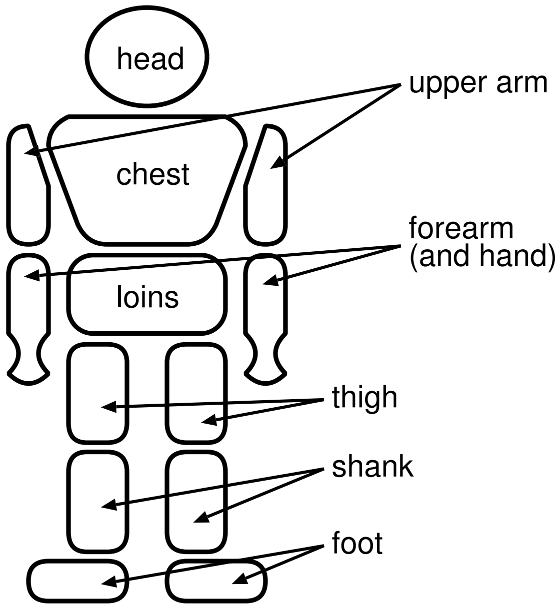

Figure 4.3: The body elements: The body is divided into thirteen elements.

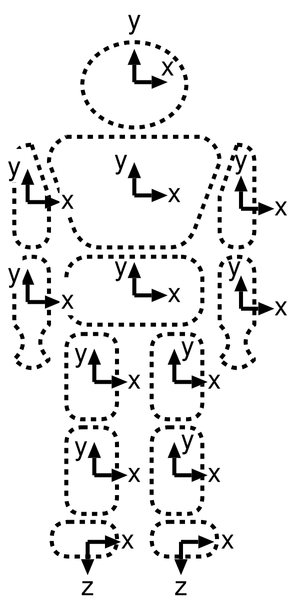

Figure 4.4: Local coordinates of the body elements: The x axis is basically set to be parallel to the pivot of the joints. The y axis is basically set to point the upward direction.

Element	Mass (%)		
head	7.0		7.0
chest	25.8		25.8
loins	17.2		17.2
upper arm	3.6	x2	7.2
forearm	2.2	x2	4.4
hand	0.7	x2	1.4
thigh	11.4	x2	22.8
shank	5.3	x2	10.6
foot	1.8	x2	3.6
total			100.0

Table 4.1: Standard mass distribution of a body

thesis, $\rho = 1.0$. Therefore, the inertia is calculated as

$$I_h = \frac{mr^2}{2} \tag{4.2a}$$

$$I_r = \frac{m(3r^2 + h^2)}{12}, \tag{4.2b}$$

where I_h and I_r are the inertia of the height direction and the perpendicular direction, respectively.

4.3.2 Center of Mass

Now, let m_i and $\boldsymbol{s}_i$ denote the mass and the CM of the i-th elements, respectively. The CM of the whole body ($\boldsymbol{s}$) is obtained as

$$\boldsymbol{s} = \frac{\sum_i m_i \boldsymbol{s}_i}{\sum_i m_i}. \tag{4.3a}$$

The velocity and the acceleration of the CM are obtained in the same way:

$$\dot{\boldsymbol{s}} = \frac{\sum_i m_i \dot{\boldsymbol{s}}_i}{\sum_i m_i} \tag{4.3b}$$

$$\ddot{\boldsymbol{s}} = \frac{\sum_i m_i \ddot{\boldsymbol{s}}_i}{\sum_i m_i}, \tag{4.3c}$$