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TECHNOLOGIES OF 2D ANIMATION
ТЕХНОЛОГІЇ 2D АНІМАЦІЇ

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Annotation. *Animation (literally means "to bring to life") is an art form that consists in the sequential change of drawn frames. Nowadays, animation is a rather popular technology and has a great importance in human life.*

Keywords*: 2D, Adobe Animation, artificial intelligence, frames per second, animation, animation principles, software.*

Introduction.

In our constantly evolving world, animation remains an enduring and beloved form of art for people of all ages. From classic Disney animations to innovative high-quality 3D animations, it captivates audiences. 2D animation technologies are not limited to the film industry; they are also applied in various domains such as video games, website creation, advertisements, presentations, and more. Their straightforward technology makes conveying information quite effortless.

Research Objectives:

- To get acquainted with the general history of animation
- Learn to understand the basics of 2D animation and the stages of its creation
- Learn the basic concepts and principles of animation.
- Consider software programs and their content.
- Analyze current trends and innovations in 2D animation.

Background. The origins of this significant art form can be traced back to the Paleolithic era. During that time, people created vessels adorned with animal drawings, and when these vessels were rotated, they produced an imitation of moving images. A vivid example is a cup discovered in southeastern Iran, dating back 5000 years. On this ancient vessel, a goat is depicted leaping to eat leaves from a tree. While this is far from the animations we know today, the underlying technology remains remarkably similar.

Our ancestors also created animations on rocks. Despite the chaotic and abstract nature of these drawings, they conveyed information that aided historians and

archaeologists in understanding that era. For instance, the Great Hall of Bulls in France features an "animated" depiction of a hunt.

Another crucial invention dates back to 1603: the "Magic Lantern". The Magic Lantern was a projector that displayed images painted on glass. Some parts of these images were movable, making it an early example of frame-by-frame animation.

In 1831, the "Phenakistoscope" was invented. This device consisted of a cardboard disk with slits. Figures were drawn on the disk, and when it was spun, motion was created. Joseph Plateau, the inventor, described it as the "principle of modern cinema or, more accurately, the law on which film recording or projection is based." The Phenakistoscope served as the foundation for many subsequent inventions. Following a similar technology, the "Zoetrope" was created in 1834.

A zoetrope is a drum-like device with strips of images attached to its inner walls. When the drum spins rapidly, it creates a sequential motion of the images. Unlike the phenakistoscope, the zoetrope can accommodate a greater number of images, making it a technological advancement in animation.

Even more closely aligned with modern animation technology is the "flip book", dating back to 1868. A flip book consists of pages with drawn images, and when a person rapidly flips through the pages, the animation comes to life. Flip books were popular among both children and adults.

In the early 20th century, the animation industry experienced rapid growth. Projects like "Mighty Mouse," "Betty Boop," "Felix the Cat," and "Mickey Mouse" emerged. One of the most significant endeavors was by the renowned company Disney, founded by Roy and Walt Disney. As mentioned earlier, Walt Disney created "Mickey Mouse" and later "Snow White", which were among the first hand-drawn animations. The technology for creating such cartoons was straightforward: different parts of the animation, such as backgrounds and characters, were drawn on separate sheets of paper. These sheets were layered and carefully framed to produce complete animated films

In 1980, the concept of CGI (computer-generated imagery) emerged, revolutionizing the animation industry. The fundamental difference between CGI animation and traditional animation lies in the replacement of hand-drawn art with 3D modeling, akin to a virtual version of stop-motion. An animation form that combines both approaches, utilizing two-dimensional computer graphics, can be considered computer animation [1].

The basics of 2D animation. From the inception of 2D animation technology, animators have strived to enhance techniques for connecting frames seamlessly, replicating natural movement, and achieving object fluidity. Over time, they systematized their experiences and developed several specialized techniques that remain fundamental principles in animation today.

Squash and Stretch. When a rigid shape transitions from one position to another, noticeable stiffness occurs. While this phenomenon is common with solid objects like dishes or furniture, less rigid bodies exhibit significant movement during transitions. To convey flexibility, animators employ compression and stretching. Crucially, maintaining the object's volume remains essential. For example, if a ball compresses vertically during motion, it expands horizontally, and vice versa (fig.1).

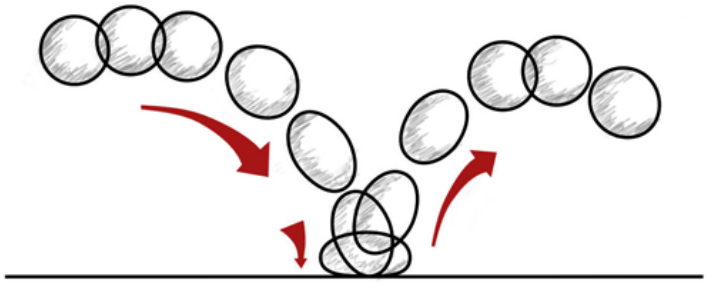

Fig. 1. Ball compression during motion

Anticipation. When viewers watch animation, they need events on the screen to occur in a clear and logical sequence. The subsequent action should be understandable even before it happens. This can be something as subtle as a character's eye movement in the direction they will take their next step, or something more significant like a fully executed physical motion: a hand swing before a throw, a low crouch before starting to run, and so on.

In contrast to this principle is the "element of surprise", which works only when the audience is not forewarned about upcoming events on the stage.

Staging. Each animation element communicates with the viewer to some extent, so it must be entirely comprehensible, leaving no room for misinterpretation. The character's intentions should be discernible from their actions, and the character's personality should influence their behavior. Emotions and experiences should evoke empathy in the audience. Every frame should contribute to the viewer's understanding of the story. Achieving this involves considering the overall scene atmosphere, lighting, play of light and shadow, camera angles, character movements, distance between the camera and characters, color palette, contrast, and more.

Straight Ahead Action and Pose to Pose are the two primary approaches to animation (fig. 2):

Straight Ahead Action: In this method, the animator creates a scene gradually, starting from the first frame and then drawing subsequent frames one after another. While the animator knows the plot and events that should occur in the scene, they can introduce new ideas during the animation process until the scene is complete. However, this approach can sometimes result in a slightly comical appearance because maintaining proportions and character positions becomes challenging.

Pose to Pose: This technique involves identifying key frames in the scene and creating them upfront. The in-between frames are filled in later. Pose to Pose provides greater control and clarity of movement. Often, a combination of both methods is used. For instance, when animating a character with long hair, their overall movement might follow the Pose to Pose approach, while the hair movement is animated using Straight Ahead Action.

Through and Overlapping Action. To avoid rigid and abrupt character motion stops and achieve naturalness, animators needed to better convey the physical laws of movement, including inertia. The movement of lighter body parts (such as limbs and hair) and relatively separate elements (like clothing) follows their own rules, independent of the body's main motion. After the character stops, some parts may

continue their movement for a few frames (fig. 3). Gradual movement also means that different parts of the character's body initiate motion not simultaneously but with slight delays or lags [6].

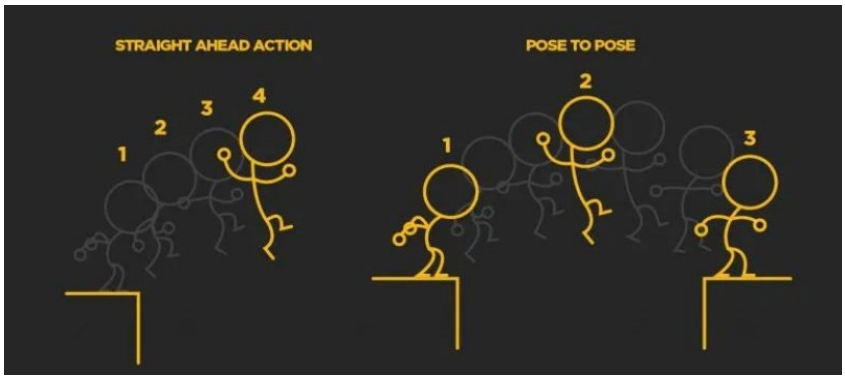

Fig. 2. Straight Ahead Action and Pose to Pose animations

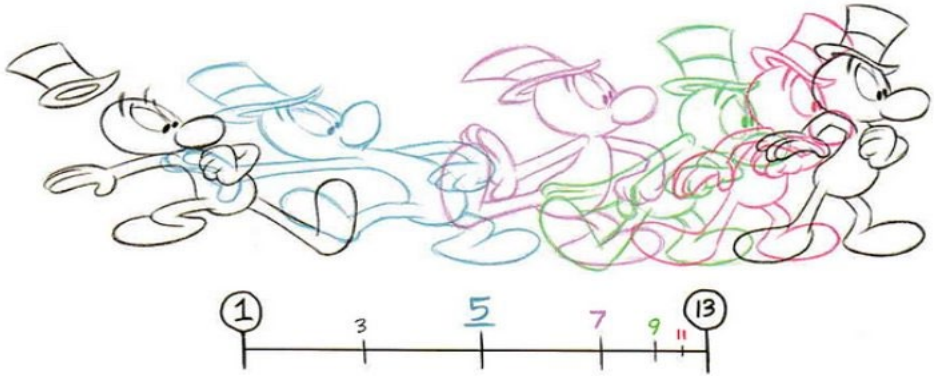

Fig. 3. An example of the effect of inertia when the character stops

Slow In and Slow Out: Undoubtedly, keyframes are more critical for perception than in-between frames. However, if the time allocated for displaying each frame were equal, viewers might miss the best elements of the scene. To prevent this, in-between frames are concentrated closer to the keyframes, leaving one frame in the middle. This approach achieves a lively result. Thus, the entrance and exit to keyframes occur gradually, giving rise to the name (fig. 4).

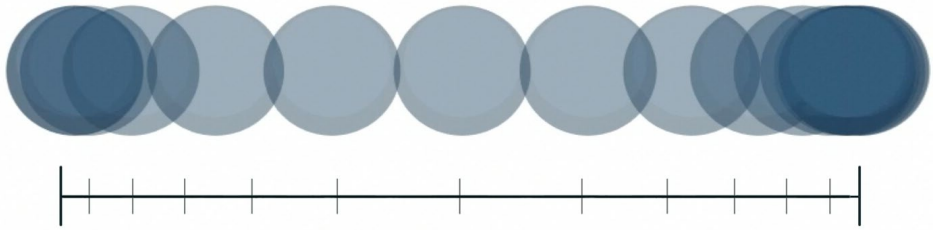

Fig. 4. Placing frames on the timeline with Slow In and Slow Out

Arcs: Most living creatures do not move strictly in straight lines; their movements follow slightly curved paths. This movement along an arc is one of the factors distinguishing living organisms from machines. Therefore, utilizing this principle is essential for achieving smooth and natural motion.

Secondary Actions: Any action that emphasizes the primary action is considered secondary. It should not distract the viewer's attention or be more interesting than the main action. For example, if a character is curious about something, they might put on glasses to underscore their interest. When applied correctly, secondary actions enrich the scene and add depth to the character (fig. 5).

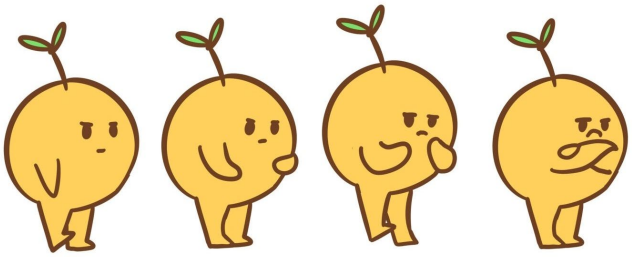

Fig. 5. An example of using secondary actions

Timing and motion. The standard frame rate is 24 frames per second. The number of frames spent on a particular movement will determine the amount of time it takes to perform it. Sometimes you don't need to create a new pattern for each frame, you can use it twice. This will make the movement look slower and smoother.

Exaggeration. For animation, excessive realism can be boring and unexpressive. Exaggerating emotions, facial features, or body structure makes it easier for the viewer to understand a character's character or role in the story.

Solid drawing. An animator needs to know the basics of drawing, because they often need to depict an object of a complex shape from all possible angles, in any position. The animator must know how objects behave in three-dimensional space and be able to reflect this in 2D, while maintaining the balance of the drawing, proportions, lighting, etc.

Appeal. Attractive things and design attract the human eye. You want to look at a good image for a long time and evaluate it. Not all animated characters have to be liked by the viewer, but they need to be interesting, even the villains and villains need to have their own charisma to make their actions interesting to watch [2].

The process of creating 2D animation

1. The pre-production stage:

✓ *Script*: development of a script for the project. A script is a text document that describes what should happen on the screen: each scene and character dialogues are described in detail with remarks.

✓ *Storyboard*: a series of drawings that show how each scene of the animation will look like. It allows animators to define how characters will move, how the camera will follow the action, and how different shots will look.

✓ *Conceptualization:* defining and approving the general idea of the animation.

2. The production stage:

✓ *Character design*: creation of detailed character designs that should depict their appearance, facial expressions, and some movements.

✓ *Background design*: development of the background.

✓ *Layout:* planning the arrangement of characters and backgrounds in each scene.

✓ *Animation*: creation of the actual animation.

✓ *Clean-up:* improving the created animation, ensuring consistency and smoothness.

✓ *Color:* adding color to characters and backgrounds.

✓ *Compositing*: combining all the elements that have been created (characters, backgrounds, effects) into the final scene.

3. The post-production stage [3]:

✓ *Editing*: arranging scenes in the right order and adjusting the timing.

✓ *Sound design*: adding sound effects, music and dialogues.

✓ *Rendering*: creating the final frames of the animation.

✓ *Quality control*: checking the animation for errors or inconsistencies.

✓ *Presentation*: providing the finished animation to the audience.

Software for 2D animation. Creating 2D animations in the digital realm requires suitable software and hardware to realize and display graphical elements. Several software solutions are available, ranging from free to conditionally free or requiring monthly or annual subscriptions. Each application has its advantages and drawbacks, but the primary goal of all is to provide users with tools to bring their creative ideas to life.

While each program offers different features, let's focus on a more detailed analysis of Adobe Animate. Considering its compatibility with other Adobe products, this application provides a broader range of capabilities [5].

As with any content playback application, we begin by creating a scene where we'll work and edit the graphics. After creating a scene with certain parameters (width, height, resolution, FPS (Frame per second), and platform type), we have access to a workspace that can be customized, but we'll consider the default settings (fig.6).

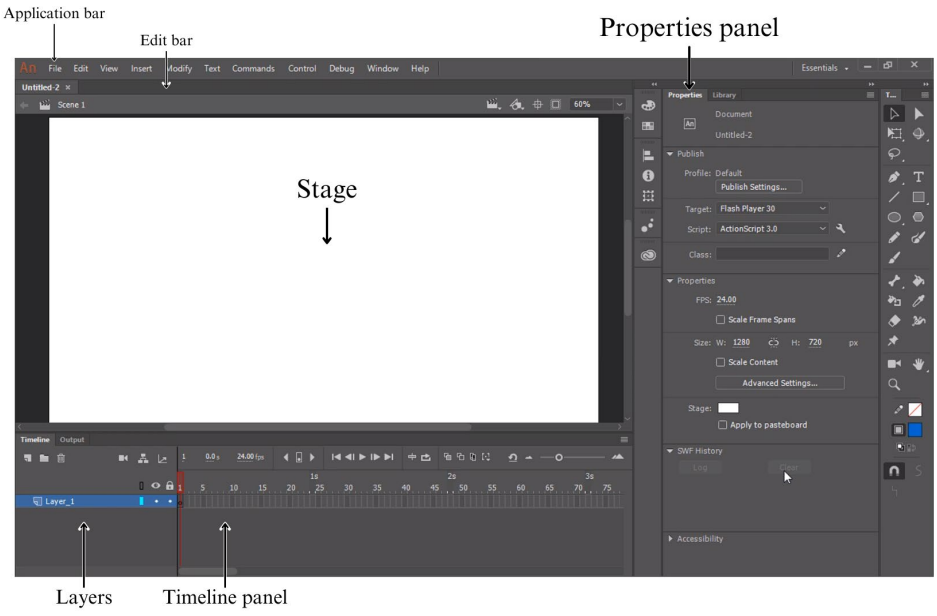

Fig. 6 Adobe Animate workspace

When working with a canvas for creating graphical elements, we can begin by utilizing layers and the timeline panel (fig.6). By adding geometric primitives using

built-in tools or importing raster images onto the scene, we can organize them into different layers and initiate the animation process.

The entire animation process revolves around creating frames, which change from one to another with each subsequent second, ultimately forming a sequence. The smoothness of the animation directly depends on the set frames per second (FPS). Keyframes play a crucial role in animation. In between these keyframes, gaps are filled using various animation methods, as described below.

Working with colors and other settings within the application is much simpler thanks to the built-in tools. One significant difference between traditional paper-based animation and computer-based animation lies in the ease of making corrections in the final project. Instead of redoing the entire work, adjustments can be made with a few mouse clicks if the end result doesn't meet the publisher's requirements [4].

Adobe Animate offers extensive functionality for creating and editing animations. However, it may not suit everyone due to its payment requirements or other issues. As alternatives, there are free solutions such as Synfig Studio, Wick Editor, TupiTube, and Pencil2D. Additionally, several paid options like Animation Desk, Procreate Dreams, and Expressive Animator cater to different needs. Depending on individual preferences and requirements, users can choose the program that best suits their animation goals [5].

Current Trends and Issues in 2D Animation. With the advent of modern computer technologies and advancements in existing animation techniques, new opportunities arise for animators transitioning to digital workstations. To comfortably use animation software and render geometric primitives or complex graphical objects, appropriate hardware is essential. Graphic tablets have become indispensable tools for professional animators. Additionally, modern computers with enhanced capabilities are necessary for working with detailed objects and rendering final animations.

Annual software updates introduce new features and enhance existing ones. These updates include working with built-in artificial intelligence (AI) within applications, integrating third-party modules, optimizing functionality, and ensuring continuous application performance. As hardware and software continue to progress rapidly, the time required to complete tasks is significantly reduced.

The utilization of trained AI has tremendous potential in graphic design and animation. It allows for the implementation of various processes with just a few mouse clicks. However, while graphic AI shows promise, it does not yet meet the standards of animation studios. Due to their novelty, these applications are typically used for experimentation rather than professional business purposes.

Despite the advancements in hardware and software, the animation process remains intricate and time-consuming, especially when dealing with complex frames. As a result, the industry faces financial challenges and a shortage of skilled professionals. The diverse nature of animation processes further complicates the situation. However, the industry holds significant promise due to ongoing improvements. The Rise of 3D animation has led some studios to shift away from 2D animation, which also contributes to the evolving landscape.

Conclusion.

2D animation has come a long way – from early animations on pottery and cave walls to Walt Disney's frame-by-frame animation and today's computerized techniques using various software. Over time, it has continuously transformed and refined itself, establishing fundamental principles that still guide animators today. The animation process involves several stages: concept development, scripting, storyboarding, actual animation, and revision. For more automated and efficient 2D animation, tools like Adobe Animate are valuable. Additionally, the integration of artificial intelligence holds great potential for the industry, provided it receives adequate funding and attracts new talent.

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