remain stiff and unconvincing. For example, the amount of squash and stretch in the animations created for the project is limited, as it was not present in the 3d reference animations. An animator who wants to become proficient in 2d animation should not depend on 3d completely, and should aim to practice their skills in fully hand drawn animation as well.

Relying heavily on 3d in the animation process also raises the question why 2d should be used at all. 3d art is in many ways more adaptable and efficient to use in animation. The decision to use 2d art is nowadays, in most cases, a purely artistic decision, as hand-drawn 2d retains a very different aesthetic from 3d animation. In hand-drawn 2d animation, each frame of animation contains the artist's personal touch. No automated process can replicate this.

Overall, the project was primarily a learning process that required assimilating a considerable amount of new theoretical knowledge and practical skills. In addition to understanding animation processes better, the project taught me significantly about the importance of planning. Should a similar project be attempted in the future, more attention should be paid to proper planning, documentation and overall being more thorough in all the different phases of the project. When undertaking a large project, it is tempting to skim through the more tedious tasks. The first mistake was beginning the animation process before becoming fully familiarized with animation theory, which led to ignoring many animation principles while creating the animations. Many solutions had to be discovered through trial and error.

The project was scheduled too vaguely without enforced deadlines. With a tighter timetable and clearly defined milestones, more animation assets could have been created for the project, which would have made its findings more conclusive. Additionally, due to lacking documentation of performed tasks, accurate time estimates could not be made for future tasks. In a proper game production, the time allocated for each task should be estimated more carefully and documented.

Too many shortcuts were used in the design and planning phases. The sprite art style could have gone through more revisions, and should have been tested with other character designs as well. A proper reference sheet for the character should have been created after deciding the final sprite art style to help with maintaining consistency. Proper palette planning was omitted, because the ultimate idea was not to create a character for M.U.G.E.N, but a character for an undetermined fighting game engine that would support advanced color palettes without color indexing. As result, the creation of palettes for M.U.G.E.N was constrained and not reflective of the actual process that is required to create indexed palettes.

Creating a detailed list of all the character's moves and their properties including frame data in the very beginning of the project would have made it easier to begin animation tasks later. Frame properties should have been taken into consideration better while designing attack animations to ensure that the result is suitable for gameplay purposes. This would have also allowed studying the conflict between visuals and gameplay in more depth.

Despite the aim being to create high quality assets, not enough effort was always put into the actual animation creation. Careless in-betweening led to many frames not looking good in still images. Lighting and shadows were poorly thought out in the beginning with some illogical stylization choices. While the shading might have been acceptable in a static image, the problems became apparent when the figure was animated. If the shading in the first frame of an animation is incorrect, attempting to retain consistency will cause all subsequent frames to be incorrect as well.

In future research, the relation between gameplay and visuals could be examined further. This could lead to a completely new approach to 2d fighting games being proposed. As it is now, the genre has largely stagnated in terms of gameplay innovation. The use of vector animation and other automated 2d procedures is another field with unexploited potential.

REFERENCES

Literature

Blair, P. 1994. Cartoon Animation. CA: Walter Foster Publishing.

Bridgman, G. 1952. Bridgman's complete guide to drawing from life. Sterling Publishing.

Laybourne, K. 1998. The Animation Book: A complete guide to animated filmmaking - from flip-books to sound cartoons to 3-D animation. Revised edition. New York: Three Rivers Press.

Loomis, A. 1943. Figure Drawing for all it's worth.

Roberts, S. 2007. Character animation: 2D skills for better 3D. Oxford: Focal Press.

Simblet, S. 2001. Anatomy for the artist. DK Publishing.

Stanchfield, W. 2009. Drawn to Life: 20 Golden Years of Disney Master Classes: Volume 1: The Walt Stanchfield Lectures. Oxford: Focal Press.

Thomas, F. Johnston, O. 1981. The Illusion of Life: Disney Animation. New York: Walt Disney Productions.

Webster, C. 2005. Animation: The Mechanics of Motion. Oxford: Focal Press.

Whitaker, H. Halas, J. 2009. Timing for Animation. Second edition. Oxford: Focal Press.

White, T. 2006. Animation: From Pencils to Pixels. Classical Techniques for Digital Animators. Oxford: Focal Press.

Williams, R. 2001. The Animator's Survival Kit. Expanded edition. London: Faber.

Online sources

Ahad, A. 2009. DeviantArt Journal 16.2.2009
http://oh8.deviantart.com/journal/omggg-spammmm-233341911 (read 1.2.2013)

Autumn Games. 2012. Skullgirls Overview
http://skullgirls.com/game/overview/ (read 1.2.2013)

Benson, T. 2010. Newton's Laws of Motion
http://www.grc.nasa.gov/WWW/k-12/airplane/newton.html (read 28.2.2013)

Bieniek, C. 2011. Article 22- The making of Primal Rage (1994).
http://www.video-game-ephemera.com/022.htm (read 1.2.2013)

Broyad, T. 2012 a. CPS Hardware
http://www.system16.com/hardware.php?id=793 (read 15.4.2013)

Broyad, T. 2012 b. SNK NeoGeo MVS Hardware
http://www.system16.com/hardware.php?id=869 (read 15.4.2013)

Caoili, E. 2012. 5 Tips for Making Great Animations for 2d Games
http://gamasutra.com/view/news/176663/5_tips_for_making_great_animations_for_2D_games.php#.UQ0qJaVWx8E (read 2.2.2013)

Cartwright, M. 2011 a. On Animation in Skullgirls
http://skullgirls.com/2011/04/on-animation-in-skullgirls/ (read 1.2.2013)

Cartwright, M. 2011 b. Animation: Getting the Details Right
http://skullgirls.com/2011/05/animation-getting-the-details-right/ (read 1.2.2013)

Chastain, S. 2012 a. Bitmap and raster
http://graphicssoft.about.com/od/glossary/g/bitmap.htm (read 1.2.2013)

Chastain, S. 2012 b. Vector
http://graphicssoft.about.com/od/glossary/l/blvector.htm (read 1.2.2013)

Crecente, B. 2010. Capcom To Adopt 2.5D For Future Fighters
http://kotaku.com/5453638/capcom-to-adopt-25d-for-future-fighters (read 1.2.2013)

Donovan, T. 2010. Mortal Kombat - A Book Excerpt from Replay: The History of Video Games
http://www.gamasutra.com/view/feature/134205/mortal_kombat__a_book_excerpt_.php?page=2 (read 1.2.2013)

Elecbyte 2011. About M.U.G.E.N™
http://www.elecbyte.com/mugen (read 2.3.2013)

EventHubs.com. 2009. Guide to understanding Hit Boxes in Street Fighter
http://www.eventhubs.com/guides/2009/sep/18/guide-understanding-hit-boxes-street-fighter/ (read 1.2.2013)

EventHubs.com. 2010. How to read frame data: Super Street Fighter 4 Arcade Edition
http://www.eventhubs.com/guides/2009/feb/17/how-read-frame-data-street-fighter-4/ (read 1.2.2013)

EventHubs.com. 2011. Svensson: Sprite-based fighters extremely difficult sell
http://www.eventhubs.com/news/2011/mar/04/svensson-sprite-based-fighters-extremely-difficult-sell/ (read 1.2.2013)

Fighter's Generation 2011. Yie Ar Kung-Fu
http://www.fightersgeneration.com/games/yie-ar-kung-fu.html (read 1.2.2013)

Geddes, A., Hatfield, D. 2007. IGN's Top 10 Most Influential Games
http://games.ign.com/articles/840/840621p1.html (read 1.2.2013)

Hardcore Gaming 101 a.
http://www.hardcoregaming101.net/fighters/fighters.htm (read 1.2.2013)

Hardcore Gaming 101 b.
http://www.hardcoregaming101.net/fighters/fighters6.htm (read 1.2.2013)

Hardcore Gaming 101 c.
http://www.hardcoregaming101.net/gundam/gundam3.htm (read 7.2.2013)

Killian, S. 2008. Super Street Fighter II Turbo HD Remix: State of t
http://www.capcom-unity.com/s-kill/blog/2008/03/12/super_street_fighter_ii_turbo_hd_remix_state_of_th (read 1.2.2013)

Killian, S. 2007. Street Fighter Art in Progress: The Good, the Bad,
http://www.capcom-unity.com/s-kill/blog/2007/11/05/street_fighter_art_in_progress_the_good_the_bad_an (read 1.2.2013)

Kwonkicker 2010. Taekwondo Spinning Hook Kick (video)
http://www.youtube.com/watch?v=hGNBMJQVG98 (accessed 16.4.2013)

Maestri, G. 2001. Animation for Games
http://www.peachpit.com/articles/article.aspx?p=22801 (read 2.2.2013)

Moleman, C. 2009. The Necessity of Interactive Animation for Games
http://www.gamasutra.com/view/feature/132445/the_necessity_of_interactive_.php (read 2.2.2013)

Neo-Geo.com. 2006. NeoGeo Master List
http://www.neo-geo.com/snk/masterlist.htm (read 15.4.2013)

Niizumi, H. 2004. The Rumble Fish Beta Report.
http://www.gamespot.com/the-rumble-fish/previews/the-rumble-fish-beta-report-6087135/ (read 7.2.2013)

Sanders, A. a. Vector Animation
http://animation.about.com/od/glossaryofterms/g/vectoranim_def.htm (read 1.2.2013)

Sanders, A. b. Animating for Video Games vs. Animating for Movies
http://animation.about.com/od/videogameanimation/a/gamesvsmovies.htm (read 2.2.2013)

Sanders, A. c. Bone
http://animation.about.com/od/glossaryofterms/g/bone_def.htm (read 28.2.2013)

Sanders, A. d. Inverse Kinematics
http://animation.about.com/od/glossaryofterms/g/def_inversekine.htm (read 28.2.2013)

Sheffield, B. 2008. Saving Street Fighter: Yoshi Ono on Building Street Fighter IV
http://www.gamasutra.com/view/feature/132185/saving_street_fighter_yoshi_ono_.php?page=3 (read 1.2.2013)

Sheffield, B. 2009. King of 2D: Vanillaware's George Kamitani
http://www.gamasutra.com/view/feature/132486/king_of_2d_vanillawares_george_.php (read 1.2.2013)

Siliconera. 2012. The Art Of BlazBlue Part 2 – Animation Phase
http://www.siliconera.com/2012/02/09/the-art-of-blazblue-part-2-animation-phase/ (read 1.2.2013)

SkullgirlsGame. 2011. Animating the Skullgirls Way (video)
http://www.youtube.com/watch?v=5VkDXBsIXso (accessed 1.2.2013)

SNK Playmore 2009 a. Creating Graphics with Soul
http://kofaniv.snkplaymore.co.jp/english/info/15th_anniv/2d_dot/creation/index.php (read 6.2.2013)

SNK Playmore 2009 b. New Frontiers in Pixel Art
http://kofaniv.snkplaymore.co.jp/english/info/15th_anniv/2d_dot/art/index.php (read 7.2.2013)

Spencer, S. 2008. The Tao of Beat-'em-ups
http://www.eurogamer.net/articles/the-tao-of-beat-em-ups-article (read 1.2.2013)

Stuart, K. 2011. 2D Forever: the fall and rise of hardcore Japanese game design
http://www.guardian.co.uk/technology/gamesblog/2011/mar/04/2d-forever-japanese-game-design (read 1.2.2013)

Suh, R. 2011. Diamonds in the Rough: Animation Clean-Up
http://skullgirls.com/2011/06/diamonds-in-the-rough-animation-clean-up/ (read 1.2.2013)

ST Revival 2013. The ST Games at EVO 2013!
http://www.strevival.com/2013/02/11/the-st-games-at-evo-2013/ (read 28.2.2013)

Wright, J. 2012. The Joy of Palettes!
http://www.mane6.com/2012/01/joy-of-palettes.html (read 1.2.2013)

Image sources

Figures 1-4. Williams, R. 2001. The Animator's Survival Kit. Expanded edition.

Figure 5. Screenshots from:
Svatopluk's Arcade. http://arcade.svatopluk.com/capcom/street_fighter_2/
Shoryuken 2012. http://shoryuken.com/2012/01/17/street-fighter-x-tekken-screenshots-featuring-balrog-vega-juri-law-paul-and-xiaoyu/

Figure 6. Sprites collected from:
SNK Wiki. http://snk.wikia.com/
The Fighter's Generation. http://www.fightersgeneration.com
The Street Fighter Wiki. http://streetfighter.wikia.com/
The Spriter's Resource. http://www.spriters-resource.com/

Figure 7. Original animated GIF-files from:
http://www.fightersgeneration.com/characters3/ryu-a2.html

Figure 8. Sprites collected from:
SNK Wiki. http://snk.wikia.com/
The Fighter's Generation. http://www.fightersgeneration.com
The Street Fighter Wiki. http://streetfighter.wikia.com/
Logical Bends. http://justnopoint.com/lbends/index.php?location=sprites
Skullgirls.com. http://skullgirls.com/

Figure 9. Arc System Works 2012. BlazBlue Concept Sketch Collection 12/12.

Figure 10. Siliconera 2012. The Art Of BlazBlue Part 2 – Animation Phase
http://www.siliconera.com/2012/02/09/the-art-of-blazblue-part-2-animation-phase/

Figure 11. Edited from a PSD-file released on Capcom Unity:
http://www.capcom-unity.com/s-kill/blog/2007/11/05/street_fighter_art_in_progress_the_good_the_bad_an

Figure 12. SNK Playmore 2009 a. Creating Graphics with Soul
http://kofaniv.snkplaymore.co.jp/english/info/15th_anniv/2d_dot/creation/index.php

Figure 13. Suh, R. 2011. Diamonds in the Rough: Animation Clean-Up
http://skullgirls.com/2011/06/diamonds-in-the-rough-animation-clean-up/

ANIMATION TASK LIST

Type	Task	Notes	Frames
Movement	Stance cycle		16
	Walk cycle, forward		12
	Walk cycle, backward		12
	Run cycle, forward		
	Dash, backward		
	Turning around		
Normals	Light punch	Jab (high)	
	Heavy punch	Hook (high)	13
	Light kick	Shin kick (low)	
	Heavy kick	Spin kick (high)	13
Command moves	Standing overhead	Axe kick (overhead)	12
Reactions	Standing block		3
	Getting hit 1	High variation	7
	Getting hit 2	Mid variation	
	Getting hit 3	Low variation	
	Knockdown	Lying on the ground etc.	
	Getting launched	Flying through the air etc.	
Specials	Special move: Anti-air		
	Special move: Projectile		
	Special move: Advancing		
	Super move		
Crouching	Crouch stance		
	Crouch block		
	Crouch LP		
	Crouch HP		
	Crouch LK		
	Crouch HK		
	Crouch getting hit		
	Crouch turning around		
Jumping	Jump, neutral		
	Jump, forward		
	Jump, backward		
	Jump LP		
	Jump HP		
	Jump LK		
	Jump HK		
Throw	Throw		
Miscellaneous	Intro pose		
	Victory pose		
	Taunt		