The Conceptual Re-design of a Humanoid Robot Based on Gait

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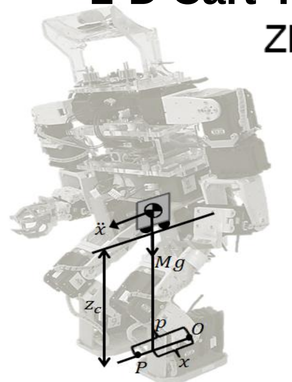
The aim of this project is to re-design the chest of the PANTHER humanoid robot. A model of PANTHER was created to simulate forward walking and turning motion and was used to investigate the effect of the chest design on the stability and energy efficiency of the robot. The Zero Moment Point stability criterion and mechanical cost of transport were used to quantify the aforementioned characteristics. The computed ZMP position was obtained using the 2-D Cart-Table model and 3-D dynamic model.

Zero Moment Point (ZMP) Stability Criterion

2-D Cart-Table model

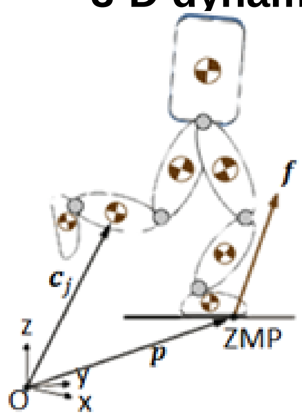
ZMP $(p) = \{p_x, p_y\}$



$$p_x = x - \frac{z_c}{g}\ddot{x}$$

$$p_y = y - \frac{z_c}{g}\ddot{y}$$

3-D dynamic model



$$p_x = \frac{Mgx - \dot{\mathcal{L}}_y}{Mg + \dot{\mathcal{P}}_z}$$

$$p_y = \frac{Mgy + \dot{\mathcal{L}}_x}{Mg + \dot{\mathcal{P}}_z}$$

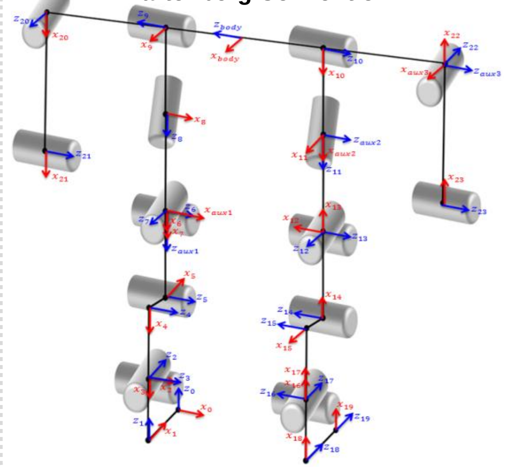
Mechanical cost of transport (c_{mt})

Quantifies the work done by actuators to produce the required motion of a robot. It is commonly used to determine the energy efficiency of a particular design.

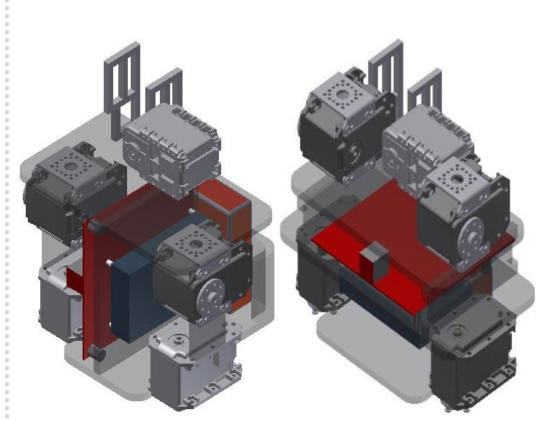
$$c_{mt} = \frac{Total\ work\ performed\ by\ actuators}{Weight\ \times distance\ travelled}$$

Modelling and Simulation of PANTHER

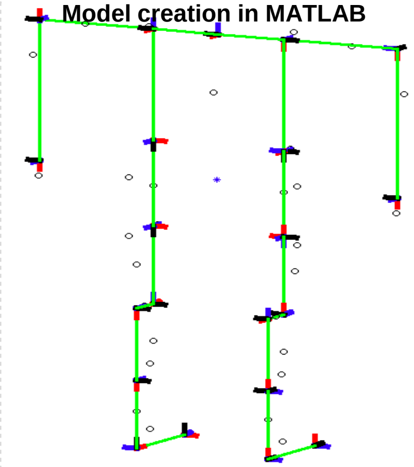
Kinematic model creation using Denavit-Hartenberg Convention



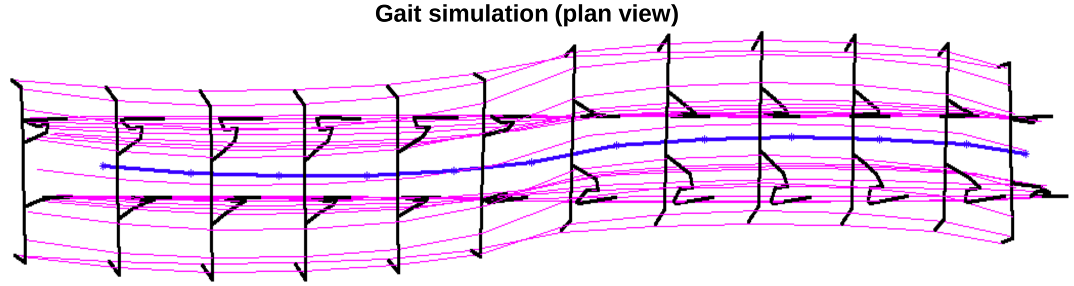
CAD models of chest and body links created to obtain centre of masses and inertia tensors



Model creation in MATLAB

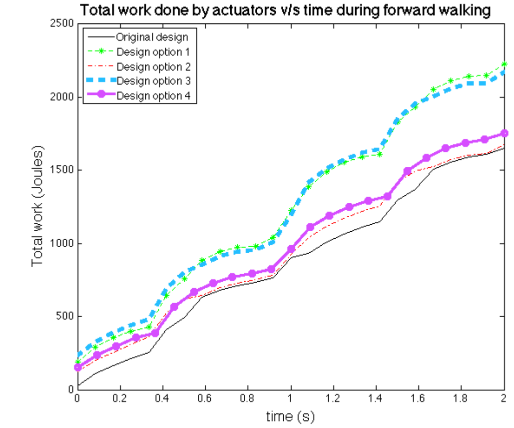


Gait simulation (plan view)



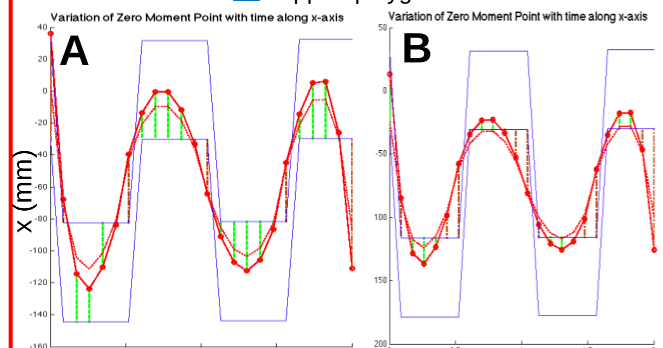
Results and conclusion

Total actuator work done during forward walking



Stability responses of the robot with original design (A, most stable) and design option 1 (B,least stable)

ZMP,x Dynamic model ZMP,x Cart-Table model Support polygon



Simulations show that the original chest design produced the most stable response when implemented on the robot, while design option 2 was most energy efficient.

Individual Research Project 2012-13