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In the previous chapter, we presented an overview of different types of display devices including cathode ray tubes, random scan display, raster scanning, etc. In this chapter, we will have a detailed look at CRT in detail and explain its importance in Computer Graphics. Cathode Ray Tube (CRT) is a technology which has played an important role in the development of early electronic displays, including televisions, large bulky computer monitors, and oscilloscopes. Although CRT technology has been largely replaced by modern alternatives such as LCD and LED. In this article, we will see the basic components and operation of a CRT for a better understanding. Cathode Ray Tube A Cathode Ray Tube (CRT) is an electronic vacuum tube that uses electron beams to create images on a phosphorescent screen. CRTs have been used in devices such as oscilloscopes, old-style television sets, and computer monitors. It operates by emitting electron beams from an electron gun, directing them to a phosphor-coated screen where the electrons produce visible light. A CRT consists of several key components that work together to display images – Electron Gun – The electron gun is the heart of the CRT. It generates and focuses a stream of electrons into a fine beam. Control Grids – These grids control the intensity of the electron beam. By adjusting the voltage applied to these grids, the brightness of the display can be modified. Deflection System – The electron beam needs to be directed precisely to the correct location on the screen. This is achieved through either electrostatic or electromagnetic deflection. Electrostatic deflection is more commonly found in oscilloscopes, while electromagnetic deflection is used in televisions and computer monitors. Phosphor-coated Screen – The screen inside a CRT is coated with a phosphorescent material, usually in the form of tiny dots or stripes. When the electron beam strikes the screen, the phosphor glows, producing light and thus creating an image. Vacuum Tube – The entire assembly is enclosed in a vacuum tube. This vacuum is necessary to prevent the electrons from being scattered by air molecules as they travel from the electron gun to the screen. There are some other components but due to simplicity we are ignoring them. How Does a CRT Work? The working of CRT is quite interesting. CRT operates by shooting a focused beam of electrons, or "cathode rays," onto a phosphor-coated screen. We can follow the following steps to get a better insight. Electron Emission – The electron gun generates a stream of electrons by heating a cathode (a metal filament). This process is known as thermionic emission. Focusing the Beam – The control grids shape the electron beam and focus it into a narrow stream. This step is important to ensure that the image displayed is sharp and not blurry. Deflection of the Beam – The deflection system moves the electron beam across the screen. In older CRTs, this was achieved using electromagnetic coils placed around the neck of the tube. By varying the current through these coils, the beam could be swept horizontally and vertically across the screen. Image Display – When the electrons hit the phosphor coating, the phosphor glows, emitting visible light. The pattern in which the electrons hit the screen determines the shape, brightness, and color of the image. In color CRTs, there are three electron guns, each emitting electrons toward a red, green, or blue phosphor. These three colors combine in different intensities to form all the colors seen on the screen. Applications of CRT CRT were used in many different devices. Nowadays they are quite obsolete but it was quite popular before. Let us see some of the applications of CRT. Television Screens – CRTs were once the dominant technology for television displays. The electron beam would scan the screen line by line to create an image. Computer Monitors – Early computer displays were built using CRTs. These monitors could display text and graphics by controlling where the electron beam struck the phosphor screen. Oscilloscopes – In laboratory settings, CRTs are used in oscilloscopes to graph electrical signals. The deflection of the electron beam is proportional to the input voltage, allowing engineers and scientists to visualize waveforms. Advantages of CRT Let us see some of the key advantages of CRT screens that are used in different applications as we have seen before. High Contrast and Brightness – CRTs can produce very bright images with a high contrast ratio, making them ideal for use in environments with variable lighting. Wide Viewing Angles – CRT displays do not suffer from the restricted viewing angles common in early LCDs, providing a consistent image quality from multiple perspectives. Fast Response Time – CRTs have near-instantaneous response times, which made them highly suitable for applications like gaming or scientific visualization. Limitations of CRT Apart from these advantages, CRTs also had several limitations, which eventually led to their replacement by modern technologies – Bulky and Heavy – CRTs are large and heavy, especially as screen sizes increase. This made them less practical for portable devices or for use in smaller spaces. Power Consumption – CRTs consume significantly more power than modern displays such as LED or LCD screens. This makes them less energy efficient and more expensive to operate over time. Screen Burn-In – Prolonged display of static images could cause burn-in on CRT screens, leaving permanent marks on the phosphor coating. Harmful for Eyes – CRT screens are very bright. To watch TVs for long times or working on computers in front of CRT monitors would lead to eye damage. Conclusion In this chapter, we covered the basic principles and components of Cathode Ray Tubes, including how they function and the different parts involved, such as the electron gun, deflection system, and phosphor screen. We also understood key examples of CRT applications, specifically in television sets and oscilloscopes, illustrating their widespread use in electronic devices. The CRT technology is obsolete now but it was crucial in the evolution of electronic displays. CRTs offered advantages like high contrast, fast response time, and wide viewing angles display. However, its bulkiness and high power consumption have led to its replacement by more advanced and efficient technologies. 17 Mar 2025 | 2 min readThe CRT Monitor display by using a combination of phosphors. The phosphors are different colors. There are two popular approaches for producing color displays with a CRT are:Beam Penetration MethodShadow-Mask Method1. Beam Penetration Method:The Beam-Penetration method has been used with random-scan monitors. In this method, the CRT screen is coated with two layers of phosphor, red and green and the displayed color depends on how far the electron beam penetrates the phosphor layers. This method produces four colors, red, green, orange and yellow. A beam of slow electrons excites the outer red layer only, hence screen shows red color only. A beam of high-speed electrons excites the inner green layer. Thus screen shows a green color.Advantages:Disadvantages:Only four colors are possibleQuality of pictures is not as good as with another method.2. Shadow-Mask Method:Shadow Mask Method is commonly used in Raster-Scan System because they produce a much wider range of colors than the beam-penetration method.It is used in the majority of color TV sets and monitors.Construction: A shadow mask CRT has 3 phosphor color dots at each pixel position.One phosphor dot emits: red lightAnother emits: green lightThird emits: blue lightThis type of CRT has 3 electron guns, one for each color dot and a shadow mask grid just behind the phosphor coated screen.Shadow mask grid is pierced with small round holes in a triangular pattern.Figure shows the delta-delta shadow mask method commonly used in color CRT system.Working: Triad arrangement of red, green, and blue guns.The deflection system of the CRT operates on all 3 electron beams simultaneously; the 3 electron beams are deflected and focused as a group onto the shadow mask, which contains a sequence of holes aligned with the phosphor-dot patterns.When the three beams pass through a hole in the shadow mask, they activate a dotted triangle, which occurs as a small color spot on the screen.The phosphor dots in the triangles are organized so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.Inline arrangement: Another configuration for the 3 electron guns is an inline arrangement in which the 3 electron guns and the corresponding red, green, and blue color dots on the screen, are aligned along one scan line rather than in a triangular pattern.This inline arrangement of electron guns is easier to keep in alignment and is commonly used in high-resolution color CRT's.Advantage:Realistic imageMillion different colors to be generatedShadow scenes are possibleDisadvantage:Relatively expensive compared with the monochrome CRT.Relatively poor resolutionConvergence ProblemNext TopicDirect View Storage Tubes Share – copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt – remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution – You must give appropriate credit. Provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike – If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions – You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. You may have heard the term "CRT," and you might know that it has something to do with TVs, monitors, video games, or computers, but what does "CRT" actually mean? We'll explain. What Is a CRT? In the context of electronics, CRT stands for "cathode ray tube." It's a technical term for the glass picture tube inside of a vintage TV set or computer monitor--the kind used before flat-screen displays became common. CRTs are electronic image display devices that have the advantage of showing information dynamically without the need for moving parts. When someone says "a CRT," they might also be referring to a TV set or monitor that uses a picture tube instead of a flat-panel display. Before the discovery of electron emission from a cathode (a negatively charged electrode), casting shadows inside a vacuum tube. In 1897, a German engineer named Karl Ferdinand Braun added a phosphorescent screen and magnetic deflection control to create the first cathode ray tube, which he used to display the waveform of AC current like an oscilloscope. Karl Ferdinand Braun Over time, other scientists discovered that CRTs could be used to display moving images without the need for mechanical moving parts, providing a key element to the commercialization of television. Later, computers began to use CRT monitors as output devices as well, making them more interactive and eliminating the need for continuous printed paper output. CRTs are sealed glass vacuum tubes that contain three major components: an electron source (often called an electron gun), an electromagnetic deflection system (that steers the electron beam), and a phosphorescent screen that glows when hit by the electron beam. In the case of a color CRT display, there are three electron guns: one each for red, green, and blue, and they are aimed at colored phosphors that glow with those colors when hit by the corresponding beams. The intensity of the beam can be modulated as well, which changes the brightness in certain parts of the image. Chemistryg v / Shutterstock<3> Chemistryg / Shutterstock CRT televisions and most CRT computer monitors draw an image on the screen line by line, from top to bottom, in a raster pattern, 30 or 60 times a second. This is called a raster display. Other CRTs, such as those used in oscilloscopes and in some early arcade video games, directly plot an image by tracing lines on the phosphor screen with a single electron gun, more like an electronic Etch-A-Sketch. These are called vector displays. Obviously, we're just simplifying things here. CRTs need a lot of additional supporting circuitry, such as a power supply and logic to receive and generate the image signals that will be displayed on the screen. Those components vary by display size, type, and manufacturer. Sure, some people still use CRTs for specialized cases—including for legacy electronics (such as in some older airplane cockpits) and for retro gaming—but otherwise, the CRT's time has come and gone. CRTs were most popular between the 1950s and the mid-2000s, first in television sets and then in computer monitors as well. In the United States, commercial CRT television production ceased largely in the mid-2000s, with some holdouts continuing into the 2010s. Today, a few specialized firms still make or refurbish CRTs, but largely for non-consumer markets. Vizio Most people don't use CRTs anymore because flat-screen display technology (led largely by LCDs) has significant commercial and physical advantages. In general, flat-screen displays are cheaper to manufacture, are lighter and thinner, use less electricity, and produce less heat than CRT displays. They also provide opportunities for digital sharpness, clarity, and resolution far beyond that of a CRT display, and flat screens can be manufactured in much larger screen sizes than CRTs. In the 2000s and 2010s, CRTs still offered advantages over flat-panel technologies in some categories, such as better color richness, better response time, and better multi-sync resolution support, but recent advances in flat-screen tech have closed most of those gaps. Still, there are people who prefer CRTs for vintage computer and video-gaming applications, since CRTs were the intended display technologies in use at the time. There are three main reasons why CRTs are often better than flat-panel displays for retrogaming. Benj Edwards / How-To Geek The first reason is that CRTs handle the odd, non-standard display resolutions of old game consoles better than modern digital displays. When used with modern HDTVs, old game console graphics can look stretched, washed out, jagged, or blurry. But when viewed on a vintage CRT, everything is crisp and correctly proportioned. Second, some video game accessories, such as light guns, only work with CRT displays. You can't play Nintendo's Duck Hunt on an HDTV with an original light gun, because the technology works in perfect synchronization with a CRT's video signal timing. Third, the visual artifacts created when images are displayed on a CRT can be considered part of the original intended art style of some video games. In fact, some games took advantage of the properties of an NTSC signal or the CRT itself to blend colors or provide the illusion of more depth, shading, and transparency than would be the case on a pixel-perfect display. (For excellent examples of this, check out this deep thread on Twitter.) Benj Edwards<3> Benj Edwards Most of those positive graphical artifacts are lost when modern games are presented in pixel-perfect formats through emulators or on modern digital displays. You'll lose the blending of colors, and the aspect ratio might be off as well, since not all pixels were intended to be square. With CRTs on the endangered species list, there is some fear that we may lose touch with this important 20th-century technology for good. But when it comes to supposedly obsolete technology, don't count anything out forever. Just look at the success of vinyl and the Impossible Project, which brought Polaroid instant film back into production. Some day, we may see the rise of CRTs again for boutique applications, but until then, it's up to today's technicians to keep examples of this culturally important display technology alive so that future generations can see how it worked for themselves. The color CRT display is a device used for presenting information to a user. The CRT produces images by projecting an electron beam onto the screen and using the phosphor colors to produce colors or light. A color television display often referred to as a TV or simply as "the telly" is an electrical appliance that emits images in order to present content, predominantly as part of consumer media rather than professional equipment. Although color televisions were used for the first time in Europe in 1928 and in North America in 1929, the first commercially successful television which could be purchased by a consumer was not available until 1939. The use of electronic devices for displaying information has become less common with the advance of computers and other digital media, but televisions are still very popular. CRT stands for "cathode ray tube". The CRT is a display device that uses a focused beam of electrons to produce images. The images can be transferred into various other output devices, like video projectors or computer monitors (see also: Digital television ). The display is built of colored phosphor dots or diodes; each dot is called a "picture element", or "pel" for short. History:First attempts at creating successful color television display date back to the beginning of the 20th century. In 1929, Westinghouse Electric Corporation demonstrated a color television display that was based on a rotating disk with three colored filter elements (red, green, and blue) and a phosphor coating. However, this system had too low a resolution for practical use at that time. Other attempts to create color television displays were made throughout the 1930s but none of them became commercially successful due to various physical defects in the devices. During the 1950s and 1960s, some television sets used multi-colored CRTs to produce colorful images, but the display device was not easy to operate and of low quality, especially compared to regular black-and-white TV sets. As a result, color television set sales did not reach a large scale until the early 1960s. In 1968 Sony Corporation of Japan demonstrated a prototype for a color television set using a new type of color CRT called an "e-CRT", which later became known as an "EDS" (electronically scanned display) because it uses an electron gun instead of phosphor dots as in other displays. Working:"EDS" CRTs emit an electron beam and the electron leaves the cathode of the CRT at a certain angle. When the beam hits a phosphor dot, the signal shifts to another color. With several layers of phosphors, one can produce multiple colors. The brightness of each color is controlled by a color wheel (sometimes called "color wheel"). The image produced in such a TV display needs to be converted into a digital format before it can be displayed on computers or mobile devices. This is done by special marking patterns on or near the screen: what are known as "luma" and "chroma". Luma is used to represent the brightness information in an image, while chroma represents the color information. The luma pattern on a CRT display consists of two vertical stripes, one dark and one bright. It is usually placed where the center of the picture is located; for example, between two vertical stripes indicating fine horizontal lines of a black-and-white image. As such, it can be scanned by a TV tuner card's (TV tuner) analog-to-digital converter with minimal loss of resolution. Advantages: The color CRT display has several advantages over other types of displays: Color CRT displays can produce very good images. The image quality of a good color CRT TV or computer monitor is still considered to be better than the quality provided by any other type of display, although advances in digital technology are beginning to make this statement less true.Color CRT displays are usually able to present images at high resolutions and can produce clear images with both analog and digital content (although they do not produce as sharp an image as a computer monitor).Color CRT displays can support several different image sizes (e.g. 4x3, 16x9, etc).Conclusion: While the overall image quality of color CRT displays is still considered to be better than other types of displays, especially for computer monitors, images colored in with digital content tend to be sharper and clearer. The recent introduction of high-definition television (HDTV) has led to sharper images, but poor color saturation. The greater cost usually associated with a color CRT or computer monitor is usually justified by the higher quality images and better resolution (especially for computer monitors). What is a Cathode-Ray Tube?A Cathode Ray Tube (CRT) is a vacuum tube that projects a beam of electrons onto a screen coated in phosphor to display images. When the beam strikes the screen, it causes the phosphor to glow, forming visible images. CRTs were widely used in older televisions and computer monitors before flat-panel displays became common. Computer GraphicsComputer graphics is the field that deals with the processing and presentation of visual content through the use of computers. It includes applying mathematics and programming methods to create visuals and animations, which makes it possible to visualize data, simulate real-world situations, and create digital art, games, and user interfaces.What is CRT In Computer Graphics?CRT (Cathode Ray Tube) was the original technology used for displaying images on screens, like the bulky old computer monitors and TVs. Electron beams generate images by directing an electron beam onto a phosphorescent screen. The brightness and placement of the images are determined by the strength and direction of these beams. Although now largely replaced by flat-panel displays like LCDs and LEDs, CRTs played a crucial role in the early development of visual media technology.CRT in computer graphics operates with an electron beam that moves to form images on the screen. A conductive layer called phosphor is placed inside the screen, which gives off light as a result of being struck by electrons. As the beam moves and strikes different parts of the screen, it lights them up, and images form on the screen. Even though CRTs are among the less frequently used display device types today, they were of huge importance in the earlier stages of computer graphics, helping to draw and display text, images, and video games dynamically.How Does a Cathode Ray Tube Work in Computer Graphics?An electric current is used to send electrons through the Cathode Ray Tube in computer graphics. The electrons hit the phosphor-coated screen, which then becomes illuminated, and hence a picture is shown on the screen.Here's how it all comes together and the working of cathode ray tube in computer graphics:Electron Gun: At the back of the CRT, there' an electron gun that shoots a focused beam of electrons.Deflection System: Both electrostatic and electromagnetic deflection mechanisms are used to steer the beam, regulating its passage over the screen in both vertical and horizontal directions.Phosphor Coating: When the beam hits the phosphor on the screen, it glows, creating a visible image. As the beam moves across the screen, this glow appears rapidly.Scant Lines: The beam moves across the screen in a raster scan pattern, going from top to bottom in lines, just like how a printer creates an image.An image visible to the human eye can be produced by using an electron beam and a cathode ray tube in regular movement. Even though the image is composed of hundreds of tiny, relatively distinct light dots, the speed at which the beam moves gives it the appearance of being solid.Raster Scan and Vector Scan(Random Scan)Raster Scan and Vector Scan are two different display techniques used in computer graphics:Raster Scan: This method displays images by scanning the screen pixel by pixel in a grid-like pattern. It is commonly used in television and computer monitors, where the entire screen is refreshed at regular intervals. It is ideal for displaying complex images and video.Vector Scan: This technique draws images using lines and curves by continuously directing the electron beam to specific points. It is used in older oscilloscopes and certain types of displays, offering sharp, precise images, but with limitations in displaying complex images.Difference between Raster Scan and Vector Scan Vector Scan Features Raster Scan Vector Scan Method Scans pixel-by-pixel in a systematic, row-by-row manner. Draws lines based on mathematical vector data. Image Generation Best suited for displaying detailed, complex images. Ideal for displaying simple shapes and wireframes. Refresh Rate Constantly refreshed to maintain image clarity. Refreshes only when new shapes are drawn. Resolution Offers high resolution for smooth, detailed visuals. The complexity of shapes limits resolution. Performance May perform slower due to pixel-based scanning. Generally faster for simple graphics, but slower with complex ones. Resolution in CRTResolution, which is commonly expressed in terms of width and height (e.g., 1920x1080), describes the maximum number of different pixels that may be seen on a CRT (Cathode Ray Tube) display. Because there are more pixels in a higher resolution, the visuals are clearer and more sharper.Intensity distribution in CRTThe change in the brightness of the display is designated as the brightness distribution. Usually, the intensity of the electron beam and its interaction with the screen's phosphors determine the brightness levels.Aspect RatioThe ratio of the screen's width to height is known as the aspect ratio in CRT. The common aspect ratio is 4:3, and the widescreen is 16:9. The image's form and the way the content is presented are influenced by this ratio.Components of CRT in Computer GraphicsA Cathode Ray Tube (CRT) is a deceptively simple piece of equipment that contains several main parts, all of which jointly produce pictures on the screen. Let's start by looking at each part separately:Electron Gun: Let's say that the electron gun is a shooter of the CRT. A narrow beam of electrons is fired in the direction of the screen. The gun usually consists of a filament that is heated and thus generates electrons, and a control grid that determines the number of electrons emitted. The spot on the screen gets brighter as the number of electrons increases.Deflection System: This functions similarly to the electron beam's "steering wheel". The deflection system is equipped with either electromagnetic coils or electrostatic plates that help the beam travel across the screen in both directions. This system is designed to guarantee that the electron beam moves at the right speed and at the exact position to create an image by lighting the phosphor coating in the correct places.Phosphorus-Coated Screen: The inner surface of a CRT (Cathode Ray Tube) screen is coated with Phosphorus. The images we see on the screen are created when the phosphor emits visible light upon being struck by an electron beam. Each time the beam hits a phosphor dot, it illuminates briefly before fading out. The overlapping lights blend effectively due to the rapid movement of the beam, creating a continuous visual experience. Apart from Phosphorus, zinc sulfide is also used in CRTs to produce green or blue light.Focusing and Accelerating Anodes: Before the electron beam reaches the screen, these components ensure that it is carefully focused and rapidly accelerated. The focal anode generates the light beam into a small, dense spot, whereas the speed of the electrons is increased by the accelerating anode, hence, they will reach the screen carrying the right energy to generate a bright picture.Aquadag: Aquadag is aqueous graphite solution, which is connected to the secondary of anode. To preserve the electrical balance within a CRT display, the electrons emitted through secondary emission must be directed and absorbed by the Aquadag coating, which acts as a conductive layer inside the tube.These components all work together in harmony to create the images and text we see on older computer monitors and televisions. While CRT technology has been replaced by newer display methods, understanding these parts shows how early computer graphics were displayed on screens.Construction of a CRTA Cathode Ray Tube (CRT) is made up of several key components:1. Glass Tube: A large glass tube with a wide back and a screen at the front, where images are displayed.2. Electron Gun: Located at the back, the electron gun emits a stream of electrons toward the screen.3. Deflection System: It uses magnetic coils or electrostatic plates to direct the electron beam across the screen in a raster pattern (top to bottom).3.1. Types of Deflection System:Electrostatic Deflection: Electrostatic deflection uses electrical fields that are formed between two parallel plates to direct the electron beam inside a CRT. When voltage is applied, the beam bends toward the charged plate, allowing precise and fast control of its path.Magnetic Deflection: The electron beam is guided to various screen positions by the magnetic fields from coils around the CRT through magnetic deflection. When electric current passes through the coils, the magnetic field deflects the beam, allowing precise and fast control of its path.4. Phosphor Coated Screen: The inner surface of the CRT screen is coated with phosphor, which glows when struck by electrons, creating visible images.5. Shadow Mask or Aperture Grille: A metal plate ensures the electron beam hits the right phosphor colours (red, green, blue) for accurate colour display.6. Neck and Focusing System: The neck holds the focusing system that sharpens the electron beam for clear images.Colour CRT MonitorA colour CRT (Cathode Ray Tube) monitor is a display device that generates images using three electron beams, each corresponding to red, green, and blue light. These beams strike a phosphor-coated screen, and by varying their intensity, a full spectrum of colours is produced. The beams are aligned carefully to ensure accurate colour mixing and sharp visuals, making CRTs suitable for early televisions and computer monitors.Beam Penetration Method In certain colour CRTs, particularly those that are inexpensive, the beam penetration method is used. The inner screen is covered with two layers of phosphor, usually red and green. A low-energy electron beam excites only the red layer, while a high-energy beam penetrates to activate the green layer. By adjusting the beam's energy, intermediate colours like orange or yellow can also be produced, although the colour range is limited compared to modern methods.Shadow-Mask MethodIn the shadow-mask technique, a metal sheet with tiny holes (the shadow mask) is placed between the electron guns and the screen. Three electron guns (for red, green, and blue) are aimed so that their beams pass through these holes and strike the appropriate coloured phosphor dots on the screen. This precise targeting ensures correct colour rendering and is widely used in colour televisions and monitors for its accuracy.Applications of CRT in Computer GraphicsBelow mentioned are a few applications of the cathode ray tube in computer graphics:Computer Monitors: CRTs were the standard for early computer monitors, used to display operating systems, software, and websites.Flight Simulation: CRTs simulated dynamic environments for aviation training.Medical Equipment: Early medical imaging devices, like oscilloscopes and X-ray machines, used CRTs to visualize patient data.Radar and Navigation: CRTs displayed real-time radar signals and sonar data for aviation, navigation, and military applications.Scientific Research: CRTs played a key role in visualizing challenging data for scientific experiments.Television Displays: CRT technology powered the first generations of television screens, offering color visuals for movies and shows.Video Games: Arcade games and early home consoles used CRTs to display dynamic game graphics and colorful animations.Control Rooms: Industrial systems used CRTs to display real-time data for machinery and process monitoring.Surveillance: Security systems used CRT screens to monitor multiple video feeds simultaneously.Advantages of CRT in Computer GraphicsHere are some notable advantages of CRT technology in computer graphics:Vivid Colors: CRTs could display rich and deep colors, which made them ideal for detailed and vibrant images.Durability: CRT screens were built to last longer than some modern flat-panel displays, with fewer concerns about dead pixels.Color Accuracy: CRTs offered superior color accuracy and consistency across different lighting conditions, making them ideal for professional work like graphic design.Fast Response Time: CRTs have almost instant pixel response, minimizing motion blur and ghosting in fast-moving images.Multiple Resolutions: CRTs supported a variety of resolutions, making them adaptable for different tasks and providing flexibility for users.High Contrast Ratios: CRTs provide outstanding contrast for vibrant images by producing darker blacks and brighter whites.Low Input Lag: With minimal delay between user input and the screen's response, CRTs were ideal for activities like gaming and real-time simulations.Limitations of CRT in Computer GraphicsHere are some of the limitations of Cathode Ray Tube in computer graphics:Bulky and Heavy: CRTs were quite large and heavy, making them difficult to move and fit in modern workspaces.High Power Usage: They consumed a lot of energy compared to newer display technologies like LCDs and LEDs.Screen Flickering: CRTs often caused flickering, especially at lower refresh rates, which could lead to eye strain and fatigue.Distortion at Edges: CRTs sometimes suffered from geometric distortions and image warping, especially near the corners of the screen.Limited Size Options: While available in various sizes, CRTs were often bulky, and the larger sizes came with heavy weight and space limitations.ConclusionIn conclusion, CRT in computer graphics played a pivotal role in the evolution of digital displays, offering vibrant colors, fast refresh rates, and wide viewing angles. While modern technologies like LCD and LED have surpassed CRTs in terms of efficiency and size, CRTs laid the foundation for graphical interfaces we use today. Despite their limitations, such as bulkiness and high power consumption, CRTs were integral in shaping early computer graphics. Their impact on fields like gaming, medical imaging, and television is undeniable. Understanding CRT in computer graphics helps us appreciate the technological advancements that have led to today's sleek, high-resolution screens.Frequently Asked QuestionsA CRT works by firing an electron beam at the phosphor-coated screen. As it moves across the screen, the electron beam illuminates phosphor dots, creating an image.2. What Are the Advantages of CRT in Computer Graphics?CRTs offer rich colors, fast refresh rates, and wide viewing angles, making them great for video, gaming, and computer graphics.3. What Are the Disadvantages of CRT in Computer Graphics?CRTs are bulky, heavy, and energy-inefficient, which led to the development of newer technologies like LCDs and LEDs for displays.4. Why Was CRT Replaced by LCD and LED Displays?LCDs and LEDs are more compact, energy-efficient, and provide higher resolutions, which made them better alternatives to CRTs in modern devices.5. What Was the Role of CRT in Early Video Games?CRT monitors played a crucial role in the early video gaming era, offering high refresh rates and fast response times that made them ideal for displaying smooth, real-time gameplay graphics.6. Can CRTs be used for High-Resolution Displays?While CRTs can support multiple resolutions, they are typically not as sharp as modern LCD or LED displays, especially at higher resolutions. However, they still offer good image quality, especially for older video games or specific professional applications.7. What is a cathode ray tube in computer graphics? A Cathode Ray Tube (CRT) is one of the early display technologies which are used to create images on a phosphor-coated screen by an electron beam. The beam draws the pixels of the screen in a pattern, and lights them up to get the picture. CRTs were once common in computer monitors and televisions. A CRT monitor contains millions of tiny red, green, and blue phosphor dots that glow when struck by an electron beam that travels across the screen to create a visible image. The illustration below shows how this works inside a CRT. The terms anode and cathode are used in electronics as synonyms for positive and negative terminals. For example, you could refer to the positive terminal of a battery as the anode and the negative terminal as the cathode. In a cathode ray tube, the "cathode" is a heated filament. The heated filament is in a vacuum created inside a glass "tube." The "ray" is a stream of electrons generated by an electron gun that naturally pour off a heated cathode into the vacuum. Electrons are negative. The anode is positive, so it attracts the electrons pouring off the cathode. This screen is coated with phosphor, an organic material that glows when struck by the electron beam. There are three ways to filter the electron beam in order to obtain the correct image on the monitor screen: shadow mask, aperture grill and slot mask. These technologies also impact the sharpness of the monitor's display. Let's take a closer look at these now. This was one the earlier CRTs to produce color displays. Coating phosphors of different compounds can produce different colored pictures. But the basic problem of graphics is not to produce a predetermined color, but to produce color pictures, with the color characteristics chosen at run time.The basic principle behind colored displays is that combining the 3 basic colors –Red, Blue and Green, can produce every color. By choosing different ratios of these three colors we can produce different colors - millions of them in fact. We also have basic phosphors, which can produce these basic colors. So, one should have a technology to combine them in different combinations. There are two popular techniques for producing color displays with a CRT are:Beam Penetration method This CRT is similar to the simple CRT, but it makes use of multi coloured phosphorus of number of layers. Each phosphorus layer is responsible for one colour. All other arrangements are similar to simple CRT. It can produce a maximum of 4 to 5 colours The organization is something like this – The red, green and blue phosphorus are coated in layers – one behind the other. If a low speed beam strikes the CRT, only the red colored phosphorus is activated, a slightly accelerated beam would activate both red and green (because it can penetrate deeper) and a much more activated beam would activate all three phosphors to produce red, green and blue in suitable proportions to get a combination of colors, but it's principle is much more sophisticated and stable. The shadow mask CRT, instead of using one electron gun, uses 3 different guns placed one by the side of the other to form a triangle or a "Delta" as shown. Each pixel point on the screen is also made up of 3 types of phosphors to produce red, blue and green colors. Just before the phosphor screen is a metal screen, called a "shadow mask". This plate has holes placed strategically, so that when the beams from the three electron guns are focused on a particular pixel, they get focused on particular color producing pixel only i.e. if for convenience sake we can call the electronic beams as red, blue and green beams (though in practice the colors are produced by the phosphors, and until the beams hit the phosphor dots, they produce no colors), the metal holes focus the red beam onto the red color producing phosphor, blue beam on the blue producing one etc. When focused on to a different pixel, the red beam again focuses on to the red phosphor and so on.Now, unlike the beam penetration CRTs where the acceleration of the electron beam was being monitored, we now manipulate the intensity of the 3 beams simultaneously. If the red beam is made more intense, we get more of red color in the final combination etc. Since fine-tuning of the beam intensities is comparatively simple, we can get much more combination of colors than the beam penetration case. In fact, one can have a matrix of combinations to produce a wide variety of colors.The shadow mask CRT, though better than the beam penetration CRT in performance, is not without it's disadvantages. Since three beams are to be focused, the role of the "Shadow mask" becomes critical. If the focusing is not achieved properly, the results tend to be poor. Also, since instead of one pixel point in a monochrome CRT now each pixel is made up of 3 points (for 3 colors), the resolution of the CRT (no. of pixels) for a given screen size reduces. Another problem is that since the shadow mask blocks a portion of the beams (while focusing them through the holes) their intensities get reduced, thus reducing the overall brightness of the picture. To overcome this effect, the beams will have to be produced at very high intensities to begin with. Also, since the 3 color points, though close to each other, are still not at the same point, the pictures tend to look like 3 colored pictures placed close by, rather than a single picture. Of course, this effect can be reduced by placing the dots as close to one another as possible.The above displays are called refresh line drawing displays, because the picture vanishes (typically in about 100 Mill seconds ) and the pictures have to be continuously refreshed so that the human persistence of vision makes them see as static pictures. They are costly on one hand and also tend to flicker when complex pictures are displayed (Because refreshing because complex). These problems are partly overcome by devices with inherent storage devices - i.e. they continue to display the pictures, till they are changed or at least for several minutes without the need of being refreshed. We see one such device called the Direct View Storage Tube (DVST) below.