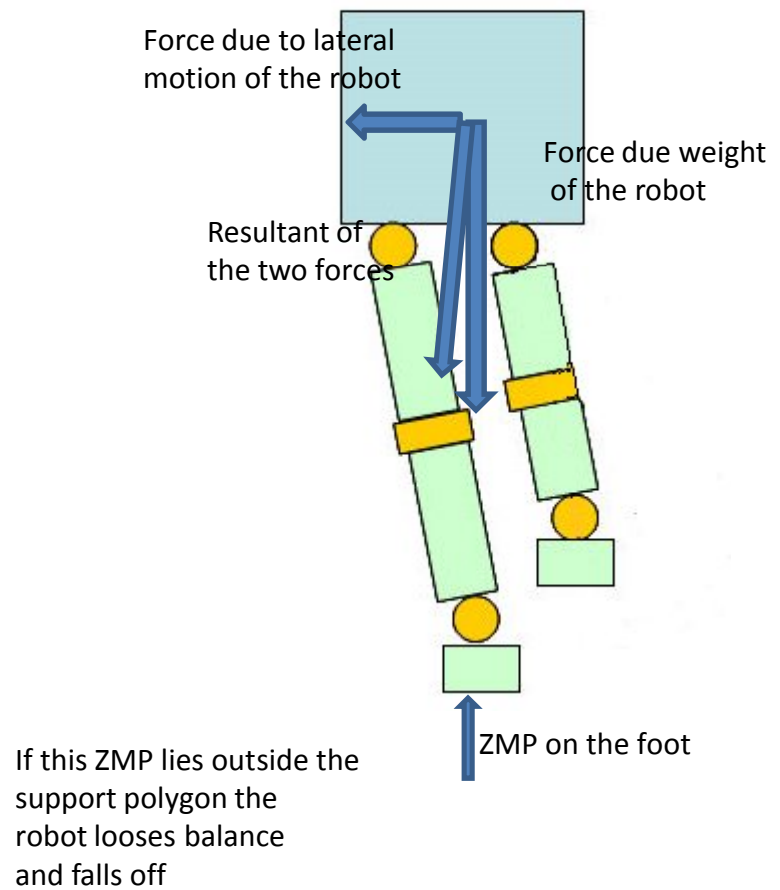
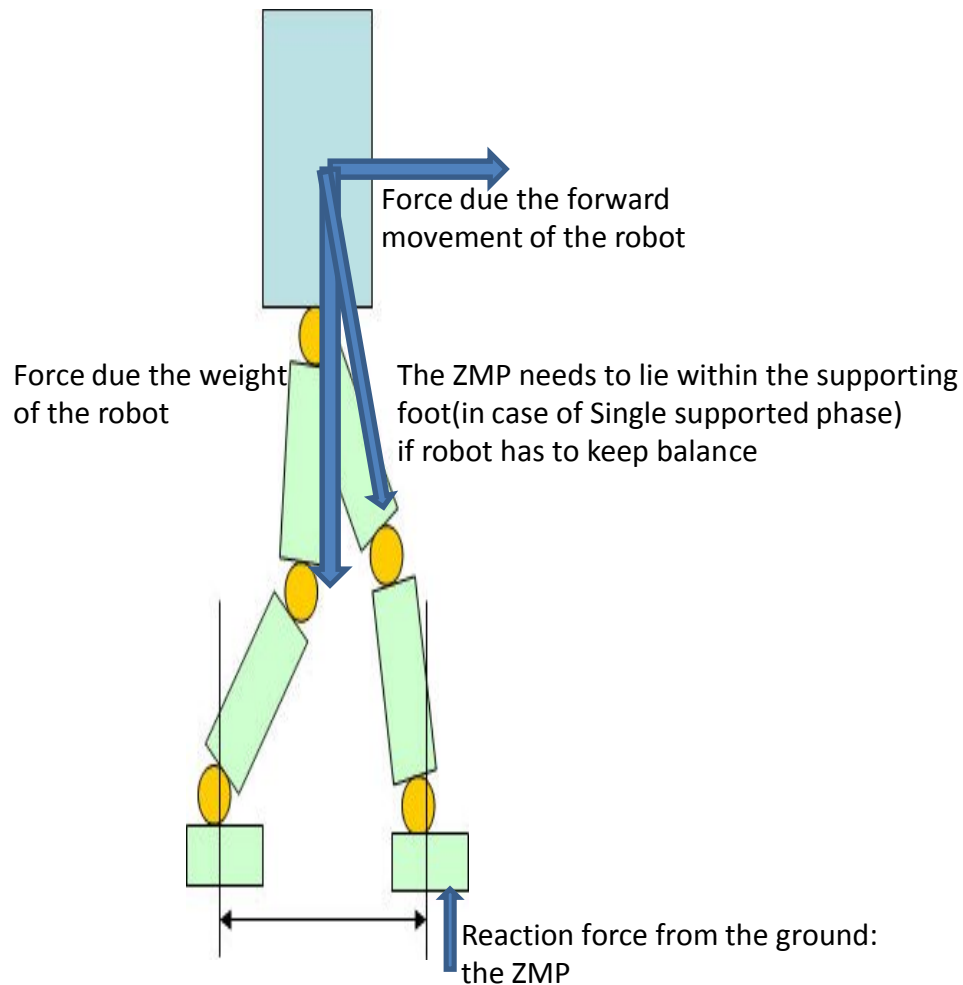


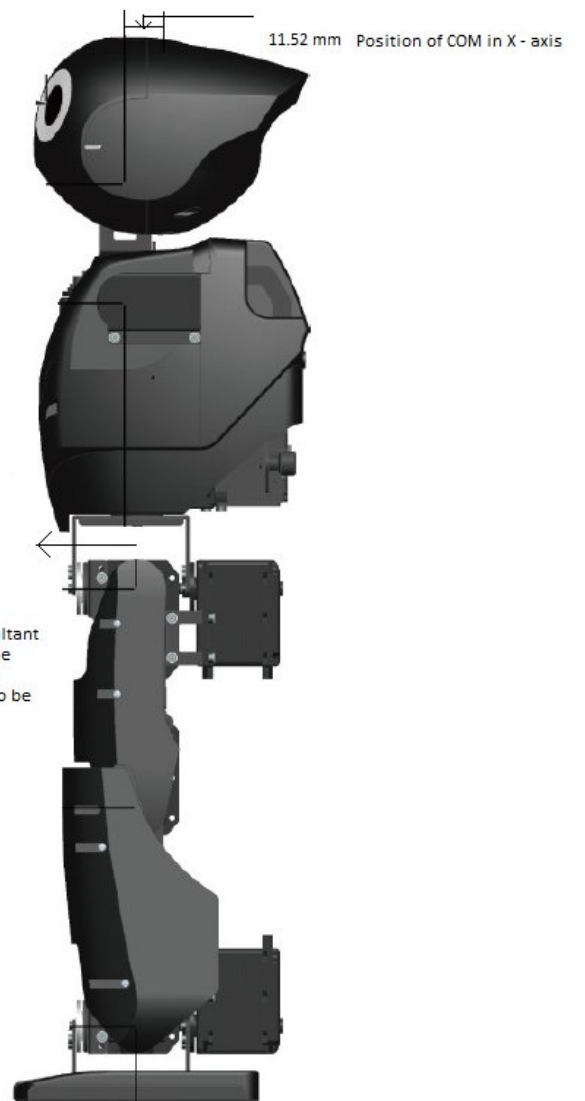
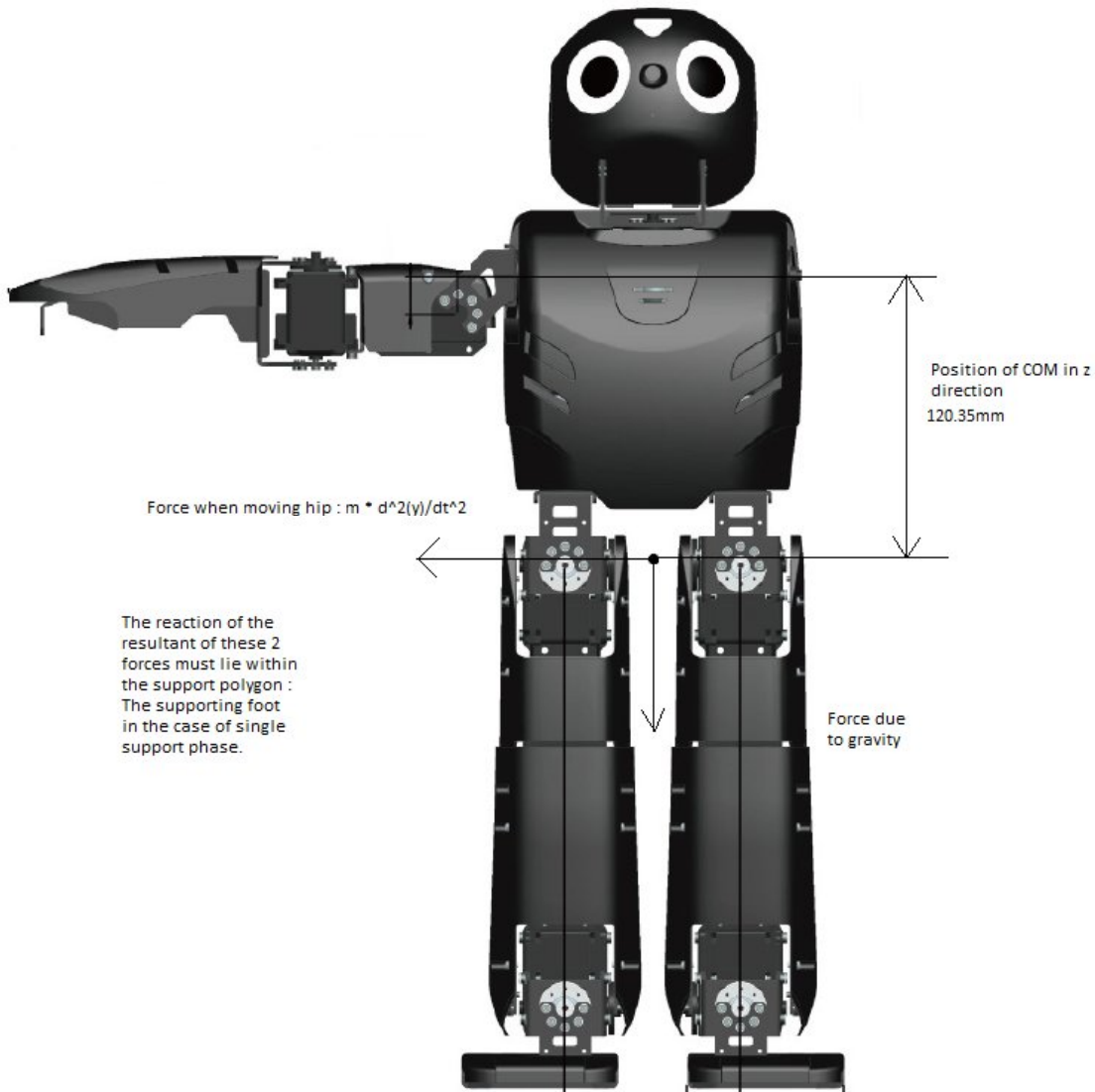
ZMP for the Darwin-OP

Bharadwaj Ramesh

Zero Moment Point

The reaction point of the resultant of all forces and moments due to robots movement must lie within the robots Support polygon





- The position of ZMP is determined based on the following formula :

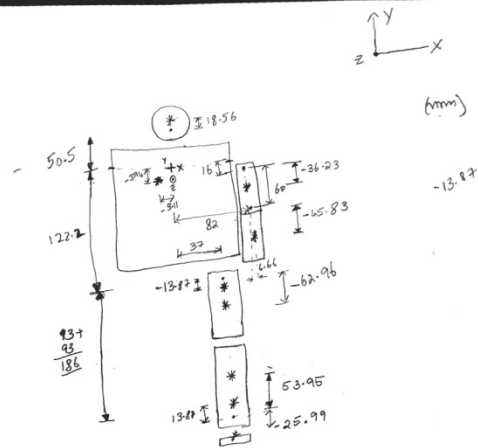
$$X_{zmp} = X_{com} - (Z_c/g) * (x''_{com})$$

$$Y_{zmp} = Y_{com} - (Z_c/g) * (y''_{com})$$

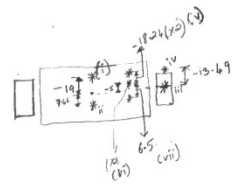
Where,

- X_{zmp} – position of zmp in x axis
- Y_{zmp} – position of zmp in y axis
- X_{com} – position of COM in x axis
- Y_{com} – position of COM in y axis
- Z_c is the distance of the COM from the ground in the Z axis
- g – force due to gravity.

Additional : Calculations for COM



TOP-VIEW



COM w.r.t Z axis:-

$$(975.59 \times (-19)) + (158 \times 7.66) + (168 \times 0) +$$

$$(59.2 \times (-13.48 \times 2)) + (167.1 \times (-18.24) \times 2) +$$

$$((119.04 + 79.44) \times (-5) \times 2) + (70 \times 6.5 \times 2)$$

$$= -18536.21$$

$$1210.28$$

$$-1597.216$$

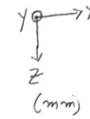
$$-12191.616$$

$$-1984.8$$

$$-910$$

$$\underline{-32189.042} \quad \text{g-mm}$$

$$\frac{-32189.042}{2793.95} = \underline{\underline{-11.52 \text{ mm}}}$$



- i - body
- ii - head
- iii - u-arm
- iv - d-arm
- v - palmar E
- vi - thigh
- vii - tibia

MOMENTS ABOUT Y AXIS:-

$$[-39.4 \times 975.59] + [(50.5 + 18.56) \times 158] + [(616 - 36.23) \times 168 \times 2]$$

$$+ [(-16 - 60 - 45.83) \times 59.2 \times 2] + [(-122.2 - 13.87) \times 167.1 \times 2]$$

$$+ [(-122.2 - 62.96) \times 119.04 \times 2] + [(-122.2 - 186 + 53.95) \times 70.3 \times 2]$$

$$+ [-122.2 - 186 + 15.87 \times 167.1 \times 2] + [122.2 - 186 - 25.99 \times 79.44 \times 2]$$

$$= -38438.246$$

$$+ 10911.48$$

$$- 17549.28$$

$$- 14424.672$$

$$- 45474.594$$

$$- 64082.89$$

$$- 35747.55$$

$$- 98365.086$$

$$- 53096.107$$

$$\underline{\underline{-336266.945}} \quad \text{g-mm}$$

$$\frac{-336266.945}{2793.95} = \underline{\underline{-120.35 \text{ mm}}}$$

position of COM of Dorsum-OP in the Y-axis w.r.t chest origin.