GRAPHICS IN VIDEO GAMES

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ABSTRACT:
In this paper I present the various graphics techniques that have been used to display game content. This paper takes you through the history of graphics and their evolution over time. From Odyssey and Nintendo to the Play station 4 and Xbox One, this evolution spans across eight generation of consoles over half a century. This paper demonstrates how the graphics were used in earlier games, their limitations, advancements over time, and how important the graphics are in games.

INTRODUCTION:
What is the first thing that you notice when you play a game? Its graphics. Today, graphics are the heart and soul of video games. From the simplest of games with no graphics like Pong to visual treats like Farcry 4 and GTA 5, graphics have come a long way. In this paper we look into the different types of techniques used in 2-D and the 3-D games e.g. Top Down, side scrolling, first person perspective, isometric scrolling etc.

1. The 2D Era:

It was in the 1970's when games like Pong and Odyssey were created, which turned out to be a worldwide phenomenon. No one could have imagined that time, that these games will revolutionize the video game industry. For the first time ever, the video games were cool.

1.1 Black and White games – The beginning of the video games started with the black and white games even though colored televisions were still available. The games had very little focus towards the graphics. Simply moving a flicker of light across the screen was incredible. This gave birth to the need for creating better visuals – 2nd Generation Consoles.

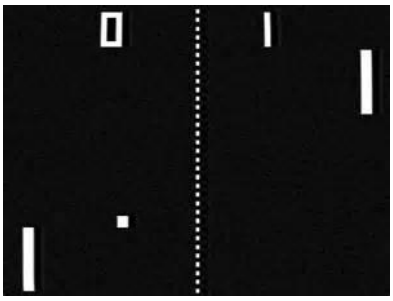

Fig. Pong [1]

1.2 Full colored graphics – Full colored graphics were the building blocks of the arcade games. Most early video games were limited to mono graphic display. Some games used colored overlays to enhance their gameplay. The black and white displays were laid over with a colored translucent screen which added a colored feel to the game. It was a very limited but a cheap workaround. As these games continued to blossom, it gave technology a chance to catchup with the need for full colored graphics. Soon racing games which used different colored cars were developed. Carpolo in 1977 was the first colored game to use a microprocessor.

Fig. Carpolo[2]

There were two main techniques that were used in games created during this era - Raster and Vector graphics.

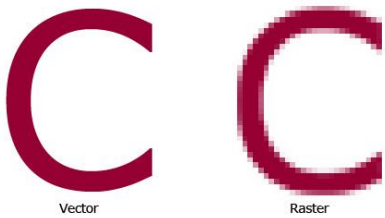

Fig. Vector graphics vs Raster Graphics [3]

1.2.1 Vector Graphics -- Vector graphics are made of mathematical calculations that form objects or lines - they do not use pixels therefore they are resolution independent [4]. They directly modify the electron beam to form images on the screen. They produce clean and smooth images but are less versatile.

Fig. Spacewar[5] with smooth lines

1.2.2 Raster Graphics (Bitmap) – "In computer graphics, a raster graphics image is a dot matrix data structure representing a generally rectangular grid of pixels, or points of color, viewable via a monitor, paper, or other display medium. Raster images are stored in image files with varying formats" [6]. The electron beam rapidly traverses each line of the display screen in sequence to form a grid and a picture is assembled line by line. The images generated using this technique cannot be enlarged without compromising the quality and when enlarged the image becomes pixelated. This technique cannot render smooth lines, but can render more complex scenes and fill shapes and hence became more popular than its vector counterpart.

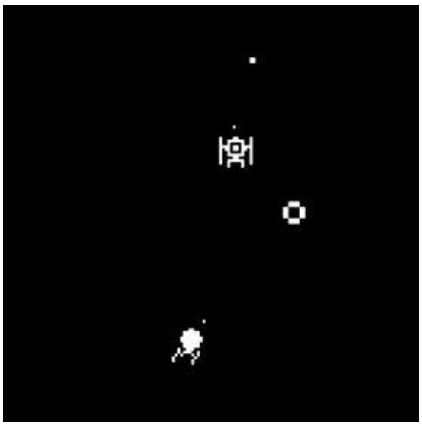

Fig- Star Cruiser's blockier pixels

1.3 The Scrolling Games:

1.3.1 Side Scrolling -- Among the rise of games like Pong and space invaders, there was another type of genre that was becoming very popular. Early arcade games had fixed playfield. The scrolling display revealed a level as the characters moved on screen from left to right as in side scrolling games such as super Mario. These games made use of the scrolling computer display technology.

Fig Super Mario [7]

These side scrollers of different types depending on the player position on the screen and the movement of the screen. In some the player can be positioned at center of the screen or can move across, and the screen could also only scroll forward and not backward, hence not allowing the player to visit a stage once crossed. Nintendo's super Mario and Sega's Sonic are considered to be pioneers among the side scrolling games.

Fig Sega's Sonic [8]

1.3.2 Top Down Scrolling -- The Top down perspective was used in the early racing games and space shooter games. "Xevious", released in 1982 is considered to be the origin of these types of games. The top down scrolling games were just like the side-scrollers where instead of going from left to right, the movement of player and the screen was from bottom to top.

Fig Xevious' [9] top down scrolling

1.3.3 Isometric Scrolling and Sprite scaling

Sega's Zaxxon was the first game that displayed game content in the form of isometric view by simulating three dimensions on a two dimensional plane where the angles between the projection planes are equal to 120 degrees. Later, this pseudo 3D appearance became popular among the strategy based games of the early 90's and is still used today in games like Sims, Age of Empires etc.

Fig. Zaxxon[10] –isometric scrolling

Similarly, sprite scaling technique used sprites of different sizes to produce a sense of depth on screen. The images at distance are shrank to give a feel of a deeper play field. Sega's Turbo pioneered this technique to create a game that resembled a 3D racing world.

Fig. Turbo's sprite scaling

As the hardware evolved, so did the ability to shift more pixels and yield more colors on screen which led to the birth of a new era of video games. With sweltering frame rates, the games such as Sega's Hang-On made a huge impact on arcade games.

Fig. Hang On[1]

1.3.4 Parallax scrolling -- The main aim of the games was to be more realistic. Games having a sense of depth to them became popular. Developers realized that 2D was not the future. The games had to be more real. Parallax scrolling was the next step towards it. The background was split into a number of layers with each layer moving at different rates to give an impression of depth. Hence, more intricate scenes could be delivered and the blasting performance of the Sega's Mega drive, gave a boost to games like Sonic.

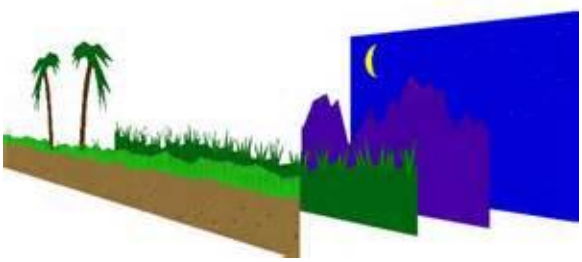
Fig Parallax scrolling example

1.4 Rotoscoping and Digitized sprites -- This technique generated sprites directly from a video. Although being a labor intensive technique, it became popular as it delivered a natural looking movement with lifelike inertia. Prince of Persia is a great example to it.


Fig. Prince of Persia using rotoscopic sprites

Digitized sprites are directly taken from a photograph and put into a game. You could literally put any image into a game. The one game that used digitized sprites and took it to the next level was Mortal Kombat. It was brutal and used photo-real characters which made the game a dubious one, but widely popular. Other games like Road rash also released sequels that replaced game characters with real ones.

Fig. Mortal Kombat using digitized sprites

1.5 Rise of the consoles: smooth scrolling at low cost -- The mid-80's featured the rise of the home consoles (3rd gen) which promised cutting-edge hardware, smooth scrolling, high frame rate, powerful graphics and high level of detail at a low cost. The 2D games ruled the market and sprites were in their prime. Consoles were promising and

games were become more popular than ever. Donkey Kong was the acme of 2D 16-bit platformers and its colorful and beautiful animations made it widely popular.

Fig. Donkey Kong

Cartoon mascots were incorporated in the games and studios were benefiting from it. Success of Mario and Sonic inspired Disney's Aladdin on the PC. This was pretty much what one could do with 2D games. It was all about having better graphics. The market was flooded with games like these and eventually reached a saturation point. As the hardware power steadily increased, the focus shifted towards 3D games.

Fig. Disney's Aladdin

2. The Origin of 3D:

The 3D games did exists in the 1980's, but due to the weak hardware available, they were limited to wireframe representations and shaded polygons with flat shading.

Fig IRobot and Star Fox with flat shading [1]

They were an amalgamation of polygonal 3D and sprite scaling and other 2D elements. It was now when the need for a separate processor for graphics was realized. VGA graphics which provided 256 colors, were a step up from the former generation and endorsed the creation of games with extra tinge.

Fig. Wing Commander[11] using VGA graphics

2.1 Fixed 3D games – This genre of games used pre rendered backgrounds and only the player characters were represented by polygons. This preserved the graphical power to a great extent and improved the overall game performance without the need more powerful hardware.

Fig Alone in the Dark [12] – Fixed 3D

Many of the games relied on tricks to simulate a 3D world. Restricted geometry and use of sprites were common. These were referred to as fixed 3D games. The Legend of Zelda: Ocarina of Time is a great example of a nearly complete 3D game, but it uses fixed 3D to represent many areas of the game. This largely limits the player's ability to navigate and interact with the game world.

Fig. The Legend of Zelda: Ocarina of Time[13]

2.2 Ray Casting and Texture Mapping: The birth of FPS -- Ray Casting has made earlier texture map games possible. It provides a proficient approach to scene rendering with the sole focus on what player can see. A simple way of rendering a scene is Ray casting which uses a geometric algorithm of ray tracing.

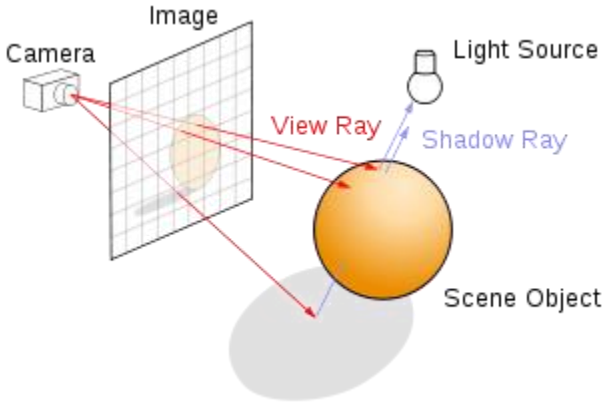

Fig. Ray Casting [14]

This algorithm renders a 3D world from 2D images.

"Geometric rays are traced from the eye of the observer to sample the light (radiance) travelling toward the observer from the ray direction. The speed and simplicity of ray casting comes from computing the color of the light without recursively tracing additional rays that sample the radiance incident on the point that the ray hit [14]." Hence, there is no way of creating real life effects such as reflections or shadows using ray tracing, although alternative methods such as texture maps, these effects can be faked.

Early 3D games like Wolfenstein 3D built the game world from a square based grid of uniform height walls meeting solid colored floors and ceilings. In order to draw the world, a single ray is traced for every column of screen pixels and a vertical slice of wall texture is selected and scaled according to where in the world the ray hits a wall and how far it travels before doing so. Even though the walls were fully texture mapped, the game was still playable on a moderate PC.

Fig. Wolfenstien 3D [15]

This lead to the birth of a new genre of games which we today know as FPS – First Person Shooters. If Wolfenstein was the grandfather of video games, DOOM in 1993 was the "daddy"[20]. Doom extended its feature set to

allow levels with more biological design, no fixed grid maps and added variable lighting and elements at different elevations. As a result doom was more impressive and pumped with high octane action and more believable locations, it proved to be a huge success. It inspired a large number of games and paved the way for the FPS genre as we know today.

2.3 True texture map 3D and Third Person games – Third person refers to a graphical perspective rendered from a view that is some distance away (usually behind and slightly above) from the player's character.[14] This viewpoint allows players to see a more strongly characterized avatar, and is most common in action and action-adventure games.[14] These games required great deal of processing power and it wasn't until the new millennia these games became popular. The 5th generation consoles could comfortably tackle 3D graphics. The Nintendo-64's Super Mario renovated itself to a colorful 3D world with dynamic camera allowing full freedom of movement and boundless exploration. Hence the true 3D games became an integral part of mainstream gaming. Crash Bandicoot, The Tomb Raider and The Legend of Zelda series are great examples of games utilizing the third person perspective games.

Fig. (Clockwise) Super Mario64, Tomb Raider and the Legend of Zelda[20]

2.4 Voxels – The Volumetric pixels, better known as voxels provide an alternative approach to construct polygons. The objects are built from 3D pixels instead of triangular faces. Initially, they showed some promise but later became obsolete due to rise of 3D acceleration.

Fig. Voxels used in game Outcast to render terrain and buildings [16]

3. From Doom to Quake: The boom of 3D acceleration

Quake took Doom to a whole new level and raised the bar it set even higher. It was a true 3D game. The sprites were replaced by 3D polygonal enemies and weapons and lack of vertical aiming in doom was gone, bi-axial aiming was introduced. Quake was a trigger to the next wave of 3D graphics development.

Fig. Quake [17]

With dedicated powerful hardware, games had power to construct smooth and high resolution detailed world without compromise. While the console hardware arrives in discrete generations the speed of PC development is incessant. Once the 3D cards reached the PC market they quickly

became a must have accessory for gaming. Doom and Quake pushed the sales of the powerful 486 and Pentium class CPU's and when paired with a dedicated GPU, PC's reigned supreme.

Fig. Unreal in 1998[20]

Unreal in 1998 took the maximum advantage of this powerful hardware. Unreal engine brought silky smooth frame rates, colored lighting, and detailed geometry with cutting edge graphics to the game. Unreal engine technology powered many other games and soon, games abandoned support for software rendering. It was all about the hardware power. It was the era of the sequels of previous generations of first person shooter. Each generation brought with itself superior visuals and state of the art graphics with an impressive gameplay - Half Life 2, Doom 3 etc. are some examples.

Fig Half life 2 and Doom 3[20]

4. Brown and Bloom effect: Desaturating colors

Brown effect is the technique of desaturating colors to make the game world more realistic. The world war shooters' resolute brown hue became a trend for a while with these subdued tones complementing the game style. The limited palate choice Shadow of the colossus to the dull yellow tones for NFS most wanted to the dull tones for post-apocalyptic setup of gears of war, the brown hues were used extensively. Although, their use has been abated in recent times.

Fig. Shadow of the colossus using Brown effect[20]

Bloom was a compliment to brown hues as it produced a bright blinding effect where bright objects bleed to their surroundings. The bright objects appeared brighter e.g. ICO's soft lighting, Neon lights of TRON are some examples. While dull tones and cinematic effects are both intended to inject realism into games, some took a more stylized approach instead. Cell shading gave 3D images a cartoon like appearance as it used a non-photo realistic technique like the one we have in a cartoon shader.

Fig. TRON and ICO using bloom effect[20]

Fig. Cell Shading in a game [20]

5. PC vs the 7th gen console generation: PS3 and Xbox 360

The middle of millennia decade was marked by the 7th generation of consoles. The 3D technology had ripened and the hardware more potent than ever. Games such as Farcry were renowned for their lush tropical setting, highly detailed and expansive levels and its open ended gameplay provided leverage for impressive technology to shine. Then came the visually outstanding game 'Crysis' which marked the PC dominance over the consoles again and embarrassed the new 7th generation consoles. Its need for an extremely powerful machine led to the phrase "Can your PC run Crysis" which served as a benchmark for hardware requirements. But this eventually became a limiting factor to the game's success.

Fig. Farcry[18] and Crysis[19]

During the same time, Wii brought a completely new genre of casual gaming. Graphically, it wasn't that impressive as its counterparts, but everyone wanted one. Games like Guitar hero and Rock Band proved to be very addictive and raised the question – are graphics that important?

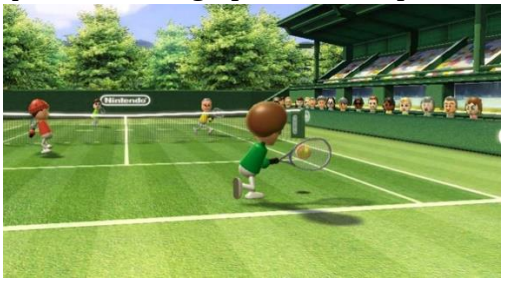

Fig. Wii Sports[21]

6. The Long awaited jump: 8th Generation Consoles

The limited hardware power of the seventh generation consoles is excellent for optimization of a game. Lately, the games like GTA 5 are so optimized that they squeeze every drop out of the consoles to produce stunning visuals. But what's next? The long awaited jump in visuals is finally here with the arrival of the 8th generation of consoles. The games for Xbox One and Play Station 4 look much more real than ever before. The focus of games has shifted towards 'cinematic realism'. As a result, developers have started to use techniques such as Chromatic Aberration, Selective Blurring and Motion Blur in the newer games. All these effects are designed make games real and visually stunning. These techniques are relatively new, but clearly are the way forward and with time will be used even more and eventually join an ever increasing palate of visual tricks.

6.1 Chromatic aberration simulates the divergence of different light wavelengths towards the perimeter of the screen. It is a type of distortion in which there is a failure of a lens to focus all colors to the same convergence point.[23] e.g. Destiny 2014, Massive light flares of Halo 4 and illumination of dust in Battlefield 4 use a newer version of bloom, Bloom 2.0.

Fig. Chromatic aberration in Destiny 2014[22]

Fig. Light Flares in Halo 4

6.2 Selective Blurring simulates the depth of field by selectively blurring a scene based on focal distance like we have in COD: Modern Warfare 2. The images near to the view point are clear and sharper where as those far away are blurred.

Fig. Call of duty: Modern Warfare 2 using selective blurring (blurred backgrounds) [20]

6.3 Motion Blur is produced by capturing continuous movement in discrete frames and with a rapid movement it produces burred streaks. It helps in smoothening the appearance of motion and enhances the feel of speed in racing titles like Forza Horizon 2.

Fig. Motion blur in games

7. Are graphics really that important?

Time after time some games tend to bring back the earlier era. The rise of Indie Games proves this.

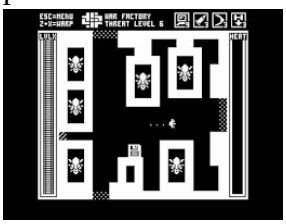

Fig. – Indie Games - Hero Core and Limbo

They purposely evoke the pre-80's era with games dipped in a nostalgia of the rich history of graphics and games like Hero Core and Limbo, released in 2010, even shunning the basic elements of graphics like color. From the time warping effects in Braid to twisting and bending mechanics of Fez, these games bring back the old times with a more modern sense of game design. And the most successful of all these games, Minecraft in 2009, supports this argument that graphics don't really matter. The low resolution textures, blocky world, social multiplayer and with huge potential for creativity, makes Minecraft the exemplar of the confluence of the old and new era.

Fig. Fez with its 3D geometry [24]

Fig. Blocky world of Minecraft [25]

Actually, graphics are 'that' important. The mainstream video games are dependent on graphics. Graphics are an essential part of them. However real or fantasized a game may look, it is its graphics that define it. With a rich heritage of graphics spanning across decades, development of new techniques, and with technology inching even further and the never ending demand of more powerful hardware, there are no boundaries to what we can create. Perhaps, someday these visuals may transcend our perception of reality. They may evolve so much that there will not be even a fine line to separate the real world from the game world. There is still a long way to go. The success or failure of a game is not determined by its graphics, but a game without any graphics is hard to imagine. The video games wouldn't have been the fun they are without graphics.

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