matrices

And their uses in computer science

What are matrices used for?

Matrices are used in a wide variety of computational problems involving linear equations, such as

- Artificial intelligence and machine learning
- Image recognition
- 2D and 3D computer graphics

Matrices are generally written using multidimensional arrays

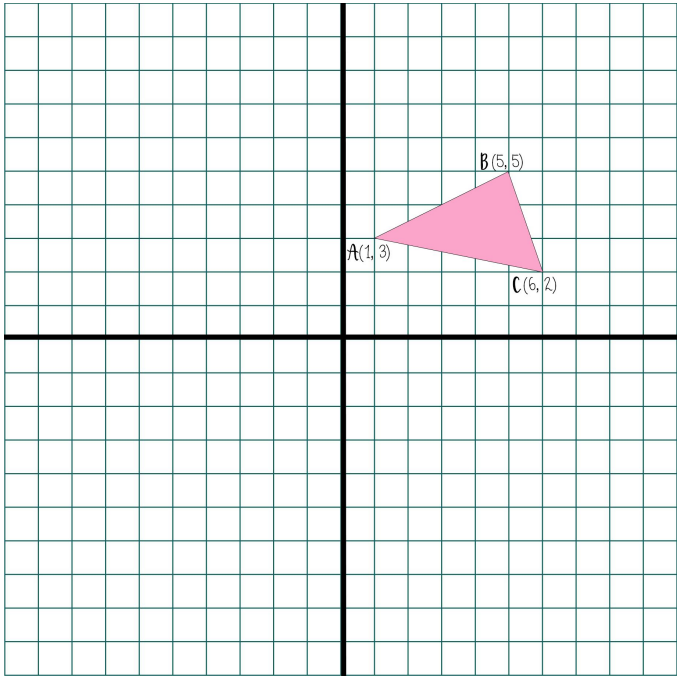
```
matrix = {
    {1, 0, 0, 0},
    {0, 1, 0, 0},
    {0, 0, 1, 0},
    {0, 0, 0, 1}
}
```

How are matrices used in computer graphics?

Mathematics using matrices are used to manipulate images and geometry. At the most basic level, they are used to apply translations, scaling, and rotations.

- Translations use simple matrix addition to move a shape from one area of the screen to another
- Scaling and rotations use matrix multiplication to perform the transformation
- Rotations are a bit more complicated since trigonometric identities need to be applied to the matrix

Translation



The points of the triangles represent the 2x1 matrices

$$A = \begin{bmatrix} 1 \\ 3 \end{bmatrix} \quad C = \begin{bmatrix} 6 \\ 2 \end{bmatrix}$$

$$B = \begin{bmatrix} 5 \\ 5 \end{bmatrix}$$

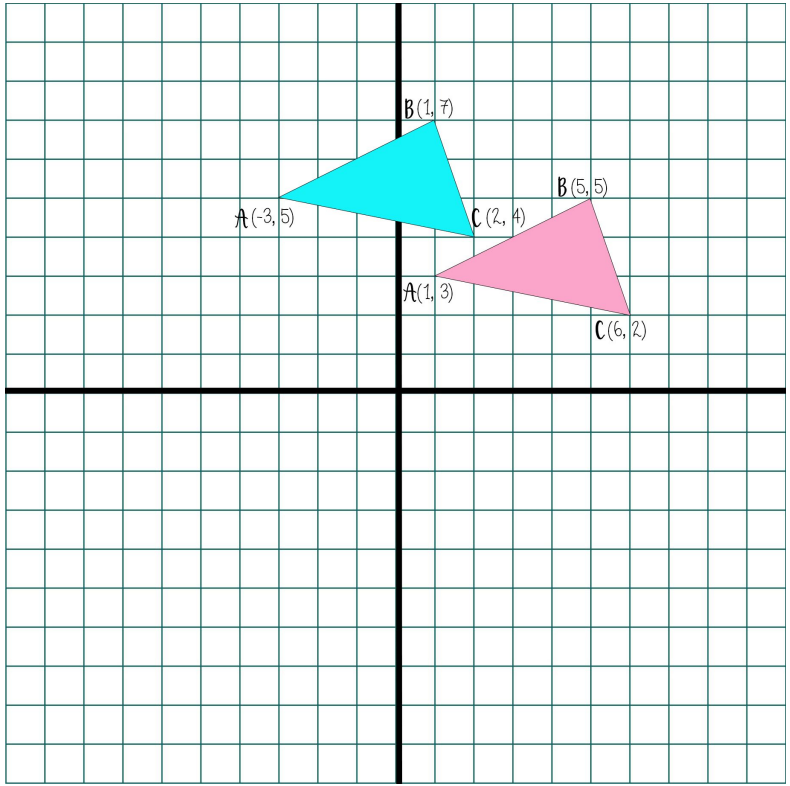
We want to translate the triangle 4 spaces to the left and 2 spaces up

Using matrix addition, we can translate the triangle

$$\begin{bmatrix} 1 \\ 3 \end{bmatrix} + \begin{bmatrix} -4 \\ 2 \end{bmatrix} = \begin{bmatrix} -3 \\ 5 \end{bmatrix}$$

$$\begin{bmatrix} 5 \\ 5 \end{bmatrix} + \begin{bmatrix} -4 \\ 2 \end{bmatrix} = \begin{bmatrix} 1 \\ 7 \end{bmatrix}$$

$$\begin{bmatrix} 6 \\ 2 \end{bmatrix} + \begin{bmatrix} -4 \\ 2 \end{bmatrix} = \begin{bmatrix} 2 \\ 4 \end{bmatrix}$$

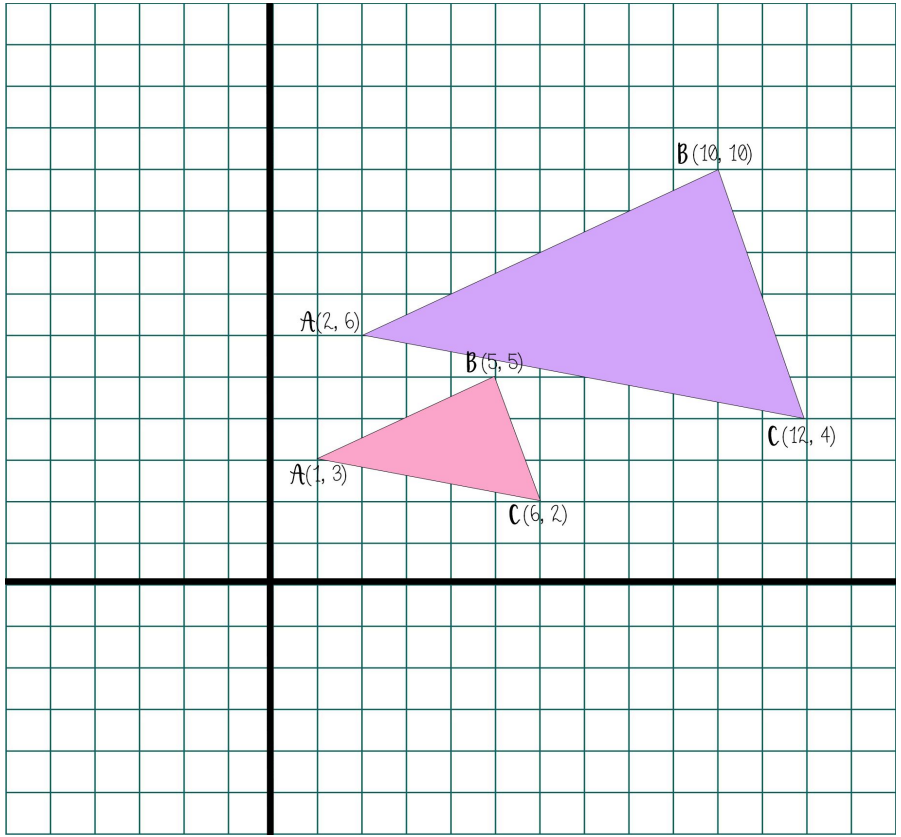


We can also scale the triangle using matrix multiplication

$$\begin{bmatrix}1\\3\end{bmatrix} \cdot \begin{bmatrix}2\\2\end{bmatrix} = \begin{bmatrix}2\\6\end{bmatrix}$$

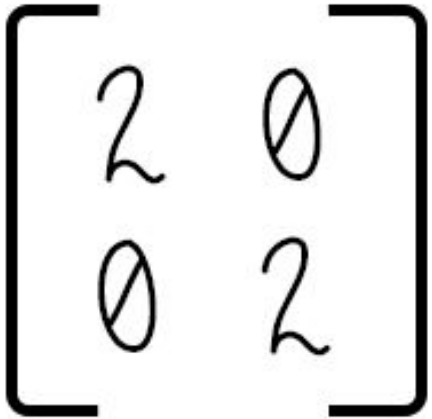
$$\begin{bmatrix}5\\5\end{bmatrix} \cdot \begin{bmatrix}2\\2\end{bmatrix} = \begin{bmatrix}10\\10\end{bmatrix}$$

$$\begin{bmatrix}6\\2\end{bmatrix} \cdot \begin{bmatrix}2\\2\end{bmatrix} = \begin{bmatrix}12\\4\end{bmatrix}$$



You can also scale the shape using a 2 x 2 matrix

- This allows us to multiply additional transformation matrices so that we can perform multiple transformations using a single operation
- This helps to cut down on processing time



Using this matrix will yield the same result for the scale transformation, but opens up more possibilities with what we can do with the shape in a single operation

In conclusion

Matrices are extremely powerful tools for generating and manipulating computer graphics

- They allow us to perform the operations that are necessary for creating 2D and 3D models quickly and efficiently
- They allow us to perform multiple transformations in a single operation which cuts down on processing time so we can implement more advanced graphic techniques
- Understanding how to utilize matrices in computer science is crucial to writing sophisticated and efficient programs

Thank you!