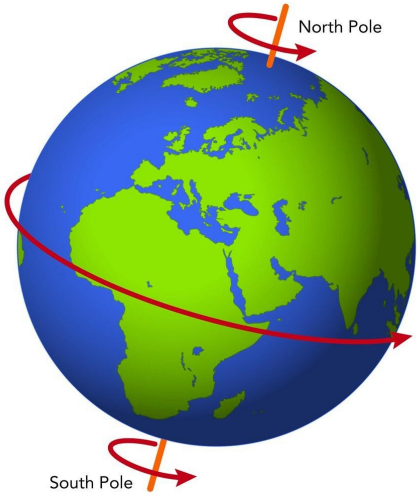
Axis Pitch Yaw

Background

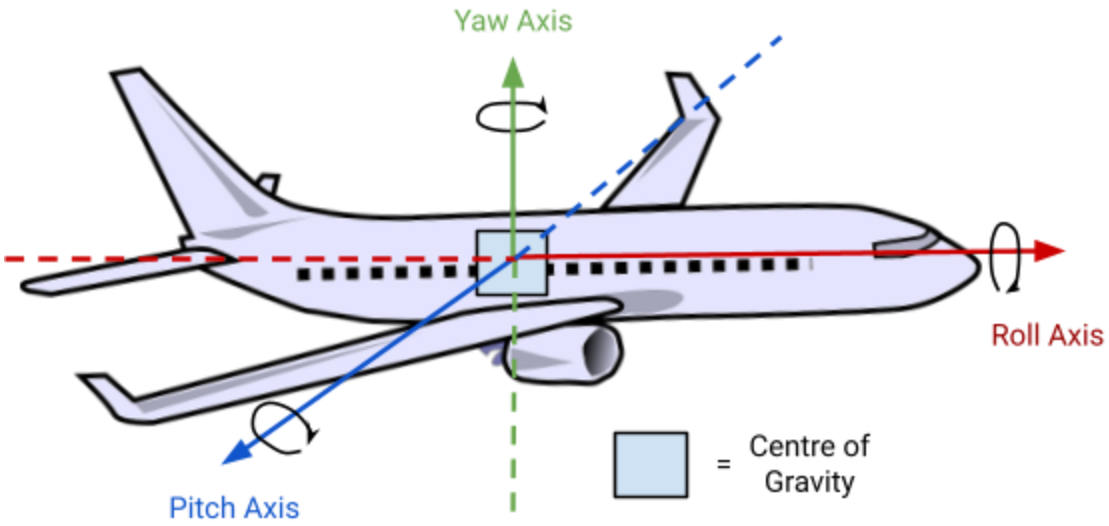
An axis is an imaginary line around which an object rotates. For example, the earth rotates around an axis that passes through the north and south poles. An object that is positioned on the earth away from this axis will trace a circle as the earth rotates. However, an object that is positioned on the axis will spin in-place instead.



Axis are important because they provide us a reference point around which we can define/measure rotation. For example, if we say that a basketball rotates in the anti-clockwise direction, this could represent any of the following rotations:

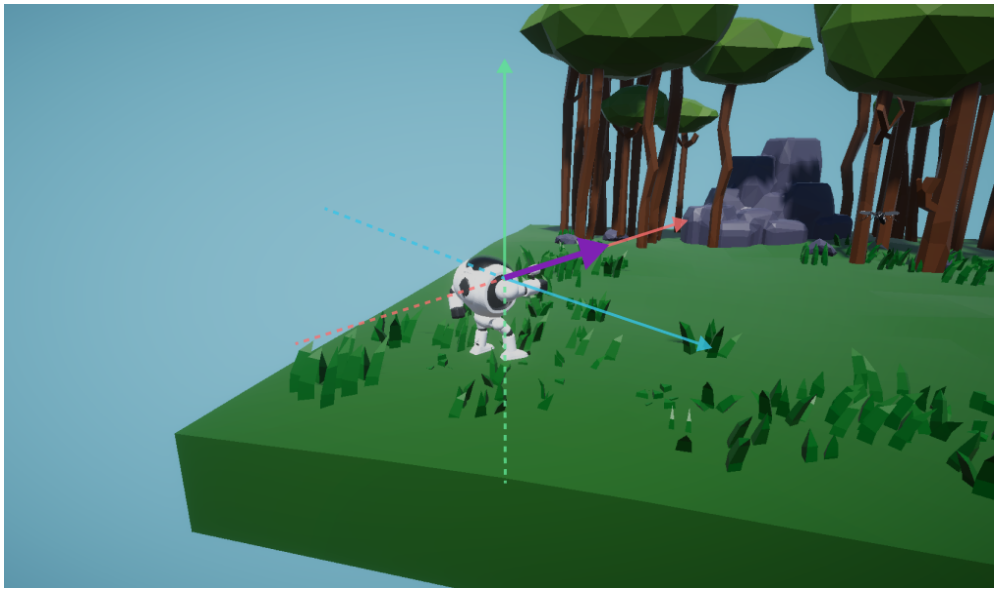
If we instead say that the basketball rotates anti-clockwise around a fixed axis that passes from the bottom of the ball to the top, then there is only one possible rotation (Note that the arrow on an axis represents the direction of that axis. We normally look down at an object from the direction that the arrow is pointing when defining clockwise and anticlockwise directions):

Some objects, like the Earth, spin around a single axis. Objects can also have multiple axes of rotation. For example, an aircraft has three: roll, pitch and yaw. Today we're going to focus on two axes called pitch and yaw. Pitch is when a plane's nose tilts up and down. The axis (centre of rotation) passes horizontally through the sides of the plane. Yaw is when a plane's nose tilts from side to side. The axis would pass vertically through the top and bottom of the plane.

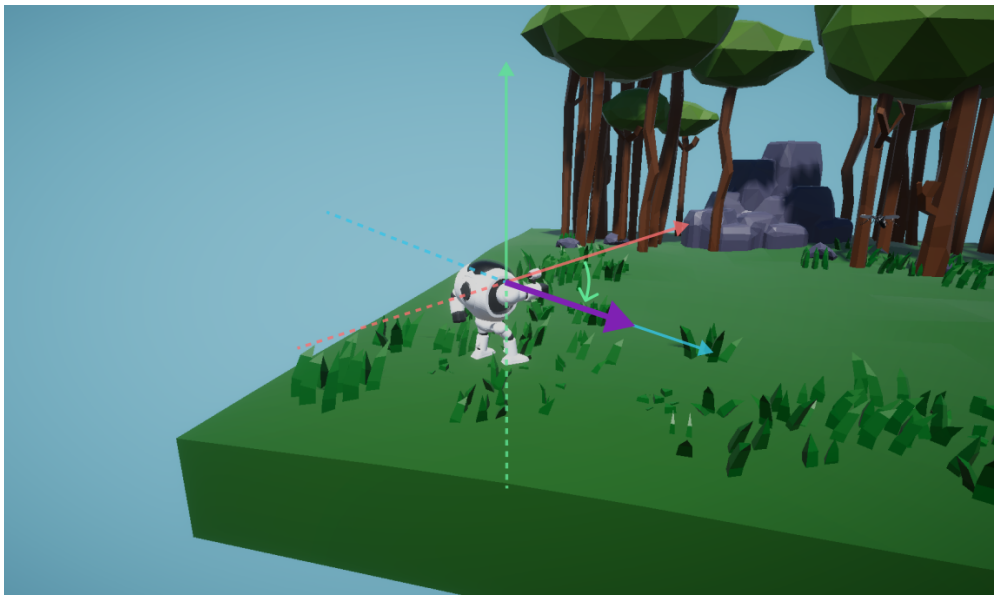


Our Situation

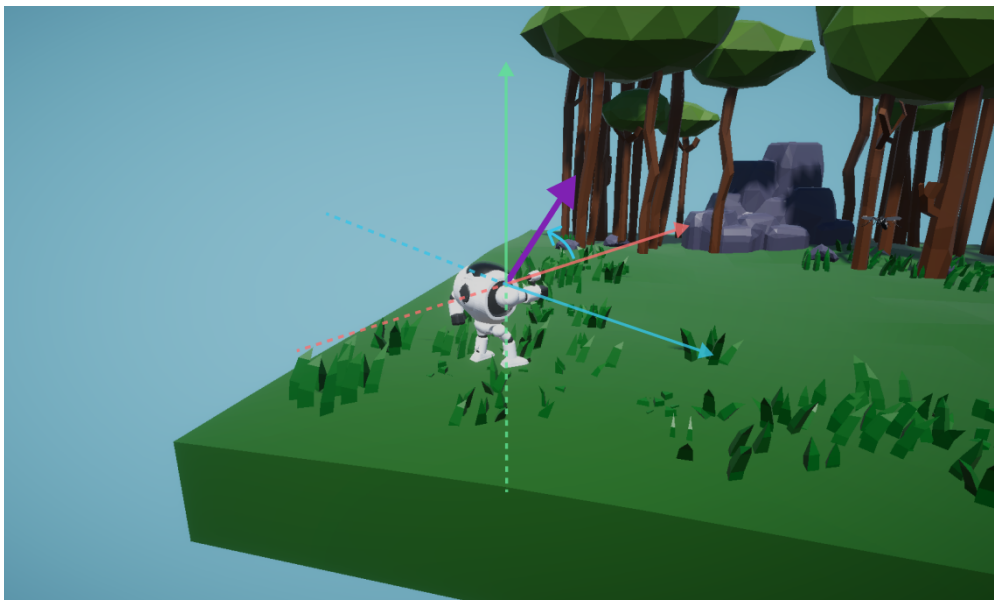
We will define our rotations around an axis using degrees. We will also use a positive number to represent a clockwise rotation and a negative number to represent an anticlockwise rotation. For example, imagine that we are standing behind our robot who is pointing its arm straight ahead in the direction of the purple arrow:



A yaw rotation of -90 degrees will result in our robot's arm rotating 90 degrees anticlockwise around the yaw (green) axis such that it is now pointing to the right:

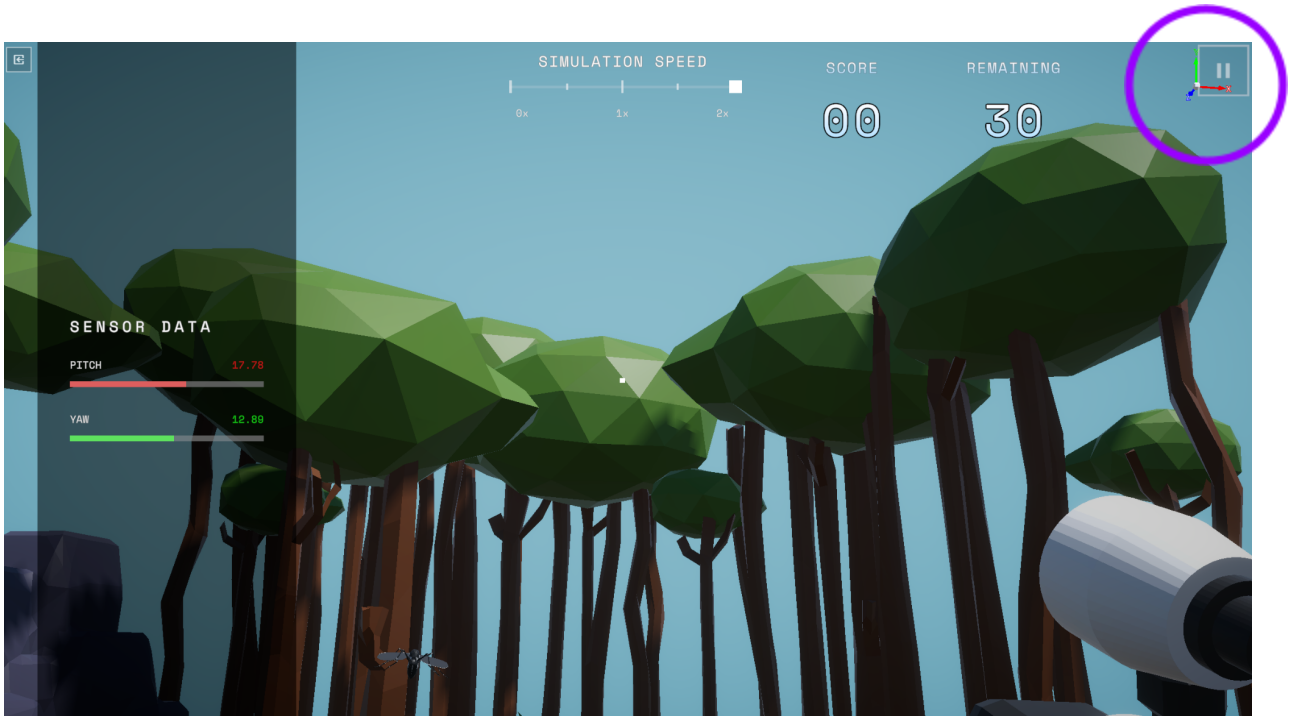


A pitch rotation of 45 degrees will result in our robot's arm rotating 45 degrees clockwise around the pitch axis (red) such that it is now pointing upwards towards the sky:



Our robot can also conduct multiple movements, performing one at a time. When doing so, it is important to note that the axes themselves also move with the robot. If our robot rotates around the green axis, then the direction of the red and blue axis will also rotate around the green axis. This means that in order to make our robot aim upwards by 10 degrees, we will always rotate around the pitch (blue) axis, regardless of which direction the robot is currently facing around the yaw (green) axis.

In addition to the axis that we use to define our rotations, we also have an x, y and z axis as our standard cartesian coordinate system. While our rotational axes are fixed to the robot, our coordinate system is fixed to the environment. There is a visualisation of the three axes in the top right corner of the simulation at all times that you can use to orient yourself, as shown below:



Your robot includes two sensor arrays. One of them can detect the position of the mosquito by returning its x, y and z coordinates relative to the environment. The other can detect the current yaw and pitch angles of the robot's arm. In order to perform our calculations, we will need to use the x, y and z coordinates to calculate the angles that our robot will need to aim at to hit the mosquito.