

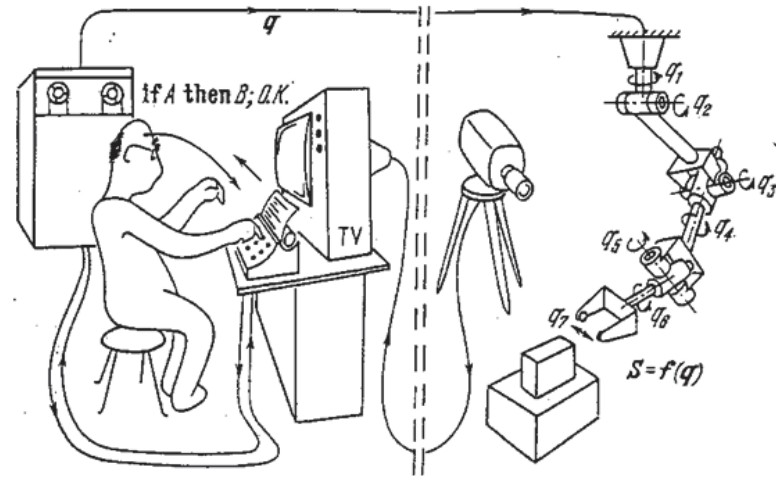
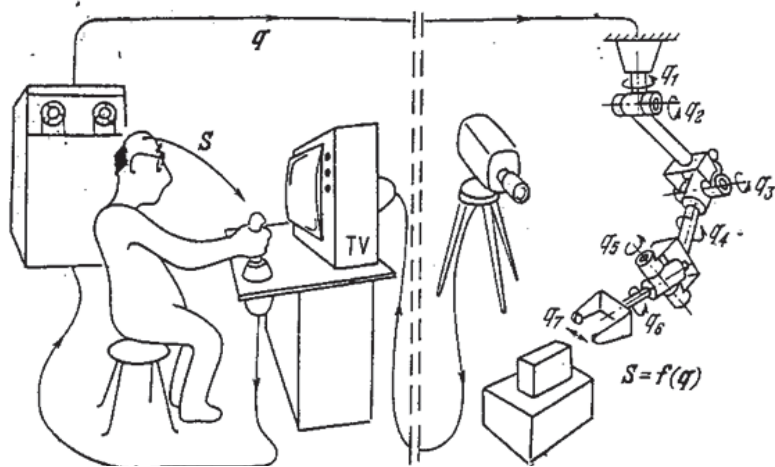
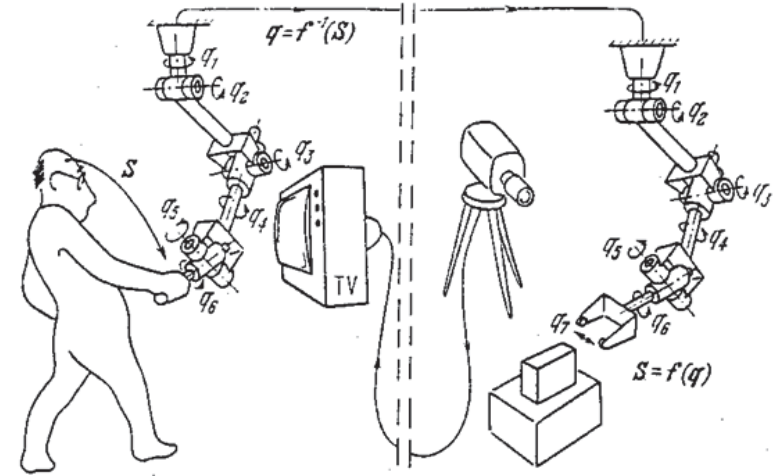
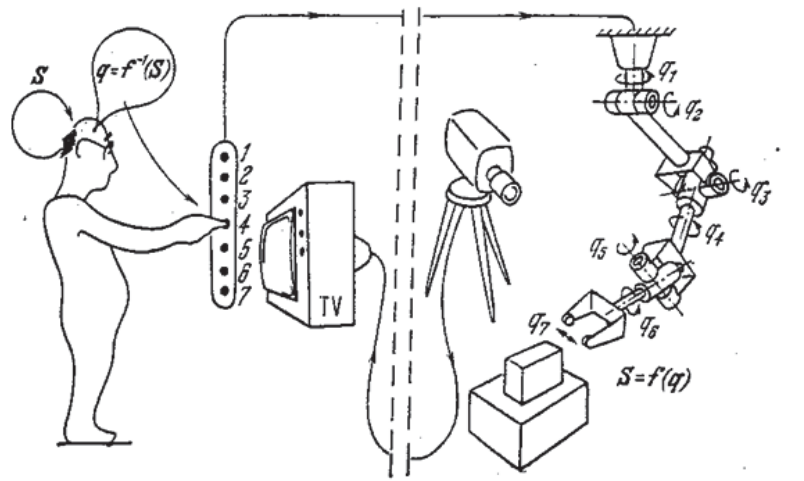
Manipulation Robot MR-99

- 5 degrees of freedom



- Basic concepts to learn
 - force perception
 - work space and joint space
 - robot programming

Robot Programming



Inverse kinematics

- Let (x, y, z) be the end-point coordinates, and $d^2 = x^2 + z^2$ and $r^2 = d^2 + (y - l_0)^2$

- base rotation angle

$$\theta_3 = -\arctan(z / x)$$

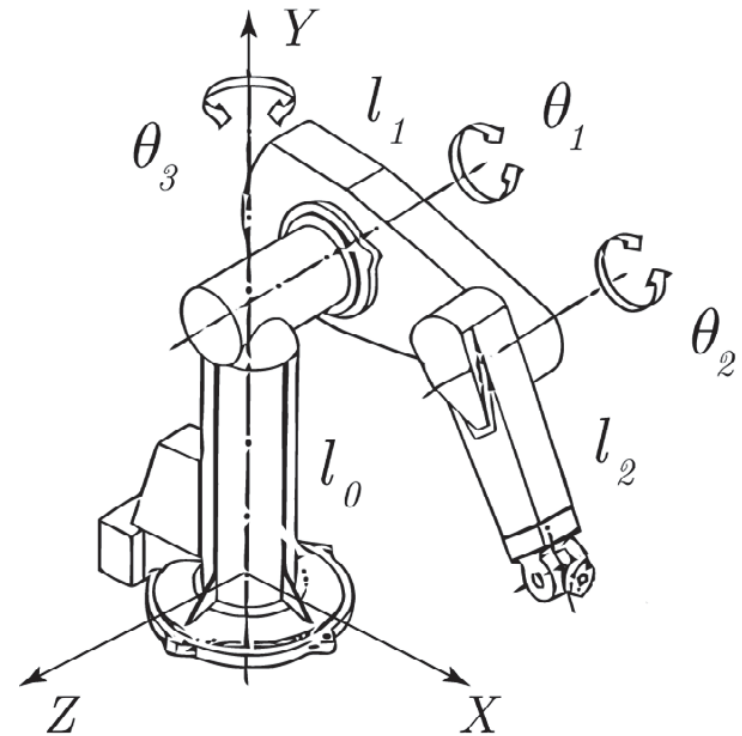
- shoulder and elbow angles

$$l_1 \cos \theta_1 + l_2 \cos(\theta_1 + \theta_2) = d$$

$$l_1 \sin \theta_1 + l_2 \sin(\theta_1 + \theta_2) = y - l_0$$

$$\theta_2 = \pm \arctan \frac{\sqrt{\{(l_1 + l_2)^2 - r^2\}\{r^2 - (l_1 - l_2)^2\}}}{r^2 - l_1^2 - l_2^2}$$

$$\theta_1 = \arctan \frac{(l_1 + l_2 \cos \theta_2)(y - l_0) - dl_2 \sin \theta_2}{(l_1 + l_2 \cos \theta_2)d - (y - l_0)l_2 \sin \theta_2}$$



Mobile robot Sphero



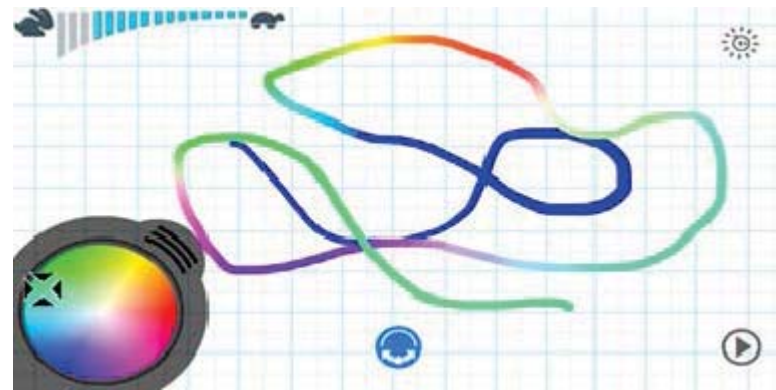
straight lines



internal structure



control panel



experiments