Humanoid Robot: Throw Ball At A Target

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Problem Statement

The objective of our project is to teach a humanoid robot(Aldebaran Nao) to identify the target in a cluttered environment and throw the ball towards the target. If the target is beyond the range then the robot conveys it's inability to do so.

Motivation

- Throwing an object to a particular target has its application in military operations like targeting explosives.
- Many applications in entertainment field as throwing a ball at a target is the basic skill required in several games like basketball.

Approach

- Detection
- Adjust Initial Position
- Throwing Action
- Feedback Learning

Approach: Detection

NAO is fixed at a position.
For target detection:

- **Convert RBG image to HSV** as it produces better results for creating binary image and also it makes the computing faster.
- **HSV to Binary Image by Erosion And Dilation**
- **Determining co-ordinates of the target**

Detection: Coordinates

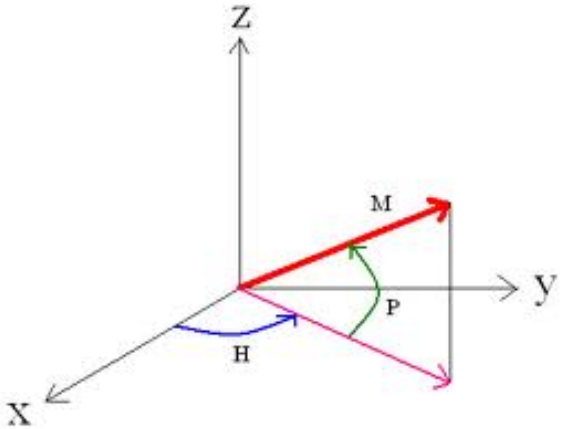

Figure: Coordinate System

- **Distance of Target:** $x = a_1 + \frac{b_1}{H}$
- **Offset of Target from the center :** $y = c_1 y_i + c_2$
- **Angle ϕ:** $\phi = tan^{-1}\left(\frac{y}{x}\right)$

Approach: Adjust Position

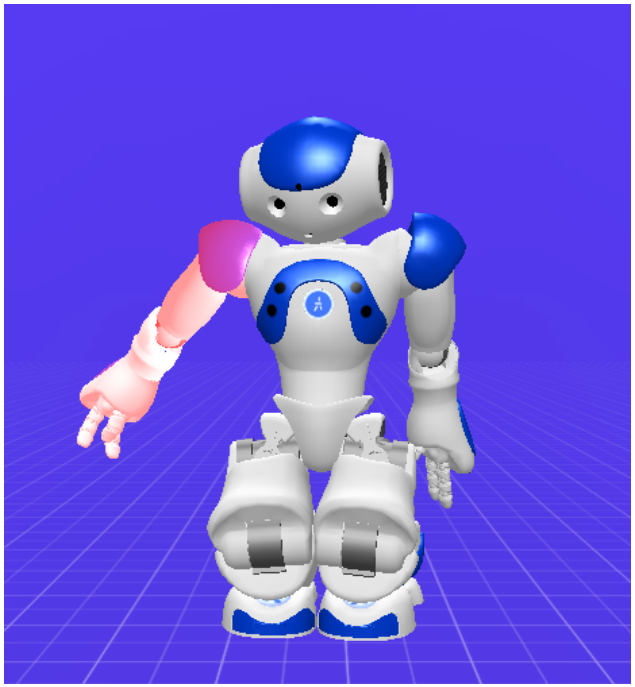

Figure: Nao

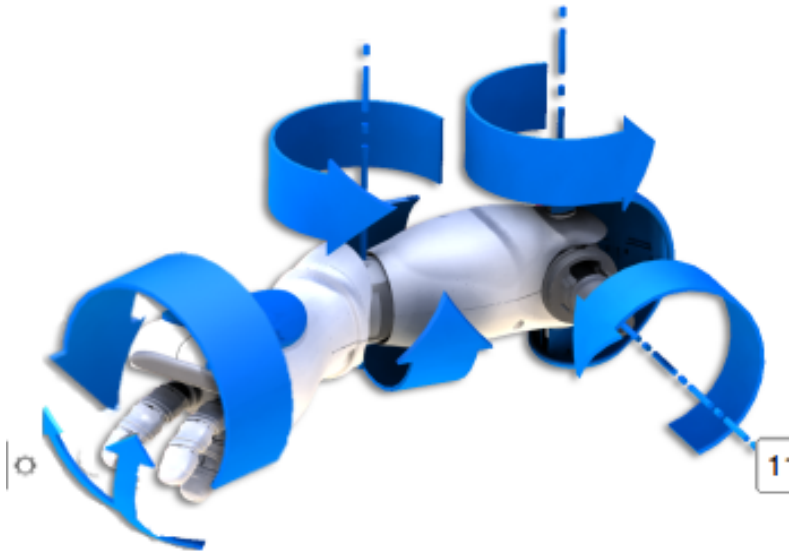

Figure: Arm Motors

Set the angle of the arm from the body so that it can move freely with maximum range.

Approach: Throwing Action

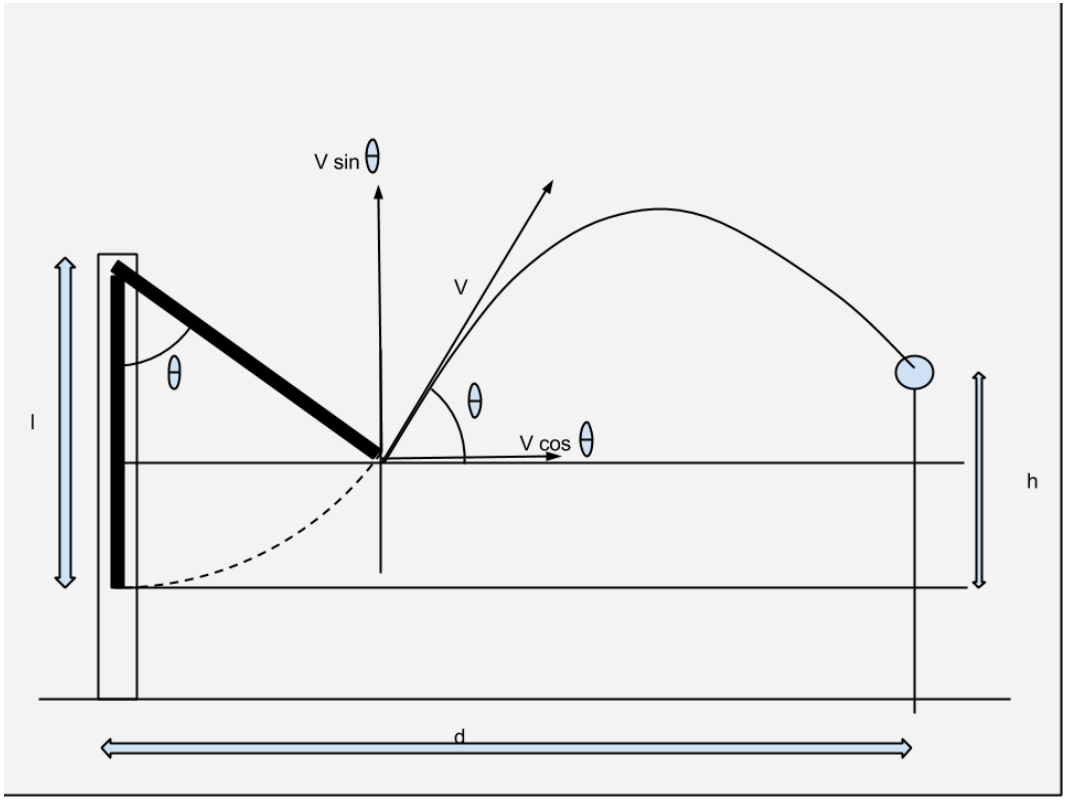

Figure: Trajectory of ball

Approach: Throwing Action

$$\frac{1}{v^2} = \frac{2}{g\left(d - lsin\theta\right)^2}\left(h - l\left(1 - cos\theta - sin\theta tan\theta\right) - dtan\theta\right)$$

where,

$v \leftarrow$ release velocity

$g \leftarrow$ gravitational force

$d \leftarrow$ distance of target from robot

$h \leftarrow$ height of target

$l \leftarrow$ NAO's arm length

When the arm reaches the desired angle, release the ball.

Feedback

4 possibilities for the ball to land wrt target:

Feedback

4 possibilities for the ball to land wrt target:
left, right, above, below

Feedback

4 possibilities for the ball to land wrt target:
left, right, above, below

- **How to**
  - Detect?
  - Correct?

Feedback: Detection & Correction

- Continuously take images of the ball and when it's radius is reduced by the same ratio as the distance of the target, following possibility may appear:
  - Ratio is reached
    - If on left side then feedback to move right
    - If on right side then feedback to move left
    - If overlap then success
  - Ratio not reached : increase target distance.

Reference

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