PROJECT PRESENTATION

ON

Design and development Of Ball Balancing Robot

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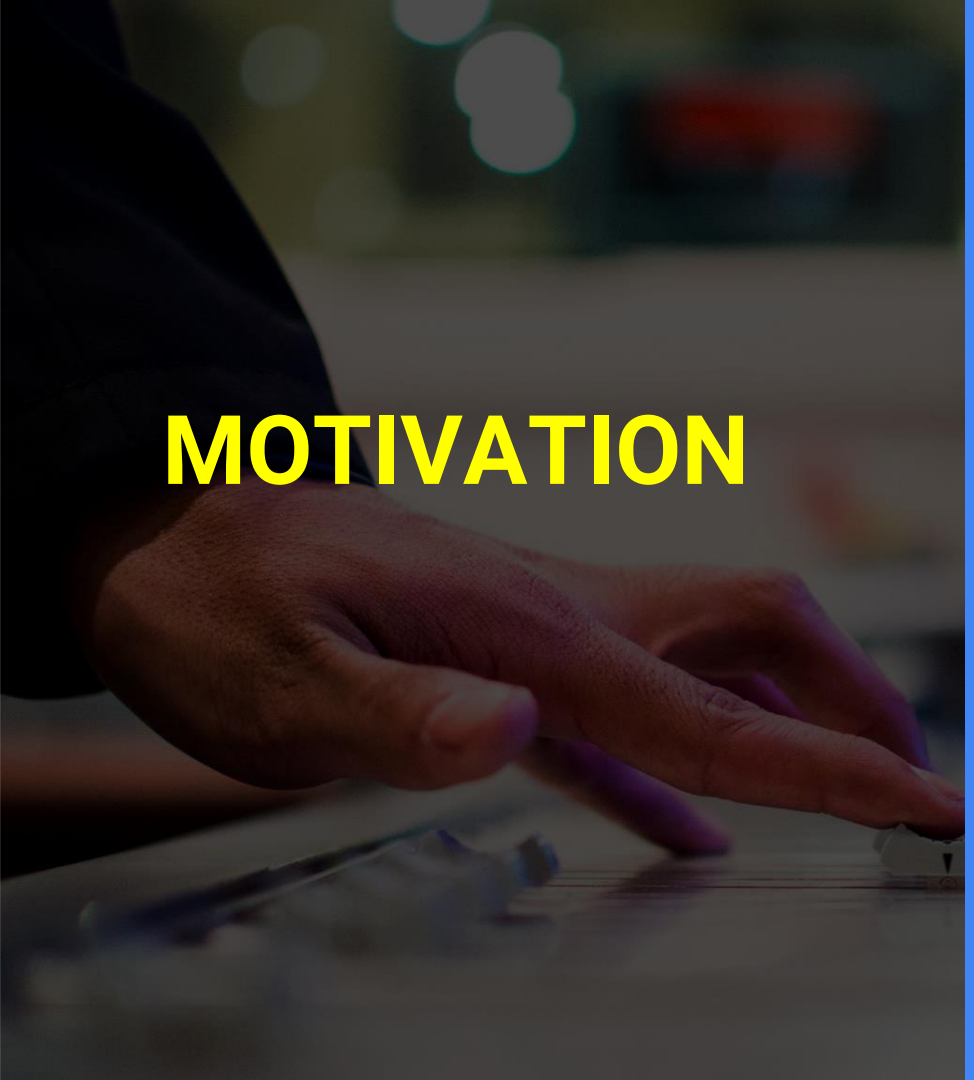
Contents

Idea:

To design & develop a Ball Balancing Robot on the principle of an Inverted Pendulum.



MOTIVATION

- Cutting edge research in the field of Robotics

- A good research topic on
  - Mechanical Design
  - Manufacturing Technology
  - Robotics Control & Automation

- Product development exposure

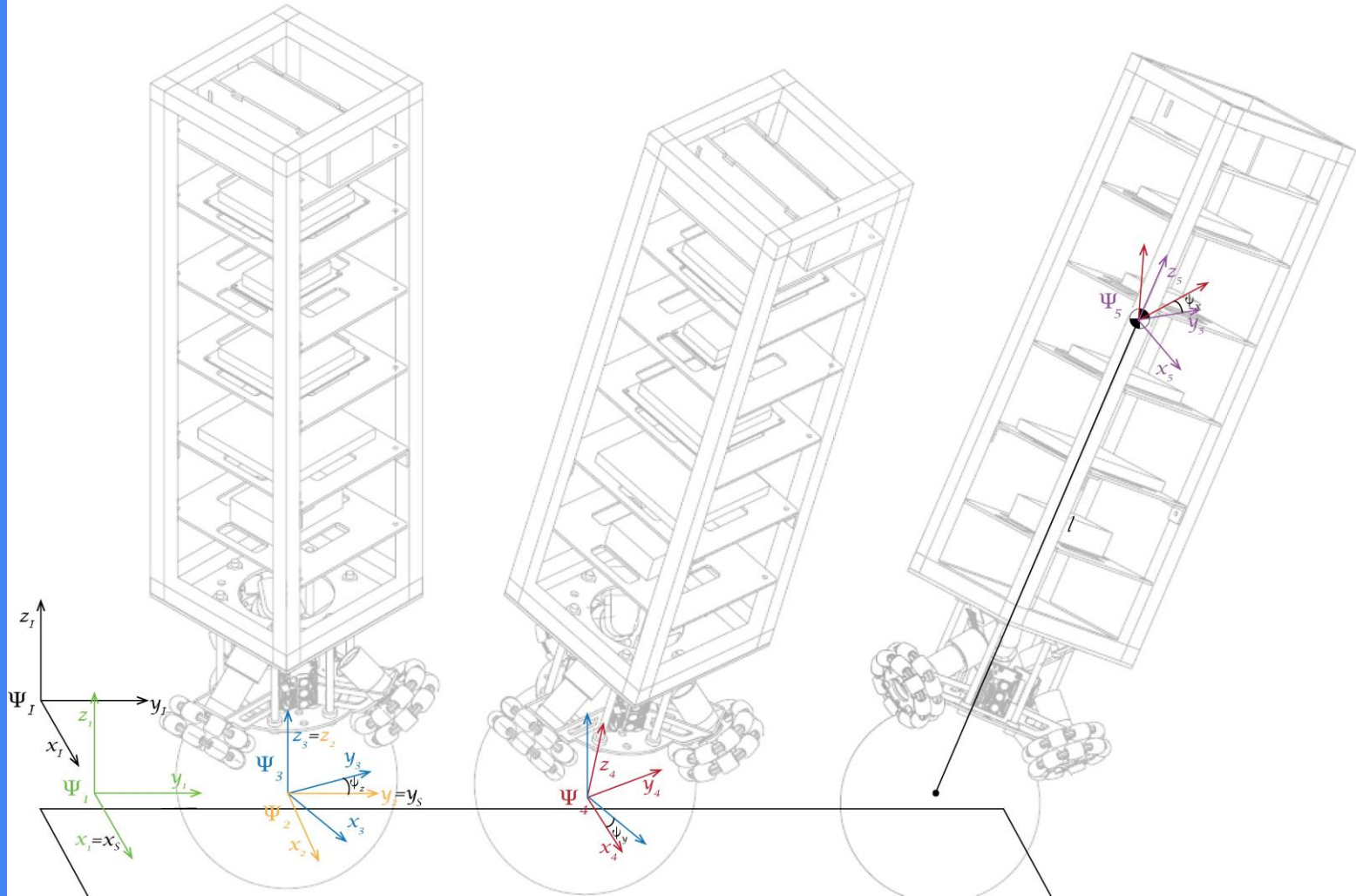
CONCEPT

- A Ball balancing robot is an OMNI directional robot balancing itself over a BALL.
- Advantageous over normal wheeled robot because of its Holonomic Drive.
- 3 DOF movement in a 2D plane.
- Dynamically stable robot- requires a fair amount of control theory to simulate the model.
- Measures the tilt of the robot from the vertical and calculates the motor torques and rpm to balance the robot.

Calculation of TILT Angle

RPM & Torques supplied at each wheel to minimize the Tilt

Move in the required direction to make it stable.


z_I
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l

Equations of Motion:

We will use the Euler-Lagranges method for the formulation of the equations of motion.:
The lagrangian is given by:

$$L = T - V$$

where

V = total potential energy of the system
T= total kinetic energy of the system.

So, we need to calculate the total kinetic and potential energies of the system

Energy of the system

Energy of the ball

$$T_s = \frac{1}{2} m_s (v^2_{2,I})^T (v^2_{2,I}) + \frac{1}{2} (R^2_I \omega^I_{s,I})^T I^2_s (R^2_I \omega^I_{s,I})$$

$$V_s = 0$$

Energy of the body

$$T_B = \frac{1}{2} m_B (v^5_{5,I})^T (v^5_{5,I}) + \frac{1}{2} (\omega^5_{5,I})^T I^5_B (\omega^5_{5,I})$$

Equations of motion

Once the lagrangian L is known, the equations of motion can be found by the followig relation

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \frac{\partial L}{\partial q_i} = \tau_{ext,i}$$

where i=1,2,..,5

The Approach

- Make the CAD of the system in SOLIDWORKs.
- Import the CAD to Matlab and simulate the model to completely balance and control its locomotion as well.
- Determination of the component specification as per the simulation.
- Manufacture the Robot as per the design.
- Design the controller with required electronics circuit.

Proposed Methodology

Step 1

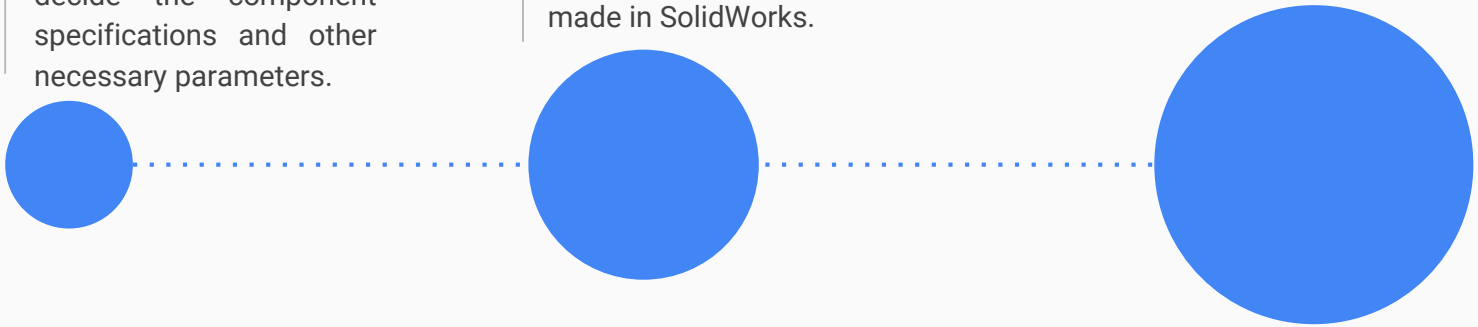
Simulation of robot dynamics in Matlab to decide the component specifications and other necessary parameters.

Step 2

With the desired specifications, a computer aided design is made in SolidWorks.

Step 3

Fabricate the hardware of the robot and make the electronic control circuit.

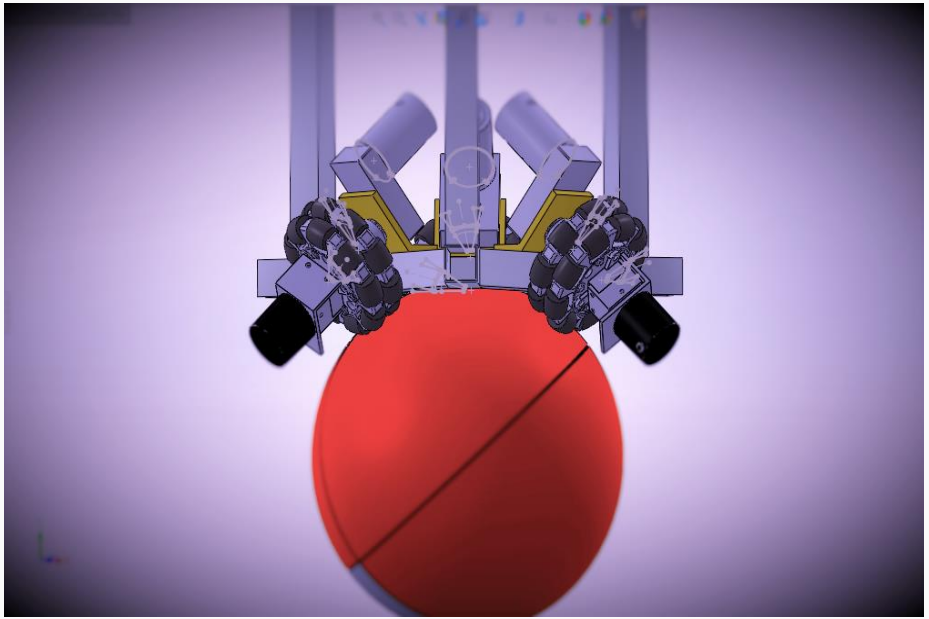


The Technology :

- ✓ HOLONOMIC Drive. (Omni directional)
- ✓ MEMS based Inertial Measurement Unit
- ✓ Design innovation taken by ETH Zurich. [*Fankhauser 2010*]

Holonomic Drive

- Omni Wheel is coupled with the DC Motor.
- By using different combination of rpm at each wheel, the robot can move in any direction.

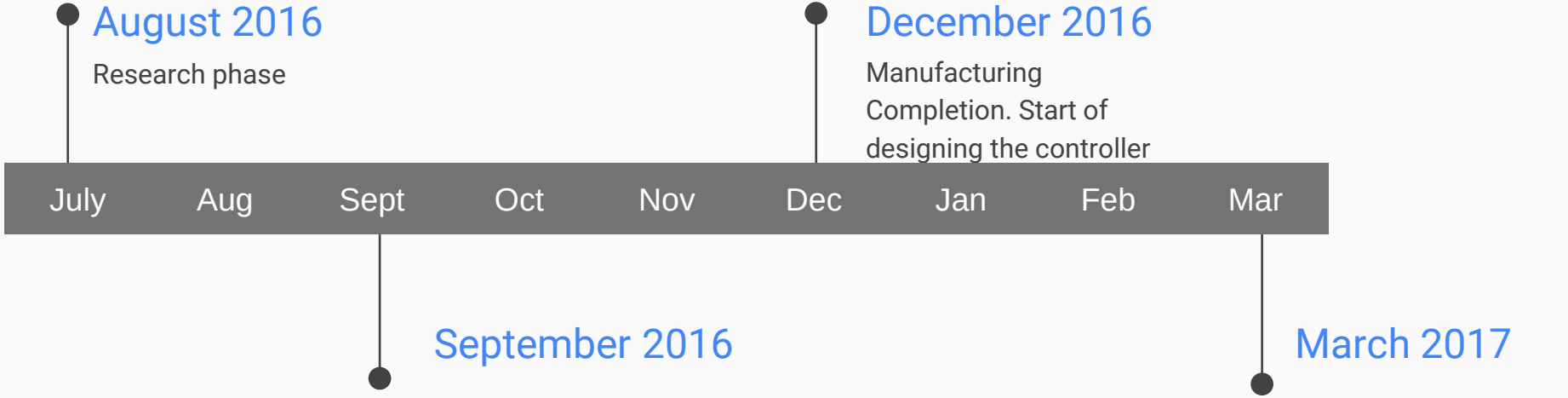


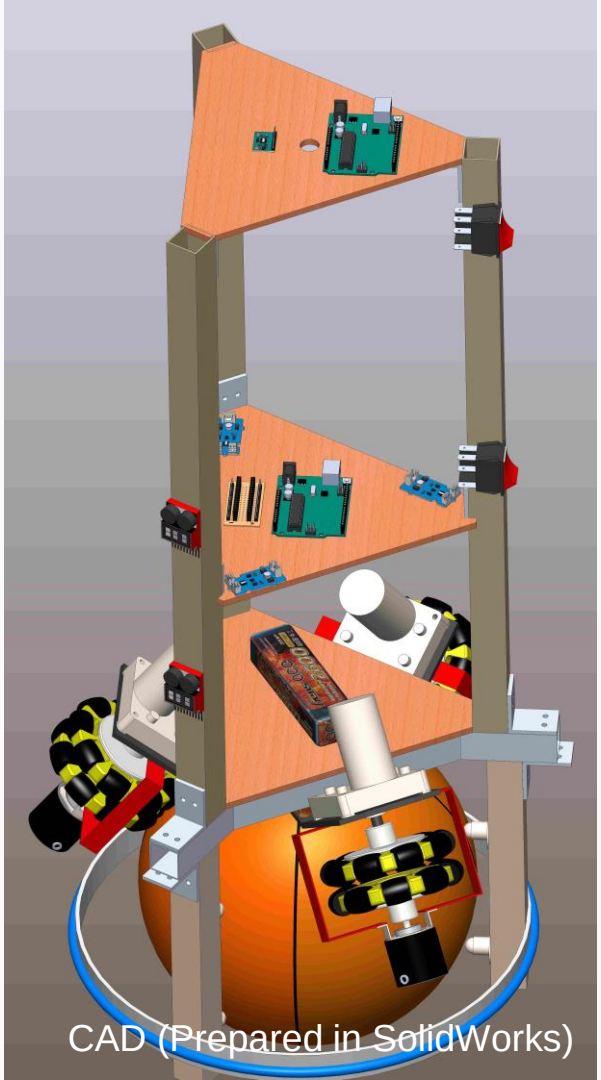
Inertial Measurement Unit

- Inertial Measurement Unit
- Consists of
  - Accelerometer
  - Gyroscope
  - Magnetometer
- Calculation of Roll, Pitch and Yaw

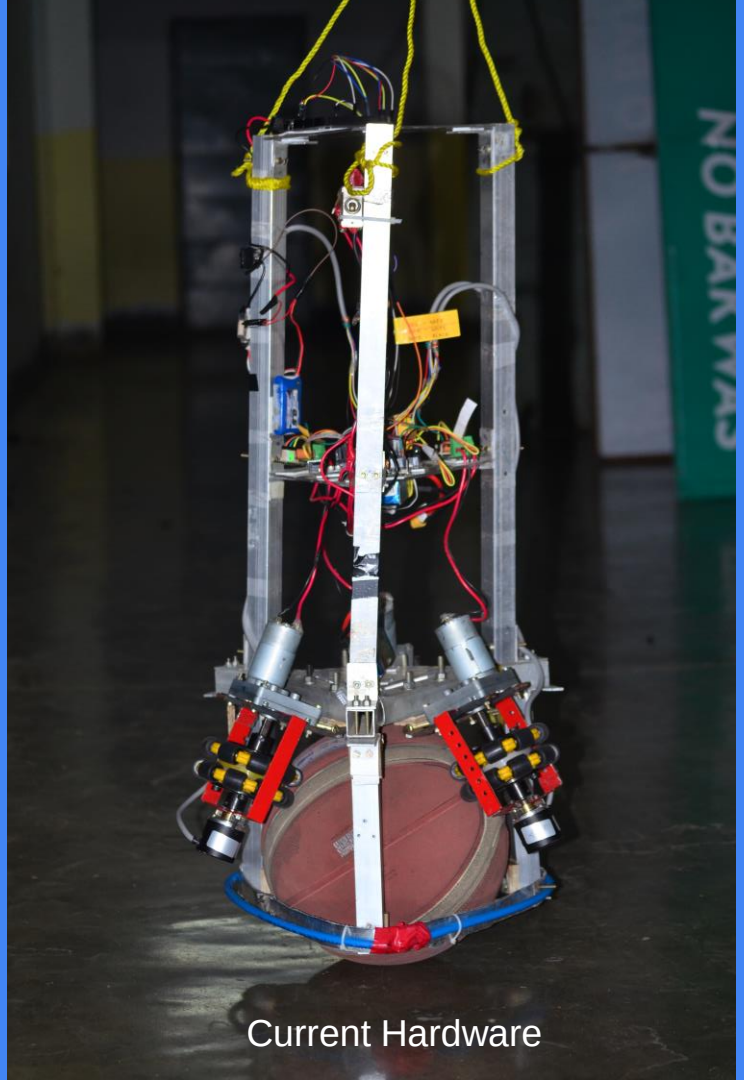
- Why IMU?
  - To measure the tilt angle.

Roadmap


August 2016
Research phase
December 2016
Manufacturing Completion. Start of designing the controller
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
September 2016
Start of CAD Modelling. Simulation of a dummy model in Matlab. Initiation of manufacturing.
March 2017
Completion of project and submission of report and WORKING MODEL



CAD (Prepared in SolidWorks)



Current Hardware

Applications

- It can be used as a personal transporter.
- Used in Rocket propulsion to make it dynamically stable while moving.
- A very productive teaching AID for teachers in Robotics.
- Can be used as a promotional robot.

- This kind of robot has not been reported in India till now and only very few prestigious universities around the world has it.

Application

Personal Transporter

COST ESTIMATE

ITEMS	QUANTIY	TOTAL COST
Planetary DC Geared Motor	3	3490 x 3 = 10470
Omni Wheels	3	2450 x 3 = 7350
Inertial Measurement Unit	2	1000 x 2 = 2000
Microcontroller	2	2875 x 2 = 5750
Incremental Optical Encoder	3	1990 x 3 = 5970
Motor Driver	4	990 x 4 = 3960
Aluminium Channels	-	2000
Welding, Nut, Bolt & other equipment	-	4000
Electrical Wiring & miscellaneous	-	3350
Basket Ball	1	1300
Shaft, Couplers, Keys & Machining	-	3000
Total		Rs. 48150/-

The Team

Sanchit Sinha

Gulshan Kumar

Hritwik Shukla

Dr. Arun Dayal Udai

Our respected guide & mentor

Thank you !!