Workspace

In order to study the workspace of a robot, the structure of the robot can be considered as consisting of the arm and the hand. The arm is the large regional structure for global positioning of the hand, which is the small orientation structure for orientating the tool.

The primary workspace of such a robot with a large regional structure and a small orientation structure is determined by the arm. The hand generates the secondary workspace of a robot.

In performing tasks, a manipulator has to reach a number of workpieces or fixtures. **Workspace is a volume of space which the end-effector of the manipulator can reach.** Workspace is also called work volume or work envelope.

The size and shape of the workspace depends on the coordinate geometry of the robot arm, and also on the number of degrees of freedom. Some workspaces are quite flat, confined almost entirely to one horizontal plane. Others are cylindrical; still others are spherical. Some workspaces have very complicated shapes.

When choosing a robot arm for a certain industrial purpose, it is important that the workspace be large enough to encompass all the points that the robot arm will need to reach. But it's wasteful to use a robot arm with a workspace much bigger than necessary.

Exercise

Detail the outer usable limit in the figure below, compare with the XYZ coordinates from Walli3, and give comment.
The limits that may be drawn on the surface of this outer sphere are those imposed on axis 0, for the horizontal plane, and on axis 1 in the vertical plan, along the meridians.

In the setup procedure during manufacturing, the numerical values for the axes are set to the following values in the range 0 to 255, to be aligned to the positions indicated:

<table>
<thead>
<tr>
<th>Axis</th>
<th>Value</th>
<th>Range°</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>128</td>
<td>210</td>
<td>arm aligned with the major axis of the robot base plan, the Y axis.</td>
</tr>
<tr>
<td>1</td>
<td>155</td>
<td>180</td>
<td>upper arm vertical.</td>
</tr>
<tr>
<td>2</td>
<td>128</td>
<td>230</td>
<td>forearm aligned to upper arm link axis.</td>
</tr>
<tr>
<td>3</td>
<td>128</td>
<td>320</td>
<td>} gripper aligned with forearm link axis</td>
</tr>
<tr>
<td>4</td>
<td>128</td>
<td>320</td>
<td>} &amp; jaw edge aligned with axes 1 and 2</td>
</tr>
</tbody>
</table>

Axis 1 height 185mm
Upper arm link length 165mm
Fore arm link length 150mm
Gripper link length 110mm

With the positional data for all axes entered as in the table above, the whole robot arm will be pointing vertically upwards.
With axis 1 value changed to 28, which should place the arm in an aligned horizontal position and the centre of the closed gripper jaws at 372 mm above the workcell surface, rotation of axis 0 in this position will describe the equator of the sphere, as shown below:

The angular limits of this illustration may be measured directly by lightly holding the edge of a long (400 mm) ruler in the slot formed by the closed gripper jaws, marking the end point of the edge on the surface with a pencil.
The bottom edge of the part sphere and the limits of angular movement in that direction for axis 1, may be measured by similar technique, with the outstretched arm aligned with the X axis. The height of the mid-point of the closed gripper defines the lower rim and the angel below the X axis may be calculated using trigonometry.

The reverse limit, which also forms a circle of latitude on the surface of the sphere, may be measured similarly, with axis 1 set to value of 255.

The geometry should be compared to the specification for axes 0 and 1 (degree of movements) respectively, and to the XYZ coordinates presented in the small window below the robot graphics.