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Article

2D animation comic character action generation technology based on biomechanics simulation and artificial intelligence

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Abstract: AI can greatly improve the process of creating 2D character animations, especially for platformer games. The objective is to enhance visual effects quality and streamline production by incorporating biomechanics and AI-driven technology into the animation process. The current state of study shows that conventional 2D animation production has several problems, such as lengthy procedures, complicated technical requirements, and the requirement for human involvement. Both efficiency and innovation are limited by these limitations. To solve this problem, we suggest generating 2D character animations using AI-driven generative methods and biomechanics simulation. Consistently high-quality outcomes can be achieved by automating aspects of animation design. Improving animation industry innovation, streamlining production workflows, and decreasing manual labor are crucial. The viability of 2D animations generated by AI has been demonstrated in preliminary studies. Artificial intelligence's effects on animation's expressiveness, realism, and aesthetics are covered in detail. Furthermore, it has presented challenges with training data, choosing the right model, and fine-tuning. Beyond the field of gaming, our research has wider implications. Several industries may benefit from the benefits of 2D animations enhanced with AI and biomechanics technology. These industries include advertising, entertainment, and education.

Keywords: 2D animation; artificial intelligence; system engineering modelling; generative processes; visual effects; platformer games; biomechanics simulation; character action generation

1. Introduction

The quick succession of images displayed to give the impression of movement is called animation. The motion frequency used in classic video animations is typically twenty-four frames per second. The kind of gameplay and the device's capabilities determine the frame rate utilized in arcade games [1]. The frame rate of contemporary games typically ranges from 30 to 60 frames per second. Fast-paced combat games especially require rapid frame rates. An essential component of making animated storytelling is character motion design, whether in 2D or 3D [2]. Compared to conventional keyframe-based processes, accomplished animation offers a more practical means of defining character movement. Technology advancements concerning the animation technique have made it easier to tell enlivened novels. As with traditional animation procedures, performers can directly generate animations by acting out their characters rather than defining key frames [3]. The main goal of two-dimensional (2D) animation is to create backdrops, narrative boards, and creatures for two-dimensional (2D) environments. The figurines may move forward, backward, upward, or downward. They are frequently referred to as traditional animation. 2D biomechanical simulation can be integrated to enhance motion realism, using principles of human anatomy and physics for more lifelike actions. 2D geometric transformation can be used to change the position, scale, and orientation of the 2D visual elements [4].

The gaming business is evolving due in large part to artificial intelligence (AI), which is enabling programmers to create more accurate and engaging experiences when playing games. AI is crucial in modernizing game representation over time, making it easier to create complex and realistic characters, settings, and exchanges [5]. As a result, the gaming industry is growing because of improved visuals and more exciting gameplay that appeal to a larger audience. Here, artificial intelligence (AI) is used to control NPC (non-player character) units while making decisions regarding strategy, which raises the difficulty and intricate nature of gaming [6]. Additionally, AI approaches provide more accurate and thrilling 2D gaming worlds by mimicking variables like climate trends and fauna interaction [7].

The term game representation is the application of artificial intelligence methods and tools to improve the quality of a game's visual elements, such as its imagery, cartoons, and virtual settings. Generally speaking, it refers to the use of AI and graphics processing algorithms to produce and display the graphical components of a Spiel, especially the surroundings, individuals' things, and illumination and shadowing techniques [8]. In the past few decades, there has been a substantial advancement in the usage of AI with 2D game visuals, which have enhanced the entire experience, immersion, and authenticity of video games. Utilizing artificial intelligence in game visuals has enormous potential to improve the playing experience in general and enable programmers to create more vibrant and authentic gameplay environments. However, putting AI into practice also brings with it several difficulties and moral dilemmas, such as making sure AI-driven systems are transparent and equitable [9]. Resolving such issues is becoming more and more important as the video gaming sector develops to promote ethical and equitable AI adoption, which will eventually maximize the advantages of AI-enhanced game visualization while limiting any possible disadvantages [10].

The process of motion translation with the majority of three-dimensional characters is quite simple. Since every articulation on the actor usually matches a corresponding facet of the personality, it is possible to relate the performer's constant motion precisely to the 3D character, resulting in realistic, subtle animations [11]. Efficiency animation is therefore employed in a variety of 3D animation contexts, including activities, movies with special effects, and feature films. This study focuses on a 2D form known as "carved animation," which is an alternative to 3D animation. Layers of graphics with a blend of ongoing deflections and abrupt changes are used to portray characters [12]. Additionally, cutout animation has served as the focus of contemporary HCI and visual development. While parameters are necessary for classic cutout animation, more recent methods employ human activity to power animations. A few of the performance-driven technologies available transform sound input into mouth movements or translate facial and head movements to 2D characters [13].

Performance-driven 2D animation is far more expressive than it was with previous 2D animation systems since they allow spontaneous activation of arm/hand positions via the actions of humans. As a consequence of a discrepancy in the amount of mobility of the performer and personality, transferring performances animating to 2D characters is more difficult than it is for 3D figures. Although it is theoretically possible to translate an actor's constant movement into 2D and then map that projection straight to continuous distortions of the required layers, this leads to uncomfortable results for everyone except the smallest positional modifications. While these continuous 2D deformations can result in little motions, many posture transitions entail more significant adjustments, such as folding arms or going from a finger pointing to a thumbs up [14]. Because of this, animators frequently mix uninterrupted movement with individual graphic swaps to indicate more significant shifts in position when creating 2D animations by hand.

The incorporation of inter is the main distinction between animating for video games and motion pictures. Animation in films is intended only for passive viewing. But in a game, the player controls every move. By the player's instructions, actions begin. At the appropriate times, individuals or things in the surroundings have to respond to the player's activities with their responses. Gaming animation's primary goal is to enhance gameplay; graphics come in second. The movements need to be sufficiently brief and happen as soon as the player gives a command to maintain an instantaneous sense within the interface. The player will become irritated with even the most visually stunning animation if it requires too long to finish. Certain games have severe limits on the number of frames that can be used for each animation [15]. Game animators are considerably less free to convey their point of view than their cinematic counterparts.

There are extra technical limitations on gameplay animation when it is being utilized in real-time. The intricacy of the animations must be determined by considering the equipment's capacity. The majority of a game's animation consists of short bursts that are continually repeated to provide a continuous motion. These cycles encompass fundamental movements like strolling, footing, and attacking. The animation must seamlessly transition from the cycle's last frame to its initial frame to look natural. The main achievements of the research on creating 2D gaming characters are enumerated here.

1) Generating AI techniques and system engineering modeling were used to design the 2D character animations with biomechanics simulation.
2) Investigate the core concepts and techniques of artificial intelligence development and biomechanics through a 2D animation game character simulation.
3) The findings from the study indicate that the recommended model improves Visual Effects and Platformer Games more than the various approaches previously in practice.

In module 2, a Literature Review of 2D animation simulation was initiated. In module 3, 2D character animations using AI-driven generative methods have been proposed. In module 4, the results of the trials that were conducted. In module 5 A summary of the result and the potential for the future are provided.

2. Literature review

In a study by Wu et al. [16], authors explored the many uses of artificial intelligence (AI) in video game graphics, including deep learning techniques for illumination, character graphics, and environment creation that adhere to PRISMA standards. Increasingly sophisticated and realistic artificial intelligence (AI) models are predicted to result from the use of AI in game development, more extensive use of artificial intelligence (AI) and greater cooperation with additional cutting-edge technologies, all of which will result in more customized and captivating experiences while playing. Additionally, there's been a growing movement to use AI to develop real, sentient fictional characters by using machine learning algorithms that enable characters to arrive at judgments and adapt to shifting gameplay conditions.

In a study by Bai et al. [17] authors presented a cohesive approach that blends traditional key framing tactics with modeling. By combining these two methods, emulation grows more adjustable and keyframing gets more automated, improving over both ends of the spectrum. The suggested system sticks apart because it handles dramatization and attractiveness when examined in light of the core animation concepts. The suggested technique makes it simple to reuse expertly created animations and supports sudden leaps and massive flexible deformities. New opportunities for interaction are introduced by the handle interface in the proposed unified framework. Designers can gain from alternative computations and generative techniques in addition to relying solely on kinematically keyframed movements.

In a study by Choi et al. [18] authors discussed a manufacturing tool built on a generative stochastic network that can rapidly and simply create 2D character sample pictures. In the realm of gaming asset creation, when artificially generated statistics are inadequate, a method was first devised for creating an artificial set of information to be utilized for training using real-world photographs. Furthermore, optimized input from customers during the tool's operation while enabling efficient sprite production. To achieve this, an alternate input technique comprising skeleton bone drawings and a limited number of subdivisions was developed. By employing the skeleton loss, the suggested translation of images to the images network successfully produced sprite pictures from the user-input photos. Experimented to determine the number of images needed, and the results demonstrated that even when dealing with a minimal number of separation signals and a single skeletal bone design, 2D sprite elements could be created.

In a paper by Sierra et al. [19] authors presented the study employed a 2×2 between-participant layout with a baseline condition to examine the effects of a virtual gaming character's look on compassion and participation. The physical appearance of the video game characters was tested under the four circumstances. Discovered that, in contrast to inconsistent physical appearance and facial expressions, researchers virtual animals with harmonious appearance and facial expressions exhibit higher levels of expressed context-dependent feelings of compassion and participant entanglement in a virtual setting. The results of this investigation indicate that the virtual animal's look has a significant impact on the person's experience.

In a study by Farahani et al. [20] authors dispensed the impact of varying 2D animation playing speeds on professional football players' decision-making reliability and response times. In response, respondents selected the most effective assaulting alternative in each 2D animation loop from a list of options. Players also judged how "game-like" or genuine the situation felt for every instance after it was shown. The findings demonstrated an important distinction across all categories, with individuals becoming more precise and quicker as they became older. Additionally, the under-16 age group exhibited significantly worse perceiving reliability compared to the under-18 and under-23 age groups, according to the results of "game-like" observation challenging material matching each group's experience to its own pace. This demonstrates how knowledge undergoes processing more quickly for players with greater competence.

In Zufri et al. [21] study, authors examined the creation, fundamental design tenets, and fundamental principles associated with character models that are frequently seen in video games nowadays. This conversation is about the resilience of pixel aesthetics in the face of the many ideas that are shaping the design trends of the contemporary digital art period. The fundamental building blocks of design that can result in visually appealing work are pixels. Despite the widespread use of 3D-based visual works, pixel styles continue to have a significant impact on contemporary developments in the field. More creative professionals are continuing to utilize and apply pixel-based layouts in various forms of video games.

In Willet et al. [22] study, the author introduced a system model that addresses a video of the intended human performer. Structure monitors both arms and hand gestures within a sample targeted video. To assist artists in choosing exemplary postures that best express the actor's manner and individuality, the user interface shows the clustering of these stances. An animated sequence from a fresh performance video can be produced by the suggested approach using the association of pose information to characters artwork. It uses a technique based on programming languages to maximize performance for fluid animations that correspond to the positions seen in the film.

In Subamonyon et al. [23] paper, authors become acquainted with TakeToons a script-driven method that enables writers to add pertinent animation events, such as figure movements, camera angles, and scene backdrops, to ordinary screenplays. Create a narrative model out of this script that will be used throughout the recording. The resulting structure will give a consistent framework for putting together and organizing captured appearances and for spreading script or timing changes to previously released performances. TakeToons makes it possible for writing, acting, and producing to occur in a seamless, interwoven manner that speeds up production and encourages iteration. Ultimately, TakeToons creates an animated film by piecing together the narrative model records.

In a study by Stone et al. [24] authors conferred a process for creating an animated conversational character by employing a database of speech recordings and motion capture images. Create productivity data management and collection solutions that take advantage of this framework. The tools facilitate the creation of actor scripts, the annotation and segmentation of performance data, and the organization of character-specific messages for use in program contexts. By framing issues for phrase creation and composition so that they can intimately draw on a competent display, strategies enable the swift creation of cartoon characters with rich and appropriate expressiveness.

In a study by Yan [25] author presented the taxonomy, guiding placement, applicability breadth, and perspective of gaming characters. This paper investigates the use of San Xing Dui Ruins' culture aspects in the preparation and development of game cases, after which a case study is undertaken for the development of characters of several outstanding games available in the marketplace. Based on consideration for history, verifiability, and testimony, game character designers should faithfully include aspects of conventional Chinese culture in their creations. The Guyu Cavity game is used as a case study to examine the entire process in detail, from conception to execution. Guyu Cavity's characters are created with a contemporary aesthetic throughout; the character's headgear is enhanced by the incorporation of San Xing Dui mask features.

The poll results show that the current techniques have several issues. The third section that follows goes over the suggested 2D character animations using AI-driven generative approaches in brief.

3. Proposed work

The area of artificial intelligence (AI) is broad and includes a variety of methods and strategies designed to build systems that can behave intelligently. Artificial intelligence (AI) in video games can provide players with intelligent enemies and companions that can respond to the player's actions in meaningful ways, which can improve the immersiveness and fluidity of gaming situations. A brief description of artificial intelligence in video games will be provided in this part of the article.

3.1. Artificial intelligence for video games

The video game's visualizing process is a series of stages that create and present the visual components of the game itself. Conceptual approach, artwork approach, parametric modeling and cartooning, shading and illumination specialized effects, post-processing, and interface development are generally the major steps in the visualization procedure of a video game.

Designing concepts with artificial intelligence: From the outset of the visualization phase, the gaming development group collaborates with architects to establish the overall aesthetic concept and aesthetic of the game. This involves choosing the game's general visual aesthetic, subject matter, scheme of colors, and graphic style. According to preset criteria or preexisting artwork, AI techniques like productive algorithms can help game creators and artists generate imaginative designs and styles. This can involve creating visual themes, palettes, and graphic styles that complement the game's intended look.

Artificial intelligence in the creation of artwork: Designers and illustrators are in charge of producing the video game's visual aspects at this phase, which include character designs, surroundings, costumes, multimedia elements, and more. They execute intricate design assignments, draw ideas, and produce texture elements using high-end design equipment and applications. By automating some operations, AI can help designers and artists create visual pieces. AI-based technologies, for instance, can speed up the process of creating art by helping to create or improve character models, surroundings, materials, additional effects, and texture.

AI for two-dimensional models and animations: Designers use two-dimensional modeling tools to create 2D models of the game's characters, circumstances, and objects. Depending on the needs of the architecture, these representations can undergo additional maintenance, pattern organizing, and motion. In line with this, AI-powered algorithms have the potential to improve two-dimensional modeling and animation. For example, machine learning techniques might be used to automate or improve certain aspects like motion capture, physics-based calculations, and characterization rigging to produce more precise and efficient character and object films and animations.

Artificial intelligence in illumination and graphics: Software developers and designers work together at this step to convert the 2D structures and surroundings into finished graphics utilizing rendered engines and illumination approaches. This includes figuring out the sources of light, providing substances, arranging the darkness, and creating effects with the light. Rendering and lighting processes can be made better by using AI approaches, which increase the visual effects' clarity and authenticity. To create more realistic and aesthetically pleasing scenes, this incorporates immediate rendering efficiency, planetary brightening methods, and AI-powered noise reduction techniques.

Unique effects and subsequent processing with artificial intelligence: The game's ambiance and appearance are improved by using techniques for post-processing including unique visual effects. This covers grading colors, blurring effects, fumes, detonations, and component effects, among other things. Machine learning algorithms can create novel outcomes or enhance how they look at features that currently exist by learning from existing results or inventive ways. AI can aid in the development and improvement of creative effects.

Designing user interfaces with artificial intelligence: Developers are in charge of producing the game's graphical user interface (GUI) at the end of the visualizing phase. Creating menus, interfaces, designations, controls and other graphical elements that communicate with the user falls under this category. By executing tasks like layout generation or adaptive UI technologies that customize the interface's appearance based on user choices or game context, artificial intelligence (AI) can improve user interface design. Furthermore, by optimizing user engagement and responsiveness, AI approaches can create a more intuitive and captivating encounter for users.

Figure 1 illustrates the stages of artificial intelligence used in video games and visualization to produce visual elements. One application of AI that can be quite helpful is in the creation of more intelligent and adaptable NPCs. With the use of machine learning technology, NPCs may tailor each player's experience to increase their level of challenge, engagement, and pleasure in the game. Even more fascinating ways to improve the engagement and interaction of video games through the use of augmented and virtual reality technology are presented by artificial intelligence (AI). For example, AI upscaling is a helpful tool to improve video game graphics and produce realistic object depictions. Additionally, AI has a significant impact on participant behavior evaluation and game customization. By analyzing information regarding player interests, gaming practices, and in-game actions, supplying game developers with the necessary support allows them to create more customized gaming adventures for each player. This may mean creating custom game suggestions, changing the difficulty of the game, or even tailoring in-game advertisements to the participant's tastes. AI can also be used for individual behavior evaluation, which helps game developers comprehend how players interact with their offerings and identify areas for development. Examining the player level of involvement, identifying places where individuals typically lose interest, and identifying tendencies in player activity that can be used to improve the whole gaming experience are some instances of this kind. As a result, the incorporation of AI into gaming has already started to completely transform the sector, offering fresh and creative approaches that can improve users' gaming experiences and assist game developers in producing more engaging and captivating content.

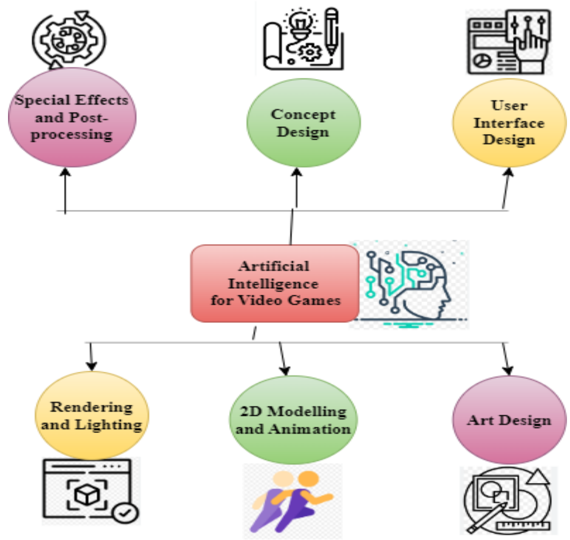

Figure 1. Artificial intelligence for video game.

3.2. Game character design and modelling

The player character is intended to be used in a game where the viewpoint is from the side. It's helpful to start with a 2D character because, in any case, character creation frequently begins with 2D drawing. The 3D model uses the 2D character as an example as well. It functions similarly as a guide, much like a sketch does for line art in digital painting. **Figure 2** shows the character design workflow diagram.

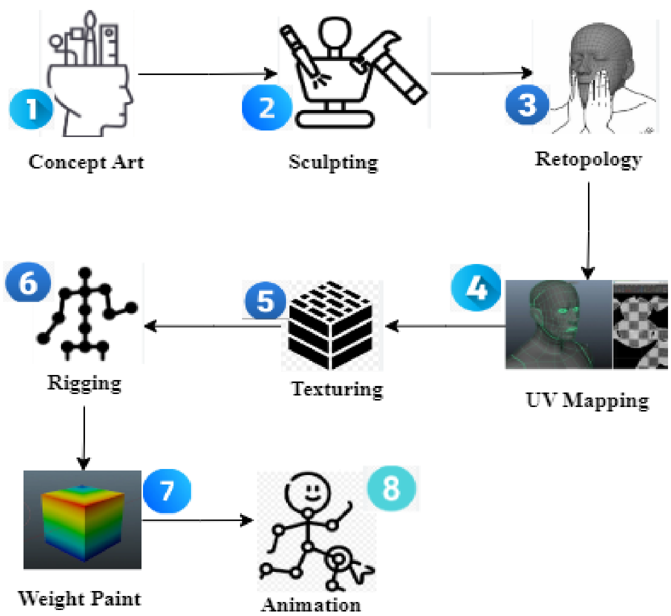

Figure 2. Character design workflow diagram.

3.2.1. The first configuration

A sketching pad is required for the development of 2D characters because a mouse is typically insufficiently accurate for digital drawing. Moreover, digital drawing software is required. For this character creation, the researcher used a Wacom One M drawing tablet and a Clip Studio Paint digital painting program. The last phase is rigging, which gives the character bones so that they can move the sprites to generate animation. For rigging in this case, the program Backbone will be utilized.

3.2.2. Character design and concept art

Making concept art for the character is the fundamental step. The intention is to simplify the design to maximize 2D and 3D adaptability. The figure's cel-shaded visual style has a cartoony authority, which is also evident in how the character looks.

3.2.3. Outline sketch

Employing lighter brushes, the ultimate character sketch is completed next. Creating a rough sketch of the character's shape and appearance is the aim of this stage. Because the sketch may be used as a reference to draw on top of, it becomes simpler to draw the contours of the art after that. Since each limb must be rendered as a separate sprite, the character is drawn having its limbs separated. This facilitates the character's subsequent animation. **Figure 3** illustrates the sketch of the character.

Figure 3. Sketch of the character.

Line art.

Using a sharper and more sophisticated brush, the sketch is now drawn over to produce the line art. The artwork needs to be more precise and detailed because it will serve as an example of the result design's shape and overall aesthetic. **Figure 4** establishes the line art of character.

Figure 4. Line art of the character.

3.2.4. Color and shading

Figure 5 reveals that the character is now given the finishing touches, including coloring and shading, using the line art as an example. The base colors are added first. To maintain visibility over the colors, an additional layer is positioned beneath the line art component. Shading is applied on top of the previously added color in a newly created layer with the multiple mix option selected. If more detail is required, another layer for lightning and shine might be added. To save a period they were excluded from the process in this instance. The shading is rendered in a vector shading technique reminiscent of cartoons, with strong shadowing edges.

Figure 5. Color and shading.

3.2.5. Rigging

In the beginning, the character must be assembled again from the individual sprites. For each component of the body, additional bones are inserted once everything is in its proper position.

But since this character is meant for a side-scrolling, side-view game in which the character isn't too close to the big screen, such straightforward movements are adequate in this instance.7.

The primary bone in the body is the one from which every other bone is derived as its offspring. This implies that the individual can be moved as a whole using the main bone. **Figure 6** validates that Rigging of character.

Figure 6. Rigging.

3.3. Machine learning approach for 2D animation

The technique offers a framework for posture estimation on several publicly available standards that can be performed competitively. To figure out game character attitudes based on pixel-level image verification, it employs a bottom-up methodology. To achieve this, a multiple-phase predictor with two branches of an entirely convolutional neural network can tackle the challenge by improving the output of every phase. A feed-forward network that predicts a series of 2D heat maps in a sequential manner. A collection of 2D vector fields and Cs of various body component positions Af of similarities that indicate how closely related the pieces are. As seen in the formula below, the neural network's last action yields a matrix with 57 vectors. However, the final operation only concatenates two distinct vectors, such as heat maps and AVFs. Understanding both of these feature vectors is crucial.

$$HeatMap: R^2 \rightarrow R \; Affinity\,Vector: R^2 \rightarrow R^2 \quad (1)$$

The network is split across two branches: regions of part affiliation are predicted by the bottom branch, while mappings of conviction on each body part are predicted by the top branch. The technology provides CNN Network with source video frames that have dimensions of $width\ (W)\ x\ height\ (H)$. As a result, the system produces the morphologically important points in 2D positions for every frame as if they were game character output. The very first step, known as the heat map, analyzes the input image and uses a degree of trust to forecast the potential positions of each key point. Every conviction map should ideally have just one peak when the correct region is visible if an individual is present in the picture frame. The definition of the position of value L_{Cs} in Cs is

$$Cs \times (L_{Cs}) = e^{-\|L_{Cs}-X\| / \sigma^2} \quad (2)$$

where $X \in R^2$ is the ground-truth location for every body part for the individual in the frame, and σ determines how it is distributed over the peak. Next, another CNN branch is introduced, which predicts 2D vector fields that are known as Affinity Vector Fields (AVFs), by taking advantage of the fact that some joints are connected by limbs. AVF represents the path from one part to a different one. A limb is formed by joining two parts together; each limb is referred to as the zone of attraction between the body's parts. Af_{Limb}, the numerical value of a point L_{Af} in the AVF, is a vector representing a unit that points from the joint's beginning point to the limb's ending point if the point is inside the limb; if it's located outside, the value is zero.

$$Af_{Limb}(L_{Af}) = \begin{cases} \vec{v}, if\ limb\ on\ L_{Af} \\ 0, otherwise \end{cases} and\ \vec{v} = {X_2 - X_1}/{\|X_2 - X_1\|_2} \tag{3}$$

As a result, the network generates a collection of affinity vector fields $Af \in R^2$ throughout the subsequent stages, $t \in \{1, ..., T\}$, and a set of confidence scores $Cs \in R$ for each key point.

$$Cs^t = \alpha^t(F, Cs^{t-1}, Af^{t-1}), \forall t \geq 2 \tag{4}$$

$$Af^t = \beta^t(F, Cs^{t-1}, Af^{t-1}), \forall t \geq 2 \tag{5}$$

where the CNNs for prediction at every phase are denoted by α and β. The picture's characteristics F for the following phase are condensed with the forecasts from the two separate branches at every stage. To instruct the computer network to continuously forecast the body's component mappings in the primary branch and AVFs in the second branch, two loss functions one at each branch are built at the end of each branch. With approximation monitoring at each level, every division of the incremental forecasting architecture optimizes predictions over a series of phases. This makes the forecast better after each stage; that is, after going through all four phases, the trustworthiness map becomes more reliable.

3.4. Animation process

In the beginning, the 12 fundamentals of animation were explained. Squash and Stretch, Anticipation, Staging, Straight ahead action and pose to pose, Follow through and overlapping action, Slow in and Slow out, Arc, Secondary action, Timing, Exaggeration, Solid drawing, and Appeal are the twelve principles of the Animation process. Therefore, choices made regarding character design are crucial, but applying all of these animation concepts can also enhance a character's appeal. Since human performers are physically incapable of moving like cartoon characters, even if they exaggerate their movements or utilize padding to simulate different body types, keyframe animation is strongly advised for cartoony creature dimensions.

4. Results

The Big Five character TIPI exam was used to evaluate a dataset of 26 samples before character testing and post-test survey responses to ascertain that character animations impact play patterns and vary based on players' personality characteristics. The Big Five personality characteristics scores for players who were allocated to the extrovert and introverted characters are shown in **Figure 7**. In particular, the chart shows that extraversion is not homogeneous.

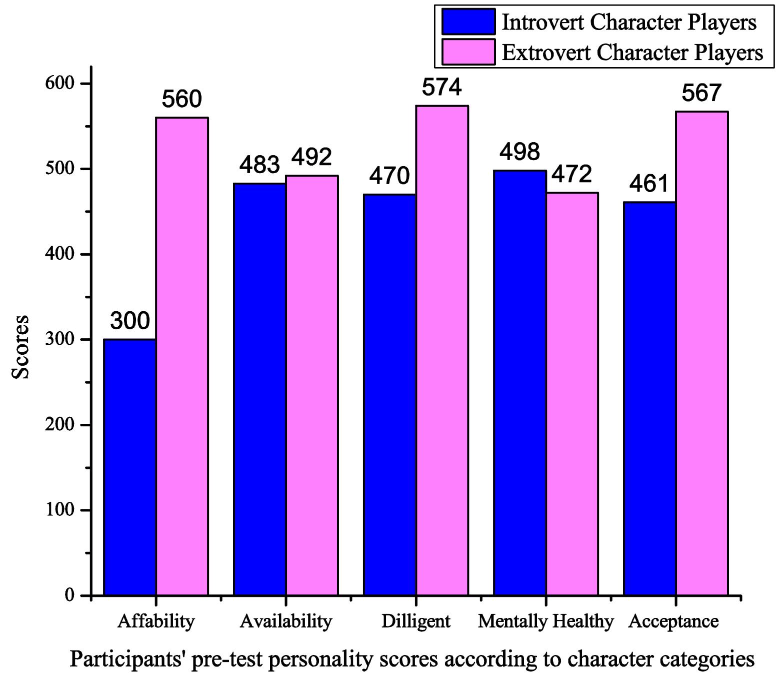

Figure 7. Big five TIPI score.

The evenly distributed introverted and extroverted groups were then subjected to a two-tailed Wilcoxon Signed Rank Test with an initial sample size of $N = 13$. At an alpha level of 0.05, the analysis produced a W-value of 5, which was greater than the crucial value of 0. Since the test results showed that participants who identified as introverts or extroverts were equally adept at distinguishing the personality traits that characterized each of their personalities, the null hypothesis was maintained. To find out if the introverted group scored higher than the extroverted group, a right-tailed test was also administered. With a p-value of 0.25 and an alpha level of 0.05, the result was not statistically significant, suggesting the null hypothesis was not rejected. To confirm the Wilcoxon Signed Rank findings, Mann-Whitney U tests were run on unique personality variables for both introvert and extrovert groups. The findings showed that there was not enough data to disprove the null hypothesis about the cooperative characteristics among the groups. This indicates that the group of introverts thought their personality was cooperative.

The groups' capacity to identify alternative personality traits (with a U score below 30) showed significant differences, suggesting their aptitude for recognizing the personality features of the assigned characters. For the perception of introverted, cheerful, grounded, skeptical cautious, social, assured, timid inventive, adventurous, and anxious qualities across introvert and extrovert groups, a critical value of 30 was established at an alpha level of 0.05 (**Table 1**). The null hypothesis was rejected after comparing the U values for each characteristic to the critical value to determine whether there were any significant differences between the groups.

Table 1. Mann-whitney *U* tests results for every trait.

Trait	*U* Value (critical value = 30)	*P* Value (α = 0.05)
Introverted	0	0.000096
Cheerful	35	0.094
Grounded	8	0.015
Skepticism Cautious	96	0.00078
Social	0	0.0056
Assured	0.06	0.00062
Timid	1	0.000045
Inventive	0.63	0.000056
Adventurous	2	0.00017
Anxious	0	0.009
Qualities	1.25	0.0067

Significant differences were found among the introvert and extrovert groups in the effects of character animations on gameplay style ($U = 34.5$, $p = 0.036$) and overall gameplay satisfaction ($U = 35$, $p = 0.027$) according to the outcomes of the statistical analysis (right-tailed). The fact that both p-values are below the selected significance level (alpha = 0.05) suggests that the extrovert group's gameplay style was positively influenced by the character's animations. Consequently, the null hypothesis was disproved. In support of the earlier findings, **Figure 8** shows how the respondents rated the introvert and extrovert groups' character animations, confirming that the animations accurately reflected the intended personality attributes of the characters.

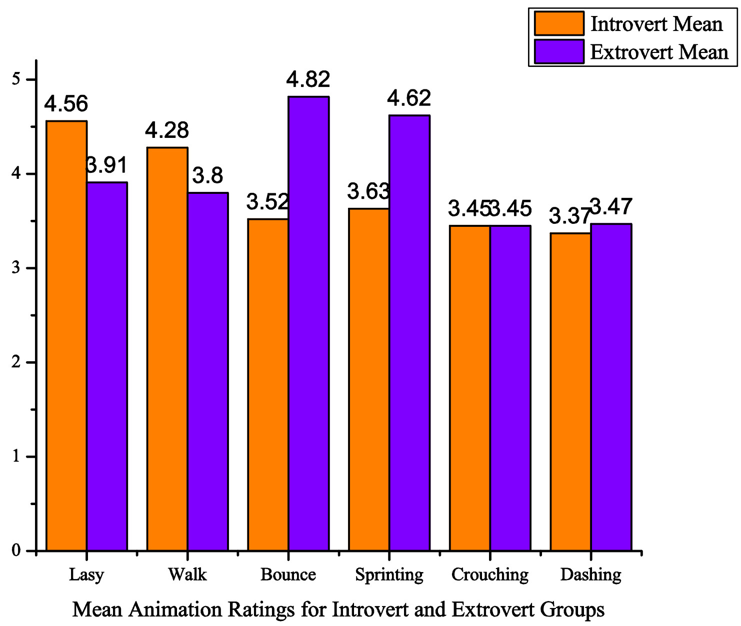

Figure 8. Mean animation ratings.

Furthermore, there were no significant variations found in the game behaviors between the introvert and extrovert groups (**Table 2**) for jumping ($U = 49.5$, $p = 0.441$), sprinting ($U = 44.5$, $p = 0.274$), crouching ($U = 37.5$, $p = 0.125$), or dashing ($U = 48.5$,

p = 0.383). These results suggest that introvert and extrovert participants similarly used these behaviors.

Table 2. Mann-whitney *U* in-game actions test results.

In-Game Actions	*U* Stat (critical value = 30)	*P*-value (α = 0.05)
Jump	49.5	0.441
Crouch	44.5	0.274
Sprint	37.5	0.125
Dash	48.5	0.383

Additionally, **Figure 9** illustrates how the participants perceived animations of introverted and extroverted characters. The most often chosen animations in the introverted group were those of strolling, crouching, and idleness, suggesting that these actions are connected to introverted traits. The extrovert group, on the other hand, seemed to choose animations that involved running, jumping, and dashing, indicating that these types of animations were seen as extroverted.

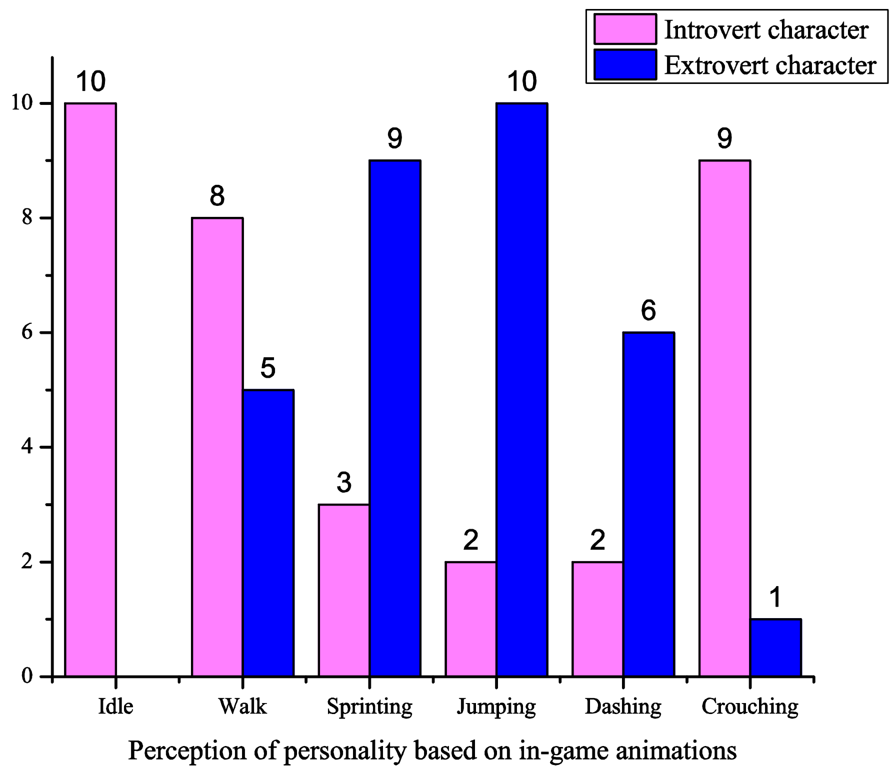

Figure 9. Perception of personality.

The observational data showed that there was no difference in the aggressive (U = 39, p = 0.150), cautious (U = 49, p = 0.423), exploratory (U = 49.5, p = 0.441), strategic (U = 55.5, p = 0.704), and precise (U = 36.5, p = 0.121) gameplay styles between the introvert and extrovert groups. Since there were no discernible differences in gameplay styles ($U > 30$), the null hypothesis was kept.

Now that the practical implementation is complete, 2D visuals have been conceived and created for a video game character. A sideways-looking game served as the character's application case. In Clip Studio Paint, the 2D character was made first because it was thought to be speedier and serve as a foundational guide for the 3D character. Generally, creating a character in 2D was quick and easy. Using Clip Studio Paint was easy and intuitive. But because the character was meant to be used and animated in a game, the process became a little more involved. However, both the quantity and the size of the steps stayed reasonable. Achieving a satisfactory level of visual quality was simple. If the graphics and gameplay aren't too complicated, a lone game creator can save time by using a 2D method. Drawing the character only once and from a single viewpoint might not be sufficient if the character requires numerous animations. Although a large number of sprites from various perspectives could be required, the scope of this study was regrettably insufficient to produce them. When creating 2D graphics, there aren't many quick and simple ways to add or modify them afterward. Vector art would likely be more effective than rasterized visuals.

Regarding animation, framework models can be used to animate both 2D and 3D characters. Armatures allow for the creation of animations by the manipulation of the armature's bone positions, which are linked to the character's movement along the framework. This is still constrained in 2D by the sprites' design viewpoint. For instance, the side-view sprites are static and cannot be rotated, therefore it is not possible to construct a top-down perspective using them. Most solitary creators might find that using a 2D graphics approach makes more sense unless they are creating a game with a lot of animation and a strong visual component. From a side view, 2D should be more advantageous. With 2D, one may rapidly and easily build simple images. The limitations of this study make it obvious that the research topic was overly wide. Considering the increasing appeal of independent video games, the amount of academic research on these themes has failed to keep pace with the development of the video game industry.

5. Conclusion

This research study examined a broad range of artificial intelligence (AI) applications in the graphics of video games, including machine learning techniques for lighting effects, character movements, and terrain creation. Additionally covered were the benefits, difficulties, and possible uses of AI in this field. One new trend is the use of AI to improve the graphical quality of video games. This can be achieved by improving the way graphics are rendered or by applying machine learning algorithms to create more realistic images. Among them, based on what was seen in this 2D animation project, the animated presentations are brief yet packed with quality material. Viewers are satisfied as a result of this. Furthermore, the animation is merely displayed in motion with accompanying sound. In terms of biomechanics simulation, the character animations were enhanced by applying principles of kinematics and dynamics to simulate natural human movements. The integration of inverse kinematics allowed for realistic limb articulation and posture alignment, improving the fluidity and believability of character actions. Additionally, biomechanics data collected from real human subjects were used to refine the movement patterns, ensuring that the generated motions closely resembled those of actual human behavior. This resulted in animations that were not only visually appealing but also biomechanically accurate, providing a more immersive and lifelike experience. After an explanation of the modern and historical methods and technologies used in the animation process, it was linked to this project. The juxtaposition of previous efforts helps to further refine the goals and experiments for this project. The endeavor's procedure was elucidated by the way it was done. Both the software and hardware prerequisites are mentioned in brief and will be covered in more detail. Because the right colors and lighting have been used throughout this animation, the user can interact with it quite well. The findings show that participants were able to recognize the perceived personality features of the characters they were given, proving that the character animations used were successful in communicating the desired traits. Ultimately, the results show how crucial character animations are in influencing players' opinions and offer directions for further study and advancement in the gaming sector.

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