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Mastering the Elements – Basics of 2D Effect Animation

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Opinnäytetyön tarkoitus oli tutkia efektianimaation perusteita sekä syventää osaamista tutustumalla tarkemmin etukäteen valittujen luonnossa esiintyvien efektien käyttäytymiseen. Teoriaa sovellettiin tämän jälkeen kaksiulotteisten animoitujen efektien tekoon opinnäytetyötä varten määriteltyyn kuvitteelliseen projektiin.

Työ aloitettiin tutustumalla animaation perusteisiin kahdentoista animaation perusperiaatteen kautta. Näiden jälkeen siirryttiin efektianimaation perusteisiin, joista ensimmäisenä tutustuttiin energian vaikutukseen efektin liikkeeseen ja muotoon. Seuraavana käsiteltiin siluetin tärkeyttä ja muotokieltä sekä tapoja niiden parantamiseen. Näistä siirryttiin keinoihin saada efekti yhteensopivaksi muun teoksen kanssa muun muassa tyylittelemällä sekä ottamalla huomioon sen rooli teoksessa. Viimeisenä tutustuttiin itse efektin luomisprosessiin luonnoksesta viimeisteltyyn efektiin. Perusteista saatiin pohja luonnollisten efektien tarkemman käyttäytymisen tutkimiseen. Tulen, veden, savun, höyryn, pölyn sekä räjähdyksien toimintaan ja ominaispiirteisiin syvennyttiin tarkemmin, minkä jälkeen selvitettiin, miten näitä tietoja voidaan käyttää taianomaisuuden luomiseen lainaamalla tai rikkomalla kyseisiä tunnuspiirteitä.

Projektia varten kehitettiin pääpiirteinen suunnitelma graafisesta ulkonäöstä, yleinen idea projektille sekä luonnoksia hahmosta että ympäristöstä. Nämä luotiin, jotta voitiin johtaa projektille oma tyyli sekä efektien käyttötarkoitukset. Efektit tehtiin luonnostelemalla ne ensin Adobe Photoshop -ohjelmalla ja tekemällä viimeistellyt animaatiot Adobe Animate -ohjelmassa. Teoriaa soveltamalla luotiin viisi efektiä: kaksi yksinkertaista lumiefektiä käytettäväksi hahmon liikkumisen korostamiseen ja kolme erilaista taikaefektiä, jotka käyttivät pohjanaan luonnon omia efektejä: vettä, tulta ja savua.

Opinnäytetyö toimi tukena ammatilliselle kehittymiselle peligraafikkona ja opintoja voidaan syventää jatkuvasti tästä eteenpäin. Luotuja efektejä voidaan käyttää tulevassa projektissa tai luodun suunnitelman ympärille voidaan kehittää lisää materiaalia, mikäli tämä nähdään tarpeelliseksi tulevaisuudessa.

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ABSTRACT

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Keywords: visual effect, VFX, effect, special effect, 2D, animation, animated, game graphics, graphics, game development

The purpose of this thesis was to study the basics of effect animation and deepen the knowledge by examining selected natural effects. These learnings were then applied in making animated 2D effects for a project created for this thesis.

The process began with familiarizing with basics of animation through the twelve principles of animation. Basics of effect animation were then studied, of which energy's influence on the effect's movement and the shape were examined first. Next, the importance of silhouette and form of the effect, and ways to improve those, were covered. After these, techniques to make the effect fit in with the rest of the project's visual style were inspected, such as stylization and taking its role into consideration, to name a few. Lastly, the effect's creation process itself was covered from the sketch phase to the completion of the finalized effect. These basics laid a foundation on getting to know the characteristics of selected natural effects. The physics and nature of water, fire, smoke, steam, dust, and explosions were examined more deeply, after which the knowledge on how to create an impression of magic by breaking or borrowing those characteristics was researched.

For the thesis, a concept of a character and an environment were created. From this, a certain setting, use, and style were acquired for the effects. Animated magical effects were then created for the project based on the learnings. The effects were made by using the program Adobe Photoshop for the concept phase, and producing the final animations with the program Adobe Animate. Five effects were created: two different, simple snow effects to emphasize character movement, and three different magical effects which each used a different natural effect as a base: water, fire, and smoke, respectively.

The thesis supported the author's professional development as a game artist, and the studies can be furthered endlessly from now on. The created effects and concepts can be used in a project in the future, and the whole graphical design itself could be expanded if deemed beneficial.

FOREWORDS

Visual effects usually have a minor role in games, so while I always knew about their existence, it was not until very late in my game graphic studies that I woke up to their versatile and fascinating world. Most of the time, visual effects may be seen as very technical, because more than often they are created with the game engine's editor by working with numbers and curves. It was the same for me, until I saw a collection of animated 2D effects from the game *Rayman Legends* (2013). The effects' beauty and creativity left a big impression on me. Later, this admiration surfaced again when I was given the chance to delve into a chosen topic for a long-term school assignment. I was slightly hesitant in choosing effect animation as my topic, because I knew almost nothing about it, but I'm glad I had the courage to take that step in the end. That time learning more about the art of effect animation caused me want to master this part of game art, and that enthusiasm has led to me writing this thesis.

A significant part of my later admiration of effect animation is thanks to the books written by the very talented animator Joe Gilland. His books *Elemental magic, volume I: The art of special effects animation* (2009) and *Elemental magic, volume II: The technique of special effects animation* (2012) have helped me tremendously in understanding the art of effect animation and have inspired me endlessly. Effect animation doesn't have much written about it, but Joe Gilland's books have been written with such knowledge, confidence, and creativity that it has allowed me to create this thesis. I also greatly thank my friends and coworkers for their encouraging words, support, and invaluable feedback during the creation process of this thesis.

CONTENTS

LIST OF SYMBOLS

FPS = frames per second, the rate at which the frames are displayed in an animation

In-betweens = frames between the key frames, aid in creating the illusion of motion in the animation

Key poses = main poses that define the decisive points in an animation, can also be known as “key frames” or “key drawings”

Onion skinning = a visualization tool enabling the user to see multiple frames on top of a selected frame, aiding in working on a certain frame of the animation

1 INTRODUCTION

Games are a collaboration of multiple different fields such as game design, programming, graphics, sound, and many others depending on a project. Inside game art even more possible areas of expertise can be found, ranging from user interface design to character art and environment graphics. One of these fields is visual effects, a part that sometimes may be left in the shadow of more popular sections of game graphics, such as characters or environments. However, visual effects are also a very diverse and creative field in the same way as other parts of game art, as there are multiple different ways to creating effects. Every artist - and every project - has their own styles and methods for visual effects. This thesis will be concentrating on a certain section of the field of visual effects: animated hand-drawn 2D effects.

The goal of the thesis is to study and become familiar with the overall basics of animation and effect animation, and explore deeper the characteristics of a few basic effects found in nature. This is executed by studying literature written about animation and effect animation. The learnings will be applied to actual work by making a few 2D animated effects using characteristics from different natural effects as a base. These will be made using digital art programs such as Adobe Photoshop and Adobe Animate.

The thesis is meant as a way to evolve and learn more as a game artist by studying a special field inside game art. The learnings are not only for effect animation, as many of the basic principles can also prove helpful in animation overall. While the focus is on hand-drawn 2D animation, the knowledge is also applicable to all the other ways of making visual effects, such as 3D and computer-generated effects, to name a few.

When creating visual effects, their meaning and purpose should be understood. Visual effects can be defined in multiple ways, as they are used in several different media from films to animation and games. In order to describe the term visual effects for this thesis, several explanations from different genres can be inspected and used to create a basis for the definition used in this work.

The VES Handbook of Visual Effects (2010) defines visual effects as a term used to describe imagery that has been created, altered or enhanced for a film – or any other moving media – and is not possible to be achieved during the shooting of the film itself (Zwerman & Okun 2010). In films, visual effects can be easily defined as pictures that have been added to enhance the filmed material, but with animation it is different. In the animation industry, visual effect animation is mostly described as animation of everything else but the characters, so the visual effect department is usually also responsible for the animation of objects. (Gilland 2009.)

Most of the definitions for visual effects focus on the movie industry and do not separate the films' and games' visual effects from each other. The most important difference is that in games visual effects are in most cases real-time rendered, whereas in films they are created on top of the filmed material. Most techniques for visual effects in films are not applicable to games, because in games the effects should work from all the angles and in all places the player is able to see them.
In the article *Visual Effects in Computer Games* (2009), visual effects in games are defined as graphical effects used for a specific purpose. For example, this purpose can be to awake a certain emotion from the player or to simulate

something from the real life. For example, fog can be used to create a mysterious, eerie atmosphere, or to simply simulate a weather phenomenon. Another important aspect of visual effects in games is to give feedback to the player. The effects should primarily support the gameplay and, for this reason, games' visual effects usually work very closely together with the animation and the code, for they should happen at the right time and in the right place to work to their full potential. (Xubo Yang, Milo Yip, & Xiaoyue Xu 2009.)

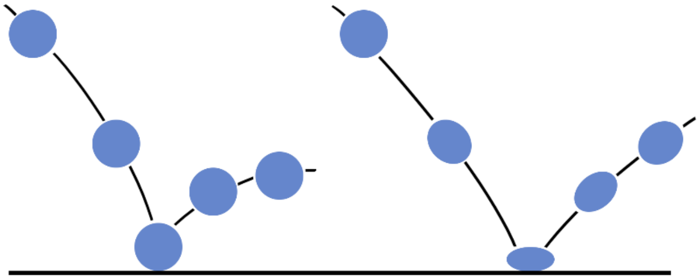
In this thesis, visuals effects are defined similar to how the *Visual Effects in Computer Games* (2009) defines environmental effects: animated effects that are used in games real-time and are something else than characters or static environment: flames, clouds of smoke, water, or effects enforcing the character's movement, like special attacks or simple dust rising from the ground in response to movement, to name a few examples. For these effects, it is important to reinforce the chosen atmosphere, add a feeling of reality to enhance player immersion and make the player experience pleasant by making the game react to the player's actions.

2 BASICS OF ANIMATION

To understand the basics of effect animation, it will be helpful to first get familiar with the basics of animation in general. With this, looking at methods from early Disney's animation studios can be helpful, as in there techniques were created to produce more interesting animation than before. These were then passed on to new animators and, in the end, became fundamental principles in western animation. The twelve principles were first introduced in the book *The Illusion of Life: Disney animation* (1981). The principles are mostly introduced through character animation, but they can be applied to all animation – including effects.

2.1 Squash and Stretch

With living flesh, in every movement there is a sense of elasticity. In a very simple form this is seen with the bicep straightening with the arm and squashing when the arm is bent. If an animation is missing this flexibility, the animated object will seem rigid, which works for firm props but not for the living. To understand this, a bouncing ball can be imagined: if the ball retains its shape when it hits the floor, the ball's material will be perceived as hard and solid. On the opposite, if the ball squashes against the floor when it hits and stretches when it speeds up, the ball seems very elastic and lively. (Johnston & Thomas 1981.) This can be seen in picture 1.

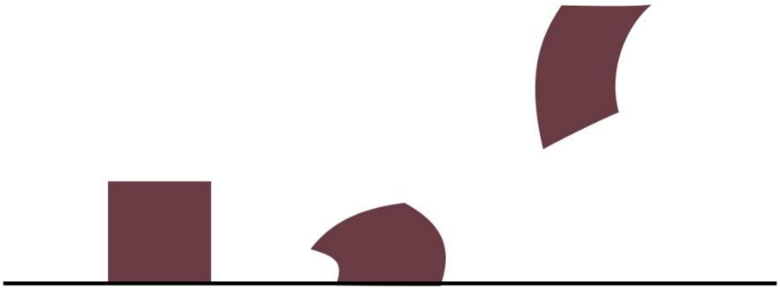


Picture 1. Bouncing ball without and with squash and stretch.

As seen in the picture, the two balls feel very different depending on the amount of squash and stretch in the movement. This can be utilized not only when trying to illustrate an object's material, but also to give any animation more life and interest. (Johnston & Thomas 1981.)

2.2 Anticipation

Before almost any action, there is a preceding movement making us anticipate the upcoming action. Without anticipation, a viewer can miss an action completely, as it was too surprising, or the action loses all its strength. For example, when someone prepares to punch they pull their fist back first, which is the anticipation for the punch. Without the anticipation, the punch will seem powerless. (Johnston & Thomas 1981.) An example of an anticipation in a movement can be seen in picture 2.



Picture 2. Jump with anticipation.

In the drawing, there is an anticipating movement of squashing down before the cube jumps up. With the anticipation, the jump feels more powerful and it doesn’t happen too suddenly. With a more nonconcrete example, anticipation can also be seen in an animation of an explosion. Before the big, main explosion, the explosion can shrink to create anticipation, as if it was mustering its strength, and then suddenly expand rapidly. (Gilland 2009.)

2.3 Staging

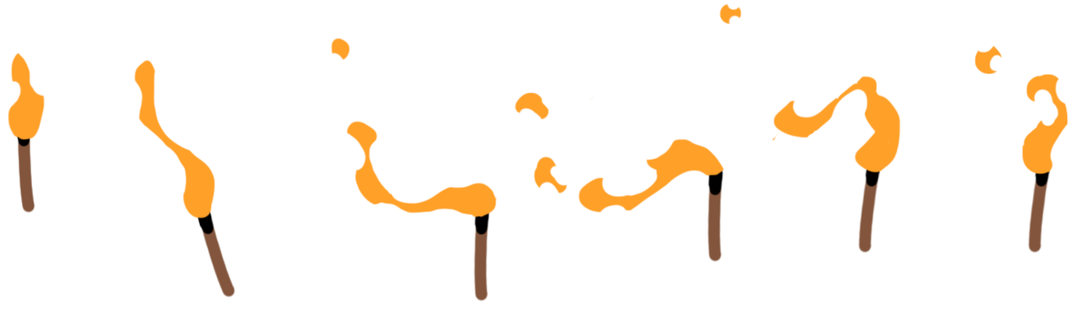
In its most simple meaning, staging is presenting something in a way that its idea is completely clear to the viewer. Whether it is an action, a mood or a certain atmosphere, staging is displaying it in a way the viewer understands it. Staging is not only the drawings themselves but also from which angle, in what kind of scene, and with what kind of surroundings is the main object or action presented so that it is the easiest to understand. (Johnston & Thomas 1981.) An important part of staging is also paying attention the silhouette, especially by avoiding overlapping, as it is harder to see parts that are on top of the overall silhouette (Gilland 2009). To give an example, it may be important for the viewer to understand that a character is feeling sad in a certain scene, in which case it may be the best to choose an unenergetic pose, show the character from an angle where their sorrowful expression and tears can be seen, and maybe even enforce this with melancholic music and a cool color scheme.

2.4 Straight Ahead Action and Pose to Pose

Straight Ahead Action and Pose to Pose are two mainly used approaches to creating animation. Straight Ahead Action is starting from the first drawing and creating the frames in order from first to last. Pose to Pose is illustrating the key poses first and then returning to create the in-betweens. The two techniques can be used together when needed and are not the only techniques for an animator. They both have their strengths and weaknesses. For example, with Pose to Pose it is easier to take the perspective and surroundings into account, and create very strong key poses in the movement. But with Straight Ahead Action, the whole drawing process is easier to keep creative and surprising, as the movement does not have to be planned beforehand and the animator can go with the flow of their ideas. (Johnston & Thomas 1981.)

2.5 Follow Through and Overlapping Action

If a character or an object has loose parts, which get dragged around instead of having a life of their own, the parts should follow the main movement slightly delayed and continue to move after the main action has already stopped. This enhances the feeling of weight as the objects follow through the action. The same is with actions in general, as every part in the body does not move at once but rather something moves first and another part of the body follows it. This is called follow through. (Johnston & Thomas 1981.) For example, this can be seen with a torch in picture 3.



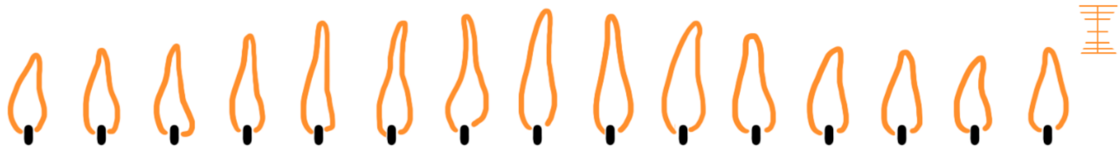
Picture 3. A movement of a small torch on fire.

As visible in the drawing, the fire follows the torch's movements slightly delayed, because the fire isn't firmly attached to the torch and gets dragged around by the fire's source.

If a character comes to an abrupt, complete stop between actions, it will feel unnatural. If raindrops all fall at the same time and create splashes on the ground with the same timing, it will feel unnatural. This can be avoided by overlapping the actions, meaning the actions should happen so that when the previous action is ending the next action is already starting, as it makes the overall movement flow more naturally. (Johnston & Thomas 1981.)

2.6 Slow In and Slow Out

Slowing in and out in an animation is organizing the frames in a way that it has more frames in certain parts of the movement. Cushioning an action with more frames in the beginning or the end of an action makes it seem like the movement slows in and slows out of the action. (Johnston & Thomas 1981.) This has been illustrated with a small candle flame in picture 4.



Picture 4. A small candle flame bopping up and down, the graph illustrating the highest points of the different drawings.

In the picture the heights of the flames are more concentrated in the extreme points of the animation. So, in other words, the flame slows in and out as the fire slowly grows taller and then shrinks shorter.

By putting more in-betweens close to the key poses the movement can become very spirited as the character seems like it's zipping from one extreme to the other. Too much cushioning can make the movement seem too mechanical, but when used well it makes an energetic animation. (Johnston & Thomas 1981.)

2.7 Arcs

With most living creatures, their movements follow arcs instead of straight lines. This is because how the inner structures, such as joints, work. When we move our arm, the whole arm moves in an arc, because the shoulder joint only allows this kind of movement. Using a straight line of action makes the movement look very mechanical - or powerful if done fast – so guiding the actions in arcs can help retain the feeling of naturalness. (Johnston & Thomas 1981.)

2.8 Secondary Action

An extra action supporting the leading primary action is called a secondary action. A secondary action enforces the idea behind the main action and should not conflict with it or become dominating over the main action, unless meant so. For example, when a sad character turns away, a secondary action of wiping a tear from their eye can be added. It complements the idea of the feeling the character has and the mood of the scene. Care must be given to make the actions work together as intended and for them all to be clear for the viewer. Secondary actions can be used to make the scene more interesting, the actions more natural, and tell more about the character's personality when used well. (Johnston & Thomas 1981.)

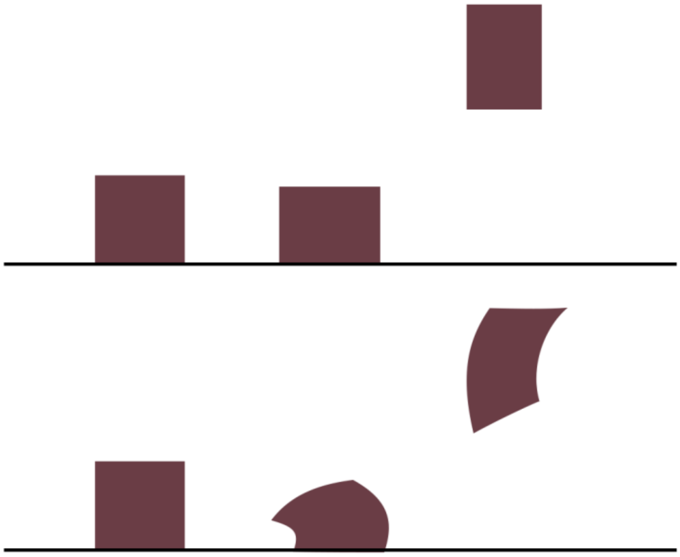
2.9 Timing

Before in animation the number of frames used to determine how long an action takes. Nowadays, this is not always the case, as the frames-per-second can be altered freely. As such, timing can be described as how long an action takes to happen. Changing the timing of a certain action can give it a completely different feel; if someone moves their head quickly, they seem surprised, but if the same movement happens very slowly, the character seems very tired or bored. (Johnston & Thomas 1981.) But timing is not only about showing a personality or a state of mind, as it can also be used to create an illusion of huge size for example, because larger entities of mass move slower than smaller objects (Gilland 2009).

Another part of this principle is holding a pose. When a certain frame is held longer on the screen than others, it can enhance the important part of the action. But if the same frame is held too long, it may start to feel odd when there is no movement at all. So, it is better to hold a pose by having a similar pose held for multiple frames, but making slight adjustments and taking it further by every frame. (Johnston & Thomas 1981.) This can be seen in effects with a splash; when a splash reaches its highest point, it holds its state for a moment before the gravity takes over bringing the water back down. (Gilland 2009)

2.10 Exaggeration

Exaggeration is taking actions a bit further than intended. This makes the actions more interesting and clearer. With animation, realistic movements are the goal, but it is better to take the realism farther with exaggeration. That way, it becomes not only more convincing and clearer, but also more interesting for the audience. (Johnston & Thomas 1981.) An example of exaggeration’s effect on the animation can be felt from picture 5.



Picture 5. A toned-down version and an exaggerated version of a cube’s jump.

Both two jumping cubes have squash, stretch, and anticipation applied to them, but one has been exaggerated more. This can give the animation more life and personality. Most of the time, exaggerated poses and shapes in animation are meant to be kept only for a frame or a few, so that they’re felt in the movement rather than seen as separate pictures. A single exaggerated frame is not always on the screen long enough for the viewer to see it, but rather the energy of the frame is felt in the overall movement. With exaggeration, it can be better to push the drawings as far as possible at first, exaggerating the motions and designs, maybe even the perspective and physics itself, because it makes the movement more dynamic and interesting. A too exaggerated drawing can always be toned down, but breathing life into a boring animation can be far more difficult. (Gilland 2009.)

2.11 Solid Drawing

During the process of creating an animation, in most cases the animated objects must be drawn many times, from many different angles and in many different positions. The task will be a struggle for the artist if they're unable to draw these frames. Therefore, one of the important principles of animation is solid drawing, or in other words, being proficient at drawing. Animation is no exception when it comes to art, as all the drawings need to have the basics of solid, three dimensional drawings: weight, depth, and balance. (Johnston & Thomas 1981.)

One mistake to watch out for is "twins" in poses, meaning that the legs and arms of a character shouldn't mirror each other. It seems very unnatural, because people do not naturally pose perfectly symmetrically. (Johnston & Thomas 1981.) The same can be applied to effect design, as avoiding parallel lines and symmetricity can make the effect seem more interesting and natural. (Gilland 2009.)

2.12 Appeal

Appeal does not mean that designs must be beautiful, handsome, or cute, but rather they must be fascinating and interesting. This is because people rather look at something that is pleasing to watch for them, whether it is an expression, a character's design, a movement, or a whole situation. If a drawing is crude or a character is ugly, it can be unpleasant to watch. On the other hand, if used purposefully, unsightly pictures can be a powerful tool in evoking certain emotions in the viewer. (Johnston & Thomas 1981.)

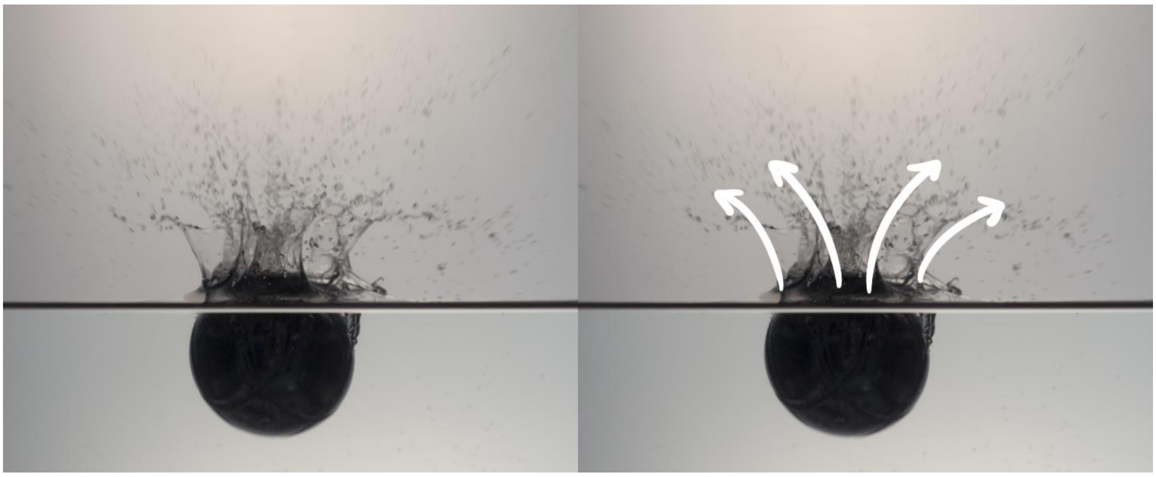
3 BASICS OF VISUAL EFFECT ANIMATION

The principles of animation are always applicable to visual effect animation, but effect animation also has some guidelines of its own to help with creating good effects. These basic principles can prove helpful when kept in mind to apply them in effect design no matter what is being created.

Similar to character animation, learning through observation, research, and interaction can be considered vital in effect animation too. In animation, it is agreed upon that studying movement through traditional observation and drawing techniques is an efficient way to learn the ropes. Learning the hand and eye coordination not only through watching, but also by applying the skills to drawing, sculpting, and animating can be said to be invaluable to any artist. When becoming familiar enough with the effect being animated, the characteristics of the effect can start being self-evident also during the creation process. It is especially important to learn from real life because all humans experience a range of natural effects in their everyday life and thus can tell when an effect looks unnatural or does not work the way it should. But if they are asked to draw the effect in question, the results are usually the iconic representations we are used to, but have very little to do with the original look. If seeking for natural looking effects, it is for the best to observe nature itself. (Gilland 2009.)

3.1 Energy patterns

All these natural phenomena are caused by laws of physics and follow the fundamental patterns of their energy. In the same way that humans are made of a skeleton and muscles, which control our movement, in a water splash similar basic structures can be seen. These structures are called energies. In every effect, this basic skeleton can be found and it will determine the motion in the animation. Outside forces such as gravity, character movement, objects and air currents of different temperatures can mold that energy pattern. The forces can be opposing or pushing, with an underlying cause-and-effect between the forces and the effect matter itself. When the effects have been studied with care, these patterns of movement can be found instinctively. They can then be used to help in shaping the effect and its movement. (Gilland 2009.) A simple example of the initial energy of a splash can be seen in picture 6.

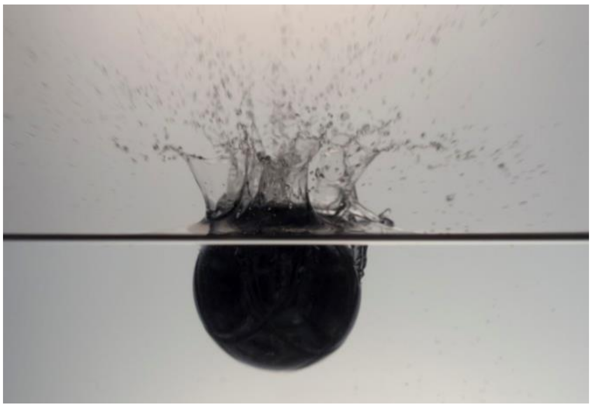


Picture 6. Photo of a small splash (From textures.com, 14.10.2017) and the initial energy pattern illustrated on top of it.

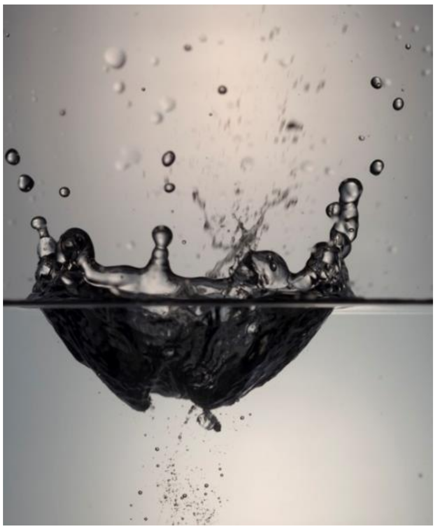
These energy patterns help with even the simplest effects, but are especially helpful with more complex effects. In these complex cases, it can be good to start with the cause-and-effect interaction the elements of the effect have with each other. This can be done by deciding a starting element and gradually going through how it interacts with the other elements, until the whole situation is clear. For example, some effects can have other closely related effects accompanying them. A classic example would be fire and smoke, and some effects could have flying debris or liquid effects can have bubbles and ripples related to the effect. Many effects are filled with different cause-and-effect scenarios like these, which can be hard to illustrate off the top of one's head, but can become very simple after finding the cause-and-effect interactions happening in the scene. (Gilland 2009)

Different effects may have very similar energy patterns, but their individual characteristics make the crucial differences. Dust kicked up looks similar to a rising smoke, but smoke's energy is a result of hot air and it will continue to rise until it dissipates. The dust's energy is from the movement that kicked it up, so gravity will soon pull it down. Also, a splash of fluid and a glass smashing on the ground have similar energy patterns, as they both go plunging away from the impact point. These resemblances can help when illustrating effects, but the differences should not be forgotten. (Gilland 2009.)

In addition to the timing and movement of the effect, the energies can help shaping the effect too. When an effect is born from a sudden burst of energy, the design is generally a very sharp edged and energetic shape. When an effect moves slower, or slows down after the initial explosion, it becomes a softer and more lull shape. (Gilland 2009.) For instance, this is visible in pictures 7 and 8.



Picture 7. A photo of an initial, explosive and spiky look of a splash. (From textures.com, 14.10.2017)



Picture 8. A photo of a splash in a later stage. (From textures.com, 14.10.2017)

As seen from the pictures, a splash of water starts as a spiky spray of water, but ends in round shaped droplets, ripples and bubbles. Also, an energetic explosion starts with sharp sparks but ends up as soft shaped smoke dissipating in the air. (Gilland 2009.)

3.2 Shaping the effect

The human brain has a tendency to favor repetitive shapes and bilateral symmetry in design. It can be attributed to pattern recognition and relating certain natural phenomena with stereotypical imagery. An example of these stereotypes could be the iconic popcorn shapes usually used to illustrate clouds, even though they are quite different from the natural versatile shapes seen in the sky. Making natural effects very icon-like may work with some other art forms, but it can do harm with effect animation. An example of repetitiveness can be found in organic objects such as fur or grass, where it is common to draw a repetitive buzz saw pattern. This type of design can be boring, but it can be fixed by varying the spacing, avoiding direct tangents and using a variety of different sized shapes. This creates contrast and a more interesting silhouette, which also results in a more natural shape. It is important to make the main silhouette interesting, as paying too much attention to secondary shapes and neglecting the main silhouette can result to effects that are difficult to animate and confusing to look at, so the main shape should always be given the most attention. (Gilland 2009) This can be observed in picture 9.

Picture 9. Illustrations of water and fire with a very symmetrical shape and a varied shape.

As visible, the shapes can become noticeably more interesting with just an interesting main silhouette. Even though in nature fairly symmetrical shaped effects can be seen, in order to create visually appealing and dynamic designs, they have to be further exaggerated and stylized, in which avoiding symmetry is crucial. With this, the point should be the overall main silhouette, as some details may be asymmetrical, but it is the main body of the element that matters the most. Another important asset to keep in mind is avoiding parallel lines when possible. This can be done with pinching and stretching some parts to create variation. The same can be used for shadows and light too, as if the shadows follow the outer lines too much, the feeling of three-dimensionality and volume within the effect can be lost. (Gilland 2009)

The same guidelines to avoiding repetition can be used not only in the design but also with the movement and timing of the effect to further the naturalness. Effects' dynamicity can be improved by overlapping the timing of different details and making them behave in varying ways. Droplets in a splash or broken off flames in fire can have different paths of movement and ways of moving. The effects themselves can also be overlapped, for example, raindrops should not fall to the ground at the same time but rather their timings should overlap to create a feeling of randomness. (Gilland 2009)

3.3 Fitting in

Taking the overall style of the work into account is another vital part in designing an effect. When making a visually coherent piece of work, such as a game or an animation film, it is important that different visual parts – such as characters, backgrounds, and effects – look like a part of the same world. Whether the style of the work is photorealistic or very cartoony, the effects should be incorporated into the style too. (Gilland 2009.) In addition to the style of the whole creation, the effects can also reflect the imagery of the world itself. The designs can be inspired by plants, everyday objects or even exotic beings, anything to help them fit with the world created. These borrowed shapes from the effects' surroundings can help to give the effects something familiar that resonates with the viewer and hooks them in better. Early Disney effect animators did this in the animated film *Fantasia* (1940), by finding designs for a splash from a flower to create very stylized splashes. With stylizing, it can be easy to do a single design based on it, but the difficulty comes from making the stylized design move in a natural-seeming manner. Care should be taken to retain the stylized look through-out the animation. (Gilland 2012.)

Simplifying the effects is also a part of stylization. Bringing the level of detail to the same standard as with the other graphics can help with fitting the effects into the world. While even the smallest real-life effects are filled with thousands of microscopic details, there's no need to illustrate this all when creating effects. (Gilland 2009.) As visible in the picture 10, a splash created by an orange is a fairly small splash, but there are hundreds or even thousands of droplets breaking from the main body.

Picture 10. Photo of a splash created by an orange (From Pixabay, 14.10.2017).

If the animation would include all these details visible in photo, not to even mention the complex ripples on the surface of the splash and the hundreds of splashes the little droplets cause, the effect would quickly become too overwhelming to animate (Gilland 2009.)

With simplification, it can be kept in mind that humans are very good at understanding simple symbols, so it could be almost impossible to oversimplify an effect. For example, if given just a squiggly line, humans may think of the sea, when in reality that huge body of water is significantly more complex. With just a few details, an impression of great amount of details can be given. The most important aspect is to convey the idea of the effect, which is easy with just the overall shape, and enough details and dynamics to tell the viewer what they're looking at. (Gilland 2012.)

Another important factor in making the effects suitable for the needs is considering the effect's role. In most cases, the effect brings an added subtle realism and should not draw much attention, as the intended focus of the scene is somewhere else. Rather than dominating the scene, it can be better for effects to complement it. Most of the time, the effect has a secondary role after the character, but an exception can be seen in scenes where the effects are the force driving the scene forward. (Gilland 2009) An example of a scene like this in a game could be a character's special attack, in which case the whole screen can be filled with effects underlining the power of the attack.

Stylizing can also concern other aspects of the effect than the outer appearance. Rather than trying to perfectly mimic nature, by stylizing and idealizing the timing it can be easier to bring the visual story of an effect to the viewer and give it a more interesting design. In a real-time splash, the naked eye doesn't have time to catch all the different actions, but the timing of the effect can be done so that the audience can see all the separate parts of the splash, thus making it seem realistic. (Gilland 2012.)

3.4 Drawing process

A solid foundation is needed for every effect, meaning that having the environment and accurate perspective in place before the sketching process can be a major help. For example, a perspective grid can be laid out for the effect beforehand. When the foundation is in place, it is easier to relax and begin the more creative progress. (Gilland 2009.)

When starting to sketch the effect, the drawing hand should be relaxed and move with as much freedom as possible. The designs for effects may hold countless of small details, but it is important to first strive to capture the most vital information: movement and the rough overall shape. This is similar to figure drawing, where it is encouraged to first loosely find the gesture of the human figure. It can help to draw with a side of a pencil by holding it gently between the thumb and forefinger. This posture allows a broad range of motion originating from the shoulder rather than the wrist. It also aids in drawing more in arcs and creating broader paths of action. At first, the rough animation should be kept generally simple and focused on creating a force of powerful energy, dynamic movement, and avoiding intricate details. By first representing the effect as a simplified version more attention can be given to improve the motion and timing itself. The details can be added once the effect seems to be working in these categories, as during the first phases having details in the effect can make iterating more difficult. (Gilland 2009.)

When the base for the effect is working, details can be added. The forces affecting the details may be the same forces guiding the overall effect, an opposing force, or a subset of either energy, but in any case, the smaller details should follow some energy affecting the effect. While at first glance it may seem that effects are filled with random details, it is helpful to understand that the details are informed with the very same energy. Details are especially important if seeking to illustrate scale and perspective within the effects. Scale can be achieved by creating highly detailed drawings, and by animating them very slowly and heavily. This leads to a larger amount of complex drawings, which does increase the amount of work tremendously, which makes large-scale effects especially laborious. (Gilland 2009)

4 ANIMATION OF NATURAL ELEMENTS

Characteristics of basic natural effects can be used to understand and create many different elements. They can be utilized as a base for other effects the easiest because the artist is able to observe them in real life. First, this chapter will go through the behavior of most basic natural effects, and then take a look on how the learnings can be applied to everything else.

4.1 Water

Characteristics from fluid can easily be translated to many other types of effects, because many effects resemble fluids quite a lot. This can be seen when ink is poured into water as the resulting shapes resemble smoke or even fire. Effects' characteristics are quite applicable to each other and applying learnings from one natural effects can make interesting designs for another effect. This is why starting with understanding fluid behavior feels the most suitable in the beginning. (Gilland 2012.)

4.1.1 Behavior and appearance

Water is a very basic natural effect and the learnings from it can be applied to all liquid animation with small changes. In the beginning, to understand liquid's appearance and behavior, it is good to realize that shapes seen in water are reflections of light. Water phenomenon like bubble, ripples and splashes do not actually create any lines, but rather reflect light differently. Even the smallest changes in water shapes can change the way the light behaves on the surface which allows the eye to see these changes. (Gilland 2009.) Another important aspect of liquid behavior is the skill to seamlessly move out of the way when disturbed. This is called the principle of displacement. It explains how water behaves: if water gets pushed around, the water molecules change their way of occupying space and slide immediately to the next space available, which causes the fluid-like motions. This can be seen well when placing an object into a container with water, as the water immediately fills the surrounding available space. (Gilland 2012; Roberts 2007.)

Water, and fluids in general, have morphological tendencies, which means that in motion they're constantly morphing from one shape to another and are inconsistent in retaining a shape. The underlying structures in water effects can be consistent, but the shapes themselves are in an unchanging state of flux. This tendency can be incorporated into fluid animation by allowing the shape's outlines to fluctuate and change from one frame to another, while accurately keeping the directional energy of the movement. This tendency can be seen in its simplest form in a droplet as it wobbles, stretches, and squashes wildly while traveling through the air. Therefore, with the in-betweens of a fluid effect, it's not important to retain the exactly same shape throughout the movement, but rather the fluctuation makes it more natural. Ripples are similar, as what we see in them are reflections of light, which shouldn't keep a consistent shape but should rather wobble to resemble a real ripple. Same with waves; the leading edge can be changed from a foamy, jagged edge to a smooth, calm edge, or any abstract shapes the artist wants to. As long as the physics of the animation are kept consistent and some of the shapes follow the movement, the animation will work. (Gilland 2012.)

Surface tension also significantly affects water behavior. It makes the liquid cling to itself and fight the effects of different forces, such as gravity. (Gilland 2009.) This is at its simplest very visible in a behavior of a water drip as seen in picture 11.

Picture 11. Surface tension visible in a dripping water (Doladimeji~commonswiki, 2006).

During the first frames in a water drop sequence, the surface tension keeps the liquid together, as visible in the previous picture, until the mass grows so large the gravity is too much for the tension to handle. The liquid stretches until it reaches its breaking point, snapping from the surface tension’s power. At that moment, the surface tension tries to pull the molecules back together, which creates a string of different sized round droplets. (Gilland 2009.) This can be seen happening in photo 12.

Picture 12. Photo of droplets breaking away from the surface tensions grip (Dschwen, 2006).

The largest droplet is usually in front of the group as seen in the photo. During the fall, the droplets squash and stretch as the tension tries to pull it back to a sphere shape, fighting against the gravity. The splash the droplet hitting a surface causes is similar to a splash created by a raindrop, quite quick and small, but because it usually does not have a velocity as big, it can be a bit subtler and rounder. With raindrops and small splashes, three to four frames can be enough for a splash animation. (Gilland 2009.)

When making a water effect with more size, simplifying the water formations as much as the scene and art direction allows can help a lot, because the amount of detail in even the smallest splashes is surprisingly large, as was observed earlier from picture 10 (Gilland 2009). Even with computer generated graphics simplification is sometimes needed, as a small splash created by a small object can create thousands of droplets and hundreds of ripples. In a bigger splash, this level of detail could easily become too much to handle for a real-time rendered game. Simplifying the reflections on water's surface are also needed in animation, because a disturbed body of water has extremely complex surface reflections, but with computer simulations they are possible to be replicated to an extent. However, the style of water should follow the overall style of the creation in this case too, as perfect reflections can make the water look very realistic, which won't work unless the overall art style is realistic. (Gilland 2012.)

When designing water, the first design to come to mind is usually the iconic representations of water seen everywhere. While these symbols that have come to represent the elements almost like letters are very distinctive, they miss the mark when it comes to the organic nature of the elements. They can be a good starting point, but must not be left as they are. Reference can be found in natural water effects and, if the created design is too repetitive, parts here and there can be stretched or squashed to create variation. It is simpler to start with a very basic design and add more elements to it on the way in order to create a working design for the water effect. (Gilland 2012.)

All the learnings from water can be applied to other liquids, but the viscosity - or the thickness - of the liquid should be taken into account. Liquids of greater viscosity than water can be illustrated by drawing them as more rounded and blobby, because the molecules cling more tightly together. The movement should be slightly slower because of this. Smaller parts break apart from the main body more rarely, as the greater viscosity keeps it tightly together. Liquids of smaller viscosity than water are thinner, so their movements are quicker as it is harder for them to resist the forces moving them, and they can easily break up into very small parts and thin sheets. (Gilland 2009; Whitaker 1981.)

4.1.2 Splash

To understand how a splash works, the main phases should be examined step-by-step. The primary force in a splash is usually an object disturbing the liquid. As the object enters the liquid, it forces the liquid out of its way and causes the violent reaction of a splash. The liquid moves violently outwards and upwards from the impact point. The air dragged into the liquid by the object breaks apart into air bubbles. Depending on the size of the object ripples or waves form in the liquid, emanating outwards in circular pattern from the impact point. As the sheet of water gets to its apex point, there is a small “hang time” as the mass of liquid slows down before gravity completely takes over and forces the liquid to fall back on the surface. This hang time has a significant impact on the feeling of scale in the splash. Bit by bit, gravity starts to break the sheet of water apart by opening small holes. The duration of the collapse and the way the holes appear on the sheet is depended on the viscosity of the liquid. During all this time, the liquid starts to regain its status by rushing back into the hole caused by the impact. This creates a secondary splash as the liquid fills the hole and is propelled upwards by the impact. As the secondary splash falls back into the liquid it can cause another splash. The droplets from the main splash fall back into the liquid, causing smaller splashes here and there. The ripples continue to emanate from the impact point for a while, slowing down and diminishing in size and intensity while traveling further away. The small splashes can create their own ripples too. Finally, the last ripples calm down and the liquid returns to the same calm state it was before the impact. (Gilland 2009; Whitaker 1981.)

Characteristics of a splash are very depended on the attributes of the object striking the water, such as the object's shape, velocity, and trajectory. First, the influences the object's shape has on the primary splashes' shape will be looked at. A round object of enough size and mass will almost always create a splash that can be called a bowl-shaped primary splash. This is because the splash's shape is almost a sphere, so it seems like a bowl. The splash's shape seems to be created by the round sides of the object that shape the splash as the water is forced up and around it. This kind of splash will usually fall on itself. In some cases, the bowl shaped is pushed much more outwards, so it will not close on itself but rather spreads out from the point of impact. A round shape is not required for a bowl-shaped primary splash to appear, as sometimes the entry angle and rotation of an object can have an effect on it. Different from a bowl-shaped, an object with a flat side striking the surface will usually create a sheet-shaped primary splash. Once again, the water adheres to the sides of the object, which causes it to shoot upwards as a straight sheet of water. The caused primary splash is not a solid sheet of water in all cases, because sometimes the splash can be mostly just a spray of individual drops. This can be caused by a very uneven or rugged shaped object, a high velocity upon impact, or when the object just slightly grazes the water's surface. (Gilland 2012.)

Secondly, the effect of the object's trajectory will be looked at. A round shaped object will create a fairly symmetrical splash if dropped from above, but if it comes from a slight angle the splash gets more weighted on the opposing side, as the force of the impact is stronger on that side. There is also more variation with the object's path underwater as it reacts more to the impact. Instead, if an asymmetrical pointy rock is dropped into water head first, it will pierce the water quite easily and the splash will not be very powerful. As soon as the rock plunges underwater it will turn forcefully, because the water hinders its movement. If the same rock is dropped on its side instead, it will create a more pronounced splash, usually emphasized on the side of more mass, as the water resists it more. (Gilland 2012.)

With primary splashes, it also becomes important to understand how the sheet tears apart. As the primary energy forces the water to shoot upwards in a certain fashion, the water stretches until the surface tension cannot hold it together any longer and the sheet of water rips and tears apart in certain way. The tearing starts with small holes, which then expand and spread until the sheet is broken into tiny water droplets. The process starts when the splash is still shooting upwards and continues until the last drop has fallen back in the water. The tearing of the sheet of water must follow the directional energy causing the splash in the first place. The changes in the appearance of the primary splash can be seen through the changes in energy. In the beginning, because the water is forced away from the point of impact by an explosive energy, the splash has a very explosive and sharp look. But as the energy fades away, the splash becomes more fluid-like again. (Gilland 2012.)

As the primary splash has some common shapes, the secondary splash also has its characteristic shapes. Most common is the jet, a squirt of water shooting upwards from the exact point of impact. It is caused by water rushing to fill the hole with a force so great it forces a column of water straight up into the air. The jet may twist and squirm, and throw off droplets. After reaching the apex, it then collapses on itself, creating small waves or ripples. The shapes seen in jet can be very similar to a small gurgling fountain shooting a small jet of water upwards, or a water hose with a low pressure held upwards. (Gilland 2012.) An example of a jet can be seen in picture 13.

Picture 13. Photo of a jet-type secondary splash (From textures.com, 30.11.2016).

A jet can be witnessed also when a very small and dense object hits the water, piercing the surface cleanly. It usually creates no primary splash but still a small jet shoots up from the point of impact. In these cases, there should still be a small pause before the secondary splash. Sometimes, even a second secondary splash can be observed, as the jet falling on itself creates a pocket of air. (Gilland 2012.)

Another common secondary splash is seen when a very large and heavy object collides with water. In these cases, a big pocket of air is created underwater. As the primary splash is spreading away, the surrounding water rushes to fill the hole and the weight of it creates a huge, solid surge of water shooting upwards. This can be called surge or geyser secondary splash. Depending on the object, this type of secondary splash can be more profound than the primary splash. (Glland 2012.)

A third type of the common secondary splashes is called a boil or surfacing bubbles. With these splashes, the air pocket created by the object gets pulled completely underwater rather than creating a visible hole on the surface. When this group of bubbles reaches the surface again, it doesn’t shoot up forcefully, but will rather slightly push up and then roll out. It creates a convex shape which rises higher than the surface and resolves itself by spreading outwards. This could for example happen with a car, as it has shapes that can trap huge amount of air bubbles and drag them underwater. (Gilland 2012)

If all the variables are considered, it is possible to guess if the primary or the secondary splash will be more pronounced in the effect. If a tiny rock is thrown into the water forcefully, it pierces the surface quite easily and very little water gets splashed. However, the rock has still created an air pocket in the water, so the water will rush to fill the pocket and a secondary splash happens. Same if the small rock is dropped straight down or a raindrop hits the water, as they’re so small and light they will not cause much of a splash, but their momentum creates a hole in the water which causes a second splash. On the opposite, if a pebble is thrown so that it skips across the surface, it will create a primary splash, as the force splashes the water around, but because it doesn't go underwater, no secondary splash is created. A similar situation happens if the object thrown into water is extremely buoyant and will not sink underwater at all. The buoyancy of an object– or in other words, the upward force affecting a floating object – influences how it interacts with water. An object with little buoyancy, for example a rock, will penetrate the surface deep when hit with water. An object with greater buoyancy, for example a piece of wood, will bob back up on the surface quicker. It can splash the water around depending on its force, but doesn't make an air pocket in the water. (Gilland 2012.)

A splash has many different effects accompanying it in addition to the splashes themselves. Examining these effects on their own can help understanding them. To begin with ripples, they emanate away from the point of impact or an object in a circular shape. With ripples, it must be kept in mind that in order from them to feel natural, the shapes must not be perfect circles and the timing of the ripples should be varied. (Gilland 2009; Whitaker 1981.)

With very large-scale water effects, such as ocean's surface or a huge splash, waves are more commonly seen than ripples. When thinking how waves work, it can help to imagine the waves as tubular shapes of energy moving horizontally under the surface. The wave displaces the surface as it rolls underneath, returning the details in the same spot they were before. A small boat can be imagined, bopping up and down as waves pass underneath it, but the boat keeps returning to the same spot after the wave has passed. (Gilland 2009.) Even thought at first glance ocean full of waves seems to be monotonous and not very varied when it comes to waves, if the ocean is illustrated by making very repetitive wave shapes, it seems off. In reality, no two waves are identical, so their sizes, shapes and timings should be varied. The waves seen from a distance do not have to be as varied as with close shots, because telling the waves apart can be harder in a smaller size. (Gilland 2012.)

Another effect usually accompanying liquid effects is bubbles. Bubbles are air pockets, pushing their way through the liquid to reach the surface, trying to find a path of least resistance and wobbling on the way. The stretch and squash principle can be especially applied fully to bubbles to create dynamic movement for them. Bubbles can be seen forming when an object pushes a hole into the liquid, as the object pulls an air pocket with it under the surface and downwards. This air gets stretched on the way and, as the object continues sinking, the air starts to travel back up to the surface, breaking into small wiggly pockets of air as known as bubbles. In the end, the bubbles reach the surface of the liquid and continue to expand on the surface until the air breaks free as the bubble pops. (Gilland 2009.) Objects with enough weight and an appropriate shape may continue to drag multiple bubbles of air with it underwater. These bubbles will then continue to rise back to the surface even after a very long while. A good example once again would be a sinking car, as it shapes and large mass allow it to keep air bubbles trapped for a long time. (Gilland 2012.)

The size of the splash influences the animation greatly. The amount of details, size of the drawings, and how many frames the motions last are all connected to how large the splash is. With an enormous splash – for example, caused by chunk of glazier falling into the ocean – in order to get the feeling of immense volume, the splash needs to be very slow and requires multiple frames. The secondary splash should also be huge and the ripples it generates should be more like waves. When animating a huge effect, the amount of details can easily get overwhelming. In these situations, the concentration should be on the parts of the effect that have the greatest impact on the silhouette, as details overlapping with the main body of the effect get easily lost. For the eye, it is easiest to see details that break from the overall silhouette instead of blending into it. (Gilland 2009.)

Splashes are not only created by single objects striking water, as every interaction with water is constantly creating splashes, ripples, waves, and bubbles in water, from washing our hands to a tree falling and crashing into river. Understanding the principles and characteristics of waves and splashes and how water reacts to outside forces can help to create more complex water elements, such as a flowing river or washing hands under a flowing tap, because the learnings can be applied to all liquid effects. (Gilland 2012.)

4.2 Fire

When conducting zero gravity experiments, it was discovered that without any outside forces fire will burn as a perfect sphere (Gilland 2009). Fire is particles of the combusting matter and luminous gases being thrown around through the air currents caused by the violent interaction of the intense heat and the surrounding cool air (Gilland 2012).

This seemingly chaotic action can be illustrated with a basic wave movement, which is a mostly simple action caused by energy interacting with a matter which is not entirely rigid. This basic wave principle can be applied to tails, hair, and ropes, and can also be useful when trying to understand the movement of fire. The smaller parts of the fire emerge from the bottom, rising while reacting to the turbulence caused by the hot air sucking the cooler air around it to fuel itself with oxygen. The pieces of the fire are pinched and squeezed by the air around it as they rise, which causes them to finally break away and fade completely. To give these shapes a flickering effect like in real fire, they can keep inverting their curves from one frame to the next when breaking off from the main body of the fire. (Gilland 2009; Whitaker 1981.) Fire is very inconsistent and so there's no need to follow through with every shape and piece of the flame carefully. In reality, pieces of flame disappear and appear very randomly. What is important is the base for the animation, and the shapes, volumes, and details can be played with quite freely. (Gilland 2012.) From time to time, fire can even get a sudden burst of volume as it suddenly gains more oxygen and simmer down again as the fuel runs out (Gilland 2009).

Starting with a simple fire such as a small flame usually seen in a candle or a match, the flame is wider at the base, narrowing to a dull point. With little outside forces, it subtly moves by stretching and squashing in a wave-like motion, as it slightly gains mass but soon loses against the cooler air around it. (Gilland 2009.) A flame like this can be seen in picture 14.

Picture 14. Photo of multiple candle flames (From Pixabay, 14.10.2017).

As seen in the photo, there are no parts breaking away from a fire this small, unless there is a powerful outside force. Slowing in and out can be used in the highest and lowest parts of the motion to make the movement cushion at the peak points. (Gilland 2009.)

The bobbing motion seen in the small fire becomes more obvious with a bigger fire, as well as the reversing internal arcs. This wave motion is caused by the cool air around the fire, because while the other side cools down faster the hotter side rises until a part breaks from it. Then once the hotter side loses its dominance and cools down, the other side has heated up and starts to rise faster. This cycle goes on continuously. (Gilland 2009.) All fire’s twists and turns are a result of the gases trying to expand to the outside world but the cool air resisting them. It can help to think fire as the air currents shaping it. (Gilland 2012.)

After the basic flow of the fire animation is shaped, the overall appearance can be constructed on top of that by imagining the main interior shapes as sections of masses moving upwards while decreasing in size. The main silhouette can them be built by connecting these shapes with sharp edges. The main idea of a fire can be seen as triangular shapes - or just a one triangular shape - feeding one another. The larger silhouette is formed by these triangles depending on the forces affecting the fire and the amount of fuel from the burning material. (Gilland 2009)

When the size of the fire is increased, details and more pieces breaking of from the main fire should be added as it gives the illusion of a larger effect (Gilland 2009). An example of a large fire can be seen in picture 15.

Picture 15. A photo of a large fire (From texture.com, 14.10.2017).

The iconic sharp and curvy shapes of a fire can also be seen in the photo. As these shapes are fairly small and there are plenty of them, and the broken off pieces are small, the flames seem large. As fire gets larger, small holes can start forming inside the main body as well. This can be used to keep consistency with the volume of the fire because by opening holes in the center of the fire it will help to break off sections from the main body. The direction of the forces should be kept in mind while making the holes, as they follow the same patterns as the main body. (Gilland 2009.)

In order to avoid twinning in the fire's design the broken off shapes' sizes should be varied greatly. The flames can be broken off from the fire by different ways, be it pinching it in the middle or even twisting it as it was a washcloth being wringed. A loose fire piece's life span is very short, so keeping it on the screen for a few frames is usually enough. When disappearing, shrinking into a direct center point should be avoided, as the flame is at affected all times by the cool air pushing it around. (Gilland 2009)

Not only the main silhouette and details shape the fire, but there are also the interior details. These details illustrate the core, the hottest part of the fire, so they must follow the timing and direction of the overall shape. The secondary shapes inside the fire should enhance the shape and volume of the fire, similar to how shading works. The interior details can help to describe the geometry in the sphere shapes used in some fire drawing techniques, giving the fire its three-dimensional look. Especially when the fire is wrapping around the burning material, which it does to gain as much fuel as it can, the interior details can be used to describe these shapes under the fire. (Gilland 2009)

To give the fire its finalizing touches, some additional effects can be added. When it comes to fires bigger than a candle light, cinders begin rising from the fire. (Gilland 2009) Even though fire's embers are also pushed by the same energies as the rest of the fire, some of them don't follow the same paths as all the others.

Instead, they get propelled to a completely different path by the heated air trapped in them that gets forced out and boosts it to a completely random path. Some of them wildly shoot off sideways or get spiraled off to a very different direction. (Gilland 2012.) The feeling of heat from the fire can be enforced by giving it a soft outer glow while coloring the fire (Gilland 2009). The burning material can also be taken into account, as fire's intensity and color vary noticeably with different materials. Also, depending on the availability of oxygen and quantity of material, not only the color but also the size and behavior of the fire can be different. (Gilland 2012.)

With a very large fire, the drawing can be started by imagining the fire as multiple flags waving in the wind. This can help to find the overall shape and movement. Everything from smaller fires can be applied to large scale fires but more details and a slower movement should be added to enforce the feeling of large size. Also, as there are more powerful forces of wind in play, the cinders and the flames themselves will fly out more violently. (Gilland 2009)

When animating a fire igniting, it should be started with the fire blossoming quickly outwards, as in the beginning the fire is well fueled with oxygen and the ignited material. As it expands upwards, the cooler air around it starts to push the fire down from above, slowing it down. At the same time, the fire sucks cool air into itself, causing currents that move inwards. The collision of all these forces creates a familiar mushroom shape. As the fire continues to push up, the cool and hot air interact, creating twisting currents of air, which give the fire the familiar shapes. The rapidly rising hot air disappears into the air little by little and a burning flame is left on the ignited spot. (Gilland 2009.)

4.3 Smoke, steam, dust

Smoke is air currents filled with smoke particles, a by-product of material reaching its combusting point, usually seen emitting from a fire. The air and even the particles themselves can be very hot, which causes the smoke to continue to rise upwards unless there is a hard air current pushing it in another direction. Smoke can take a significantly long time to disappear, sometimes even days, as it is made of visible particles traveling through the air. The smoke – and the fire creating it - are affected by the temperature changes, the different air currents, availability of fuel, and the amount of material being burned. (Gilland 2009.)

At first, smoke from a fire is driven up fast by the intense heat from its source. As the smoke begins to cool down because of the cooler air around it, it slows down. This collision of warm and cool air will cause the iconic twists in the smoke. As the smoke rises further it starts to spread out, because the cool air on top of it pushes the smoke down while the warmer air filled with smoke continues to push up. This causes the air caught between to get pushed on the sides. This smoke-filled air on the sides gets then sucked back into the rising warm air and thus creates a slow, rolling effect on the smoke. (Gilland 2009.)

Fundamentally, the same wave principle used in fire can be applied to smoke too. The upward flag motion can be combined with a rising, expanding ball shape, which rolls upwards with the flag motion. A smoke in a calm air continues to rise and expand as the force of hot air pushes it upwards. This simple smoke design can be used as a base for more complex designs as well. With smoke, it must be kept in mind that it will move slower than the fire it is usually emerging from, as fire is notably hotter than the smoke. (Gilland 2009.)

The rolling direction of the smoke should be kept in mind with medium sized smoke. This is determined by the forces affecting the smoke. Similar to fire, the smoke will specifically roll in clockwise and counter-clockwise directions, according to the forces in play. Understanding this can by aided by imagining a rocket being launched, as the smoke generated by the fire is being pushed outwards from underneath. The left side of the smoke will roll clockwise and the right side counter-clockwise, which causes the smoke to curl over. (Gilland 2009.)

Smoke’s geometry and shapes can be implied with shading and lighting rather than having clear lines connect them. The different tones in the smoke will give shape to the smoke and illustrate how the different parts fit together. With smoke, it is important to vary these different shapes and not to think it as actual rising circles. Smoke behaves with a fluid randomness, being affected by the air currents around it. Usually the bigger shapes of smoke have more energy in them and will then rise quicker and consume smaller shapes on their way. Overall, the smoke’s shapes are dependent on the driving forces behind it. A smoke can be an explosive, rapidly moving blast of smoke, a billowing smoke rising as pillar, or a more linear and delicate smoke, rising from a small source point, to name a few. (Gilland 2009.) Examples of these types of smoke can be seen in pictures 16 and 17.

Picture 16. Photo of a smoke rising from a small source point (From textures.com, 14.10.2017).

Picture 17. Photo of a large cloud of smoke rising from a pipe (From textures.com, 14.10.2017).

The types of smoke in the two pictures have very different densities. The density of the smoke determines its life span, and in turn the igniting fuel determines the density. A linear smoke, the type of smoke in picture 16, seen in cigarette or incense smoke for example, will stretch while following the path of the source and the smoke stays visible for a long while, especially when comparing to a fire.

Smoke from a camp fire can be seen from miles away, as its life span is much longer because of its greater density. (Gilland 2009.)

The initial stages of smoke, steam and dust being kicked up can be very similar looking. But since they are all made from completely different elements, the forces moving them cause the elements to react and resolve very differently. Steam’s behavior is slightly similar to smoke because it is also heated molecules, which causes it to move upwards. (Gilland 2012, 2009.) Steam can be seen in picture 18.

Picture 18. Photo of steam rising from a boiling geyser (From Pixabay, 14.10.2017).

From the picture, it can be seen that initially steam looks quite similar to smoke. But as steam is vaporized water instead of particles, it will be absorbed in the air. As the absorbed water molecules become invisible to the naked eye the steam appears to vanish very quickly. Smoke can also disappear, but will break down into smaller shapes before disappearing. Steam created by a boiling water or breathing on a cold day can have very little variety in its silhouette or tones, but when it comes to a large-scale column of steam, it can look very much the same as smoke, expect for its lighter color. (Gilland 2012, 2009.)

Dust is the most different of the three, because its energy does not come from it being heated up. (Gilland 2012.) Dust kicked up can be observed in picture 19.

Picture 19. Photo of dust being kicked up by a motorcycle (From Pixabay, 14.10.2017).

A cloud of dust has similar shapes as a cloud of steam or smoke, but their trajectory is quite different. Usually, dust is being moved by some other outside force, such as wind or someone walking. Dust particles are also usually much heavier than smoke or steam, so gravity will pull it down back on the ground in time. In some extreme cases, dust can travel in the wind or with storms even for long periods of time, but will always eventually return to the ground.

4.4 Explosion

Explosion can be not only a big, fiery explosion, but rather all violent expansions of energy moving outwards can be considered explosions. There can be explosions of very different sizes and shapes, and they’re not tied down to certain materials or having heat or combustion involved. An impact of objects, such as a car crashing into a wall or a glass cup falling on the floor, is as much of an explosion as a gas tank exploding due to pressure building up. (Gilland 2012, 2009.)

When matter is being rapidly forced outwards from the point of impact or ignition in an explosion, the energy patterns are always almost identical and thus the matter takes a very typical shape every time. Even though the human eye doesn’t see these shapes, all explosions retain this almost identical shape until the matter returns to their own natural state again. The first frame in an explosion is the matter in its most energetic expansion, showing the initial speed and direction of the forces very clearly. This shape is the iconic, spiky, and sharp-edged explosion shape many are familiar with. The matter at this initial state is moving too rapidly to show the characteristics for the element. The movement is so quick that the viewers eye only needs to understand the rapid movement and direction, until the explosion returns to its normal state in just a matter of a second. The farther the matter gets from the initial point of impact, the more it starts to look like itself. (Gilland 2012.) This could be seen earlier with a splash in pictures 7 and 8. The shapes of the explosion are also very depended on its surrounding materials, as they can oppose the forces, and the material initially causing the explosion (Gilland 2009).

After the initial explosion, the explosive force starts to calm down. From the beginning, the explosion collides with its surroundings, which resist the energy. They can be simply air, or physical objects it collides with, which slows the explosion down eventually. (Gilland 2009.) Little by little, the matter moved by the explosion begins to be more invulnerable to other outside forces such as wind or gravity, which can change their path of movement, and their movement becomes more flowing and calm. Some pieces flying off can continue to tumble or roll, or very light matter can continue to calmly rise to the sky. (Gilland 2012.)

The basics of an explosion are simple: it's a violent outward expansion which slows down abruptly, and real explosions continue to expand smoothly and increasingly outwards from the beginning to the end. However, with explosions created by artists, exaggeration is needed to make the explosion feel more life-like, even though it would look slightly different. For example, a bit of anticipation can help greatly. In the first frame, the explosion can begin to move outwards, but in the following frames the explosion can sunk into itself for a bit, as if to load up before exploding violently. This can give it a needed additional feeling of energy. After the anticipation, the speed of the expansion can be exaggerated greatly and pushed quickly to the final, slower phase. Exaggerating a motion's dynamics can be a great tool with effect animation and make the effects significantly more interesting and dynamic. (Gilland 2012.)

4.5 Magic

With magic, rules of physics can be broken as much as the artist wants. Simply, if the effect just doesn't follow its natural principles or the laws of the nature, it will seem magical to the viewer. Even by just breaking the rules of gravity, anything can be made to seem like magic. However, the characteristics learned from natural effects can help to give a basis to the design rather than trying to start from zero. From instance, movement pattern for a magical pixie dust can be borrowed from a billowing steam or droplets of water. Even though magic is something completely unnatural, giving it internal characteristics from something natural can make it feel more believable for the viewer, as there's something familiar to them in the effect. All the same design principles from natural effects apply to magical effects too, because good design is still good design. (Gilland 2009.)

A magical effect can derail from its initial starting dynamics at any point. The effect can start as bubbles wobbling upwards and turn into something completely different in the middle, such as burning flames. The artist is free to create an internal logic of their own for the magic effect, and this in turn can help to make it feel even more magical. (Gilland 2009.)

Implying scale and perspective with magical effects can be tricky, since there are no already existing reference points like with natural effects. Tricks from natural effects, such as the speed of the movement and amount of details, can still be borrowed when implying scale with magic, but usually these should be exaggerated much more than with natural effects. Especially with perspective there might be a need to exaggerate the difference in sizes even more to make it work. (Gilland 2009.)

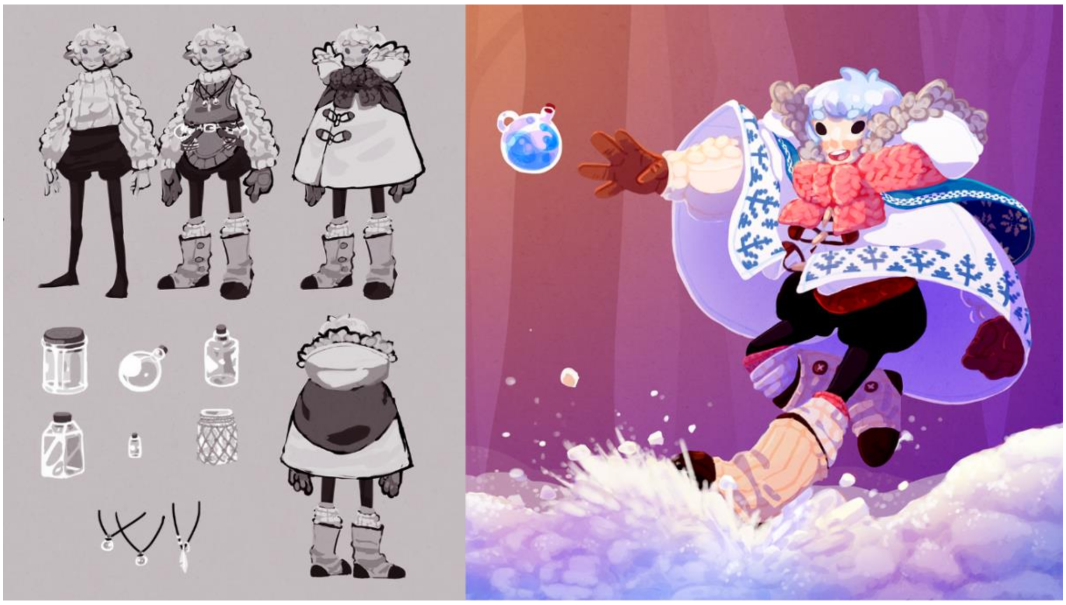
Games can have many unnatural effects that aren't quite magic but not nature's own effects either, such as swinging effects with weapons. In these cases, the learnings from natural effects can be applied in much the same way as with all the other effects. Not only characteristics and dynamics can be borrowed to make the effects more interesting and to help shape their movement, but also the design principles can be applied to make the effects' appearances more interesting.

5 EXECUTION OF THE EFFECTS

After studying the basics of animation, effect animation, and the most common natural elements, the knowledge can be applied to work. An idea of a project will be created to set a style and use for the effects, and the effects will be made according to those frames.

5.1 Overall planning

When starting to design effects the role of the effect should be taken into consideration. In this case, effects will be created for a certain character, so the character’s appearance, personality, combat style and other possibly important factors should be taken into account in order to create effects fitting for the character and the world. Also, the overall style of the medium should be visible in the effect for it to fit in the world (Gilland 2009). A concept of a character created for this sake can be seen in picture 20.



Picture 20. A character design created for the thesis.

As seen in the concept, the character is drawn with a simple, very stylized, and soft style without line art, using simple shadows and bright colors. The overall color-scheme is cold, and the lighting is orange colored with purple-tinted shadows. For the effects to fit in the same world, they should also be highly stylized and simplified regarding their style and the colors should match the scheme of the overall work.

The character is designed to use glass bottles in combat. The bottles conjuncture magic, so magical effects will be needed. For this project's and learning's sake, the magical effects will rely heavily on real-life effects so that knowledge on them can be applied on the effects, be it using their characteristics or breaking them to make them magical.

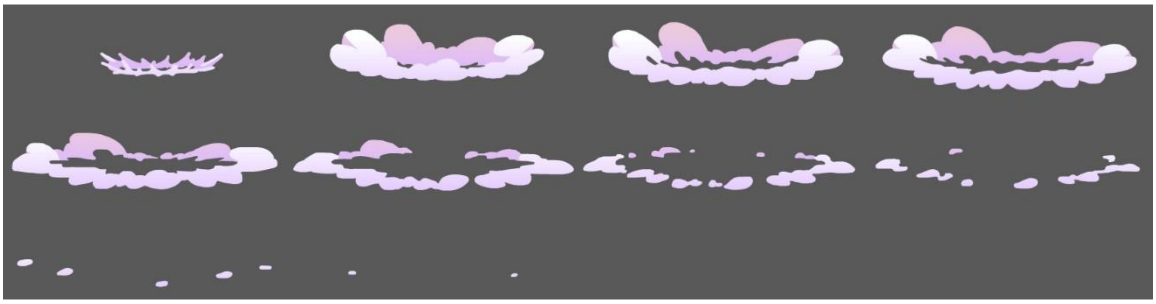
The character's environment also requires certain effects. The character moves in a cold, snowy environment, which can also be seen in their style of clothing. Instead of dust effects, snow effects will be needed for emphasis on character's movements.

5.2 First effect, Snow

While the basic idea and trajectory of a snow and a dust effect can be quite similar, the characteristics the two effects can be notably different. Especially since snow's behavior can vary a lot depending on the weather. Sometimes snow can be very powdery, and the separate crystals can be very clear to see, and other times it tends to stick together to create huge lumps of snow. The idea of a dust effect can be borrowed, but needs to be slightly altered to resemble snow. The first snow effect had the idea of snow getting kicked by and flying off from the sole of the boot while the character is walking or running. The look of the first snow effects can be seen in picture 21.

Picture 21. The effect for running on snow, the final animation can be seen in the collage video here.

As seen in the frames, the snow sticks together quite much, and it doesn’t stay afloat for long in order to give it the feeling of weight. The few smaller pieces are there to depict the texture of the snow, as it is not a cloud of particles swept up in the air but rather a slightly more solid material at times. With the same idea, an effect accompanying jumping was created, the frames can be seen in picture 22.

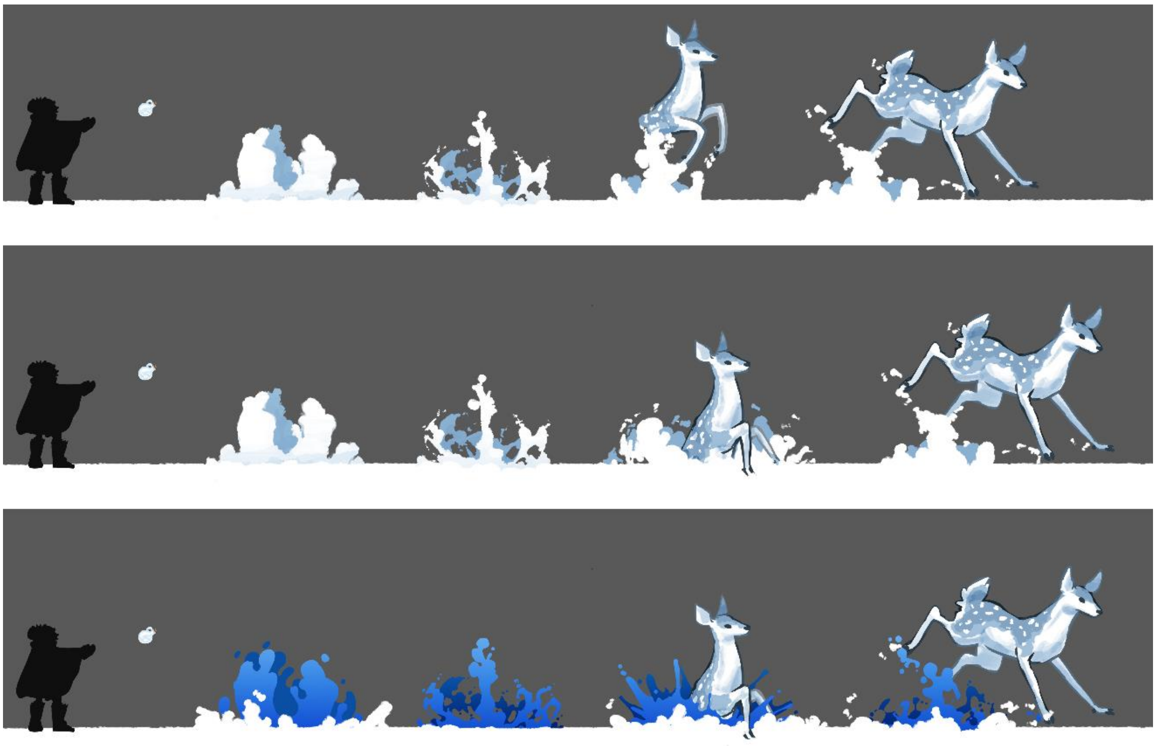


Picture 22. The effect for landing on snow, the final animation can be seen in the collage video here.

The effects had to be small and simple so that they wouldn’t take too much attention away from the important matters in the game. The first effect is 17 frames with 9 different drawings, the second effect is 18 frames with 10 different drawings, and they both run at 24 frames per second. This frame rate will stay consistent through-out the project. And as seen in the picture 7, there are more frames in the animation itself than on the pictured sprite sheet, this is because some of the pictures may last for more than one frame for timing's sake.

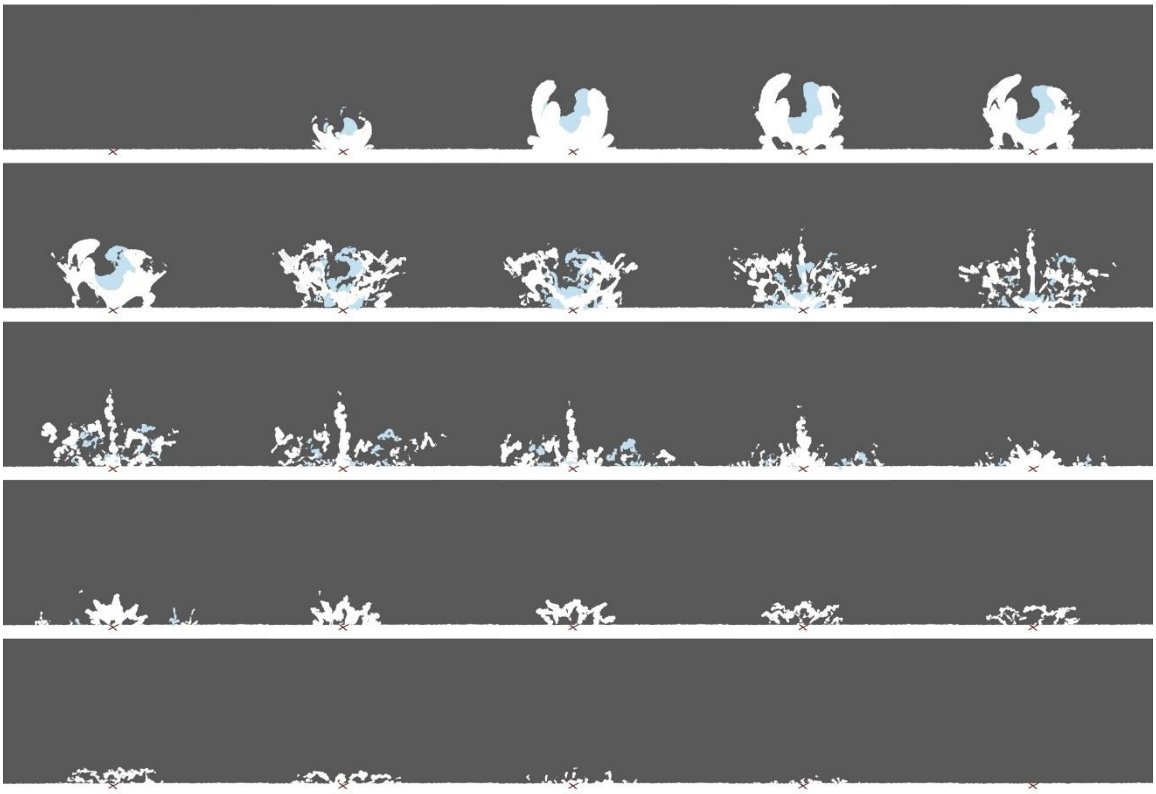
5.3 Second effect, Summon

The second effect animation made for the project is a summoning effect. The primary idea was to use water's characteristics as a base and allow the character to summon themselves a companion. The process began with rough concepts from which a few were chosen to be compiled into more detailed concepts. These later concepts can be seen in picture 23.



Picture 23. Further concept art of the summoning effect.

From these concepts above, the first one was chosen. Because the thesis's goal is to learn about effect animation, the creature itself will not be animated, as it would be character animation. The animating process began with making a very rough animation of the splash to get the movement and physics right before delving too much into the appearance of the effect. A few rounds of fixing were needed before the movements felt correct and the look of the effect at that point can be seen in picture 24.



Picture 24. The rough animation of the splash effect.

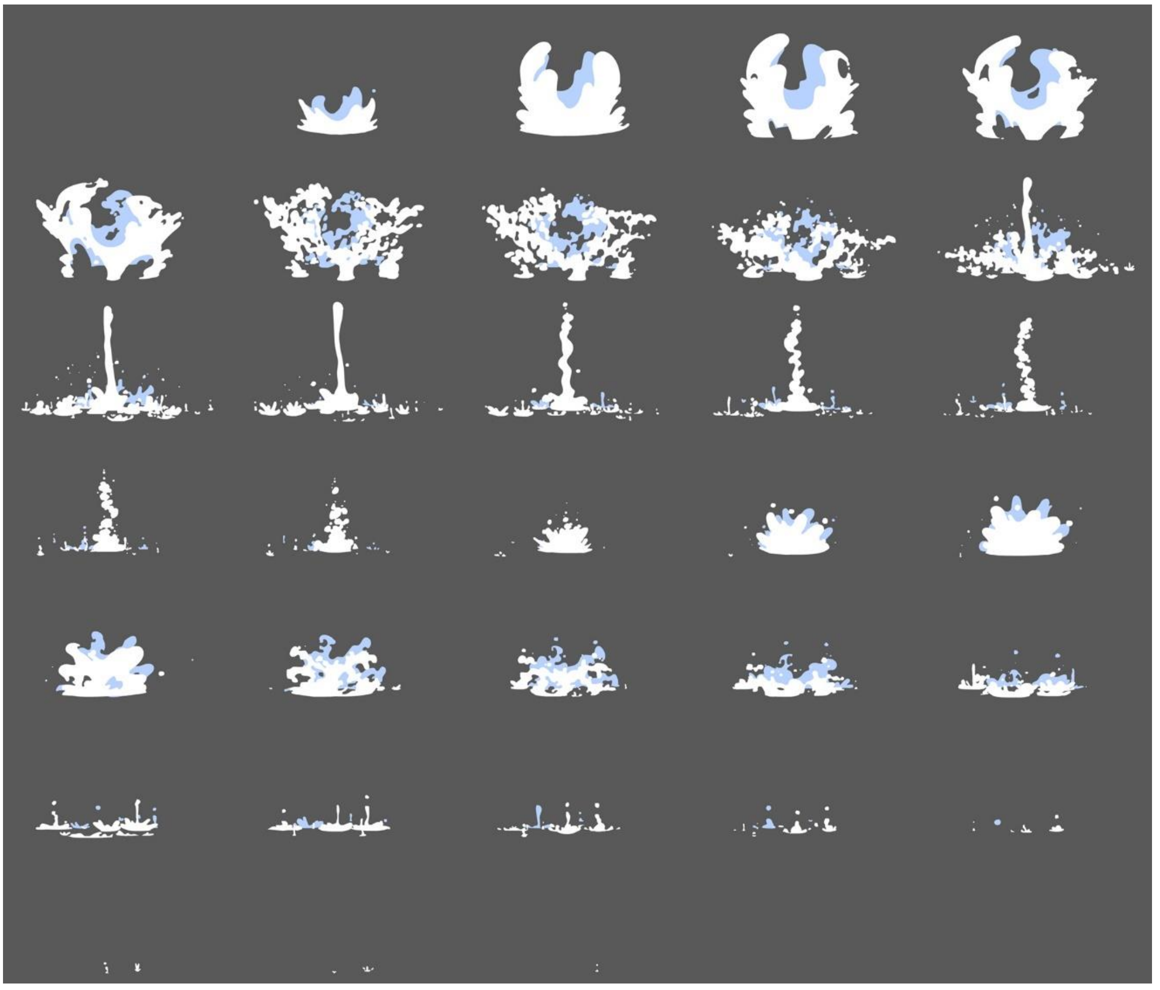
After the rough version was done, the frames were moved from Adobe Photoshop to Adobe Animate which as a program allows a better control of the frames and the overall animation. The animation was divided into different layers, which were the front side of the primary splash, back side of the primary splash, and the same for the secondary splash. This would allow making quick iterations of the timing if needed.

Layer at a time, using the rough animation as a base, the shapes were cleaned and details added. The project's assumed look would be a 2D game and, when looking at references from 2D games, it was decided that the effects should not be pictured from a straight side view but rather from an angle. As an example, this type of view can be seen in the pictures 25 and 26 which are screenshots from 2D games.

Picture 25. Screenshot from the game *Rayman Legends* (2013).

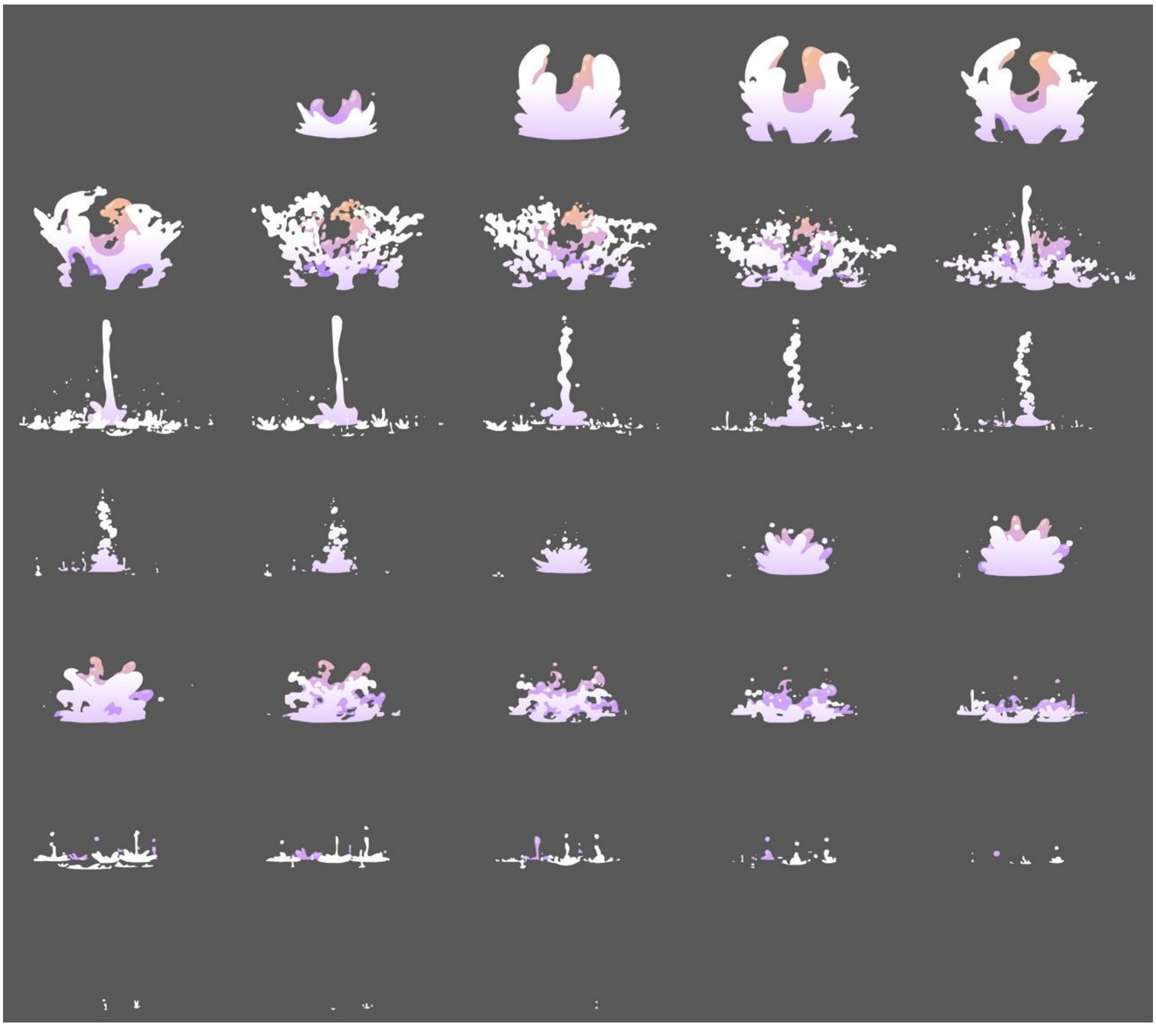
Picture 26. Screenshot from the game *Owlboy* (2016).

As seen in the screenshots above, the ground is seen slightly from above rather than directly from the side. This would mean that the effects should also be picture slightly from an angle for them to fit in their environment. This was fixed by creating a fitting perspective grid to be used in all the effects so that the perspective would stay consistent. After that, fixes to the splash were made so that it would fit in the perspective. After the initial clean-up, another round of polishing the frames was needed as some of the smaller details didn’t follow the movement naturally. The look of the effect after clean-up and adding the details can be seen in picture 27.



Picture 27. The splash animation after adding details and cleaning up the rough sketch.

On top of the cleaned shapes colors, gradients and simple lights were added to make the appearance consistent with the character’s style and the overall color scheme of the project. The final look of the effect can be seen in picture 28.

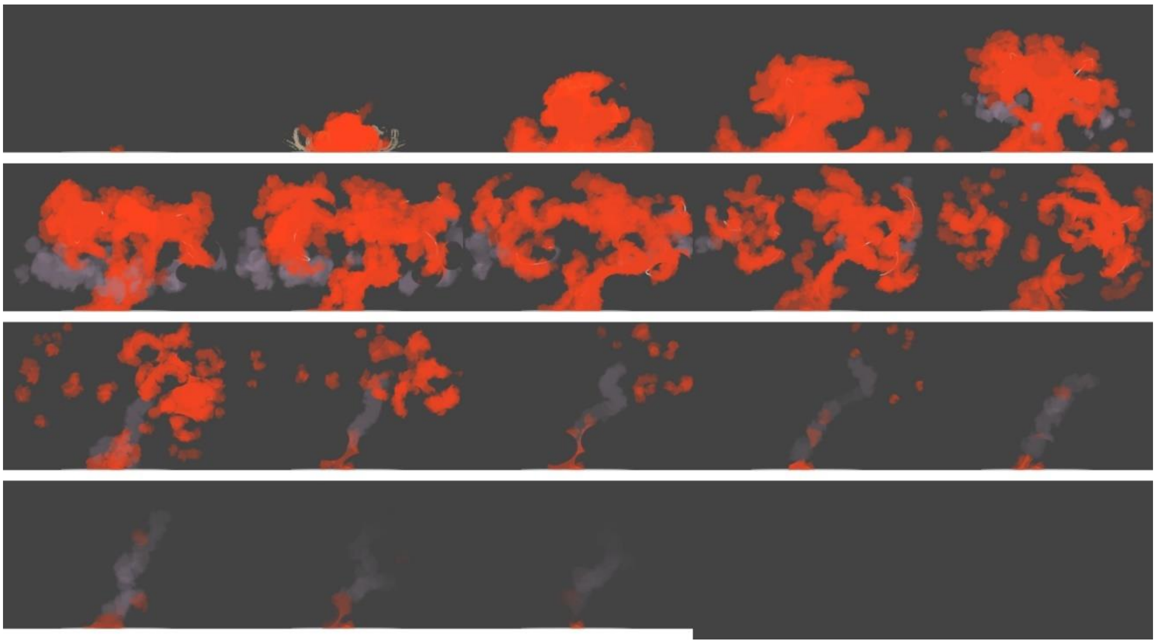


Picture 28. The final look of the effect after added gradients, the final animation can be seen in the collage video here.

Integrating the summoned character into the effect would require co-operation with the character animation and possible additional effects or changes to the base splash. This could not be done now, as animating the character is not part of the thesis. The final animation splash animation consists of 66 frames with 77 drawings on 4 different layers.

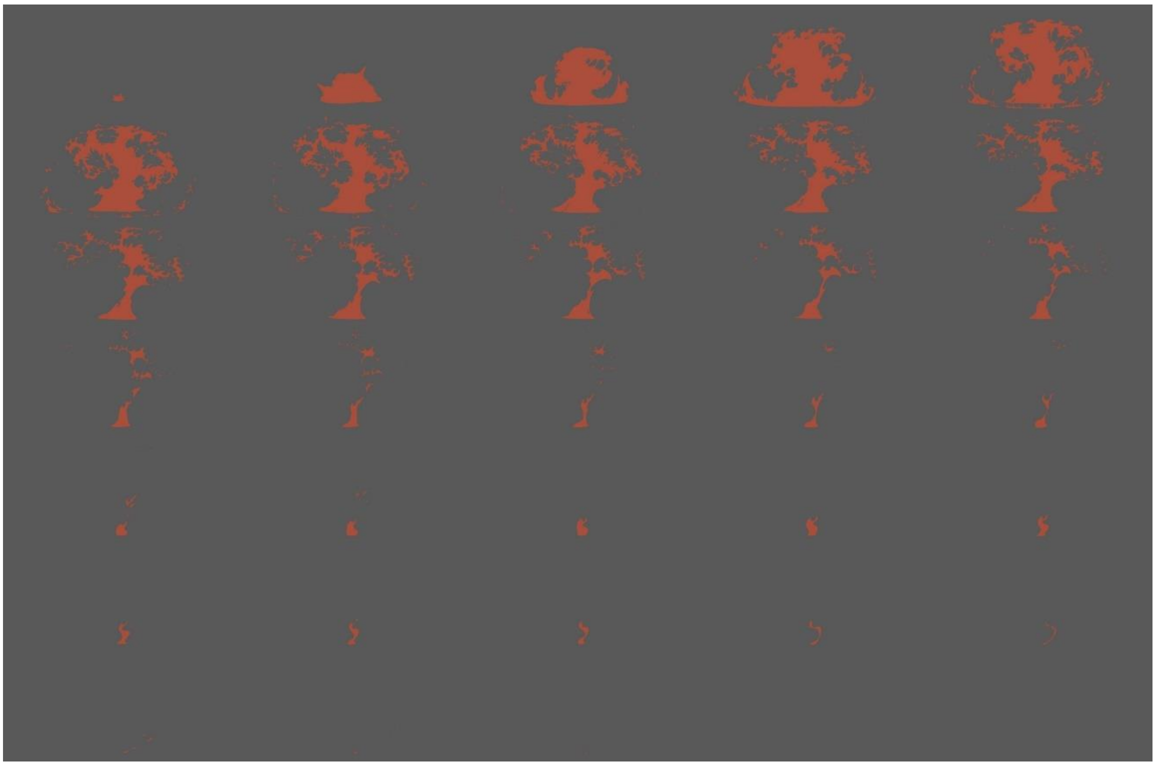
5.4 Third Effect, Flame burst

For the next effect of the project, the goal was to utilize learnings from fire animation. An offensive spell seemed fitting for the aggressive nature of fire. The process began with several rough sketches exploring the possible look of the fire. An explosion or a burst of flames seemed to possibly work the best, as the effect should be big and aggressive enough for it to feel like it does damage, but also fast enough so it doesn't disrupt the gameplay. A fire ignition was chosen as a main reference and based on it, a rough base animation was made. A very large brush was used so that focusing on the overall shape and movement rather than details would be easier. These drawings can be seen in picture 29.



Picture 29. Look of the rough sketch of the fire animation.

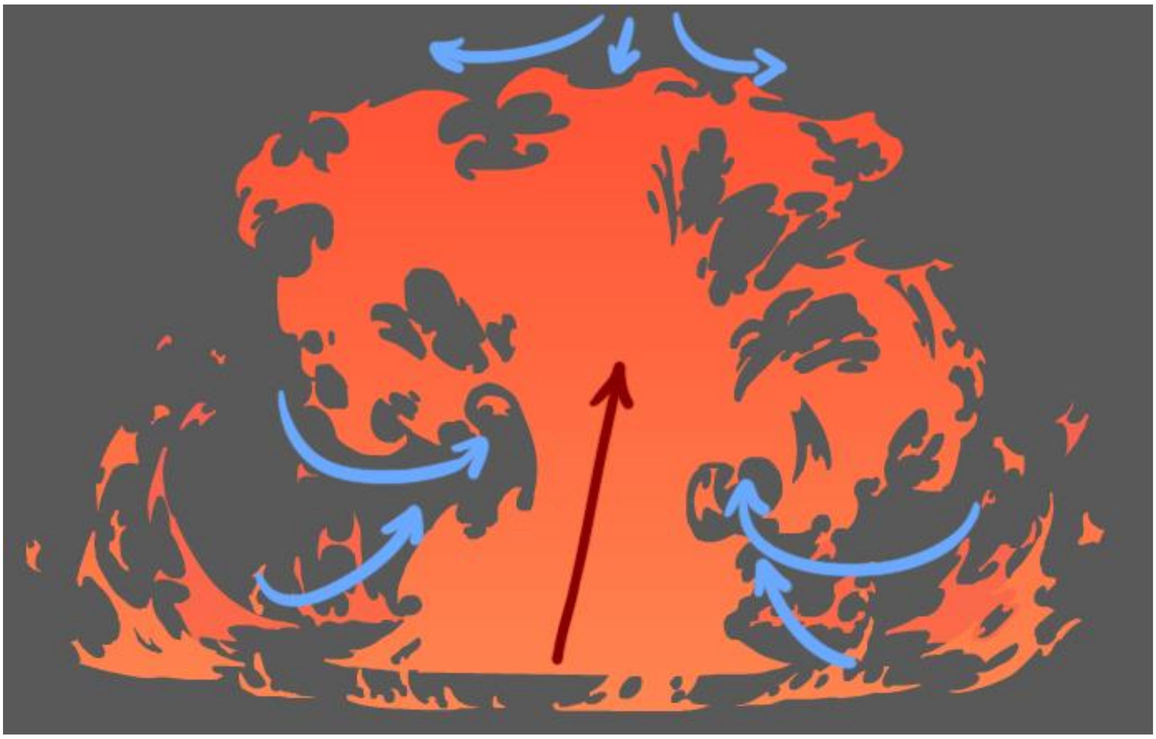
The rough animation was worked on until the basics movement felt like it was ready to be cleaned. The effect begins with an explosion and rapid growing of the flames, as it would be important for it to react quickly. The middle part of the animation - the flames dying out - takes slightly longer, because of the size of the fire. The last part of the animation, where most of the mass is gone and a small flame is left, might easily take too long. So instead of letting the flame die out on its own, the small flame gets blown out by a sudden gust of wind. It helps to cut down the effect's length and it stays true to the winter environment. The frames were imported to Adobe Animate and the animation's appearance after the first clean-up can be seen in picture 30.



Picture 30. Flame animation after first clean-up.

At the first clean-up, the focus should be on the bigger shapes rather than small details. The perspective also needed to be fixed, as the change in perspective mentioned before happened after the rough version had been made. Comparing to the rough animation, this also brought changes to the ring of flame moving outwards from the explosion, as it would have looked unnatural if it didn't move in all directions.

An important point in the fire ignition is portraying the affecting energies coherently. When fire ignites, it is a type of explosion, so the energies can be very similar to a mushroom cloud forming in an explosion. The ignition begins with the fire's size increasing fast outwards and upwards. As the air begins to resist its growth and pushes it downwards, the fire's expansion slows down and the fire gets pushed to the sides instead. At the same time, the oxygen-filled cooler air gets sucked into the fire from the sides. (Gilland 2009.) These forces can be seen illustrated in picture 31 with arrows.

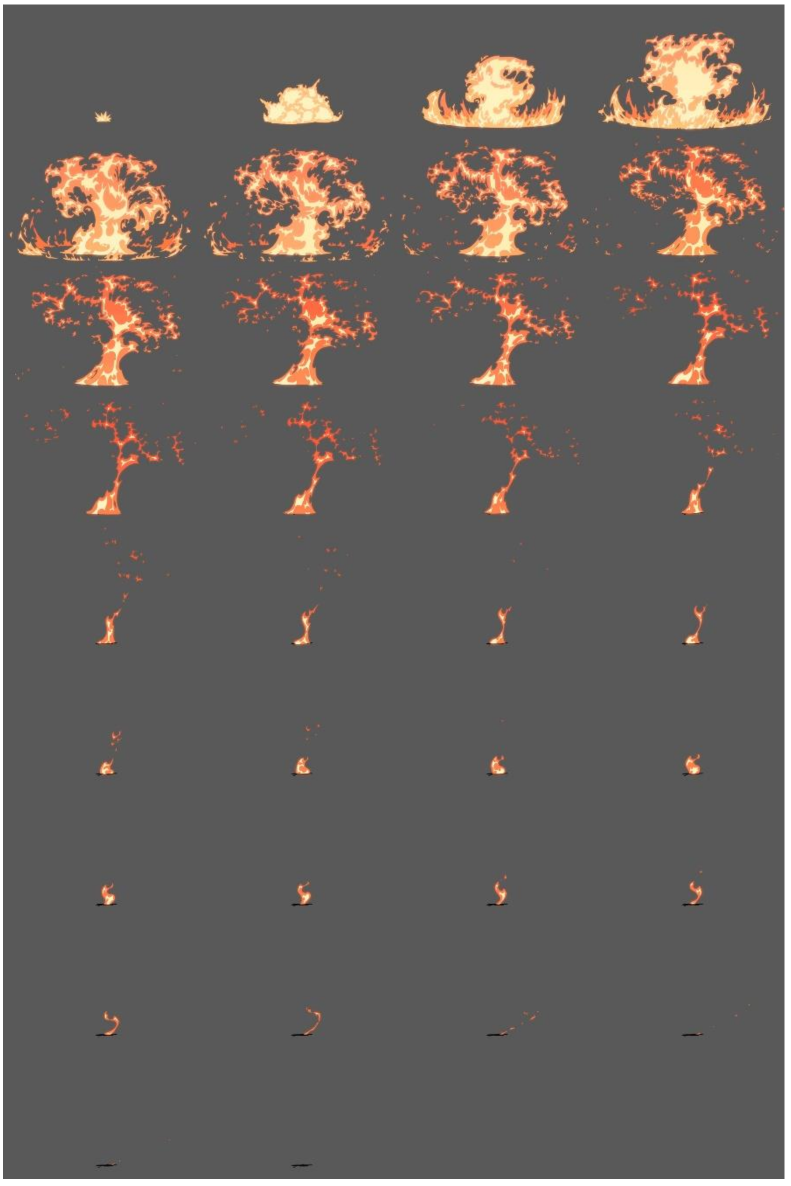


Picture 31. Different forces in fire ignition.

The forces affecting the biggest part of the fire have been illustrated with different colors in the picture. The red arrow is the fire being pushed upwards by the initial energy from the explosion. The blue arrows from the sides are the cool air being sucked in the fire, which can create curved shapes. The blue arrows on the top are the cool air resisting the fire and pushing it downwards and to the sides.

Following the first clean-up, every frame would get a polishing round, which meant giving them quite small details to give the effect an illusion of large size. After adding the details to the silhouette and making sure their paths of movement stay logical, the inner shapes of the fire could be added to the animation. This can help giving the fire its distinct look. Constructing the inner shapes works in quite the same way as with the bigger, overall silhouette. First, the bigger shapes would be made and after making sure that they move correctly, details can be added. This helps to reduce the workload, as polishing the shapes, and working with small details take time and thus if the movement would have to be fixed, more time and effort would be lost.

To give the effect its final touches, the colors got tweaked and effects – such as an outer glow – were given to the fire. This is done as the very last part when all the frames are confirmed as final, as fixing them becomes much harder if the gradients and glow effects would have to be remade several times. The final look of the effect can be seen in picture 32.

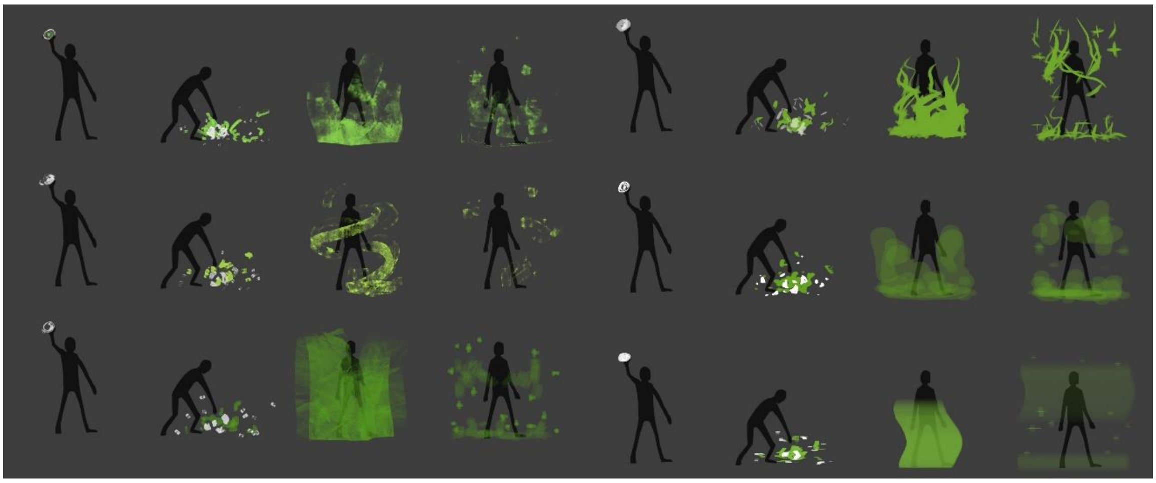


Picture 32. Final effect with added color effects, the final animation can be seen in the collage video here.

As seen in the picture, a gradual change in color was added. The fire starts as a very light-yellow colored but gradually changes into a darker, orange shade. This was added to illustrate the fire's temperature being very high in the beginning as it explodes and slightly cooling down as time passes. The final animation is 70 frames consisting of 34 different drawing.

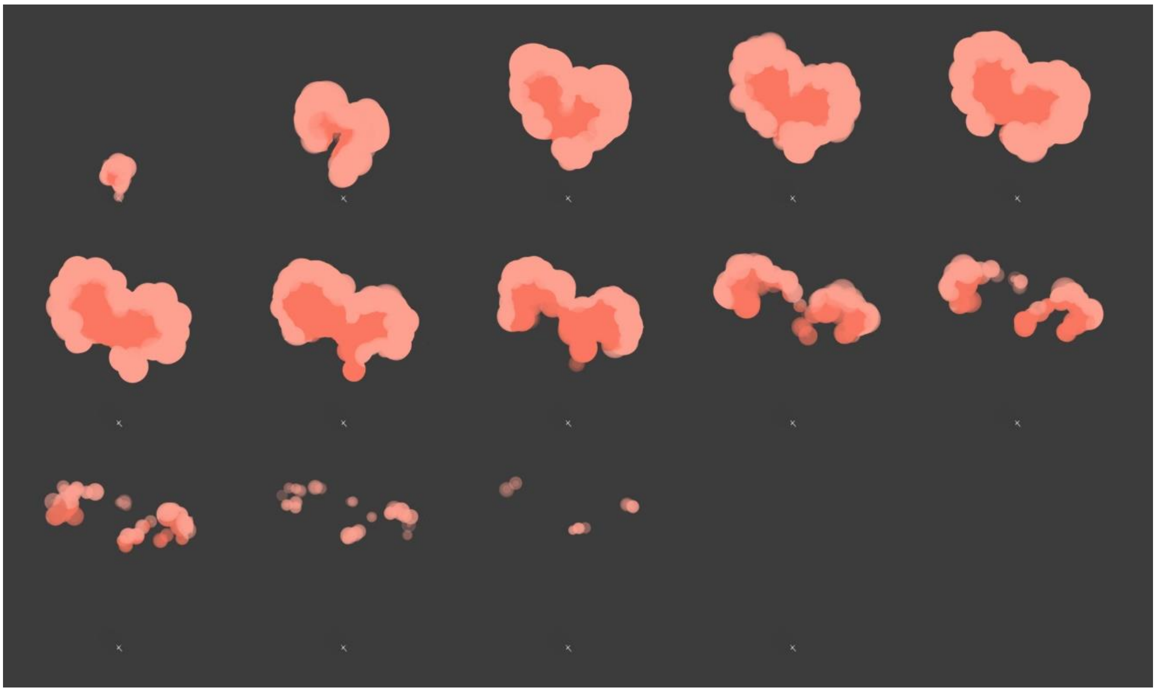
5.5 Fourth effect, Healing

In addition to water and fire, smoke's and steam's characteristics were studied, which gives the base for the fourth effect. On the very early stages, the smoke characteristics were decided to be applied to a healing effect. First ideas were that liquid from a broken bottle would evaporate thus creating a smoke effect and the concepts reflected that, as seen in picture 33.



Picture 33. First concepts on the healing effect.

A color very often seen in healing effects is green, as it is a positive color often used with user interface buttons too. The problem with using green in the effect can be that it easily makes the smoke seem poisonous rather than healing. In order to reduce this, tests with more yellow-green and symbols indicating healing were done. However, the poisonous feeling in the smoke was not fixed, and, in addition, breaking the bottle seemed very aggressive for a healing spell, and finding and interesting shape for the smoke deemed tricky. A change in approach helped to solve the situation, as changing the smoke to something rising from an opened bottle allowed the shape of the smoke to be played with. A few sketches created the idea of a heart shaped smoke. It would make it clear that it is a positive spell and give it a more magical feel. The animation process began with rough version of the animation, which can be seen in picture 34.



Picture 34. Rough version of the healing effect.

The smoke of the effect resembles steam more, as it allows the effect to disappear quickly. In addition, instead of acting the same as steam in real life, the effect was given some liquid-like shapes and the disappearance of the steam is followed by bursting heart-shaped bubbles. These characteristics were made for added feeling of magic and to make the effect slightly more interesting.

Several versions of the disappearance of the effect were made before the final version was found. Other versions included the effect getting cut into many smaller pieces and drifting away, but the very smoke-like shapes didn't seem to work and made the heart-shape unclear. Also, the motion of the animation seemed uncomfortably unnatural if the heart-cloud was stopped immediately to make it clearer and the pieces of the cloud would drift away, since it suddenly gained speed again after stopping. The best choice seemed to be to stop the effect on its tracks quite soon and keep the heart shape as long as possible until making the steam quickly disappear. These kinds of characteristics allowed the shape to be clearer and the effect's motions to be more snappy – quick start, keeping the shape and then quickly disappearing. In the beginning of the animation, a small trail to highlight the quick movement and the non-solid nature of the smoke was also added. When the movement felt like it was working, shadows were added to emphasize not only the smoke-like shapes, but also the overall heart-shape. After this, gradients and colors were tweaked to fit with the overall color scheme of the work. The final appearance of the effect can be seen in picture 35.

Picture 35. Final effect after color changes and gradients, the final animation can be seen in the collage video here.

As seen in the picture above, the color scheme was changed to a slightly more purplish hue. This is because of the overall color scheme created with the character concept, which consisted of more blue and purple hues. This way the effect fits into the world better. The final effect is 44 frames made of 23 different drawings.

6 CONCLUSIONS

An important point to address regarding this thesis is that everything is mostly from the point of western animation. Ultimately, Disney has greatly influenced almost all animation and most of my sources were from Disney's animation studios and Disney's animators. And what must be understood is that not all animation leans on their principles and ways of working. For example, eastern animation is very different, as they have different points of emphasis than western animation usually does, even though their roots lie in Disney's early animations too. This is also why it must be kept in mind that all information on how to create effects that has been stated in this thesis is mostly just guidelines to help new animators to get to a start and teach them what to pay attention to. In the end, the rules are made to be broken. What is more important is to understand why these guidelines exist, what they mean, and then either use them or break them when deemed necessary.

Also, my sources on effect animation were almost only from a single person. While I very much respect animator Joe Gilland's work and his years of working with effects, and believe that he is very deeply knowledgeable about the field, it would help everyone a lot more to have more than one perspective on the learnings. But as effect animation is – unfortunately – not that big nor a popular of a field, even though it has so much history, it is also understandable that not much literature exists on the matter. The most I can do to gain different insights on working with effects is watching how other people do them, as some videos on the subject do exist in the internet.

The project was started with Adobe Photoshop as the animation software. Adobe Photoshop is not the most optimal program for animation, as it lacks many basic features regarding animation, such as onion skinning, and controlling the frames is inconvenient. In the very beginning, I changed to Adobe Animate – former Adobe Flash -, which is primarily an animation software. While it made the animation progress itself much easier, I wasn’t familiar with the program at all, which slowed me down in the start as I had to learn to use it. Luckily, the basics were very easy to learn, and I picked up speed very fast. While Animate lacks some basic features I would have wished for, such as layer styles, and some of the basic features are very tedious to use, such as layer effects, I did not regret my decision as it did make the basic process significantly easier and faster. While Adobe Animate would have probably been an unfit choice had the style of the effects been more complex, it was a great fit for the simple style chosen for the project.

As for my own feelings regarding this thesis, in the end, the project was a huge help in learning more about animation and effects. Not only it made me learn a lot when trying to understand everything well enough to write it myself, but it also gave me a completely new perspective when looking at the world and works of other people. And by having to apply these learnings in my work taught me the most. It made me understand how much more I should continue to do to learn. But it was also rewarding, as I very quickly started to see what kind of things matter and how I could improve my work.

I also understood very early on that I had greatly overestimated my skills. What I imagined to be an easy task proved to take a great amount of time from me. While I did lower my goals for the thesis to fit my skills better, I ended up staying quite close to the original goal. This was probably not the best decision on my part, but it did help me grow and I learned a lot more by not giving up and sticking with making – from my point of view as a beginner - more laborious effects. I also did not want to settle for effects in which I was not happy with, which meant a lot of extra work, but also more learning. As I had to understand why I wasn't happy with the animation, I also understood a lot more on how the effects work. Overall, I am pleased with my work and feel that I did produce the best work that I could with my skills at that moment and I do not regret taking the time to fix the effects I was not content with, as, in addition to all the knowledge I gained, the material I produced will be a great addition to my portfolio.

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