Paperless 2D animation in production

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Preface

The medium of 2-D hand-drawn animation — often labeled cartoon animation for its most famous origins and summits — underwent a facinating story of success and decline during the 20th century. From the first experiments to the evolution of an art form; from sidekick cartoons to great successful movies; from the first feature films to seasoned saturday morning series. From hyped to declared dead — more than once.

Lately, it seemed that the story of this now called "'traditional animation"' would cease with its century and give way to new means of artistic expression. Computer generated animation (CG animation) is the buzzword. After the ever increasing spread and success of digital prodution procedures, the future clearly seems to lie with the computer. But 'computer' does not necessarily mean '3-D'. By design universally employable, the modern workstations could even lead to a revival of hand drawn animation — enhanced with the powers of digital production.

Digital 2-D hand drawn animation transfers the exact art form the paper on the animators desk to the computer monitor. Utilizing graphics tablets and digital pens to translate the motion of the drawers hand into the software. This is the digital version of the classical paper animation — hence called "'paperless animation"'.

By providing the traditionally approved process with the advantages of the computerized workspace it closes long gaping deficiencies and opens new prospects — both artistically and economically. But new ideas take time to develop. Always trying to compensate those areas where it fails as a substitute to paper, it is yet to be widely accepted by the animation industry.

The necessary hard- and software is widely available and had its time to mature. Graphics tablets, stylus pens and monitors have proven their value and applicability in many adjacent fields of visual design work. And specialized software packages have several year long change logs of improvement and innovation. Yet this does not mean that everything works flawlessly or that everything possible is already common practice. A deeper look into the available products reveals technical problems and impractical implementations — but also gives a look-out on the things that are or can be possible.

Yet an application is only as much as the applicant allows it to be. And paperless production in actual animation studios is still rather the exception.

Without an open mind to the demands and quirks of professional animators paperless animation is just an abstract case model. Those productions that have been realized paperlessly allow a glimpse in the inner workings of the industry. And the words of those animators that are willing to, have or never would employ this work process allow a deeper understanding of the art form.

In technical literature, 2-D paperless animation is — if at all — only discussed as vague dream of the future; mostly hiding in the shadows of the much more famous 3-D computer animation. An approach that already does not do the reality justice anymore. Therefore this thesis gathers information from all sorts of sources around the central question: How can, could and does the paperless workflow aid the 2-D animation medium?

Abstract

The medium of 2-D hand drawn animation — also called cartoon animation or traditional animation — underwent a process of advancing mechanization and digitalization in recent decades. Most of the production chain is already widely done with a computer. The latest advancement is on the threshold to complete this transition and make hand drawn animation a purely digital task without involving the once characterizing paper and pencil. But this "'paperless animation"' has yet to prove its use and applicability and find wide acceptance.

Since animation has a long history of mechanization, viewing it as an evolutionary process will clarify the meaning of paperless animation as a new technique. Major advances will be be revisited and revalued on their actual historical influence and the different opinions they once provoked. This will set the context for the evaluation of paperless animation as a new means of production.

Yet digital imaging is such a transition in the field of arts in general and animation in specific, that whole new options and freedoms can be drawn from employing it. A more theoretical approach to the matter will lay out the groundwork for the actual analysis of applied solutions. Available hardware devices will be reviewed on their applicability for animation in comparison to paper and popular sofware programs will be analyzed as potential replacements of the animators desk as a modern work environment.

But even the best applications are inane without an applicant. And much of of the animation industry has so far been hesitant to apply paperless animation in any — left alone all — fields of production. An analysis of those productions that did and the words of those animators that have, will or never would conduct paperless animation give a better understanding of the inner workings of the industry and the insufficiencies and strengths of paperless animation.

Chapter 1

Technological progress of 2-D animation

To better understand the meaning of paperless production techniques for cartoon animation one must see it against it's historical background. Although today traditional 2-D animation seems like a uniform device it was really an evolutionary process of invention and exploration. Behind the scenes of the fashions and visual styles almost every step of prodution has been repraced along the way — with each replacement causing as much discussion and stir as the latest step of paperless animation. Thus history allowes a better classification of potentials and limitations of the new technology, and a better understanding of the way 2-D animation is commonly approached by professionals.

1.1 2-D Animation in Production

The most famous way of producing cartoon animation, labeled Animation Pipeline, was cast by historical developments in a process of trial and error [18, p.184]. This surely does not imply that it is still valid for modern production environments — let alone optimal.

1.1.1 The Animation Pipeline

For a better understanding of the scope and focus of this thesis, the production pipeline mentioned is adapted to favor the art of animating itself over the adjacent fields necessary to create fine motion pictures.

Pre-production: The production of every animated film starts with a phase of planning and previsualization of the concept, story and style. Although these steps of storyboard and animatic creation are deeply linked to

the development of 2-D animation, they are executed before the actual animation and therefore called "'pre-production"'. Although it must be mentioned that most successful productions do not divide pre-production and production stricly — neither chronologically nor in staff — allowing later ideas and improvements to be incorporated in the concept [14, p.27]. So it should be kept in mind that pre-production is a seperate but not ideally detached process.

Animation: The actual animation — giving life to inanimate images — is produced only in this stage. The animation stage can therefore be labeled "'production"' and is shared by the animators and their assistants and inbeween artists. Firstly, an animator starts to approach a scene by defining the key phases that lay out the foundation for the shot, pinning down the motions of the characters and objects. These images are usually rather unrefined and therefore commonly called "'rough animation"' or "'ruff animation"', which is usually to crude to be used in the film. Therefore they are passed to the assistant animator whose job it is to prepare the images for further processing by cleaning and correcting mistakes and aberrations and filling in in-betweens where needed [19, p.60&99] [10]. It is important to understant that due to the illusionistic nature of the images and the animation an "'in-between"' is more than a direct blending or morphing of two images. It can however sometimes be executed rather simple and automated or "'limited"' — depending on the desired style and quality.

Ink&Paint and Camera: The clean animation phases are then passed on to be further refined, colored and stylized. They are therefore often transferred to another medium which allowes easier processing. Finally the diverse images of characters, objects, scenes and effects are arranged and combined and the final image is taken. Although these steps are commonly seen as part of the production stage, they are refferd to as "'post-animation"'-production in this thesis.

1.1.2 Division of labor and best practices

This pipeline might seem like a division only of obviously successive steps on the way to a finished image. But a closer look reveals that it is actually more about division of artistic competences than about hierachy and assemly line production. The order of production stages is simply a cause of rational necessity and best practices.

The production stage of animation splits into two distinguished areas of work — animation and assistance. The assistant takes the liability of producing clean and readable drawings that express materiality and volume and feature the ever same looking characters and objects without aberrations [14, p.229], so that the animator is free to focus on the motion and acting

that the character will convey over a series of drawings [10]. It is easy to believe that this deems the assistant to be the inferior subordinate, but the original idea of division of labor demanded and appreciated the assistant as much as the animator [14, p.185] [18, p.199]. Sadly this concept is seldom executed seriously and more often than not assistans are regarded as lesser artists which — in addition to the lack of qualified draftsmen in general — led somewhat of a decline of animation assistance [19, p.100f].

1.1.3 Innovations and mechanization

Not only from a commercial angle of producing and selling moving images, there have always been two drives to improve the production procedures: making it cheaper and making it better. The procedures of the animation pipeline were therefore always in a process of improvement [14, p186].

Inventing ever new and impressive styles is most important since entertainment in general and art and design especially thrive on the motion of creating ever new images. New styles and never before seen pictures are one of the main selling points that make a film successful and an advertisement catchy. Disney became successful not least because he was the first to offer cartoon animation with sound and colors [19, p.18] and continued to push the envelope during the golden years of animated feature film.

But since each and every image that will be displayed in the final film has come a long and expensive way, cutting costs and simplfying procedures is probably the most classic aim in 2-D animation. The drive to cut costs even precedes and often overruled the drive to create innovative and stunning images. For example the use of static background images which was started in the 1920s is nothing more than the attempt to save the laborous and costly task of redrawing the scenery in every frame. It might seem obvious and natural to any 2-D animator today, but the practice was not immideately applicable or undisputed. Animation pioneer Winsor McCay was dismissive of the cost-saving technique because he deemed it deprived of the liveliness of ever redrawn images [14, p.275], but eventually had to give in to the cheaper technique [4, p.100]. After Earl Hurd invented the procedure of laying celluloid frames of animated characters on top of static paintings (prior to that, it was done the other way round, causing several limitations), the new technique prevailed and was in common use for over 50 years [14, p.275].

1.2 Early years

Animation as an art form is inherently connected to the technology of motion picture recording and therefore its bond to film as a distribution medium has always affacted the art form. [14, p.13ff] In spite of being swayed by technology by nature, the initial production process was davoid of machines and electronic devices. The obvious characteristic of these procedures —

today commonly called "‘traditional animation"’ — is that due to the lack of mechanization all production steps are handcrafted by artists. Nevertheless these means of production allowed a wide variety of artistic freedoms and complexity.

1.2.1 Animation without electronic devices

The actual animation was done with pencils on paper, usually utilizing a specialized animators desk, more commonly known as lightbox, which implemented several basic utensils. Since paper drawings are difficult to process, the images where transferred to transparent celluloid sheets using ink. These so called "‘cells"’ where then colorized on the back side to prevent paint spilling on the line art. The dried cells where then placed in a certain composition in front of a camera which fotographed this one single frame of animation.

This process allowed a broad variety of visual styles but also critical options to reduce cost and expenditure. Drawn animation frames could be reused by cycling them or reusing various segements in different connections. The inking and painting allowed a multitude of uitilties including Drybrush and Wetbrush, Blend-Crayons and Airbrush. Although this usually ment an erratic increase of production cost, the visual liberties were impressive. The camera was mounted to a complicated scaffold that allowed independent compositioning and movement of the various cells. These "‘multiplane cameras"’ were created according to requirements and could reach terrfic proportions. Camera tricks like back-lighting and multiple exposures expanded the the stylistic possibilities of the painted cells further. The final shots sometimes contained of up to 12 different and often comlicated exposure techniques.

In a nutshell visual effects were abundant — but mostly expensive and often difficult to control. Many were based on experimental techniques and only few experts knew how to apply them.Technical obsolence also added to the cost since the equipment had to be renewed constantly.Thus even those studios that aimed for the best quality were eager to cut corners and find cheaper and simpler procedures for their production [14, 17].

1.3 Xerography

Transferring drawings from paper to cells is a rather uncreative, stylistically limited, technically difficult, repetitive and time-consuming task of tracing lines. Therefore it is not surprising that the production step of inking was quick to come under scrutiny when copying machines became available. Disneys long time associate and animation pioneer Ub Iwerks adapted the process to the production of cartoon animation — the cleaned-up line drawings

on paper where transferred unto the celluloid sheets by a modern Xerox copier[1] [14, p. 281].

The first feature film to utilize this new technnology was "'101 Dalmatians"' (1961). Since the machines where only able to produce pitch black color, the film had to match this limitation stylistically. This shows that the technology was so auspicious, that artistic choices were conformed to the technical quirks of a new production device [14, p.281]. Grey and colored lines became available only later as the process was improved [2]. The loss of the finer qualities of hand made ink lines on celluloid sheets was deplored by many, while others were taken with the new style which transferred the vitality and rough sketchy appeal of the drawings better and more precise than ink ever could [14, p.281]. This also offered new artistic freedoms to the animators, like frayed and scrubby lines to give fur a more fuzzy look [4, p.142] But since the pencil drawings were not interpretated by an human eye anymore, they had wo be both precise and strong. This meant that the assistants or clean-up men had to produce more refined line art — taking over part of the work that was originally conducted in the inking procedure. On the other hand it took a considerable amount of work from animating repetitive motions: cycles could be animated once and then be copied transformed to fit fluently behind the original sequence. These "'loops"' were also artistically difficult since the transformation must be exact and identic for every repetition of the frame — an extremly difficult task for the human eye. Also, very slow moving objects tend to be troublesome to animate and trace, since the hand and drawing medium is limited in it's accuracy. The mechanical precision of a copier allowes minimal and exact translations without quivering [3]

These new possibilities and ease of the workload ment the end of the profession of the inking artist. The meaning of that development can be seen from many sides. Some argued that it finally freed the artists from the dull and bland work of tracing lines and allowed them to persue more interesting creative tasks [14, p.280f]. But this might be an overly roseate view on the matter, since inking was often done by poorly paid and scarcely recognized women [4, p.157f].

But dispite the discussion and criticism, Xerography became an industry standard and displaced the hand crafted ink not only in cost weary budget animation but even in the most expansive high-quality productions.

[1] http://en.wikipedia.org/wiki/Xerography

[2] http://en.wikipedia.org/wiki/APT_process

[3] The Animation Podcast: Interview with Nik Ranieri, Part3, 2:14 (http://animationpodcast.com/nik-ranieri-part-three/)

1.4 Video

Apart from the obvious influences as a means of distribution, the spread of video devices also revolutionized the way animation was produced. Video allowed to view moving images instantly without the tendious and costly process of developing film and thus had a great influence even on those productions that where not distributed via those means.

1.4.1 Line testing

One of the procedures where motion pictures are required during the production is the animation test. Since the animator can observe only a limited number of drawings at a time and can not view the timing of the frames, he has to consider the key choices of timing and spacing deliberately mostly from experience. It is therefore important to every animator to see his work in motion before passing it on. These quick-and-dirty assembled animations are commonly called line tests [17, p.23]. Even seasoned animators feel the need to test their animation — albeit in different ways [19, p.68] [4, p. 97]. The Disney studios began the practice of handing the days work in for test shooting and developing to view the line test on a projector — which greatly improved the quality of the produced animation [19, p.334]. But the process of shooting developing and projecting was costly and tendious — making the animation rather unintuitive and quick corrections and experiments difficult. The video technology allowed a quick reviewing and correcting during the animation work, which also meant more freedom and reduced risk of time loss in production [14, p.531]. This however bears the danger of becoming a crutch: if the animator knows he can review the result of his work at any time he is less likely to produce considerate and well-planned action and might start to try around aimlessly.

1.4.2 Video Reels

What the line test is for the animator, the reel is for the director. Often called "‘Animatic"’, "‘Leica-Reel"’, "‘Story-Reel"’ or "‘Work-Reel"’ (depending on the usage and production stage) they previsualize the final form of the film based on the current state. Starting as an improved and filmed version of the storyboard, the reel evolves more and more into the finished movie as scene by scene is replaced with the currently produced pictures — first the approved line test and later the final color shot [19, p.334] [14, p.211,231f] [17, p.13-15]. This produces a always up-to-date version of the produced film that can be examined by the director to check the results and coordinate changes, allowing a more dynamic production style. If there are any changes to be made on the composition, the video reel helps to make those decisions as early as the need becomes visible. Thus less work goes to waste. It also

helpes to raise funds since investors are easier to convince with a visual map of how the concept and production advances [4, p.45].

Although both instruments have been in use prior to the invention of video, the simplification and acceleration had an significant effekt on their way of employment and magnitude.

1.5 3-D computer graphics

With the rise of personal computers, computer graphics quickly aroused the interest of the animation industry, promising new prospects to automate production processes and yet unseen possibilities to create visual content. Computer graphics always have a superhuman precission and correctness due to their mathematical deterministic nature — a trait on which illusionistic imagery thrives. Expressive art forms on the other hand need to stray from this correctness to evoke empathy. This makes computers perfect to create any content that is technical and rigid, but difficult to use for fleshy and lively imagery.

Thus it was quickly perceived that computer generated and human made art complements each other: *"'[...]the hardest things to do with hand-drawn animation are actully very easy to do with computers, and vice versa"'* (John Lasseter). Therefore, combining both production methods became feasible long before the idea of "'Computer Animation"' competing "'Traditional Animation"' was devised [4, p.203/Kap.20].

1.5.1 3-D computer graphics in hand drawn animation

The idea of compensating those areas where human artists are weak were not new. Since perspectively correct depiction of complex rigid bodies is a rather troublesome process, it was considered to be easier to build the desired objects in reality and then import them into the animation environment by photography. Usage of so called "'Photostats"' dates back to Pinocchio (1940), and incorporated stop motion animation into cartoon production. The elaborate process of generating those references just became faster, cheaper and easier to control with a computer [17, p.158]. The virtual 3-D objects, wether they were props or scenery, were rendered from any particular perspective, printed onto paper and handed to the respective animator or assistent [4, p.205f] [5]. Effects animation, like particles or water, also profited from the new technology and facilitated the work of the animators. If such a usage of contaminants damages the consistency of the drawn image depends on the proper application and processing. More generally it is commonly considered that it is a feature of quality if it is impossible to see how the images were created [9].

1.5.2 3-D animation as an competitor

By the time "'Luxo Jr."' — the first fully 3-D animated short film that featured empathatic character animation — was released in 1986, it became apparent that computer graphics would not only be a supplement to hand-drawn animation, but will become a competitor to the now called "'traditional animation"'[4]. Nevertheless it took until 1994 and 1995 respectively until the first 3-D computer animated series ("'ReBoot"') and feature film ("'Toy Story"') were finished. 3-D computer animation — which is as a medium rather comparable to stop-motion puppet animation than to hand-drawn cartoons — offered something completely new to the audiance: smooth, plasic and detailed pseudo-photorealisic images that were impossible to archieve before. But also the production side profited from the new technology: Being closer to puppet animation, the re-use of models and automated creation of in-betweens makes the animation easier and faster in the long run. Admittedly this means that 3-D animators are always restricted to the possibilies of their models and struggle to archieve as lively and organic motion as they would in hand-drawn animation. But since the success of a thechnology is decided by the economic profit, the decisions of the producers were perpetuity influenced by the consumer preferences and shaped the industry. Both great feature animation studios Disney and Dreamworks studios retreated from traditional animation in 2004. Hand-drawn animation was deemed obsolete and often even "'dead"'. TV series and japanese Studios on the other hand showed few recession on their proceeding 2-D production, and some even expect a large scale revival that it will threaten 3-D once technological advancements become widely utilized [18, p.412]. Disneys recent return to their catoon roots with the 2009 feature "'The Princess and the Frog"' might not be an reliable indicator, but this surely shows that 2-D animation being permanently displacing by 3-D is unlikely. Partly because there will always be fanciers and partly because of the differences between 2-D and 3-D in possible fields of application and outlay [5, 10, 11, 13, 16].

1.6 Digital Ink&Paint

Since paint and visual effects were the most costly and difficult aspects of cell animation, the computer offered a most welcome opportunity to simplify and enrich the procedure both at once. This came also opportune since since people felt the tratitional ink and paint techniques had reached their limits stylistically, and wanted to go beyond that. The common term Digital Ink&Paint seems rather narrow for a process, that at it's best includes all the production steps past clean-up, including camera and post-production visual effects. It is therefore sometimes called "'Digitally Generated Anima-

[4] en.wikipedia.org/wiki/Luxo_Jr.

tion"' [9].

History: By the end of the 1980s the digital tools started to take over the production pipeline. Disney developed it's own "'Computer Animation Production System"' (CAPS) to produce parts of "'The Little Mermaid"'(1989) and later completely replaced the traditional cells for "'The Rescuers – Down Under"' (1990). In the 90s several independent software developers created their own Ink&Paint systems like PEGS, Animo or Toon Boom and after it has been in use for 17 years, CAPS was recently discontinued [5].

Production: Instead of transferring the line drawings onto cells, the single frames were digitized with a scanner. Unlike the pysical media that were by nature fixed in their size and level of detail, the computer is able to detect, interpret and refine the strokes of the animator, making them resulation independend — an important trait especially when producing for the big screen. On the other hand this meant that the clean-up artistis have to follow the peculiarities of the computers [10] [3, 4.1.2]. But using a computer in the "'post-animation"' production steps that define the visual style of the picture simplifies and cheapens many of the procedures which have formerly been extensive and delicate. The ink and tempera colors uses prior to that were often difficult and unpleasent to use and it was generally challanging to control the results [14, p.252,269,278]. Digital Ink&Paint is a much more intuitive process further aided by the fact that a computer screen as a production device is much more similar the various consumer devices than a painted cell. Suitable computers were expansive back then, but production costs soon adapted over the saving of thousands of celluloid sheets, dozens of painters and expansive colors. It also allowed new and better uses of color and visual effects,and the "virtual camera" solved many limitations of the extremely expansive and quickly obsolescing multiplane scaffolds [14, p.267]. Transparencies, smooth gradients in both space and time, 3-dimensional and perspective transformations, distortions and unlimited layers are only some of the possibilities that allowed more diverse and impressive images [9] — some of which can be seen in figure 1.1.

In a nutshell, the computerization of great parts of the production pipeline not only accelerated and simplified the work, but also added new means of expression and gave the artists a better control of the result. On the other hand of course this meant that great parts of the production staff did not benefit from the cost reduction of the studio, since they were the reduced factor themselves.

[5] en.wikipedia.org/wiki/Computer_Animation_Production_System

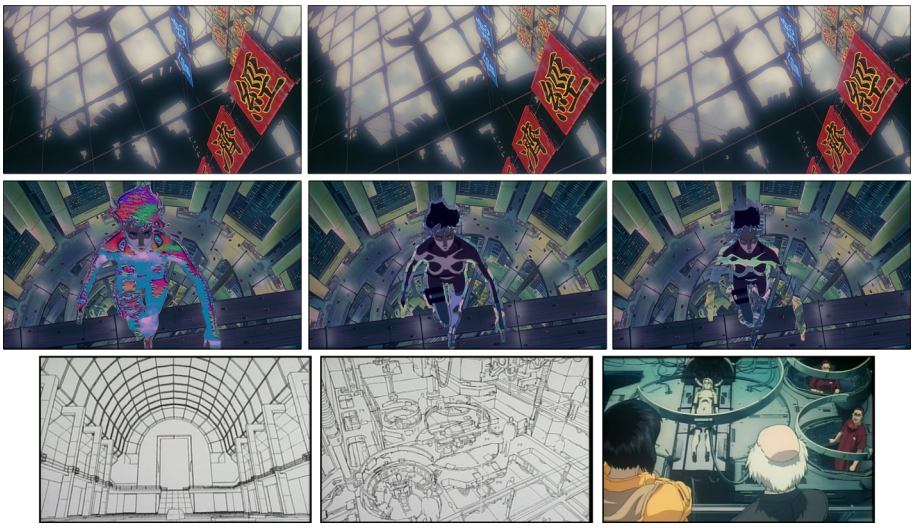

Figure 1.1: Ghost in the Shell (1995) [9]

1.7 Paperless Animation

After the Digital Ink&Paint process transferred most of the traditional production pipeline to the computer, it was only a matter of time until advances would be made to fulfill the digitalization and conduct all the work on a computer instead of translating the drawings half-way through. "'Attack of the Killer Tomatoes - The Animated Series"' (1990-1992, Fox Kid's) is claimed to be the first paperless produced TV series, and due to the natural familiarity with computers, several game companies started to produce their 2-D animations paperlessly on a tablet in the early 90s [6].

1.7.1 Digital drawing and painting

Computers as an creative medium rely heavily on the means of controlling them in a simple, effective and intuitive manner. Digital pens and tablets already allowed this for some time, but only with the spread of cheap and feasible personal computers and devices, the idea of drawing and painting digitally became prevalent. In the adjacent areas of illustration and game development the practice of creating drawings digitally is far more widespread and accepted than in the animation business. Although this might not be a reliable source for predicting the future spread of digital hand-drawn animation, it might at least be a source of new blood, since education to create illustionistic imagery and appealing characters has somewhat declined over the years — which has been a steady source of distress to 2-D animation [19, p.32-34]. Digital Art on the contrary has become a kind of modern folk art among tech-savvy creative youths, incorporating traditional painting

and comic drawing.

1.7.2 Fields of digital 2-D animation

The term "'Paperless Animation"' is not exclusivly limited to the technique of transferring the hand-drawn animation process into the digital production environment. Many completely different concepts claim the popular words "'digital"' and "'paperless"'. Of course, this thesis cannot cover all the possible interpretations of these words and has to focus on those techniques that stand in the tradition of 2-D hand-drawn animation. It will only cover other fields of work as far they are of relevance from said viewpoint.

2-D puppet animation: Although commonly underrated, animating flat paper puppets is a constant companion of hand drawn animation. Dating back to the works of Émile Cohl, animating cut-out images has always been a way to produce more limited movements much more swift — not unlike various "'limited animation"' techniques for hand drawn animation did. With the computer and dedicated software solutions like Toonz the usage of (virtual) puppets and cut-out figures has become both easier and more versatile (see section 2.3 and [1]). However at heart puppet animation is more of a stop-motion approach to animation than hand-drawn cartoons. It will therefore only be reviewed as far as it can act as a means of limited animation.

Flash: Adobe Flash technology underwent a spectacular success story in recent years. Powered by it's main field of use, the web, Flash rapidly expanded it's distribution and reputation and eventually became a household name. It's wide spread is probably one of the main reasons why so much TV cartoon animation is done with Flash or similar tools, although it was originally not concieved as a means for Television production. It does however offer many features for paperless animation and will therefore be reviewed as an appliance in 3.2 [6].

3-D sketching: Since drawing and sketching is the most intuitive way to convey ideas, there have been multiple attempts to "'combine"' 2-D and 3-D graphics by allowing the artists do control the 3-D application with a digital pen, much like a drawing tool. However resembling these technologies are to hand-drawn animation, they are actually only a new input and control device for 3-D computer graphics and therefore beyond the scope of this thesis.

3-D cartoon shading: Although photorealistic or extremely detailed smooth shading is one of the core strength of 3-D animation, there are efforts made

[6] http://en.wikipedia.org/wiki/Flash_animation#Flash_Animation_in_professional_studios

to reenact the flat look of traditional animation cells. In spite of the aesthetics it is still an area of 3-D computer graphics and is produced in that manner.

Digital Ink&Paint: In the revolutionary abolition of the traditional painting and shooting process "'digital animation"' became a buzzword that was used rather generously for anything that employed computers somewhere in it's production. Since this work focuses on the actual art and process of animation rather than producing and refining cartoon images, these methods can't really be reviewed as paperless. It will however be discussed in chapter 2 that paperless workflows can enrich or even merge with the painting and visual effects work.

Mixed hand-drawn animation: Since not all artists favor working digitally, some productions tend to mix the usage of digital drawing and paper drawing, for example to clean up digitaly created Rough Animation or to give their characters or backgrounds an analogue, sketchy paper look before it's all combined and animated on a computer. These techniques are valid creative choices for a digital production environment although they violate the term "paperless". Therefore these techniques are widely ignored in this thesis, but do not disqualify referenced works as "'traditional"'. The focus is again on the act of animation and used tools not on the aesthetic approaches or particular approaches.

Pre-Production: To complete the claim of a complete production pipeline devoid of any paper, one would have to include the pre-preduction as well. In pursuit to provide a diversified and all-covering set of tools, many developers of paperless animation software also focus on these "'pre-production"' stages. Needless to say: first ideas and concepts are still most often made on paper since it's the most simple, reliable, uncomplicated and all-available medium there is. And since concept art and storyboarding are no exclusive characteristic of 2-D animation and arguably a detachable process which features no animation whatsoever, this work will only refer to those preceding stages whenever it touches the actual animation work.

Chapter 2

Paperless Animation techniques

Unlike previous machines that were used to automate certain procedures, computers are not bound to any target operation. Indefinitely versatile they expand the possibilities of any working environment in every respect. Some of these new possibilities are improved adaptions of common tools, other became feasible for the first time with the digital media. This does not mean however that every available appliance offers these improvements to every possible extent and employment. Also the possibilities are described favorably, although they surely hold the possibitly for abuse or becoming a crutch. But these are the techniques that paperless animation has to offer as a state-of-the-art animation environment.

2.1 Advanced working environment

Apart from the actual appliance of creating 2-D animation computers offer a wide variety of supportive features that are also used in adjacent fields. Although they are not directly aimed towards the animation industry, theses traits and improvements create an environment from which animators can benefit greatly. This is especially true for software appliances, since they can build upon preceding developments and can quickly be exchanged or updated. It is surely possible to also benefit from technical progress when using paper, but therefore the sheets have to be repeatedly scanned and printed. Although such workaounds are not only possible but very common, it needn't be mentioned that working paperlessly in the first place saves a lot of effort, and that utilizing such techniques is nothing more than partly incorporating digital procedures into a traditional production pipeline. It is also common knowledge that computers bear several general and unique hitches that trouble their handling. They need power, emit heat, crash, loose data, obsolete fast, are rather expansive and so on.

2.1.1 Computers as a workplace

From accounting to illustration, many professions and idustries have incorporated computers into their workflows and procedures. On closer examination the rather mundane tasks and overhead work is quite similar in animation. Thus it must be mentioned that paperless animation benefits from the same advantages that every paperless office does. The traditional workflow of 2-D animation incorporated lots and lots of paper, which had to be elaborately organized, filed, passed along and archived (see: [17, p.22&23]). Virtual files are much more comfortable and versatile to handle. They can be instantly duplicated, sent over long distances and be automatically archived. Organized and indexed, libraries of stock animation facilitate the re-use of material, which is common and important in animation (see section 2.3). Also, the physical medium of paper will fray and wear out when used constantly and enduring and must be fostered and mended [17, p.20,21] and can only be copied a number of times before showing flaws. Computer files don't decay and can be copied and transmitted lossless. The computer can even remeber latest changes to the work — either by roll-back undo or by revisioning systems. As the famous Science-Fiction artist Michael Whelan put's it: *"'The big advantage of digital is the God-like power of non-destructive editing, the Holy Grail of the visual arts, and it's an enormously tempting prospect."'*[1]. All these and many more common traits of computer science can be instantly and immediately accessible and automatable by employing keyboard hotkeys, macros, scripting or expanding plug-ins in any operating system or software.

2.1.2 Integration and co-operation

As animation is a extensive process it is usually conducted in large teams. But there are individualists proving that working alone can be very effective as well. Paperless animation might transform the tasks associated with animation in such a way that both mentioned can benefit: by integrating the pipeline into a singular process it both supports co-operation as well as the independent efforts of handymen.

Being able to produce a fully finished 2-D animation film from a single workspace empowers lone fighters, but also diminishes overhead work and buraucracy in teams, since information that once had to be passed along and processed sepeperately (like frame hold durations (exposures) in the x-sheet) can now be incorporated directly into the animation files. This is especially important in modern productions since competences have bled into other areas of work [2].

When working in a team, computer communications and organizational

[1] ImagineFX Nov. 2009, p.47

[2] http://www.awn.com/articles/technology/flash-animation-production-flash-growing

procedures can be incorporated directly into the workspace. Virtual Sweat Boxes, groupware services and repositories have proven invaluable in other lines of work. This also makes it easier to coordinate, divide and check the output when working on a project parallel for example by building on referenced required work as it's just being produced [15, 5-8]. Whenever there is a hierarchy in production, checking and approval procedures can be sped up — prior to that the animators often had to wait for the director to come around [4, 134f] [3].

2.1.3 Digital art creation

As mentioned in section 1.7, creating art digitally has become quite popular over the recent years — not only in animation — due to the unique vantages that a digital canvas offers. A proper virtual drawing desk is freely rotateable, movable and scalable workplace without peg bars incommodating the arm of the animator. They can be mirrored — a popular trick among artists to conquer the habituation of the eye — and display all kinds of grids und guides (like animation fields, perfect geometric bodies or character sheets) directly in the work area without disrupting vision. Zooming in and out on specific areas allowes even smallest details and greatest features to be drawn with a comfortable arm movement and apt precision [8, p.199] [4].

While paper and pens are physically fixed in they way they work, the computer can be freely programmed and customized in how the applied pressure or orientation of the pen influence the stroke (as seen in figure 2.1).It is possible to use virtually infinite seperate layers and use cutting, copying and transformation techniques to create and correct images. In a nutshell: modern gaphics applications allow a wide variety of usages that would not be possible on paper. If they can be used productively is up to the animator.

2.1.4 Interoperability and augmented drawing space

Since most of the organization, production and visual effekts are already done with computers, animating paperlessly allowes a better collaboration with the established production procedures and appliances from other fields. One of them is the direct incorporation of 3-D graphics in 2-D animation (see: 1.5). Traditionally, all 3-D environments and objects were printed out on paper frame by frame — an extensive process that limited interaction. If for example a 2-D character interacts with a 3-D prop, it becomes challenging to match the movement according to the workflow. An advanced

[3] http://www.awn.com/articles/aniscene/animated-scene-paperless-animation-production-myth-or-reality

[4] http://ownerofwendys.blogspot.com/2007/01/paperless-animation.html

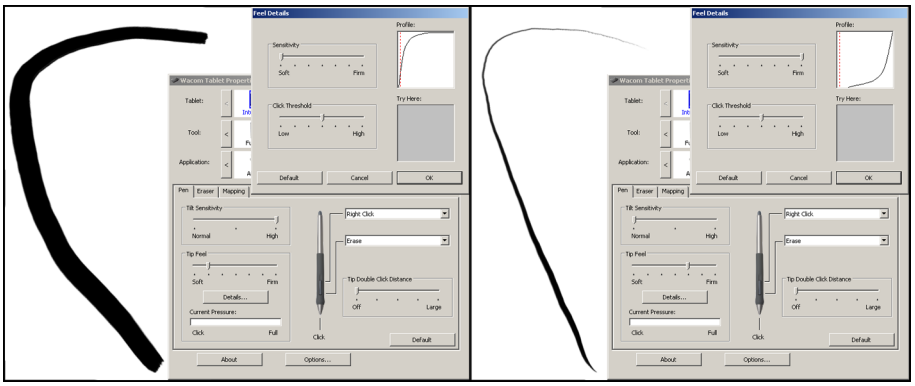

Figure 2.1: Customization of tablet properties: Wacom

paperless animation program might be able to integrate the 3-D work directly into the same drawing space that the animator uses. Another example is the combination with real filmed footage. Detachedly animated cartoon figures tend to look weightless and noncredible in a real life environment — their motion and nature must be matched to that of the reality surrounding them [14, p.528]. More general: whenever an 2-D animated figure has to interact with any effect that is done after the animation (like particles) or if any visual effect needs proper animation and acting (like a character made out of a particle cloud), it will be very helpful if these effekts can be seen and controlled directly in the animation environment. This starts as early as the surroundings of the animated figures aren't static: camera movements in the depicted environment would be extensive to print out and view frame by frame. The common answer to this is to only allow parallel tracking and zooming which does not affect the animated figures [5]. Paperless animation holds s better solution since it is possible to display an animated background to the drawing. Thus the animator can match the perspective on this assets on each frame to their environment. Of course these advanced background image can also be used for easier rotoscoping or use of references — the animator can film his own acting with a camera and then place the video behind his virtual drawing desk. And finally it allowes the animator to see any technical limitations that are caused elsewere in the production pipeline right away, like interlaced pictures (half-images), limited pixel resolution (expecially important when working on details) or simply the aperture of the environment that will later be seen in the final image.

2.1.5 Automated Leica-Reels

As mentioned in section 1.4.2 video reels are invaluable in the production process of any animation. In a digital production environment this tool not only becomes a lot easier and quicker, but also more versatile to the pro-

duction staff. Instead of requiring especially created drawings, the reel can be immedately joined from the upscaled thumbnail sketches, cleaned, corrected and reviewed by the layout artists — saving time and preserving more spontaneity [5]. Later in production the computerized environment can automatically produce the current most up-to-date and complete version of the film as possible, immideately incorporating even most recent changes. This visualization is available to anyone, allowing the animator to take an instant look on how his work blends in the entire film, and learn from, critizise, adjust to or correct other members of the team. And if his animation depends or incorporates other peoples work — like the sound of dialogue and noises or visual effects — he will always be able to view them interactively in their current state of production. Vice versa, if his work is to be re-used and incorporated, he can check how it is working in any of those deployments. And when the producer needs to find investors, he will be glad to have a visual display to show the aim and progress of the production.

2.2 Animation support

Hand drawn animation is probably one of the most unintuitive and complex art formes that exists: drawing motion. Motion itself is an elusive concept that only exists as it vanishes: if one would freeze motion, it would no longer be motion. Thus the animator has to create life, motion and character from his mind without seeing it on the single frame. it is only reasonable to equip him with every support available to see the motion and passing of time in his work. It aides the task greatly, and computers can greatly improve the common animation supporting tools.

2.2.1 Programmable Light Table

Animators greatly rely on the possibility to view several frames at once — most commonly the adjacent frames or close key frames. Since each frame represents a single phase in time and all phases are displayed successively the preceding and subsequent images gain great importance. An animator who can see the previous drawing can precisely define the change of position of an object — the speed of the motion. Viewing the two preceding frames he can see the previus speed of the motion and its direction allowing him to control the change of direction and speed (acceleration). When seeing three frames at once he can interpret the last changes on speed and direction, and so on. The same principle applies to subsequnt frames which display the future of the current drawing. Since animation is seldome done purely lineary forward, the animator will have to meet (pre)defined keyframes within a set number of frames. A task impossible to accomplish if the target keyframe is

[5] http://ownerofwendys.blogspot.com/2007/01/paperless-animation.html

not even visible. That's why traditional animation is done on a Light Table, a drawing desk which can be illuminated from below. Thus underlaying drawings will show through the current top paper and become visible. Their dull and cloudy look earnd them the nickname "'Onion Skins"'. The animator can choose which drawings he will see by simply selecting the necessary paper sheets. This process obviously needs do be redone whenever the animator needs to change the selection. In practice it is not uncommon that the animator time-consumingly changes his selection of frames on the light table every time he changes the current frame which he is drawing on. Also the number of possible Onion Skins is limited: the blending of several paper images consumes light from the source and quickly becomes confusing when to many line drawings overlap.

When working with a computer, the rendering of the visual workspace is done mathematically and can allow greater control over the process. The way in which frames blend onto the visible drawing surface can explicitly influenced — a different color and strong nonlinear fading will make them easier to seperate and understand. This is especiallially important when animating solid paintings instead of line drawings (as described in 2.5). Also the maximum number of simultaneously visible drawings virtually unlimited, and the selection of which frames to show up can be automated employing simple rules like "the next 3 frames, the last 2 keyframes and frame number 23" — the computer will update this selection whenever the current frame changes saving the animator from juggling paper sheets. Figure 2.2 clarifies the superiority of digital light tables.

2.2.2 Instant line tests

As described in 1.4.1 diligent testing of the produced animation is crucial to every animator. This starts as early as pose testing, includes rolling & flipping (consecutive looking at adjacent frames in the hand) the first drawings and exceeds reviewing the leica reel (see section 1.4.2) regularly. When animating paperlessly flipping and testing can be executed instantly and intuitively. The software allowes rolling at fixed frame rates and with unlimited images and can create a customized line test as quick as hitting a single button (most likely a hot-key). And even if the computer lacks the calculation power to display the work at the defined frame rate, the software usually has a function to quickly render the drawings into memory and then display the sequence it correctly (e.g. [15, 4-15]). This does not only make the animation work more smooth-running and intuitive encouraging experimentation and exploration of new ideas [14, p.39], it also saves drawing time. Since getting a video line test from a dedicated machine is rather troublesome, animators tend to produce more in-betweens than necessary and sort those excess drawings out after the test [3, 2.3.6.].

However easier this makes animation, it holds the risk of becoming a

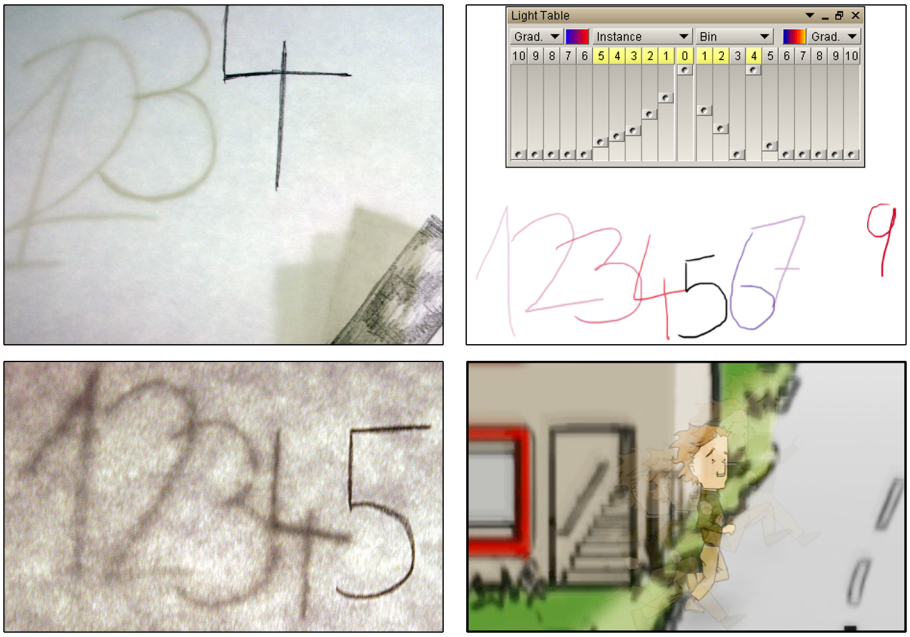

Figure 2.2: Comparison of light tables: traditional (left) and digital(right)

crutch. But it is hard to disagree that it accelerates the process 1.4.1 [10].

2.3 Workload reduction

The drive to create more animation faster and cheaper is as old as animation itself, and a wide variety of tricks to reduce the required work has been employed (see chapter 1). Often stylistic choices are made to meet these techniques — which is commonly called "'Limited Animation"'. However the notion of limited animation being only about cost reduction overruling artistic expression is rather narrow minded [4, p.154]. Instead every animator will try to produce the aspired style with as little outlay as possible. If the result will still please the eye depends on the quality of the animator and his tools, not on the techniques. Even high quality full animation can and does benefit from several tricks (or suffer when employed poorly). This shows that "'limiting"' or reducing animation is a delicate task in itself. Luckily, the computer offers several improved and new techniques to archieve efficiancy without loss of quality.

2.3.1 Tracebacks and transforms

Even in full-animation, there are often parts of the drawing that don't move at certain times (e.g. a still body while the head is talking). Traditionally the

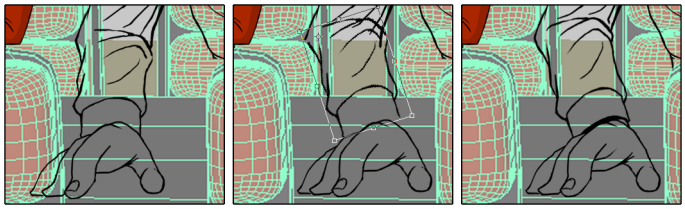

Figure 2.3: Re-usage of clean drawing parts with transformations

animators draws these parts in red on the first frame. Recreating them on the successive frames is left to the assistant, who has to copy them extremely accurate [18, p.368f]. These "'Tracebacks"' can not only be executed by the computer, it can also be automated to transform them slightly to gain more liveliness and credibility. When the motion between two frames is rather limited, it is also easier to start from a copied version of the previous frame and adjusting it accordingly. Figure 2.3 shows such an example of reusing a frame drawn beforehand. If the resultion is high enough or if splines (see section 2.4) are employed, the result is already clean and only needs minor touch-ups. The drawing can also be created in several parts, simplifying the reusage and blurring the line to rigs as described below.

2.3.2 Rigs

Limitating the animation can create aesthetics that can hardly be considered 2-D animation anymore — as is the case with puppet animation. But the principle of creating images from a basis via complex transformations that can be controlled decisively far extends the means to create animation of those specific aesthetics. The usage of "'rigs"' as they can more generally be outlined can include any creation of limited animation that can be based on algorithmic descriptions and mathematical modifications — like warp-transformations, lattice deformations or morphing operations.Virtual Rigs can be more basic or complex than any physical puppet and the line between limited hand-drawn animation and cut-out or puppet animation can be blurry. Also they do not wear out and can be reused from a steady growing library of puppets and puppet parts or simply the transformation parameters as such. Thus Rigs also allow to produce, re-use and transfer pieces of animation from different figures. They are, however, always limited in their usage and freedom and it should always be considered (and invisible to the viewer) where rigs are employed and when the drawing is completely recreated. Also because the creation of such rigs is a time consuming task in itself, transferring some of the animation work into the "'pre-production"' step — sometimes so much that animation becomed the last step in the pipeline [11]. Thus it will take longer until the first results are visible and

the overall outlay reduction by reusage of rigs and animation might not be as big as hoped for [3, 4.2.2].

2.3.3 Aided Inbetweening and Automated Inbetweening

Since most of the motion and acting lies in the key-frames and their timing, attempts are made to reduce the work on the filling inbeween images. In limited animation there are often scenes in which the created frames are used repeatedly in a varing, non-linear order. Syncing lip movements to dialoge is an example for this technique in which the animation lies not within the drawings but in their respective use. Traditionally this task was defined by the animator but executed in the compositing step, utilizing rather unintuitive descriptions. In paperless animation the animator can interactively and instantly choose the selection of images and their timing or let the selection be automated based on varying parameters such as a dialogue track is to mouth-shapes [3, 15]. Needless to say that the latter one is always limited to certain specific uses and generally fault-prone. It can however create a convenient basis which the animator can refine at will.

Exceeding the re-arranging of a fixed set of images, computers can potentially create new images as in-betweens to given key-frames. Naturally they do not understand the nature of animation or the depicted scenes and can therefore only produce satisfying results in a very limited spectrum of application. If, for instance, any rig or transformation has been used to create a consecutive key-frame from another, then the computer can as well create inbeweens between these frames by interpolating the transformation parameters. How expident the result is will depend on the usage of transformations and will be better the more defined and puppet-like the created alterations have been. When employing vector graphics 2.4, the computer can interpolate the way the splines are formed, since every stroke appears to the computer as an distinct object. This surely does only work if the consecutive key-frames are quite similay so that the computer can identify matching lines in both images. This is even more the case when the drawing is not available in the forms of splines. Although there are quite sophisticated algorithms that can match pixel motions from one frame to another and "'morph"' them to an interpolated inbetween, these techniques are rather extendsive regarding the results. But even though all these means cannot replace an inbetweening artists in complex full-animation, they can help him generate inbetweens faster an more precise when little and simple motion is to be displayed.

2.4 Vector graphics

Ever since the resources of computers were very limited, the idea of storing and handling shapes as mathematical formulae and descriptions rather

then pixel images has been furthered. The workings and impact are easily understood. Employing mathematical descriptive methods and defined proceduces, vector graphics use splines to describe what should be — lines and shapes are objects that can be altered and interpreted. Pixel ("'bitmap"') images on the other hand simply list the color values of every dot available in space. Since drawing is a rather applying process of tracing a intendet stroke rather than describing it by entering variables, software applications must interpret the sampled and recorded motion of the drawer and generate splines from it. Usually the software gets a stream of samples from the hardware at a steady rate. Pixel based drawing tools simply connect the dots and are therefore very fast at displaying the stroke on the screen. One can positively say that drawing in a pixel based fashion resebles paper more than generating splines. On the other hand spline recognition techniques allows are more intended interpretation of the stroke like smoothing jitters.

The difference in application are obvious: while pixel images are limited to their size and resolution, splines are always perfekt and do not suffer aliasing or loss of quality when enlarged or edited. Thus vector graphics eliminate the problematic limitation of pixel images — a drawing will always look sharp and crisp, wether seen on a computer monitor or on the big screen. Since they're employing rather complicated mathematical procedures, splines require more computing time when being edited which sometimes hinders the possibility to handle and view them in real time. An indefinite advancement of splines is the possibility to edit them singulary and precisely. Since every variable can be altered, a misplaced spline can easily be corrected. How this can be done by the user is a whole other issue. Employing them with handles might have prevailed in vector graphics software, but is often considered to troublesome for drawing [2,3].

The discussion between both procedures might be solved in the future by either side winning the argument, splitting the possible fields of employment or a newfound combination. But currently both approaches have their advantages.

2.5 Visual style

Creating the visual style of an animation film is normally part of the "'Ink & Paint"' step of production and refines the animated images independent of the animation itself. Those techniques that are applied subsequently will not be discussed here, since they are independed from the way the animation was originally produced. Even tough animators ideally ought to know about the procedures and artistic possibilities, they are usually not concerned with it [14]. But paperless animation offers a new set of options that extend the palette of the creative devices within the animation production step.

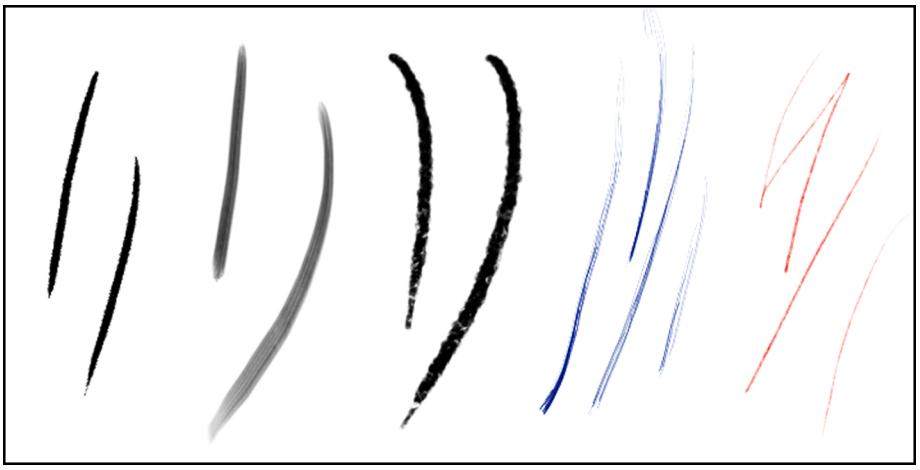

Figure 2.4: A sample variety of digital line styles — partly imitating physical drawing tools

2.5.1 Outline animation

Hand drawn animation traditionally stems from the line drawings of comics and newspaper cartoons. Thus the style and technique of animating outlines and silhouettes is predominant in 2-D animation, even when the images are not drawn by hand. Surely the vivid and crisp appeal of a pencil drawing is lost when drawing on a computer. But on the one hand that style was a controversial by-product of xerography (see: section 1.3) which was already being altered by digital ink and paint procedures (see: section 1.6), and on the other hand it can well be emulated by the drawing software. And unlike the previous post-production effects and emulations of flow and texture that just insipidly followed a spline, paperless drawings feature a real line weight and direction, giving it more expression and appeal. It can even be controlled easier and more extensive than real pencils by utilizing the various means of digital art such as adjustable pen parameters, custom brushes and underlying textures. Figure 2.4 displays some examples. These possibilities can used creatively in storytelling or simply to create an distinctive and outstanding visual style.

2.5.2 Animated paintings

More than just custimizing and styling classical line drawings, paperless animation holds the potential to produce whole new styles of motion arts unfeasible for analog devices. Animators envied the stylistic freedoms of artists from other fields for a long time and when challanged to translate a particular style in their work were often left dissapointed [14, p.192&209]. Paperless animation provides the means to create more diverse and stylistically appealing

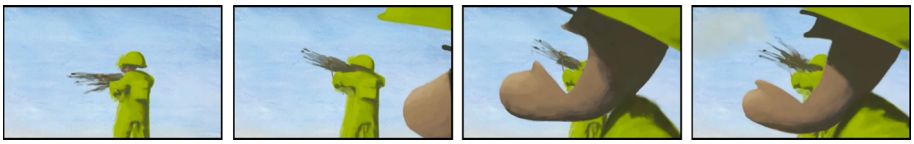

Figure 2.5: Beton ©2006 Bezalel Academy of Arts and Design http://www.tvpaint.com/v2/content/article/community/gallery.php

images without sacrificing the quality of the animation.

Departing from the established ways of creating line-drawing animation might seem like a leap of faith, but the single reason why they are predominant even in paperless animation is the long-lasting influence of earlier art forms — as was with any new medium [7, p.138-153]. Paperless animation should in this respect be seen as an wholly new medium devoid of any historical burden. A medium that finally allowes the artists to paint from the inside out, instead of just tracing borders. This is especially important for effect animators, since many natural phenomenons can only be depicted inadequately when forced to use closed outlines.

One reason why paper animation was limited to line drawings — apart from the paper only endures limited treatment — is that only lines a clearly visible on a light table. Opaque shapes block out most of the light and thus make it impossible to view several drawings at once (see section 2.2.1). A computer can facilitate alternative blending and viewing modes (like the difference image) that make it possible to animate complete paintings with the same comfort and precision as line drawings. And when they are being animated directly instead of just being filled with color later on, the animator can control more of the attributes locally and directly from frame to frame. For instance when a character was to dissolve into fog, the opacity and color would locally change within a sequence and should be animated. It would also allow a more feasible application of textures on objects, which could be transformed to fit the surface accordingly in each frame, saving the extensive (and therefore often omitted) task to re-paint it consistently. And finally, digitally created images can develop their very own aesthetics and appeal. The possibilies of animated digital art don't end here, and one would do well exploring the new medium as an creative environment rather than new means to create well-known images. Figures 2.5, 2.6 and 2.7 display just a small aperture of the possibilities of digital 2-D animation.

2.6 Compositing

Just as the visual style, the composition and rendering of the final image is a task commonly done after the animation is finished. But as mentioned, the integration of the pipeline into a single digital environment offers new

Figure 2.6: The Battle of Cable Street ©Asaf Agranat http://www.tvpaint.com/v2/content/article/community/gallery.php

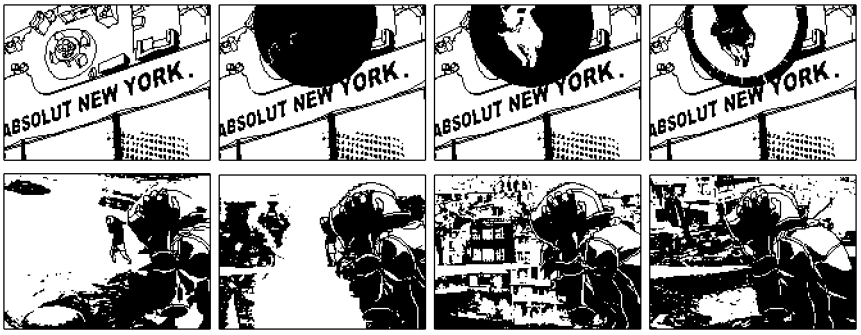

Figure 2.7: Prehistoric Animal ©Dead Karl — http://www.deadkarl.net

techniques and effects that cannot be applied retroactively.

One of these uses is the application of 3-D view spaces. As mentioned in 1.6, Digital Ink & Paint dissolved the limitations of physical cameras by implementing virtual view spaces. When animating paperlessly on can make even better use of 3-D transformations by working directly in a 3-D environment instead of having the effects applied subsequently. As can be seen in figure 2.8 the illusion of perspective increases when the 2-D images are drawn on a perspectively tilted background as those areas closer to the camera are respectively scaled stronger than those far away. Also in a 3-D frustrum, blurring can be applied according to the distance of the objects creating a depth-of-field effect. The effect surely is limited and becomes obvious to the viewer when used to strong. But when applied discreetly, it can improve the impression of depth in camera and object movements.

But also other effects could benefit if they were controlled directly in the animation stage. Applying motion blur subsequently to an already finished animation is only feasible when everything moves in the same direction. Local directional blurring (as seen in figure 4.1 in section 4.1) has to be animated frame by frame according to the timing and spacing. And since motion blur increases the optical flow of movements, this might bring new possibilities to animation quality [15, 10-9f] [16]. Other posterior effects might influence the final image so strongly, that the animator might want to see their effect while drawing to ensure the qualitiy of the final animation. This includes strong

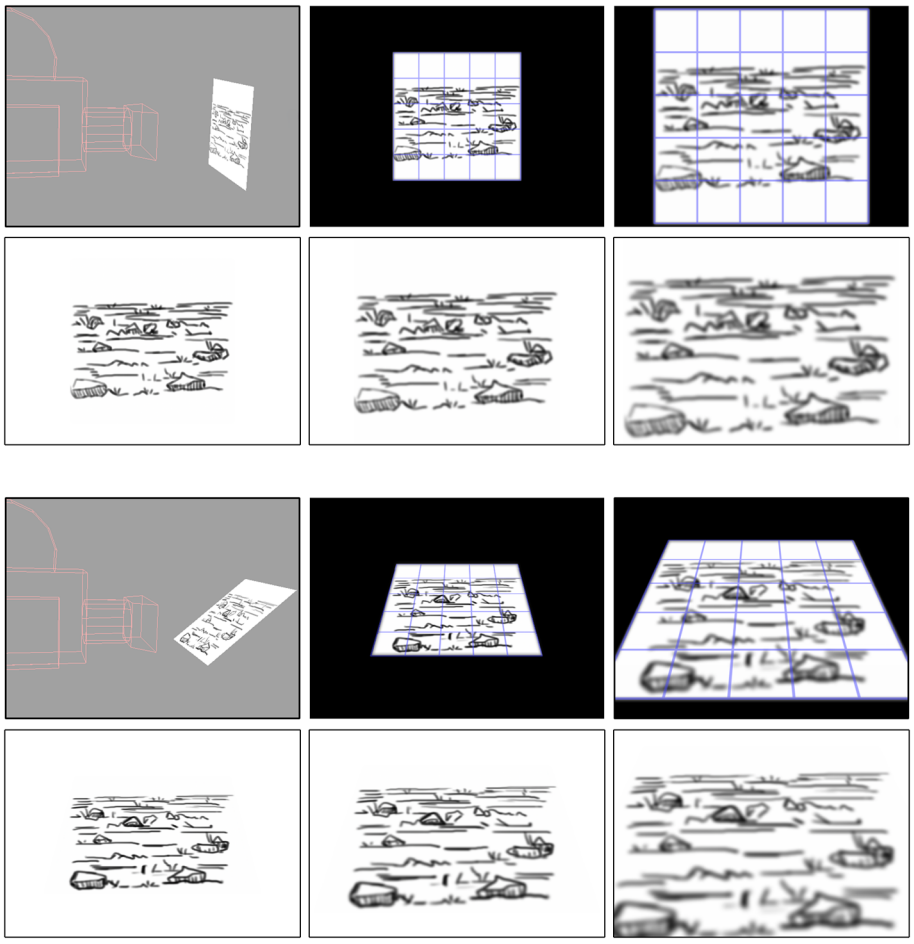

Figure 2.8: Traditional 2-D (planar) drawing area (top) and 3-D (tilted) drawing area. Note how close objects are scaled stronger and how the blur distributes over the image (depth-of-field)

distortions and estrangement as can be seen in figure 1.1 in 1.6. Finally, some visual effects tend to merge into animation, making a seperate approach unfeasible. A character interacting with a visual effect like a particle cloud might still be accomplished traditionally with a some organizational effort. But a character that consists of visual effects needs to be animated, and as previously mentioned special effects animators could benefit greatly from the freedom and possibilities of paperless animation.

Chapter 3

Paperless Animation appliances

A computer is by design a very versatile workspace. Although in itself not more than a calculation machine, this is reflected in the multitude of available devices which expand its possible uses. Naturally paperless animation requires a certain sort of appliances, specialized and adjusted to the demands of the animation artist. These are on the one side input devices — sophisticated hardware that can gauge and record the motions of drawing and translate it into computable numbers — and on the other side there are the animation programs, software suites and tools that interpret these numbers and provide the artist with a virtual workspace. Only in interplay these two parts can form the necessary unit of a digital animators desk. Yet each of them has its own challanges and requirements and limits or empowers the animator in its own way. Therefore a closer look on the real life available appliances must be conducted seperately.

3.1 Hardware

The traditional tool of the 2-D animator is the pen. Many input devices come up with additional features which can be used to simplify or even improve the work of an animator. But the heart of the key feature is the ability to produce lines and shapes by moving the digital pen over a surface in a natural way. Although it is commonly said that there really is no subtitute for paper ([18]) modern input devices can be impressivly feasible and versatile. Surely they suffer from the same difficulties that afflict all electronic gadgets: they are rather expensive, must be handled with care, require electricity and are susceptible to electric interference and electromagnetic radiation. Unlike pen and paper which is only limited by its fabric, electronic devices have an determined discrete resolution that limits the subtlety of the drawn strokes. And even though it might seem rather finical, the tactile sensation of paper

which some artists consider important is difficult to imitate with plastics. But the design of the various products is always advancing and by now many artists have been convinced that digital pens are a capable drawing device. Teething problems have been fixed and the specific advantages of drawing digitally surface. The pen can be customized in how pressure, tilt and rotation influence are interpreted and the function of each tip and button can be chosen freely (see: 2.1 figure 2.1). And even the feeling of the drawing surface has been improved over the years — although not to everyones statisfaction [1] [2].

Tablets: Common graphics tablets are the most common input devices for a digital pen. They are rather low priced and easy to handle and transport. But drawing on a different surface (the tablet) than the one that displays the effect (the monitor) can be challanging. The orientation and dimensions of the tablet might differ from the monitor, distorting the drawing movements. But commonly tablets can force the screen dimensions onto the tablet by omitting parts of the drawing space or using relative positioning, and since the hand does not operate on the display, it does not conceal parts of the work space [3, 3.3.1].

Tablet-Screen hybrids: The more sophisticated solution however is to combine the tablet with a fitting display, allowing the artist to draw directly onto the screen. The Wacom Cintiq series is the most prominent specimen of this category. Although there are competitors like Hitachi's Starboard series, they are less sophisticated and often not aimed at artists — which becomes apparant when comparing their specifications [3] [4].

Although tablet-screens are not necessarely save from common tablet limitations and headaches, he quality of the Cintiq enjoys great popularity and has allured and convinced even skeptics. Thus they are probably the most favored input device for digital artists in general and animators specifically.

Tablet PCs: A step even further than the combination of screen and tablet is the integration of a whole computer into a portable Tablet PC. Even more than the previously mentioned, Tablet PCs benefit from that integration by making sure all components including operating system and hardware drivers match flawlessly. Since they are a type of notebook (given size, battery and incorporation of keyboard etc), they are usually more expansive (considering the features and calculation power) than desktop PCs. This also grants the advantage of portability, but in a production environment that is usually

[1] http://ownerofwendys.blogspot.com/2007/01/paperless-animation.html
[2] http://en.wikipedia.org/wiki/Wacom
[3] http://www.hitachi-soft.com/starboard/products/doc/spec/Hitachi_T-19WX_specifications_0210.pdf
[4] http://www.wacom.eu/_bib_user/dealer/fac_c21_en.pdf

considered dispensable. Also they have to cut corners on the quality of the digital pen and none reaches the preciseness and comfort of a detached tablet. Therefore they are usually not as popular with artists [5].

3.2 Software

The Animators Desk in traditional animation consists of few but essential components. Modern software often seems to invert this principle by implementing abundant but sometimes disputable features. Due to the fact that software requires few space this must not be to the disadvantage. The important thing is that each feature is implemented in a way that makes it easily usable yet not distracting and that the usage of the overall workspace is streamlined and intuitive. Since these software products can be used in a wide variety of ways and offer an overwhelming amount of purposes, a direct comparison is not very suitable. However it can easily be identified where the focus of a particular progam lies. To depict the possibilies and abilities in each of the areas of application, the categories from chapter 2 will be applied:

Working environment: The software as a production environment in general and the suitability for animation in particular — including interoperability with other programs and simplification of overhead procedures.

Animation support: The features that support the animator in persuing quality in his animation.

Workload reduction: Any tool or feature that helps reduce the amount of work.

Vector graphics: Implementation of spline recognition and convenient and solid employment of vector graphics.

Visual style: Anything that helps develop and produce a wider variety of visual styles.

Compositing: The implementation of sophisticated and extensive possibilies to combine detached animations into a finished product, including rendering and post-produciton.

The respective strengths of particular products will be displayed in a mapping illustration as figure 3.1. If for instance one were to classify the historical advancements of Xerography and Digital Ink&Paint systems, they would both excel in work reduction but only the latter would include any use of vector graphics — the result would somewhat resemble figure 3.2. This is obviously rather imprecise and subjective, but can be used as a coarse classification of the purposes and possibilities of the respective program.

[5] http://www.fpsmagazine.com/feature/paperless001.php

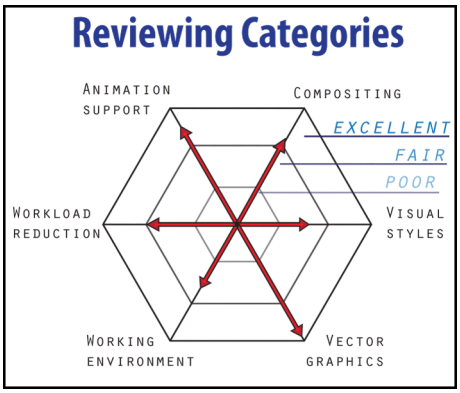

Figure 3.1: Classification grid

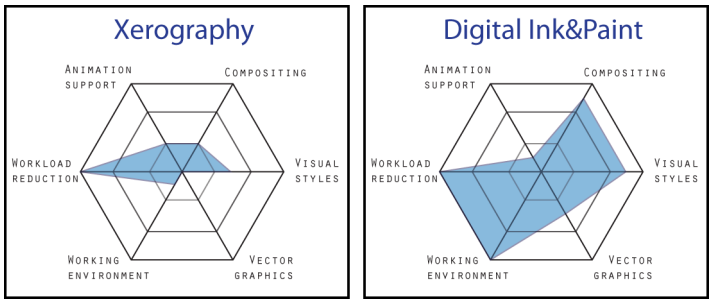

Figure 3.2: Expample classification of historical advancements

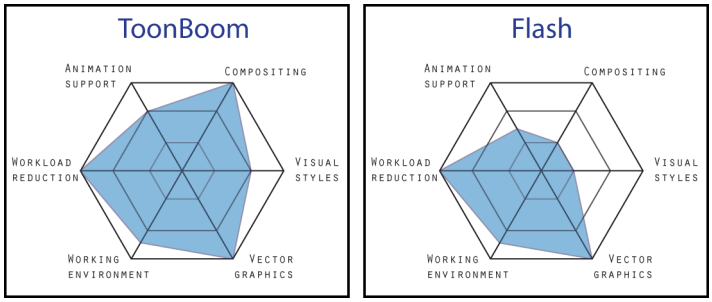

Figure 3.3: Vector oriented software solutions: ToonBoom and Flash

3.2.1 ToonBoom

The canadian software company Toon Boom Animation Inc. is one of the most famous developers of 2-D animation solutions. The list of popular and successful productions that employed ToonBoom software is long and impressive and recently the company has expanded its market area to cover every step of the 2-D production pipeline from stoyboard to post-production

[6] [7].

Since Disney Animation discontinued their own Ink&Paint system in favor of ToonBoom, it was tested if it could also be feasible for the animation production step in the 2007 short film "How to Hook Up Your Home Theater" (see: section 4.6 figure 4.2). Wether the production staff was satisfied with the result is uncertain, however the following feature film "The Princess and the Frog"(2009) was again animated purely on paper and only used ToonBoom for visual effects and Ink&Paint.

ToonBoom as a software is not a unified singular product, but consitst of a wide and somtimes confusing variety of versions which are regularly extend, updated, renamed, merged or discontinued. Although the professional and industrial origin is obvious the company tries to offer fitting solutions for every customer from large studios to independent artists or simply hobbyists. The various products differ in price, features and focus but the overall line and flagship programs can be described as well rounded (figure 3.3).

3.2.2 Flash

Even before aquired by the digital imaging market leader Adobe, Flash was an extremly successful web solution and eventually became a household name. The system actually consits of serveral parts including a virtual machine (Flash Player) and programming language (ActionScript). But this review only regards the vector animation creation software.

Although not originally intended for hand-drawn animation, it allows frame-by-frame drawing and offers some support for this task. It is however seldom used this way. Since it has strong and feasible features regarding virtual puppet or cut-out animation, it is mostly employed to create limited animation — especially in the field of television series as described in section 4.5. It can be fluenty adjusted to the intentions of the animator from simplistic cut-out to quality full-animation, but its distincive clean vector style and support for limited animation can be both a blessing and a curse [5, 11] [8] [9].

Another advantage of Flash is the strong interoperability with other prouducts of Adobes 'Creative Suit' line, which often makes up for specific limitations of the software itself (see: figure 3.3).

3.2.3 TVPaint Animation

Formerly called Bauhaus Software Mirage, TVPaint animation has some history of convincing and inspiring traditional animators [18, chapter 14].

[6] www.toonboom.com

[7] http://en.wikipedia.org/wiki/Toon_Boom

[8] http://www.awn.com/articles/technology/flash-animation-production-flash-growing

[9] http://www.awn.com/articles/aniscene/animated-scene-paperless-animation-production-myth-or-reality

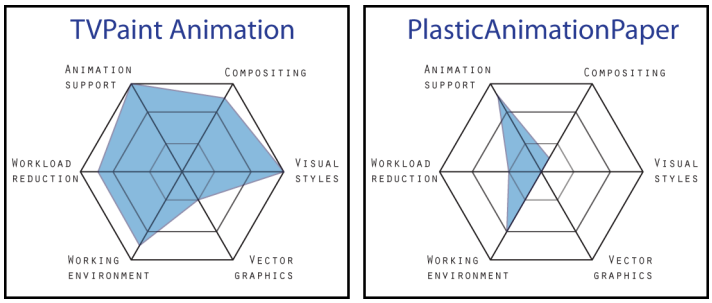

Figure 3.4: Hand-drawn oriented software solutions: TVPaint Animation and PlasticAnimationPaper

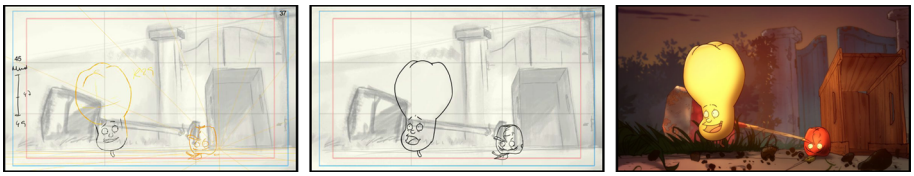

Figure 3.5: The Apple and the Worm ©Copenhagen Bombay http://www.tvpaint.com/v2/content/article/community/gallery.php

Apart from its overflowing feature list of inventive and handy tools, this is mostly due to the focus on hand-drawn full animation. Of all software products it has most likely the most mature and sophisticated animation support and the greatest potentials for creating alternative visual styles and artistic appeal [15]. The list of realized projects — of which figures 2.5 and 2.6 in section 2.5 display two examples — illustrates TVPaints status as a versatile tool for quality animation. It incorporates techniques from every step of the production pipeline and thus allows creating whole animation films from a singular workspace. It even implements its own scripting language ("George"), allowing some automation in the process. Splines are implementes, but they are obviously not meant to be the main means of image creation, as figure 3.4 visualizes.

It is being employed in every field from education to feature film productions such as "The Apple and the Worm" (figure 3.5) by the danish studio Copenhagen Bombay [10]. The company of director Anders Morgenthaler and producer Sarita Christensen uses a wide variety of media from life-action to cut-out and produced "The Apple and the Worm" paperlessly in full animation with TVPaint.

[10] www.copenhagenbombay.com

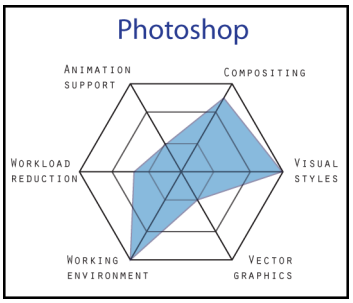

Figure 3.6: Image editing software: Photoshop

3.2.4 PlasticAnimationPaper

Another pixel based and hand-drawn focused competitor is PlasticAnimationPaper which is being developed and distributed by the Danish animation studio Krogh Mortensen Animation, which ironically mostly does 3-D animation [11]. The software was originally intended as an inhouse tool, but became popular as a streamlined hand-drawn full animation solution.

Frame-by-frame line-drawings are the main focus of the software — and its only feasible application. Ink&Paint, splines or compositing features are practically not provided. The features supporting the animator are well designed (although not as good as in TVPaint), and the streamlined and hightly customizable interface allowes very productive full-animation work (see figure 3.4). It is obviously meant as a pure animation tool which turns out to be a problem, since the interoperabiliy — required to pass the animation on to the next production step — is also rather limited.

3.2.5 Photoshop

Just as Flash, Photoshops popularity and wide distribution has made it a household name. Although not intended for motion pictures, it is sometimes used for paperless animation. Apart from the availability and interoperability with other Adobe products that are more suited for video editing, the almost unlimited stylistic freedom in image creation are its main advantage. From paintings to photo manipulations Photoshop facilitates every possible field of employment.

The short film “The Cat Piano” (see section 4.1) was realized combining Flash and Photoshop. When examining the features, Photoshop seems so complement nicely not only with Flash, but also the other products of the ’Creative Suit’ line which makes it feasible for almost anything.

On the other hand they lack specific requirements for animation and are

[11] http://www.animation.dk

not nearly as supportive as specialized tools [12]. Thus it must rely on plug-ins when not used for rather simple or limited animation. However it holds the keys to automate and reduce a great deal of work while offering the greatest freedom of visual styles.

[12] http://livedocs.adobe.com/en_US/Photoshop/10.0/WSB7275DCE-9985-4abb-A939-3B131937F386.html

Chapter 4

State of affairs in 2-D animation and paperless animators

Apart from the theoretical possibilies and provided applications, only a closer look at the real-world requirements and situations can give information about the factual potentials of paperless animation. The animation industry surely has several prerequisites that new technologies must meet before a greater spread can be archieved. These are not purely economical topics but desires shared by the animators themselves. Although reality often looks less rosy, and animators have to follow the goals of their employers. And more often than not artists wether independent or in big studios are forced to use modern technology — simply because everyone else does [12]. Still, the following discussed topics will focus on the common ground of animation professionals worldwide.

4.1 Creativity and quality

It is commonly said that the better brush does not make the better artist. Although the new tools can well be employed creatively, they mostly aim at accelerating the production rather than improving it (see chapter 2). Still the support of simplifying the procedures keep quality from declining (compared to earlier limited animation series), since it also accelerated the process of improving quality: *"'On a paper, minor tweaks and adjustments that would improve a composition mean big investments of time, that frankly, storyboard artists on a TV schedule don't have. So they don't get done. Digitally, they only take a few seconds"'* (Dave Thomas [1]). Without these supportives, 2-D animation has been a very individual effort to improve one's animation

[1] http://ownerofwendys.blogspot.com/2007/01/paperless-animation.html

quality — with uncertain results [16] [2]. On the other hand these techniques might make it to easy, neglecting the educative character of traditional 2-D animation for the animator [10, 12]. And oftentimes producers, consumers and animators do not share the same quality standards [5,10]. Furthermore some of the presented techniques and appliances can have a strong influence on the style that will coin the creative character of animation — or even worse: be purposely restricted to this style to cheapen production.

Apart from the quality of the animation itself, the power of artistic expression through the medium has shifted. Even though advertising companies sometimes leave much of the conceptual work to the studio (and probably would benefit greatly from memorable creative styles), the schedule and budget are so tightly calculated that the artistic freedom of the animator is rather limited — just as in big productions. Thus artistic expression in animation is mostly reduced to independent short films who live on their artistic appeal and novelty and have little screentime for re-usage of material. Thus 2-D full animation is best suited for these small ventures, since the lead time and pre-production expenses are much lower than in 3-D animation [16], and paperless techniques and appliances are well suited for small teams with limited budget. One example for such a creative enterprise is the 2009 short film "'The Cat Piano"' (figure 4.1) by Eddie White and Ari Gibson was realized with a mixture of Flash, Photoshop and the 3-D software Maya — although the creators admit that this was a rather unsusual usage. Up to 5 animators worked on the project which recieved funding from the Adelaide Film Festival Fund. The combination of quality 2-D full animation, a distinctive style and mature storytelling techniques aired at several festivals and won a multitude of awards [3] [4].

It however mostly mimics the aesthetics of traditional animation employing digital techniques. Developing truly new visual styles is not yet widely enough culturally accepted, and even independent productions musst meet the demands of their clientele or patronage. Individualists, students and hobbyists, who are much less pressured are more progressive in these matters and have quickly combined the new possibilities, aesthetics and culture of the digital media as figures 2.5, 2.6 and 2.7 in section 2.5 display.

4.2 Productivity

As mentioned, most of the paperless animation techniques favor speed and ease of use over stylistic freedom and support. Even though it is often argued that this leads to a decline in the quality of the art (since quality is seldom

[2] The Animation Podcast, Show 6, Nik Ranieri, 22:54; http://animationpodcast.com/nik-ranieri-part-three

[3] http://catpianofilm.blogspot.com

[4] catpianofilm.com

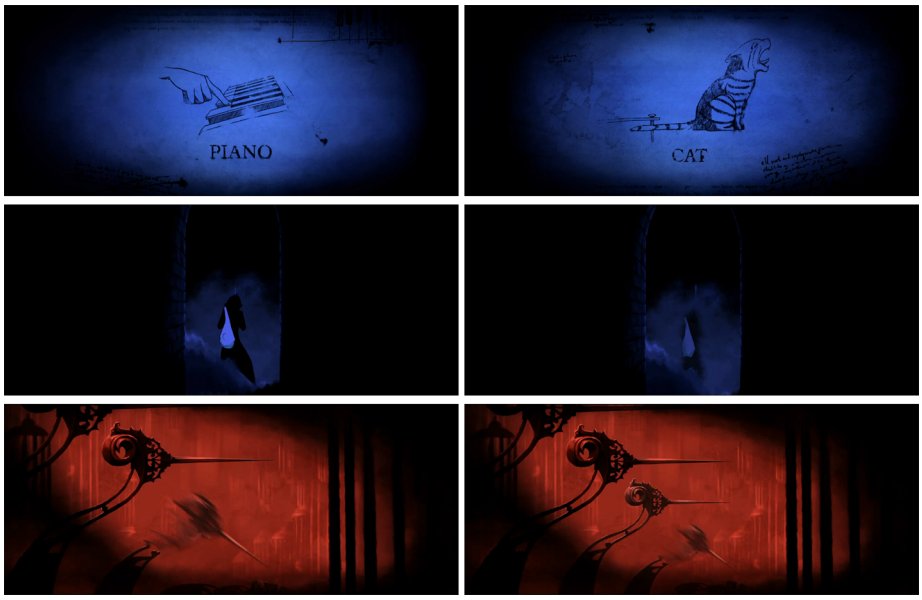

Figure 4.1: "The Cat Piano" ©2007 The People's Republic of Animation http://catpianofilm.com

encouraged in the production envionment) the increase in productivity is seldom denied [5, 11]. This is especially critical in the production of series, since the long life-span, a fixed cast and reocurring topics are predestined for limited animation. Also the short duration of an episode makes the limitations (both visual an in the story) more bearable than in long feature films. This is the main reason why recently more and more cartoon series are produced digitally — mostly employing Flash. How big the actual benefit of the accelerated process accounts is not undisputed (see section 4.5 and [3, 4.2.2]), but the increased use of paperless technologies in the production show that it is obviously profitable and preferred by many producers and directors [5] [6].

4.3 Enjoyability

When transfering from one medium to another — as with paper and computer — scepticism is natural. Many consider paper to be more comforable, even though paper based animation is not necessarely convenient itself [16]. Working with computers in general is naturally less intuitive than traditional media — their usage requires a lot of calibration, buttons, hotkeys and functions that first have to be learned and internalized. Thus the transition might be a generational problem and dissolve with the next generation of animators

[5] http://ownerofwendys.blogspot.com/2007/01/paperless-animation.html
[6] http://www.awn.com/articles/technology/flash-animation-production-flash-growing

that grew up with computers. But even among the accustomed traditional animators many converted and embraced the new media once they got accustomed to it. After all, the advantages of using a digital medium can be a source of enjoyment in itself [3] [18, p.412] [12].

This however stands in competition to the "'other digital animation"' of computer-generated 3-D imagery. When most of the animation industry converted to 3-D animation, many artists were left unsatisfied by their alternatives: the puppet-like 3-D animation without drawing or drawing without animating as an illustrator. Especially to those drawing-fancy cartoonists that had trouble adapting to 3-D, paperless 2-D animation might be the better alternative, even though the computer might not be able to replace their drawing desk adequately. Others of course have embraced 3-D animation and might not consider returning to 2-D.

What worries most animators more about computers than their ergonomics and enjoyability is the accelerating and condensing effect they have on production procedures. Having to produce animation faster with ever tighter budgets and schedules makes the work startlingly stressfull and inartistic. The possibility to employ the fancied drawing skills (even in the more limited and puppet-like productions) are vain when there simply is no time left to do so properly [11]. Naming the time-saving aptitudes of paperless animation as a solution would be sarcastic, since they are just as well the source of the problem itself.

4.4 Recognition

Not only since computergenerated imagery came around, animators have struggeled to gain recognition as artists — both professionally and publically. But the new production methods derange the picture of "'the animator"' even further. Recently the valuing of 2-D animators is on the rise again after seeing a lot of dismiss due to the more popular 3-D animation [10]. This might on the one hand be caused by a return to traditions, the wane of the 3-D hype or the introduction of new production procedures — since strangely people tend to get more credit when operating complex and expansive machines rather than mundane pen and paper. On the other hand the latter cause might be a trap, when the compexity of operations bind the animator to a single specific medium or software package and thus reduces his prospects and alternatives and recognition as a full-fledged artist. After most of the underpaid and unrecognized positions in the production pipeline have already been canceled out, the integration of production procedures might lead to new fields of activity as competences merge. However this will only be true for independent productions, not for mainstream media creation that simply strives to find "'a cheaper kind of paper"' in computers [10, 16].

Even more than general acceptance and appreciation, the tiers of fine art

are difficult to penetrate for the art form of animation in general — although it has been tried repeatedly [4, chapter 12]. An pedagogic, elucidating approach proved more successful to both justifying an art form and imparting knowledge about its inner workings. This however was strongly buit on production artefacts like celluloid sheets — which had therefore been artificially rarefied [4, chapter 12]. But even without tangible relics the public appreciation of the fine art of animation might grow out of the knowlegde of how it was created. It had been that way with the earliest experimental animations [4, p.98-102], and might be true again whenever employing new media. Others migth argue that 2-D animation mostly benefits from the mysticism that Disney created around cartoons, and should best not be interfered with. However this public admiration was built on large-scale well funded feature films, and it is doubtful if there will be many more produced if the public interest in 2-D animation doesn't rise.

The single animator might be left cold by the problem, since seldom any of the public recognition get's through to him. Since it was believed that the cult around a single person or brand name would be more apt to the public expectations, the majority of those creating motion pictures are concealed from the public perception. And it could even worsen when modern technologies are employed in the production. Since working digitally is less a tangible task to the common viewer, the loss of wonderment can turn "'it was done with a computer"' into "'a computer did that"'. Thus, personally receiving any public recognition is mostly reduced to those independent animators that show their work at festivals [5, 12, 14].

4.5 Prospects, fields of employment and labor market

In the wake of the 3-D animation buzz many traditional animators were appalled to suddenly find their job positions at risk [11, 16]. Understood that computer technology might not have a good reputation when it comes to securing employment, paperless 2-D animation must still be regarded seperately.

As already mentioned, many of the paperless techniques center around saving time and cutting cost — sometimes so much that they cut out all the work. Many studios have ceased to employ traditional animator/assistant teams. Utilising computer technology the animator is expected to produce final quality animation directly. The animators on their part are often displeased by this practice which gives them less support and more responsibility at the same time [5, 11]. This is also problematic since it reduces the educational possibilities in a production team while less and less public institutions offer courses for 2-D hand drawn animation. Paperless technologies with their intuitive approach, advanced support and less relying on drawing

skills can aid the eduction, but they cannot counterbalance this cultural decline. Combined, this might lead to a lack of skilled 2-D animators. While many young artists can't find training and are drawn to the more modern 3-D animation world, many accustomed artists retire from animation.

But many fields of animation production like the short-lived television area will most likely continue to rely on 2-D animation, since it is more suited for some applications. With high production value per screen second, few possibilities of re-use and the importance of having an inventive and catchy look, advertising is often named as one of these save areas and especially suited for the new stylistic possibilies of paperless animation as described in section 2.5. Strangely the agencies are often devoid of any artistical or quality demands as long as the message is conducted [10]. But also cartoon series — a field of production which long suffered from outsourcing to low-wage countries — seems promising again as more and more produtions are being returned. As producer Vincent Aniceto puts it: *"Perhaps the biggest misconception about Flash I hear is that it saves money. We spend as much on [Fosters Home For Imaginary Friends] as we do on other shows at the network. The difference is that we spend all the money over here, instead of splitting it between the studio and an overseas animation house."* [7]. This might be due to paperless technologies making animation more of a high-tech field of employment or due to the better possibilites for "glocalized" studios in the digital production world [4, chapter 7]. One way or another: 2-D animation currently seems to be a growing market again.

Another area that has just been revived is the 2-D gaming industry. Since 3-D real-time graphics became widely available and because 2-D animation could not so well adapt to the variable frame rate of games, most of the video game industy transitioned to purely 3-D during the 1990s. But recently several independent productions have proven the public interest in hand drawn 2-D imagery. Daedalic Entertainment's point-and-click adventure game "'The Whispered World"' (2009) is such a successful enterprise. The production employed a mixed system of paper animation and digital imaging, requireing several steps of printing and scanning [8] — an additional expense that animating paperlessly could supersede. And even when not interactivly employed, many games like Mirrors Edge (Digital Illusions - 2008)[9] repeatedly rely on the 2-D animation for intro sequences and cut scenes. As another platform for interactive entertainment Flash has become extremely popular in recent years. The strength of Flash is the unity of production and distribution software allowing fixed frame rates, platform independance and both great availability and approachability via the web. But even Flash incorporates more and more 3-D features and might be superseded in the long

[7] http://www.awn.com/articles/technology/flash-animation-production-flash-growing

[8] http://www.makinggames.de/index.php/magazin/428_2d-animationen_in_the_whispered_world

[9] www.mirrorsedge.com

Figure 4.2: "How to Hook Up Your Home Theater" ©2007 Walt Disney Pictures

term by alternative web standards. Still this all shows the great prospects and acceptance of 2-D animation in interactive entertainment and web services.

4.6 Progress

Traditional 2-D animation was an always evolving and changing process and culture. Wether paperless techologies are to be considered another step in the ladder or a different medium, it is unreasonable to think that the development has come to an halt with it and that current difficulties and limitations are permanent. Both aesthetical and technological developments are always possible, but require ventures that support their progress.

A source of innovation can again be the production of short films, since they are less pressured to be profitable right away. The 2007 Goofy short "'How to hook up your home theater"' stands as an excellent example for this (see section 3.2.1 and figure 4.2). It is the revival of a series of pseudo-educational "'How to"' short films which were popular in the 1950s. The first episode, "'How To Ride a Horse"' (1950) *"'led to the development of new techniques in the use of held drawings, limited animation and limited life"'* [14, p.512f]. With the latest installment being produced paperlessly the spirit of progress and develpment without decline in quality lives on. Although it was stylisitcally designed to revive the 50s look, it was produced to test the feasibility of modern digital animation techniques in full animation for possible later installments. Eventually the following feature film was not animated paperlessly — which illustrates the importance of not relying on a positive result right away when questing[10] [11].

[10] http://www.awn.com/articles/production/how-hook-your-animated-short-disney
[11] http://en.wikipedia.org/wiki/How_to_Hook_Up_Your_Home_Theater

Chapter 5

Conclusion

As the historical background suggests, 2-D animation is innate to embrace and incorporate new technologies quickly and thoroughly — sometimes regardless of the consequences. Thus it is just the more surprising that paperless technology which promises so many new possibilies — both economically and artistically — has been ignored so long. Possibly it just became feasible at the wrong time — when the future of 2-D animation was ambiguous and 3-D being considered more modern and popular. For said reason, there still is few literature discussing paperless 2-D animation. Therefore in the research for this thesis I relied on interviewing animators (see: [5, 10–13, 16] which helped me gain insight to the inner workings and state of affairs in the animation industry. All of which concurred that 2-D animation will surely not go extinct — as was propagated so many times — although the glorious days will never return. On the other hand: this was not the first time that cartoon animation was in the doldrums and the glourious days are deemed bygone since the 60s. Great expectations towards paperless 2-D animation might still be undue, since it never was a technological development that caused nor solved the slump [19, p.318]. It was always a question of great productions and their acceptance in the population — among which many wouldn't even notice technological leaps. A starting signal that jump-starts a great comeback like a high-quality 2-D animation feature film would be helpful, but not imperative. More generally the technologial side of production tends to get overrated. which also concerns more and more 3-D productions [16]. The perception of technical quality of most viewers can easily be deceived [13]. The warning of putting to much faith in technology isn't new, but with the new media invading more and more areas of the daily life it is more relevant than ever before. Vice versa fostering aversions and prejudices is insentient and counterproductive, in spite of any abuse. Like any tool they should be examined unbiased and objective while concentrating on the essentials.

In this spirit: thank you.

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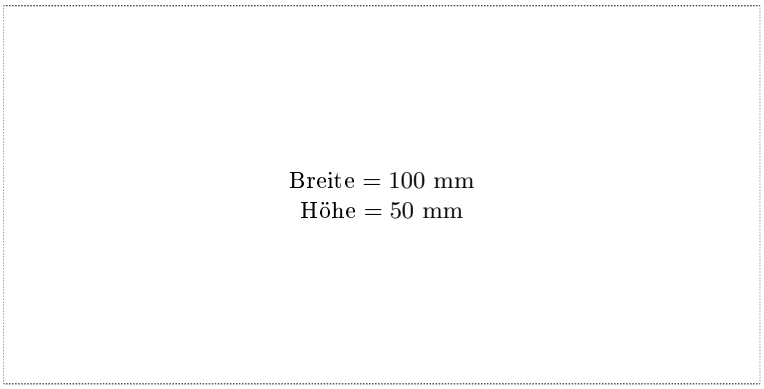

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