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VECTORS FOR COMPUTER GRAPHICS

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VECTORS FOR COMPUTER GRAPHICS

INTRODUCTION

Mathematics is the study of numbers, shapes and patterns. There are some mathematical studies that include such as number, structure, place and change. Mathematics is important because it help human to solve the problem. Math is also important in Computer Graphics as it is used to create graphical models that use multiple calculations. The mathematical calculations used can be complicated but the basic math is still required to produce the computer graphics aspect. The most common mathematical calculation that computer graphics used is linear algebra.

WHAT IS VECTORS

There are three distinct but related ideas about vectors, which is the physics student perspective, computer science student perspective and mathematician's perspective. The physics student perspective about vectors is that arrows are pointing in space. It defines as vector is its length, and the direction it's pointing in, as long as those two facts are the same. The direction can move all around at space with the same length and it is still have the same vector. Vector that live in the flat plane are two dimensional (2D) while those in broader space like human being live in are three dimensional (3D). Computer science perspective is that vectors are ordered lists of numbers and an entity that has magnitude and direction.

Example: (2, 3, 1) represents as **displacement** from the origin of two units along x-axis, three units along the y-axis, and one unit along z-axis. Vectors can do the basic mathematics operations as usual but unlike real number multiplication, vectors cannot multiplied among themselves. So, there are two special type of vector multiplication that can be used called: **Dot Product** and **Cross Product.**

$$\vec{u} = \begin{bmatrix} u1, \\ u2, \\ u3 \end{bmatrix}$$

Addition

Vector addition mathematically represented as:

$$\vec{u} = \begin{bmatrix} u1, \\ u2, \\ u3 \end{bmatrix} \quad \vec{v} = \begin{bmatrix} v1, \\ v2, \\ v3 \end{bmatrix}$$

$$\vec{u} + \vec{v} = \begin{bmatrix} u1, \\ u2, \\ u3 \end{bmatrix} + \begin{bmatrix} v1, \\ v2, \\ v3 \end{bmatrix}$$

$$\vec{u} + \vec{v} = \begin{bmatrix} u1 + v1 \\ u2 + v2 \\ u3 + v3 \end{bmatrix}$$

Example;

$$\vec{u} = \begin{bmatrix} 4 \\ 2 \\ 3 \end{bmatrix} \quad \vec{v} = \begin{bmatrix} 1 \\ 5 \\ 3 \end{bmatrix}$$

$$\vec{u} + \vec{v} = \begin{bmatrix} 5 \\ 7 \\ 6 \end{bmatrix}$$

Subtraction

Vector subtraction mathematically represented as:

$$\vec{u} = \begin{bmatrix} u1, \\ u2, \\ u3 \end{bmatrix} \quad \vec{v} = \begin{bmatrix} v1, \\ v2, \\ v3 \end{bmatrix}$$

$$\vec{u} - \vec{v} = \begin{bmatrix} u1, \\ u2, \\ u3 \end{bmatrix} - \begin{bmatrix} v1, \\ v2, \\ v3 \end{bmatrix}$$

$$\vec{u} - \vec{v} = \begin{bmatrix} u1 - v1 \\ u2 - v2 \\ u3 - v3 \end{bmatrix}$$

Example;

$$\vec{u} = \begin{bmatrix} 4 \\ 2 \\ 3 \end{bmatrix} \quad \vec{v} = \begin{bmatrix} 1 \\ 5 \\ 3 \end{bmatrix}$$

$$\vec{u} - \vec{v} = \begin{bmatrix} 3 \\ -3 \\ 0 \end{bmatrix}$$

Scalar multiplication and division

Vector multiplied with a scalar stretches the length of a vector.

- o Multiplying vector by positive scalar = affects the magnitude only
- o Multiplying vector by negative scalar = affects magnitude and reverse the direction

$$\vec{u} = \begin{bmatrix} u1, \\ u2, \\ u3 \end{bmatrix} \quad k \text{ is a scalar}$$

$$k\,\vec{u} = k \begin{bmatrix} u1, \\ u2, \\ u3 \end{bmatrix} = \begin{bmatrix} ku1, \\ ku2, \\ ku3 \end{bmatrix}$$

Example;
Scaling vector by 3

$$\vec{u} = \begin{bmatrix} 2 \\ 3 \\ 1 \end{bmatrix} \quad k = 2$$

$$k\,\vec{u} = 2 \begin{bmatrix} 2 \\ 3 \\ 1 \end{bmatrix} = \begin{bmatrix} 4 \\ 6 \\ 2 \end{bmatrix}$$

Vector Product

Dot Product = vector operation that calculates the angle between two vectors.

$$\vec{u} = \begin{bmatrix} u1, \\ u2, \\ u3 \end{bmatrix} \quad \vec{v} = \begin{bmatrix} v1, \\ v2, \\ v3 \end{bmatrix}$$

$$\vec{u} \cdot \vec{v} = u1v1 + u2v2 + u3v3$$

Cross Product = produces vector operation that is perpendicular to both vectors.

$$\vec{u} = \begin{bmatrix} u1, \\ u2, \\ u3 \end{bmatrix} \quad \vec{v} = \begin{bmatrix} v1, \\ v2, \\ v3 \end{bmatrix}$$

$$\vec{u} \times \vec{v} = \begin{bmatrix} u2v3 - u3v2 \\ u3v1 - u1v3 \\ u1v2 - u2v1 \end{bmatrix}$$

WHY DO WE NEED TO APPLY VECTORS

Most of the calculation in computer graphics requires vector as it can represent directions, such as the direction from an object to a light source or the direction in which a surface faces. In those cases, we are more interested in the direction of a vector than in its length.

Other than that, vector graphics use geometrical shapes, points, lines, and curves, which are all based on mathematical equations, to represent images in computer graphics. The most recognized applications which handle vector based graphics are Adobe illustrator, Macromedia freehand and Corel draw. Vector graphics are generally used for line art, illustrations and embroidery. This is because vector graphic creates a clearer and accurate art line. As a result, it will create a nicer graphical images and illustrations which important to graphic designers. This helps them in creating designs that are clear and not pixelated to ensure that the design and the picture the intend to print stays in the proper resolution and design.

Additionally, in development of game, it often can be used to describe a change in position, and can be subtracted or added to other vectors. You will find a vector as a description of its 3 components X, Y, Z in most current game engines. This is because the game is defined in a 3D world so when we apply a force to a game object in our engine, we can apply it in each arbitrary direction inside the game. For games like 'Angry Birds', vectors are used to store the positions(X), directions(Y) and velocities (Z). The position vectors indicate how far the object is, while the velocity vector indicates how much time it will take or how much force we should give and the direction vector indicates in which way we should apply the force.
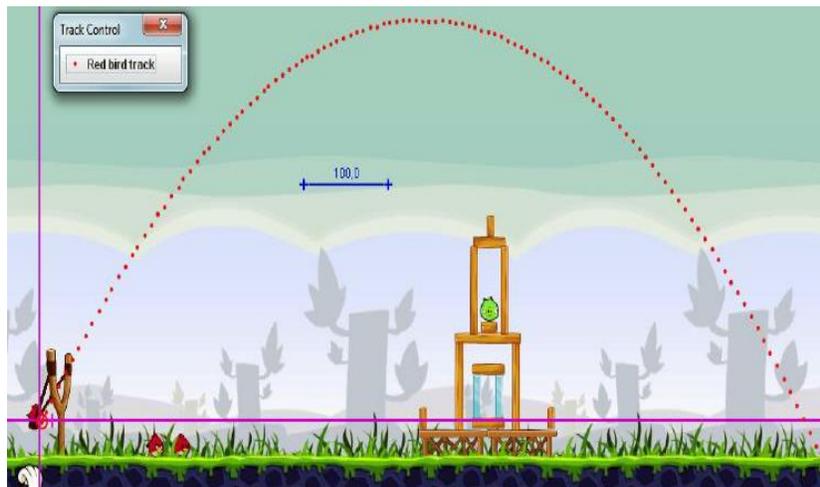

Game 'Angry Bird' that use vector

HOW WE USE VECTOR IN COMPUTER GRAPHIC

A Vector image is usually created by using professional graphics program such as Adobe Illustrator, InDesign and CorelDraw in the form of vector image files. Graphic designers use vector to create graphics that need to be scaled. A vector image use mathematical formulas to draw lines and curves that can be combined to create an image from geometric objects such as circles and polygons, each line, shape, color and curve in vector are mathematically defined to creating images that can scaled down for a name card or banner printing. Vector is suitable for printing since it is able to print very crisply even when resized an image because vector is made from a series of mathematical curves. Moreover, a high-quality typography is based on character drawings which are stored as vector graphics and able to adjust to any size nowadays. Postscript fonts and TrueType fonts are the examples of these vector formats for characters.

Besides, a vector image could be converted into a raster graphics image sometimes which bitmap directly to a display space so it can be ported between systems. A raster file is usually larger than a vector file. This is because raster image has to store color information for each individual pixel that forms the image while a vector image only has to store the mathematical formulas that make up the image which occupy less space. Even though there are specific tools that can convert a raster file such as GIF and JPEG files into a vector file such as scalable vector graphic (SVG) file for refinement but it is hard to modify without loss of information. For example, a vector logo can print on a sheet of A4 paper and resize the same logo to billboard size without changing the crisp quality. If we using a low-resolution raster graphic instead of vector to enlarge an image to billboard size, then it will become extremely unclear.

Raster graphics can be used if there are no crisp lines or edges in the file due to it consists of individual pixels which does not work very well to depict lines that does not follow the boundaries of individual pixels. This is because it consists of individual pixels and it does not work very well at depict lines that does not follow the boundaries of individual pixels.
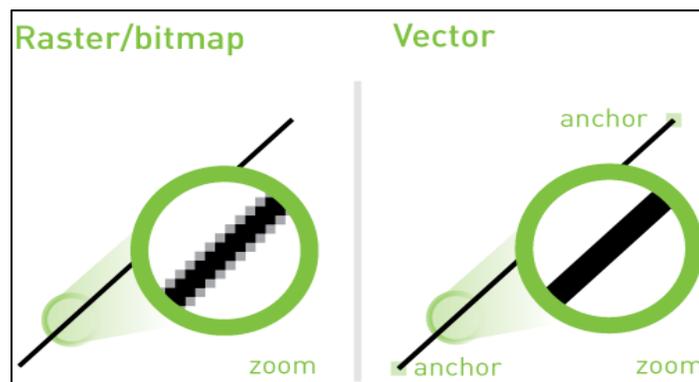
Difference between vector and raster graphic

RELATED ISSUES

What if vector never was never invented? What kind of issues would we be facing now? And what modern inventions or scientific discovery would not be possible without vector? To know all the answers, we need to first see some basic applications of vector.

1. To know how gravity exerts a force of attraction on a body - describe motion at an angle to the force of gravity, since the vector can be broken into its vertical and horizontal components.
2. To calculate motion of a body in a moving object.
3. Used to build structures by engineers – the holding force must be much stronger than the structure for it to sustain, else it will collapse.
4. In various propagations (sound propagation, wave propagation).
5. Quantum Mechanics & Fluid Mechanics.
6. Acoustics and Music: The frequency or Fourier analysis of sounds and musical notes is essentially a vector space analysis. Acoustic materials in auditoriums can absorb or reflect certain frequencies.
7. Images: Luminosity and luminous intensity are derived from polynomials whose coefficients can be represented by vector spaces. Pixilation uses vector space analysis, and as an extension, image processing algorithms apply vector space theory.
8. Nature: Fractals common in nature. Fractal analysis is an application of vector space theory.

One of the latest applications or systems that use this vector calculation is Adobe Illustrator because it uses a lot of vectors to determine physical movement. If vector was not invented, basically means we could have done nothing in physics because vector is one of the fundamentals in physics. We will not be able to express the motion of any particle in 2D only with respect to its time and speed or distance or displacement or acceleration. Without vectors we cannot build linear vector spaces and we cannot have related development in quantum mechanics. Hence, it is difficult to think as to what would have happened to physics without vectors. Probably tenors also would not have been there as in the precise definition of vector we have to have transformation property.

CONCLUSION

In conclusion, the use of vectors is important in everyday life in improving the way of life. Besides, the use of vectors in computer graphics also helps in determining the direction during which an object is created. That's why vectors are important because they can solve problems in measuring a motion

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