

# A Study on the Dimensional Evolution of Computer Animation

Anamika V. Bhagat

*Assistant professor, Department of Computer Science, Dr S. G. Gulhane Prerna College of Commerce, Science and Arts, Nagpur*

## ABSTRACT

Computer animation has experienced a significant change, evolving from simple two-dimensional drawings to complicated, immersive, and interactive experiences. The basic aspects of computer animation 2D, 3D, and 4D are examined in this research study with an emphasis on its traits, methods, resources, and uses. The study emphasizes how each dimension shapes contemporary simulation, visualization, education, and entertainment technologies by introducing a fresh level of realism and interaction.

**Keywords:** Introduction, 2 dimension, 3 dimension, 4 dimension, structural design.

## 1. INTRODUCTION

The method of creating moving visuals with computer graphics is known as computer animation. It creates realistic motion and narrative by fusing creativity and computation. Animation has developed through several distinct stages over time, each of which adds more depth, intricacy, and user interaction. Gaining knowledge of these three dimensions 2D, 3D, and 4D allows one to better understand how this profession has developed creatively and technologically.

Motivated by the advancement of digital technology, the computer performs the two-dimensional animation design's introduction of digital technology. Two-dimensional animation processing, such as character modeling, scene sketching, coloring, post-special effects, etc., to lower business costs and boost businesses' fundamental competitiveness [1]

Modeling and creation of a human drawing using a 3D production application is referred to as 3D animation. A virtual reality first environment is generated on the computer, after which the designer can produce designs and pictures in the three-dimensional virtual reality environment based on the dimensions and form of the

objects shown. Then, the animating track of the modeling, the virtual reality camera's motion orientation, and other the animation technical parameters are set in accordance with the specifications, and finally, specific materials are assigned to the predicting in accordance with the specifications plus lighting. And once everything is finished, the computer may run it automatically to create the finished video. [2]

Experienced 3D animators will probably recognize the graphical user interface. A collection of curves that specify movement in each dimensions or rotation plane is used to produce keyframe animation. Slicing and projection are two of the many visualization techniques available in an interactive viewport. Navigating across virtual 4D space and manipulating 4D objects are both possible using the viewport. [3]

## DIFFERENCE BETWEEN 2D AND 3D ANIMATION

Since its inception, animation has advanced significantly, with 2D and 3D techniques transforming visual communication and narrative. Both 2D and 3D animation have special benefits; 2D is better at artistic expression, while 3D adds depth and realism.

The conventional method of 2D animation

consists of producing a sequence of flat pictures that appear to move. It might be more economical for some applications and is ideal for stylized designs. 3D animation, on the other hand, uses computer-generated graphics to produce realistic settings and multi-dimensional figures. Complex scenes and realistic depictions are best suited for this method. The target audience, project goals, and available resources are some of

the variables that influence the decision between 2D and 3D animation. While 3D animation necessitates technical expertise in modeling and rigging, 2D animation frequently requires good illustration skills. Both formats offer distinctive ways to effectively engage viewers and communicate information, and they have a place in corporate communications, entertainment, and education. [4]

Dimension	Axes	Key Feature	Example Tool	Type of Experience
2D	X, Y	Flat, simple motion	Adobe Animate	Visual only
3D	X, Y, Z	Depth and realism	Blender, Maya	Visual realism
4D	X, Y, Z + Time	Sensory interactivity	Unity, VR systems	Immersive and physical

## 2. LITERATURE REVIEW

### 2023 – Wenming Liu & Xintong Zhang

*Research on the Application of Computer Rendering Technology in Two-Dimensional Animation Design [5]*

DOI: 10.2991/978-94-6463-192-0\_74

Liu & Zhang (2023) analyse the use of computer renderer technology to 2D animation creation, with emphasis on practical application and the use of software such as Adobe's After Effects to construct rendering pipelines and post-effects. In order to create layered composite and effects common in contemporary 2D production, they go over important rendering procedures, workflow optimisations, and useful plugin utilisation.

### 2023 - Jinning Zhang

*Survey of Skinning Method in 3D Character Animation [6]*

DOI: 10.25236/AJCIS.2023.060916

A brief overview of the skinning techniques used in 3D character animation is given by Jinning Zhang (2023) (linear blend skinning, dual quaternion skinning,

physically-based approaches, energy-based and geometric adjustments). The study catalogues advantages/shortcomings (e.g., LBS suffers from joint collapse; geometric/energy-based adjustments address volume loss but at computational expense) and explains popular ways for achieving realistic deformation while balancing performance.

### 2024 - J. Zhu, C. Hu, E. Khezri et al.

*Edge Intelligence-Assisted Animation Design with Large Models: A Survey [7]*

DOI: 10.1186/s13677-024-00601-3

An overview of edge intelligence (EI)-assisted animation design is presented by Zhu, Hu, Khezri, et al. (2024), with a focus on the integration of large models (such as massive neural nets) as on-device/edge computing to enable distributed workflows and interactive, low-latency tools.

### 2024 - Yahya Saiful, Ivan Eliansah, Anang K. Adisusilo, Adita A. Kusumasari

*Developing 2D Animation with a Lateral Thinking Theme Using Facial Motion Capture [8]*

Link:

<https://ejournal.upi.edu/index.php/Edsence/article/view/75582>

Saiful et al. (2024) examine the use of face motion capture to generate 2D animations with a lateral-thinking theme. Their stated data indicate facial mocap can greatly speed up production, eliminate manual in-betweening, and improve communication when coupled with proper retargeting and cleaning techniques. The authors suggest that mocap lowers manual effort and optimises production workflow for 2D character animation.

### 2023 - Shi Yuxin & Chen Chunyan

*Research on the Application of Computer 3D Digital Technology in 2D Animation [9]*

Link:

<https://www.scitepress.org/Papers/2023/122763/122763.pdf>

Shi & Chen (2023) enhance this concept by illustrating how 3D digital technologies (particle systems, 3D modelling, and simulation plug-ins) may be linked into 2D ink-style animation to imitate ink smearing, fluid dynamics, and to impart volumetric signals to otherwise flat art. In their paper, they provide specific examples (such as the use of particle plug-ins and TFD-style fluid simulation) and make the case that digitisation lowers costs, speeds up transfers, and enhances quality by allowing for non-destructive editing.

## 3. STRUCTURAL DESIGN ON 2D, 3D AND 4D

### Workflow for 2D Animation

Storyboarding is the first step in the 2D animation process, which is used to lay out scenarios and character actions. At Educational Voice, we begin with character design and concept creation.

Steps in pre-production:

- i. Timing and script development
- ii. Style guides and character design
- iii. Making a storyboard
- iv. Setting up an asset library

Digital puppets or frame-by-frame animation are used throughout production. To achieve smooth animation, we typically use Adobe Animate or Toon Boom Harmony. Every frame requires precise timing and distance. 2D rendering is quite easy. After completing a scene, you export it with the appropriate settings as a video file. Because of this, 2D animation can be produced more quickly than most 3D projects.

### Workflow for 3D Animation

Modeling, texturing, lighting, animating, as well as rendering are additional phases in 3D animation. To do it all, you'll need a strong computer and additional technical expertise.

Essential Production Phases:

- i. Modeling: Create digital 3D objects and characters
- ii. Texturing: Include materials and surface details
- iii. Lighting: Install lifelike lighting.
- iv. Animation: Time and move anything
- v. Rendering: Produce finished pictures

Each step requires a separate set of abilities and tools, such as Cinema 4D, Blender, or Maya. Particularly during rendering, the 3D animation process consumes a significant amount of computer resources. "Knowing the technological pipeline is crucial if you want your 3D images to satisfy customer expectations," explains Michelle Connolly, president of Educational Voice.

### Workflow for 4D dimension

Sensory contact over time (motion, vibration, air, light, temperature, aroma, or touch feedback) is the fourth dimension that a 4D computer animation system adds to

standard 3D animation. Therefore, 3D visual animation plus temporal sensory synchronization is 4D animation. Primary goal is to provide realistic, emotionally

compelling, and immersive animated experiences that transcend the screen and incorporate environmental change and bodily sensation. [10]

<b>Layer</b>	<b>Description</b>	<b>Key Components</b>
<b>1. Content Design Layer</b>	Storyboarding and animation design	Scripts, Storyboards, 3D models, Environments, Character rigs
<b>2. Animation Production Layer</b>	Visual animation generation	Blender / Maya / Unreal Engine (3D animation + keyframes)
<b>3. Temporal Synchronization Layer</b>	Adds “time-coded” sensory events linked to animation frames	Timeline-based event scripting system (Unity Timeline / Unreal Sequencer)
<b>4. Sensory Mapping Layer</b>	Maps events to physical output devices	Haptic engines, Air jets, Motion platforms, Scent diffusers, Light/sound systems
<b>5. Control &amp; Communication Layer</b>	Connects software to hardware	Microcontrollers (Arduino, Raspberry Pi), Bluetooth/Wi-Fi relay modules
<b>6. Rendering &amp; Playback Layer</b>	Real-time rendering with synchronized sensory playback	Unity/Unreal playback engine with actuator plugin
<b>7. Feedback &amp; Monitoring Layer</b>	Collects user reactions for adaptive animation	Sensors: HR, GSR, Eye tracker, Microphone feedback
<b>8. Storage &amp; Data Management Layer</b>	Stores animation, events, and user data	Local/Cloud Database, File system, Version control (Git/LFS)



[11]

#### 4. CONCLUSION

In my research, I found that in **2D animation**, hand-drawn images can be connected to the computer and animated, similar to using Paint software.

In **3D animation**, digital characters can be given movement, emotions, and realistic expressions, making them appear alive.

In **4D animation**, moving characters are combined with the element of time and real-world effects to create a more dynamic experience.

After studying 2D, 3D, and 4D animation, I now want to explore how artificial intelligence can be used to invent 5D animation.

This research focuses on the basics from 2D to 4D, and my future goal is to develop a **5D dimension of animation using AI**.

#### 5. REFERENCES

[1] **Yanjun Yang**. *Research on the application status of digital Technology in animation creation [J]*, *Art Education Research*,2013(18):69

[2] **Yan Shun**. *Research on the application of Digital Technology in two-dimensional Animation Design [D]*, *Shandong University*,2010.

[3] **Justin A. Jensen, Robert P. Burton**, *Fourveo: Integration of 4D*

- animation into conventional 3D animation workflows* 21 May 2018
- [4] **Michelle Connolly** *2D and 3D Animation: Comparing Techniques and Visual Impact* November 25, 2024
- [5] **Wenming Liu, Xintong Zhang,** *Research on the Application of Computer Rendering Technology in Two-Dimensional Animation Design,* 4 July 2023.
- [6] **Jinning Zhang,** *Survey of Skinning Method in 3D Character Animation,* 2023
- [7] **J. Zhu, C. Hu, E. Khezri et al. ,** *Edge Intelligence-Assisted Animation Design with Large Models: A Survey,* DOI: 10.1186/s13677-024-00601-3 (2024)
- [8] **Yahya Saiful, Ivan Eliansah, Anang K. Adisusilo, Adita A. Kusumasari ,** *Developing 2D Animation with a Lateral Thinking Theme Using Facial Motion Capture,* <https://ejournal.upi.edu/index.php/Edsence/article/view/75582> (2024)
- [9] **Shi Yuxin & Chen Chunyan,** *Research on the Application of Computer 3D Digital Technology in 2D Animation* <https://www.scitepress.org/Papers/2023/122763/122763.pdf> (2023)
- [10] <https://educationalvoice.co.uk/2d-vs-3d-animation/>
- [11] <https://dezipad.com/2025/06/27/harnessing-2d-and-3d-animation-for-greater-creative-impact/>