Computer Graphics

Lecture - 04

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Gentle Introduction

- No Mathematics

Gentle Introduction

- No Mathematics
- in this Lecture

Different Types of Games

- First Person Shooter (FPS)
- Strategy Games
- Simulation Games

First Person Shooter (FPS)

- Type of game where you run around 3D levels carrying a big gun shooting stuff
- Examples of this sort of game include Doom , Quake , Half Life , Unreal or Goldeneye
- There are other games that look very similar, but aren't first person shooters, for instance Zelda: Ocarina of Time or Mario 64

Strategy Games

- The Strategy games are divided into two main types
  - Real Time Strategy (RTS)
  - Turn Based Strategy
- These games usually involve building and managing a city or civilization and also fighting wars by controlling troops
- Examples of real time strategy games are Age of Empires , Command and; Conquer , Tiberian Sun
- Examples of turn based strategy games are Civilization and Alpha Centauri

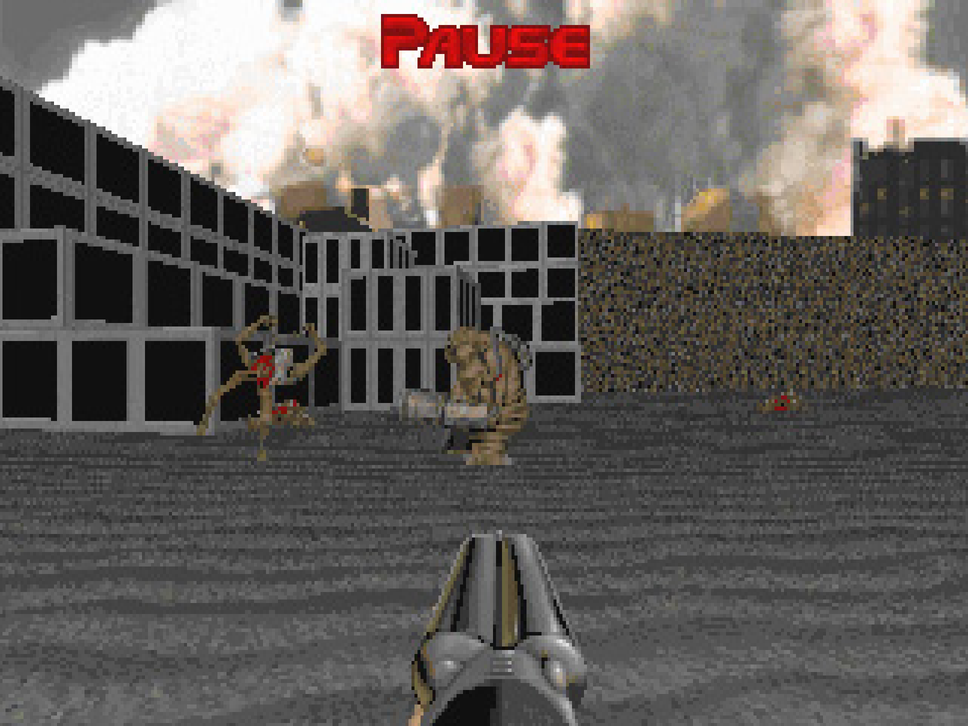
Simulation Games

- Games that try to make something as realistic as possible
- For instance, Flight Sims are computer games which try to realistically simulate flying an aeroplane or helicopter
- Two games of this sort are Microsoft Flight Simulator and Red Baron
- Space sims are like flight sims, but with spaceships instead of planes.
- For instance, Wing Commander or X-Wing vs. Tie Fighter .
- Racing games are games which simulate driving different sort of cars.
- For instance, Need for Speed , NASCAR Racing , Gran Turismo or Driver .

First Person Shooters

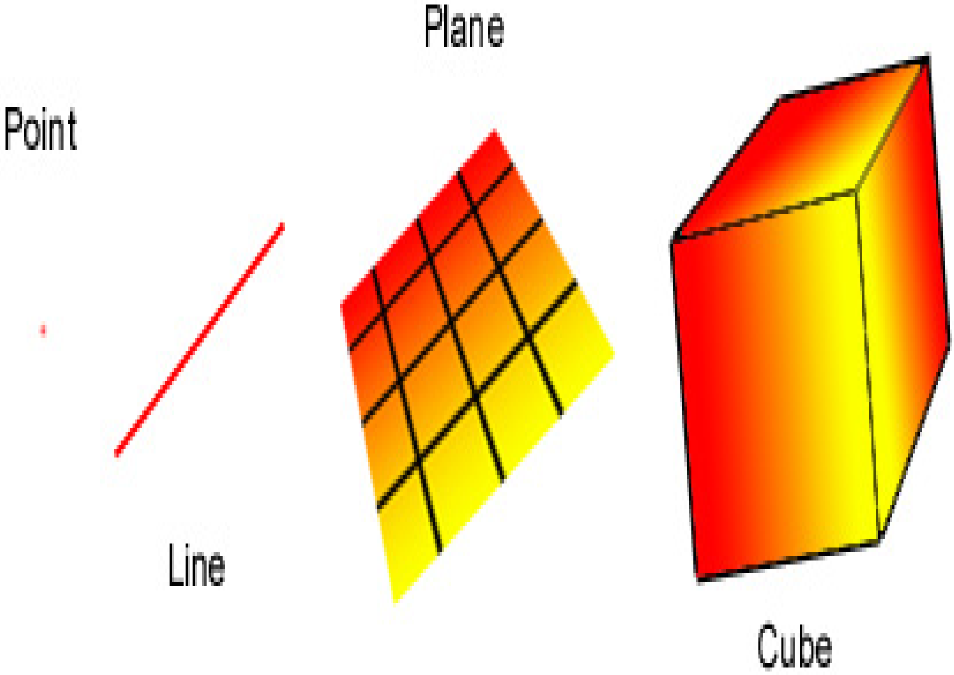
- The most amazing things about FPS are their incredible graphics.
- They look almost real, none of this would have been possible without the use of advanced maths.
- Here are some pictures from the early games (Wolfenstein) to the most recent games (Quake III Arena).
- All of the following screen shots are from games by iD software.


FLOOR
6
SCORE
0
LIVES
1
HEALTH
32%
AMMO
99


PAUSE

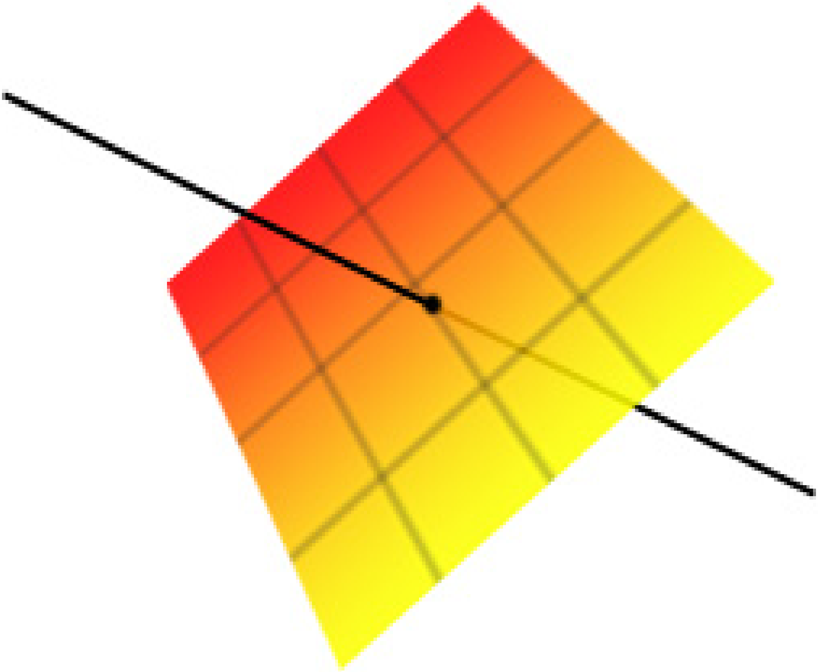
Geometry, Vectors, and Transformations

- Geometry is the study of shapes of various sort
- The simplest shape is the point
- It's quite difficult to explain what a point is, it is basically just a position
- Another simple shape is a straight line
- A straight line is just the simplest shape joining two points together
- A plane is a more complicated shape, it is a flat sheet, like a piece of paper or a wall
- There are more complicated shapes, called solids , like a cube or a sphere


Plane
Point
Line
Cube

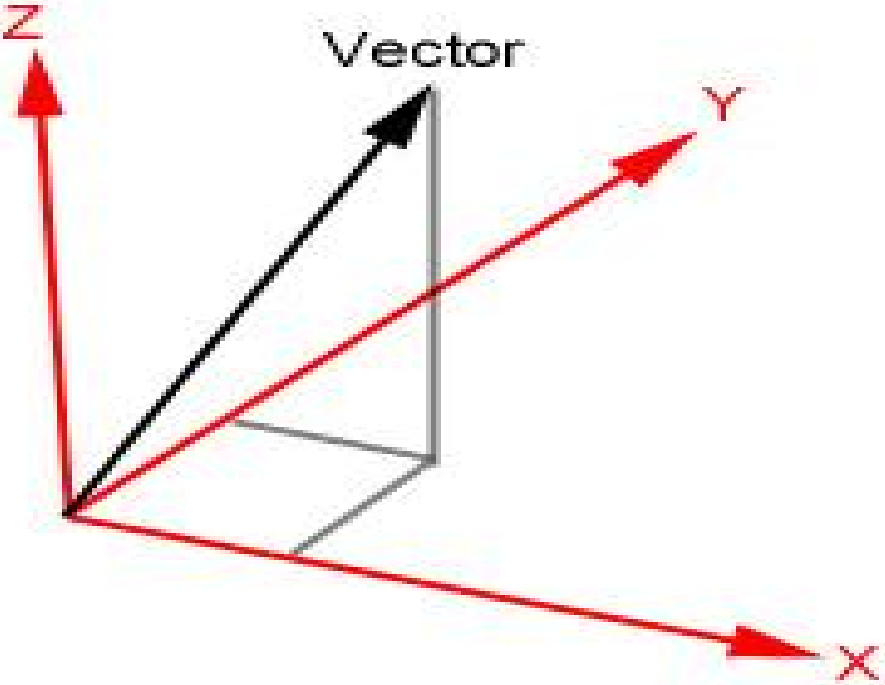
Intersection of a Line and Plane

- If you have a line and a plane, you can find the point where the line cuts through the plane
- In fact, sometimes you can't find the intersection, because they don't meet and sometimes the line is inside the plane so they meet at every point on the line
- We call this the intersection of the line and the plane



Vector

- A vector is a mathematical way of representing a point
- A vector is 3 numbers, usually called x, y and z
- You can think of these numbers as how far you have to go in 3 different directions to get to a point
- For instance, put one arm out pointing to the right, and the other pointing straight forward
- I can now give you a vector and you'll be able to find the point I'm talking about
- For instance, if I say $x=3$, $y=1$, $z=5$, you find the point by walking 3 metres in the direction of your right hand, then 1 metre in the direction of your left hand, and then getting a ladder and climbing up 5 metres

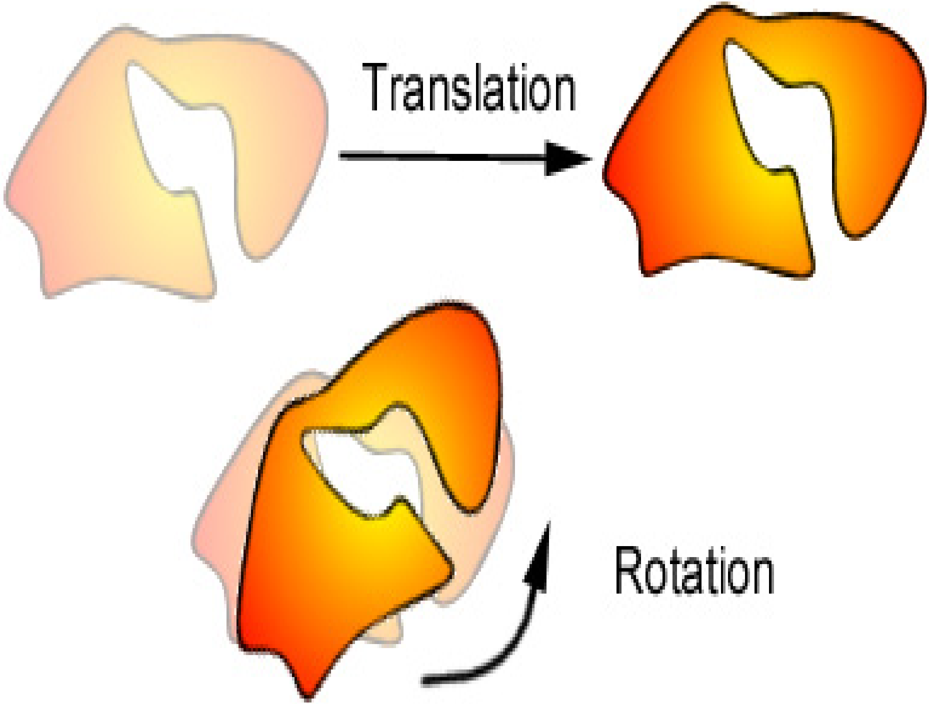

Z
Vector
Y
X

Confusing Part about Vectors

- Vectors are written as (x,y,z), for instance (1,2,3) means move 1 in the x-direction, 2 in the y-direction and 3 in the z-direction.
- One confusing thing about vectors is that they are sometimes used to represent a point, and sometimes they are used to represent a direction.
- The vector (1,0,0) can mean both "the point you get to if you move 1 unit in the x-direction from the starting point", or it can mean "move 1 unit in the x-direction from where you are now".

Transformation

- A transformation moves a point (or an object, or even an entire world) from one place to another
- For instance, I could move it to the right by 4 metres, this type of transformation is called a translation
- Another type of transformation is rotation
- If you take hold of an object (a pen for instance), and twist your wrist, you have rotated that object


Translation
Rotation

3D Graphics I

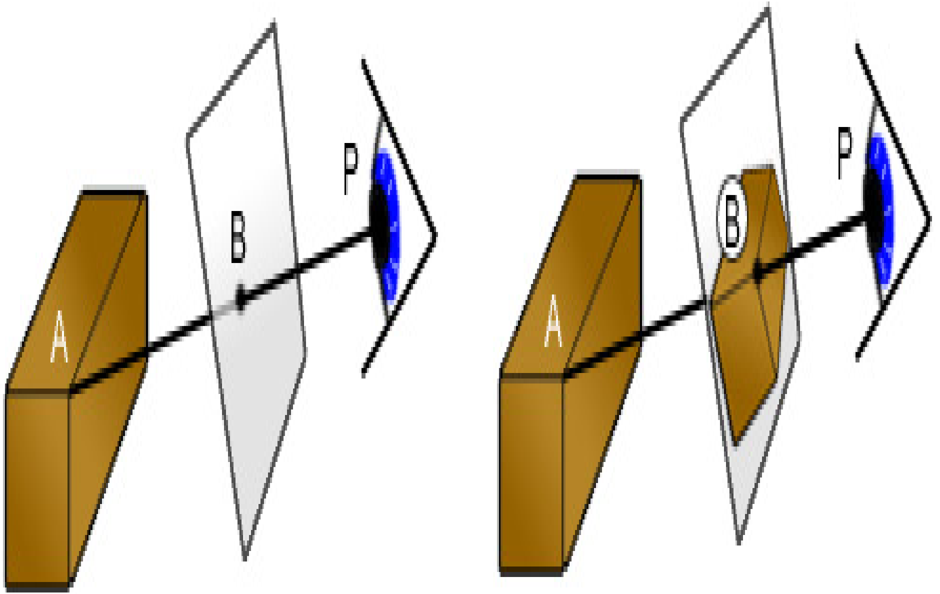
- The basic idea of 3D graphics is to turn a mathematical description of a world into a picture of what that world would look like to someone inside the world
- The mathematical description could be in the form of a list, for instance
  - there is a box with centre (2,4,7) and sides of length 3
  - the colour of the box is a bluish grey
- To turn this into a picture, we also need to
  - describe where the person is
  - what direction they are looking
  - for instance: there is a person at (10,10,10) looking directly at the centre of the box
- From this we can construct what the world would look like to that person

3D Graphics II

- Imagine there is a painter whose eyes are at the point P.
- Imagine that he has a glass sheet which he is about to paint on.
- In the room he is painting, there is a wooden chest.
- One of the corners of the chest is at point A, and the painter wants to know where that corner of the chest should be on his glass sheet.
- The way he works it out is to draw a line L from his eyes (P) to the corner of the chest (A), then he works out where this line goes through the canvas, B.

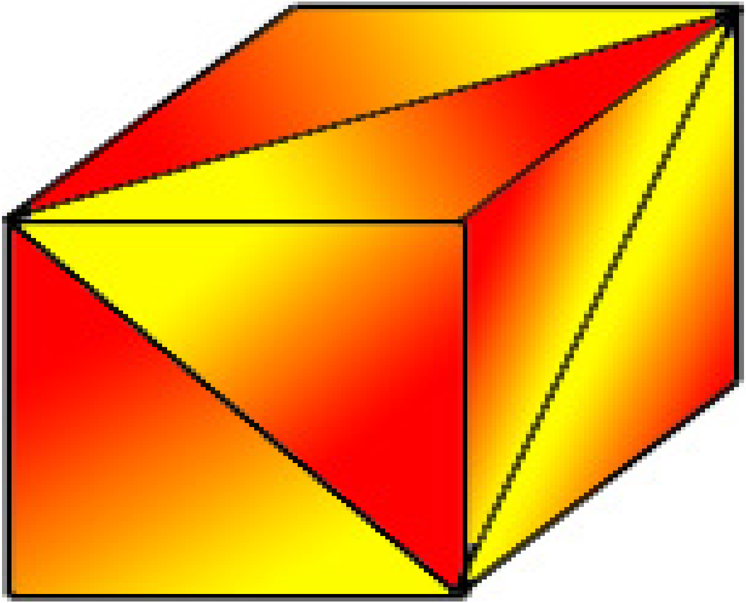
3D Graphics III

- He can do this, because the glass sheet is a plane, and I mentioned that you can find the intersection of a line and a plane above.
- This point B is where the corner of the chest should be in his painting.
- He follows this rule for every bit of the chest, and ends up with a picture which looks exactly like the chest.
- Here are two pictures, the first one shows the painting when he has only painted the one corner of the chest
- the second one shows what it looks like when he has painted the entire chest
- This process is called: Projection to a Plane


P
B
A
P
B
A

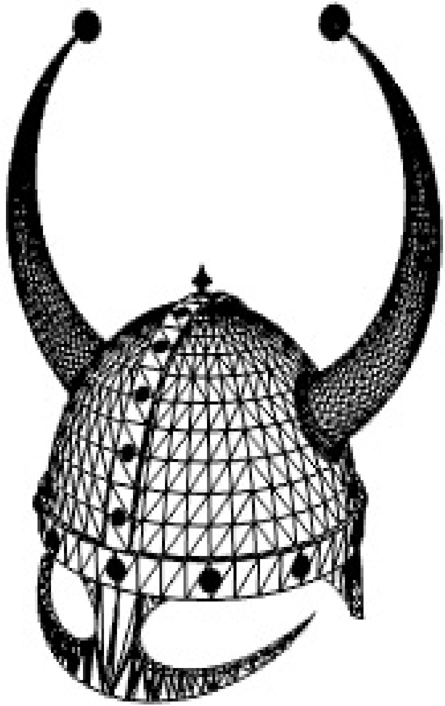
3D Graphics IV

- What I just described above is similar to what the computer is doing (50 times a second!)
- every time you run around shooting hideous monsters in Quake , although the details are slightly different.
- In computer games (at the moment) the description of the world is just a list of triangles and colours.
- The newest computer games are using more complicated descriptions of the world, using curved surfaces, NURBS and other strange sounding things, however in the end it always reduces to triangles.
- For instance, a box can be made using triangles as illustrated below.



3D Graphics V

- Here is a much more complicated example, using thousands of triangles.
- The first picture shows the triangles used
- the second picture is what it looks like with colours put in
- The reason for using triangles is that they are a very simple shape
- if you make sure that everything is made from only one type of shape, you don't have to write a separate program for each type of shape in the game.




3D Graphics VI

- Each time the computer draws a picture of the world, it goes through the following steps:
  - Firstly, it transforms the world (by rotating and translating), so that the person is at position (0,0,0) and the centre of the glass sheet (the centre of the screen in computers) is at (1,0,0). This makes the rest of the calculations much easier.
  - Secondly, it removes all the triangles you can't see so that it can forget about them, for instance the triangles that are behind you or the ones that are so far away that you can't see them.

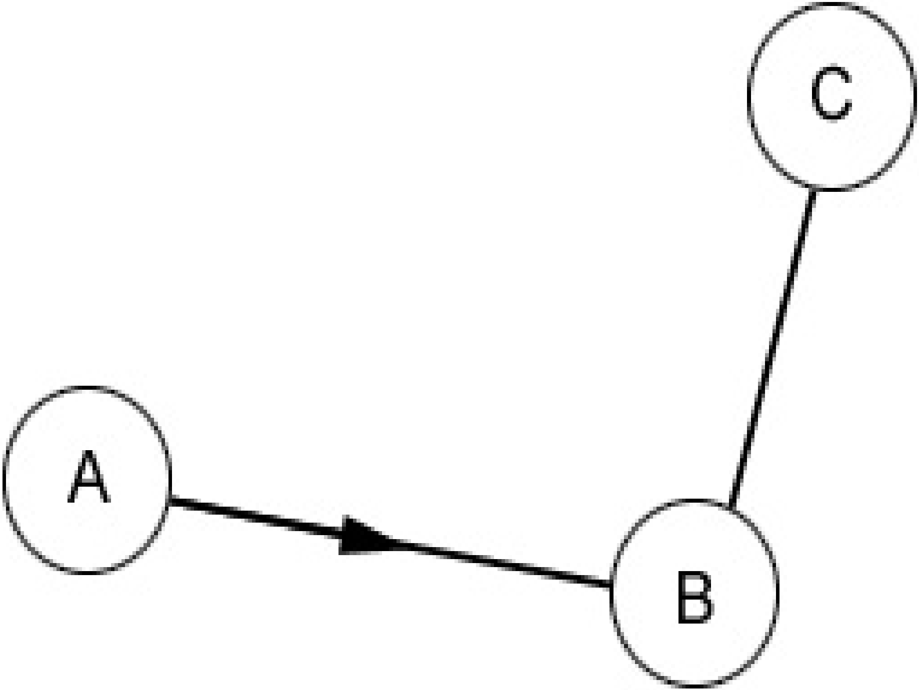
- Each time the computer draws a picture of the world, it goes through the following steps: (cont.)
  - Thirdly, for every remaining triangle, it works out what it would look like when painted on the glass sheet (or drawn on the screen in computers).
  - Finally, it puts the picture it has drawn on the screen.
- Nowadays, computers are so fast that they can draw hundreds of thousands of triangles every second, making the pictures more and more realistic

Strategy Games

- Strategy games usually have much simpler graphics than FPS games
- When you click on a little soldier in a strategy game, and then click somewhere else, telling him that he should walk to the place where you have clicked, what happens inside the computer?
- How does the computer know how to make the soldier get from where he already is to where he is going.
- So you can't just say, "look at the map and work out the best route to wherever you are going", he needs to be given exact instructions at every stage of his journey.

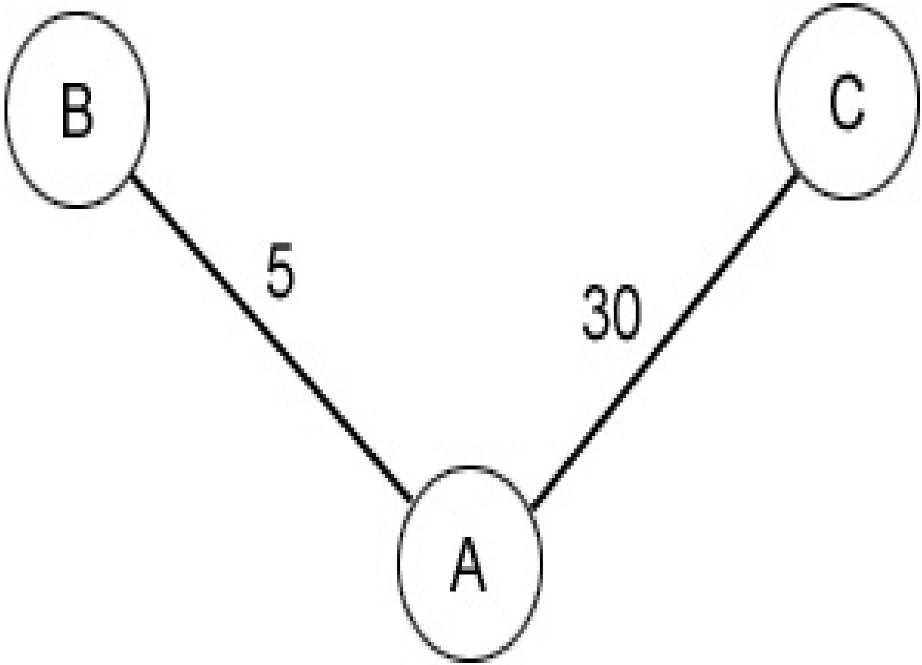
Nodes, Edges, and Graphs

- This problem is called path finding
- To explain how the computer works out the best route, you need to know what nodes , edges and graphs are.
- You may have heard of graphs before in maths, but they mean something slightly different here.
- The simplest example of nodes and graphs is a map of some cities, and the roads between them (or an underground map).
- Each city is a node, usually drawn as a circular blob.
- Each road is an edge, and connects two nodes (cities), these are usually drawn as straight lines.
- The whole collection of nodes and edges (cities and roads) is called a graph.


C
A
B

Nodes, Edges, and Graphs II

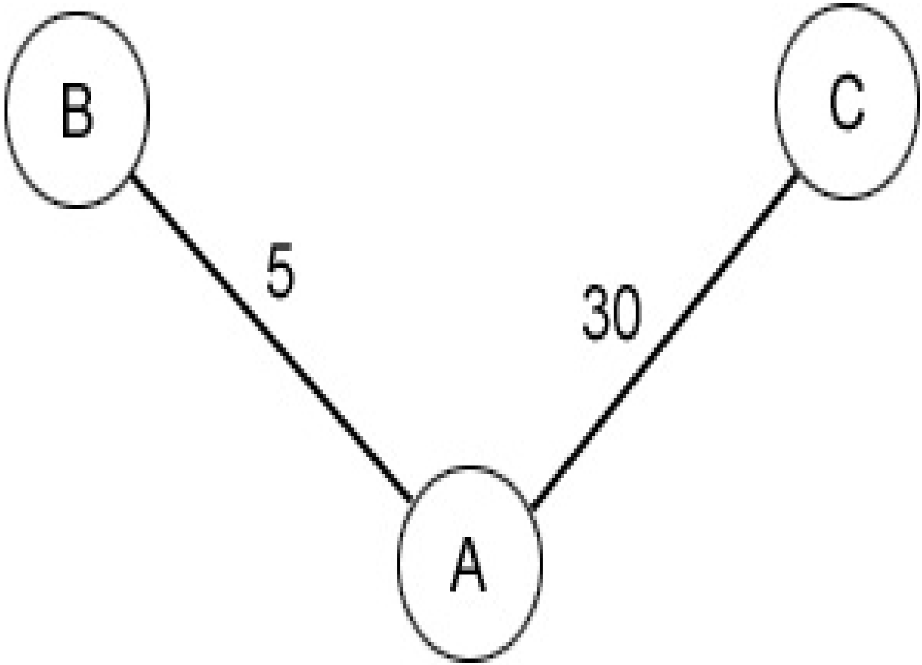
- Sometimes there is a one way road, called a directed edge , and we draw an arrow on it to show which way you can travel along it.
- For instance, if there are two cities A and B, and a line with an arrow from A to B, then we can travel from A to B, but not from B to A.
- Here is an example of a graph, you can't travel from B to A, but you can travel from A to B.
- You can't travel from C to A or from A to C, but you can travel from B to C and from C to B.

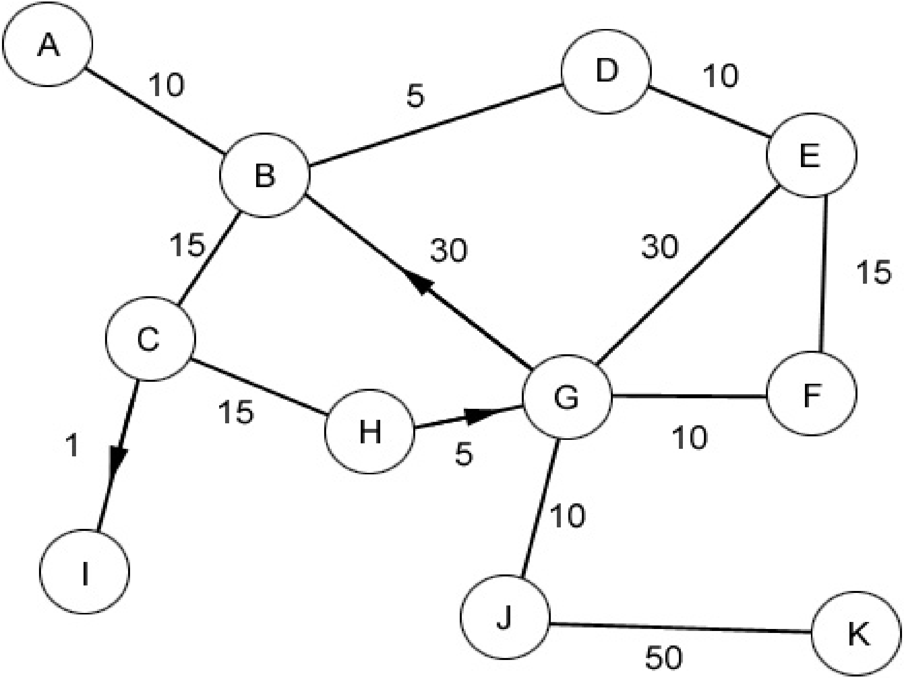


B
C
5
30
A

Graph with Cost

- To complicate things even further, we sometimes want to add something called a cost to each edge.
- The idea of a cost is that it indicates how much it would cost to travel down that edge.
- In this graph, most of the people in city A want to get to city C, whereas only a few want to get to city B.
- Unfortunately, both roads are the same size, this means that there are long traffic jams on the road from A to C, it takes about 30 minutes to get there.
- To get from A to B is much easier as most people are going to C, so it only takes 5 minutes.
- The numbers written next to the edges indicate how long it takes to travel along that edge.


B
C
5
30
A

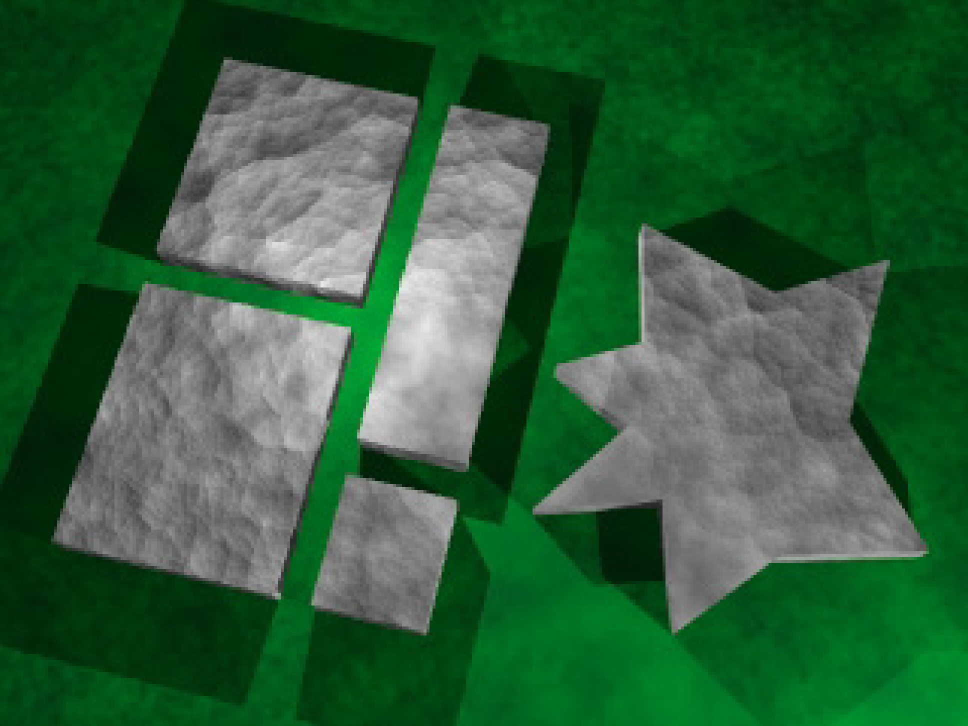

A
B
C
D
E
F
G
H
I
J
K
10
5
10
15
30
30
15
15
1
5
10
10
50

Path Finding I

- Now you know all you need to know to be able to understand path finding.
- How does all this stuff about graphs help the computer guide troops around levels?
- It makes a graph where every interesting point is a node on the graph,
- and every way of walking from one node to another is an edge,
- then it solves the problem
- There are some complications

Path Finding II

- For starters, what are the interesting points?
- You might think that every position on the entire level is interesting
- For most games this would lead to hundreds of thousands of interesting points, and finding the path would take years.
- Instead, the people making the game decide where the interesting points are.
- For instance, if there is a wide open expanse (a big field perhaps), you don't need a node at every point on the field, because the troops can walk in a straight line across the field.
- Basically, you only need nodes around obstacles.



Simulation Games

- The most important thing about simulation games is that they try and make the game like the real world
- Usually this involves physics simulation
- More Details - Later