Humanoid Robot

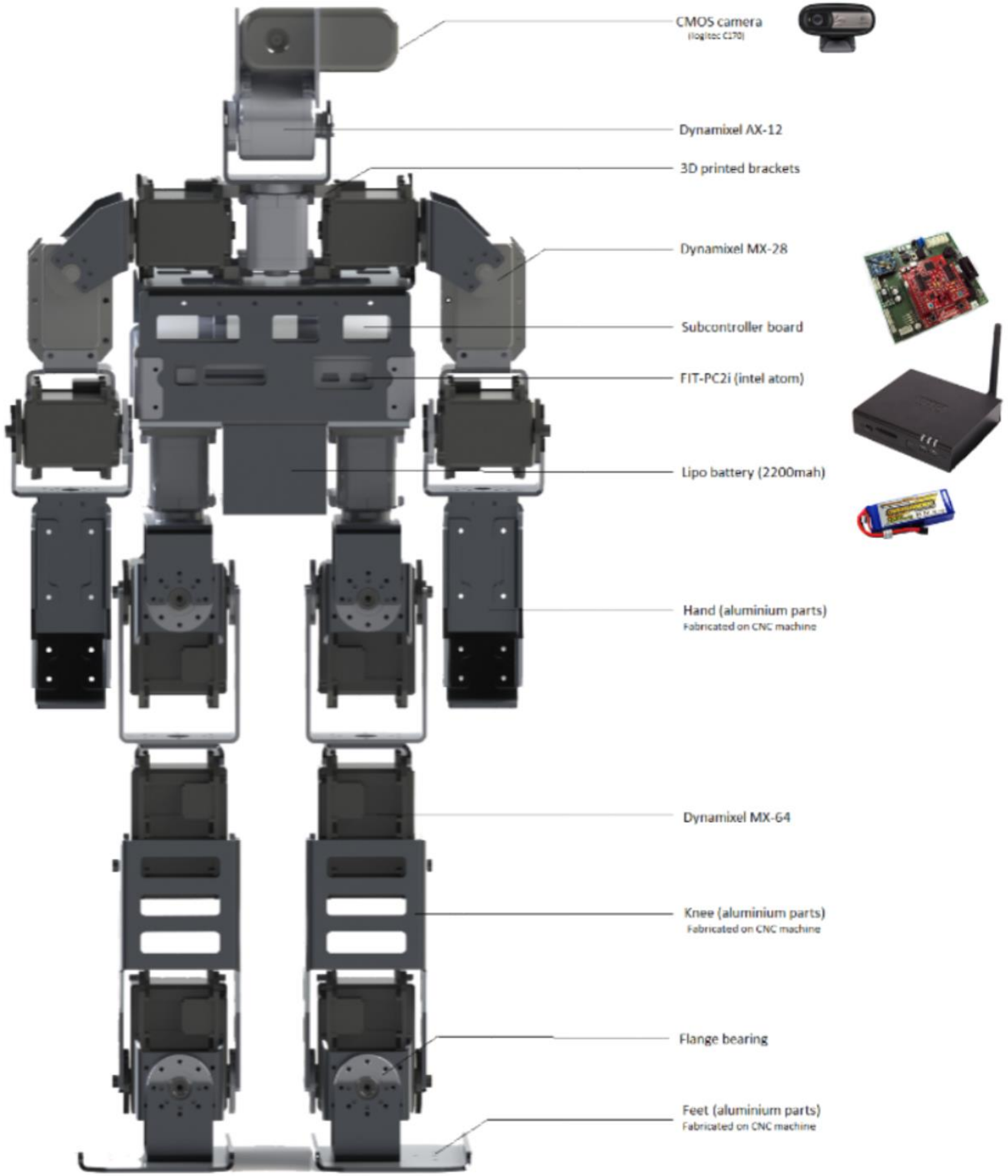
Dr. S.S. Chiddarwar | Dr. K. M. Bhurchandi

VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY

Humanoid Robot

- A **humanoid robot** is a robot with its body shape built to resemble that of the human body.
- A humanoid design can be for functional purposes, such as interacting with human tools and environments, for experimental purposes, such as the study of bipedal locomotion amongst other purposes.

- Height: 55 cm | Weight: 3.5 kg
- 22 Degrees of Freedom
- Intel Atom 1.6Ghz Processor Board
- Operating on Robot Operating System(ROS) platform
- Closed loop control using MATLAB and Simulink
- 9 Axis Inertial Measurement Unit
- Completely fabricated by CNC Milling, Mechanical Engg. Dept.



CMOS camera
(logitec C170)
Dynamixel AX-12
3D printed brackets
Dynamixel MX-28
Subcontroller board
FIT-PC2i (intel atom)
Lipo battery (2200mah)
Hand (aluminium parts)
Fabricated on CNC machine
Dynamixel MX-64
Knee (aluminium parts)
Fabricated on CNC machine
Flange bearing
Feet (aluminium parts)
Fabricated on CNC machine

SWAYAT

Major Focus Areas

Fabrication and Mechanical Designing
- Designed and Simulated in SolidWorks 2014
- 3D Printed Parts for precision
- Parts fabricated on CNC Milling using Aluminum Sheet Metal

Image Processing and Electronics
- ARM Cortex M4 Subcontroller
- 9 Axis Sensor Hub for acceleration and orientation
- Stereo Vision to detect and recognize objects

Control and Kinematics
- Dynamixel Smart Servo Motors with integrated magnetic encoders
- Wireless closed loop control algorithm
- Dynamic Balancing using ZMP method

Software Architecture
- ROS platform operated in Linux/Ubuntu 12.04
- Many-to-Many Nodal communications between the devices
- Graphical User Interface for Simulation and Visualization

Goals and Future Implementation

Our major aim is to participate and win in FIRA HuroCup in Sprint and Weightlifting Categories.

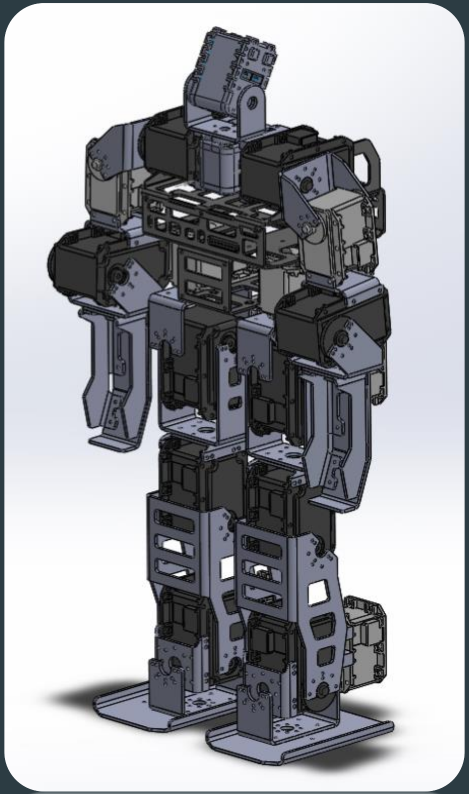
1.
- To make the robot completely autonomous and robust.
- To replace the robot's manipulators with a 4 finger claw grippers.

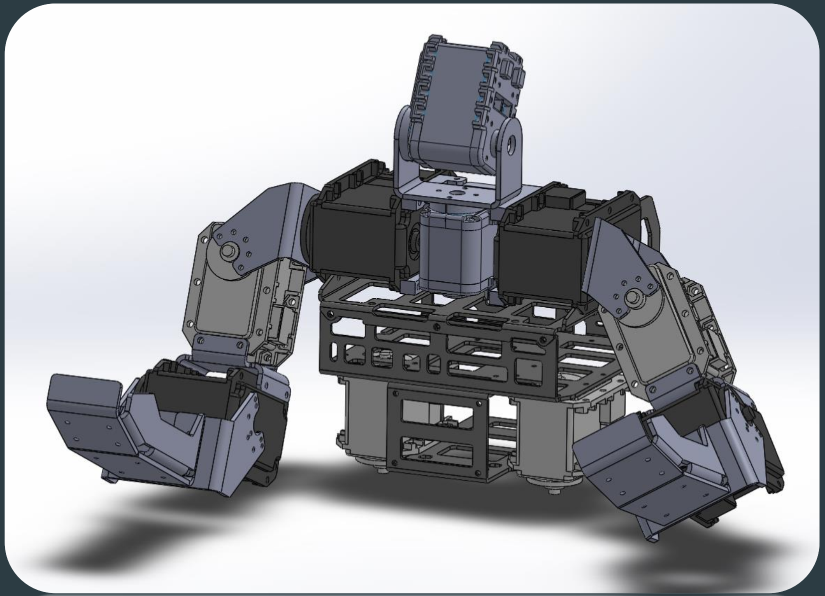
2.
- To participate and win the FIRA Huro Cup under Sprint And Weightlifting Categories.
- To participate in International RoboSoccer Olympics.

3.
- To provide a research platform for areas such as Artificial Intelligence, Motion Planning, Stereo Vision and Adaptive Control Systems.
- To implement Simultaneous Localization and Mapping.

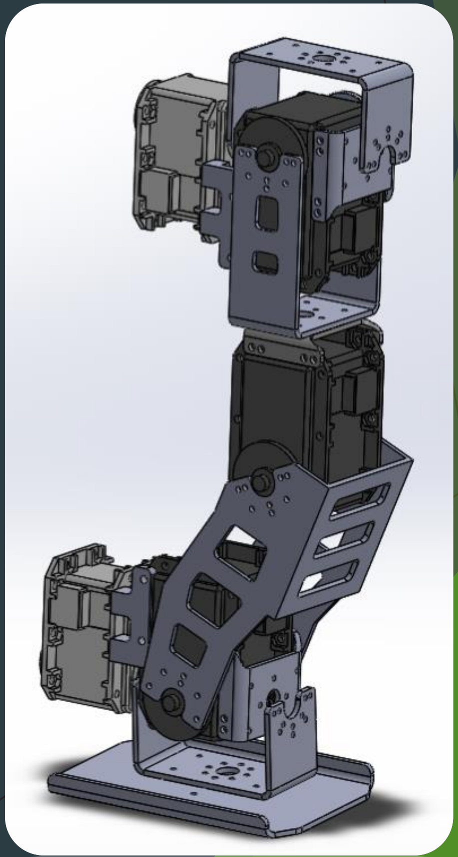
Fabrication and Mechanical Design

- Designed in SolidWorks 2014 according to requirements.
- Modelling and Simulation for individual subassemblies of the robot was performed.





Views of Humanoid and its Sub-assemblies

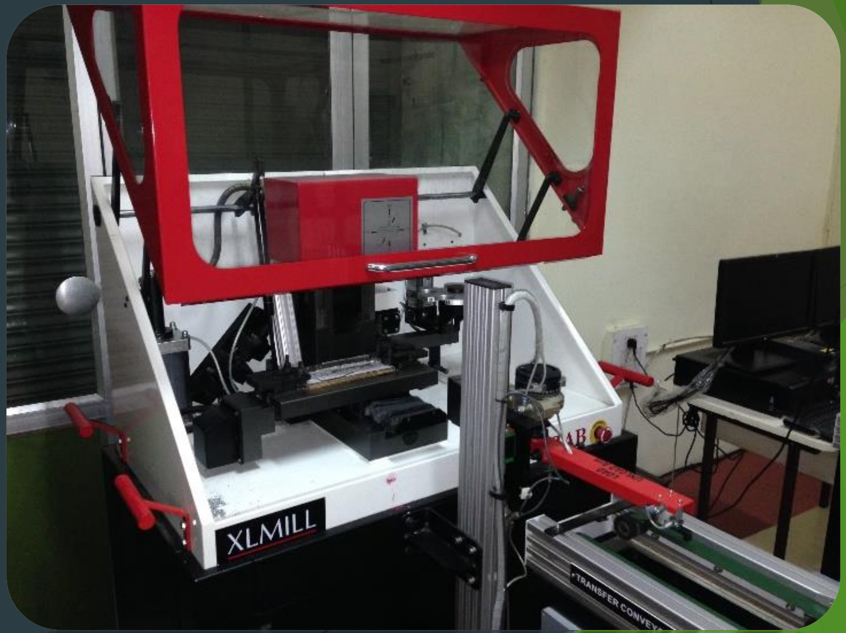


Fabrication and Mechanical Design

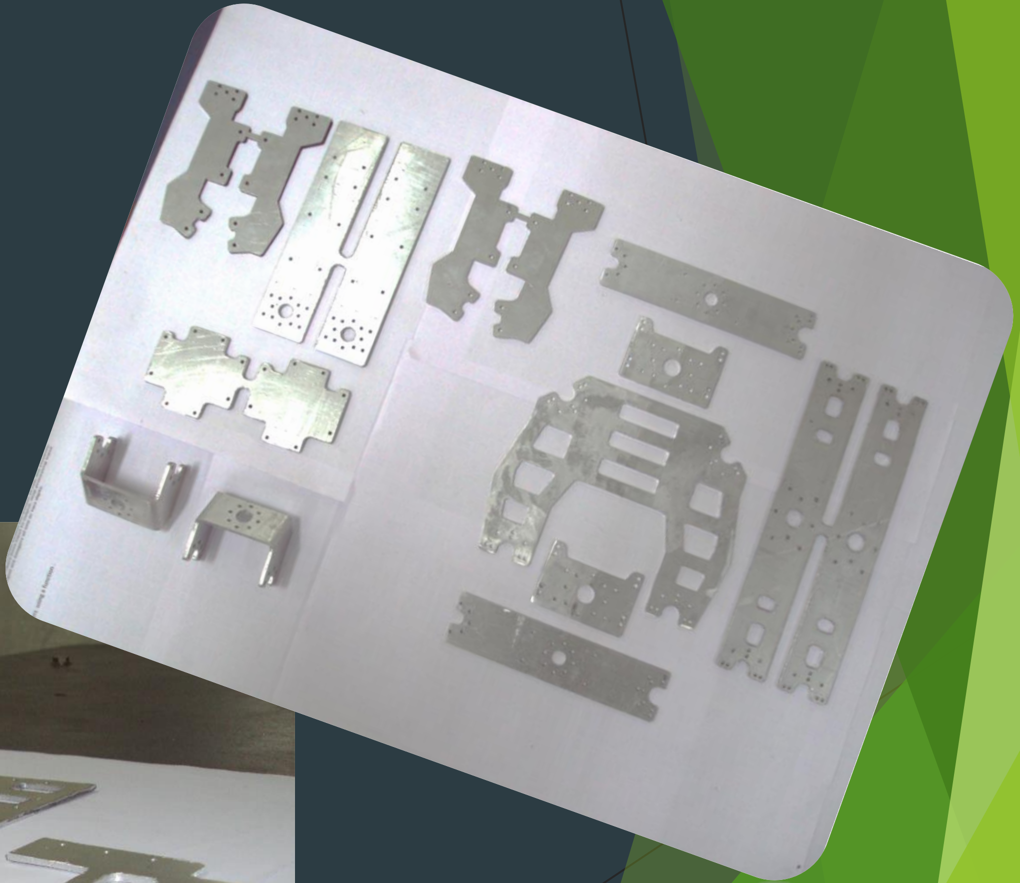
- Generation of G-Code by importing 3D Model in Edge-Cam Software.
- Sheet Metal Milling done on XLMILL Computer Numerical Control (CNC) for precision in parts. All the parts required have been fabricated.
- Aluminum 6062 used for strength and dynamic load withstanding ability.

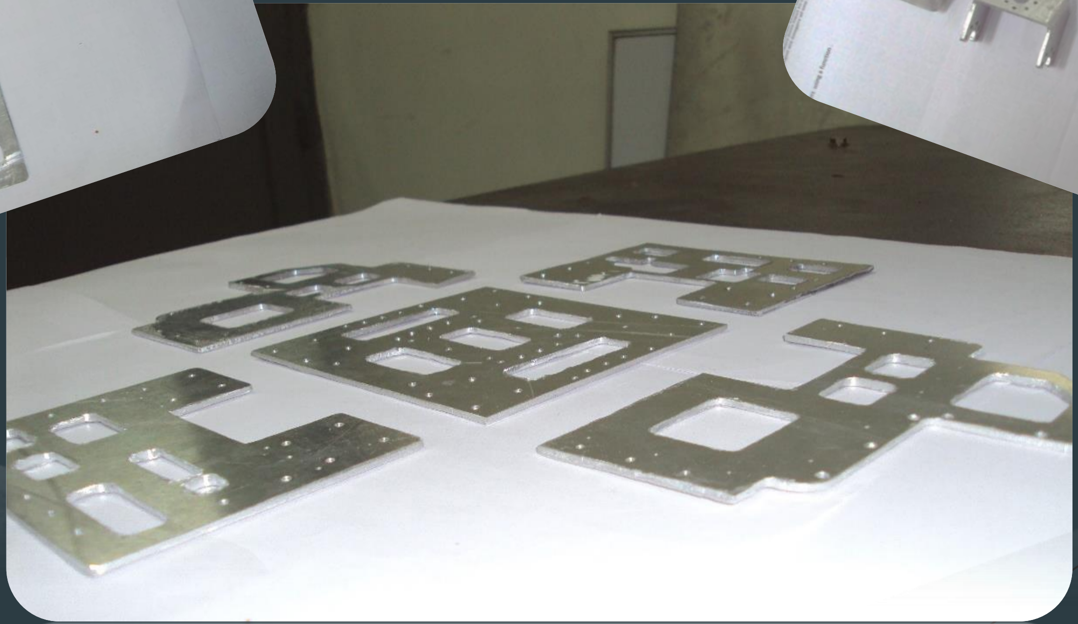
Left: Knee Bracket after Machining

Right: CNC Machine at FMS Lab.



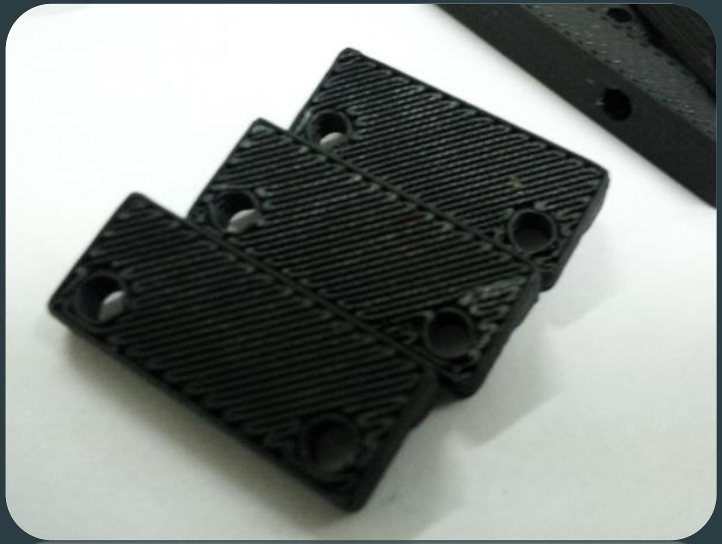
Fabrication and Mechanical Design





Fabrication and Mechanical Design

- 3D printed parts have been used for accurate smaller sized parts, eg: Flanges and Idler Horns.
- ABS Plastic used for higher strength, wherever required



3D Printed Parts, Flanges and Supports

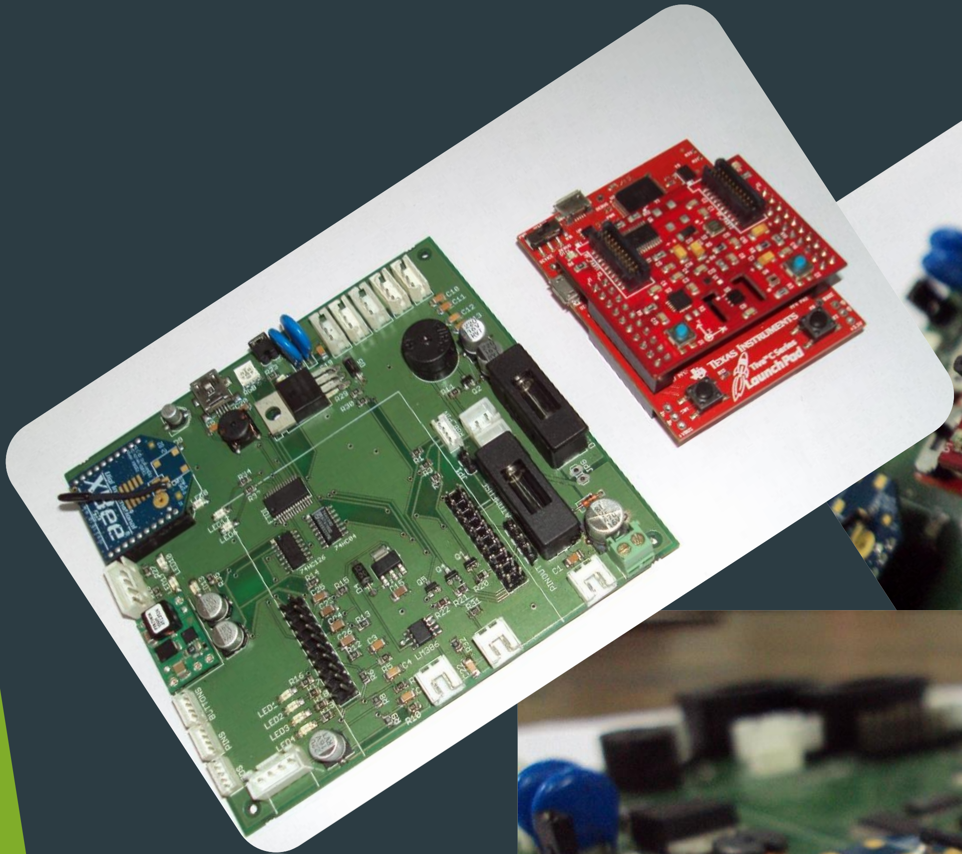
Electronics and Image Processing

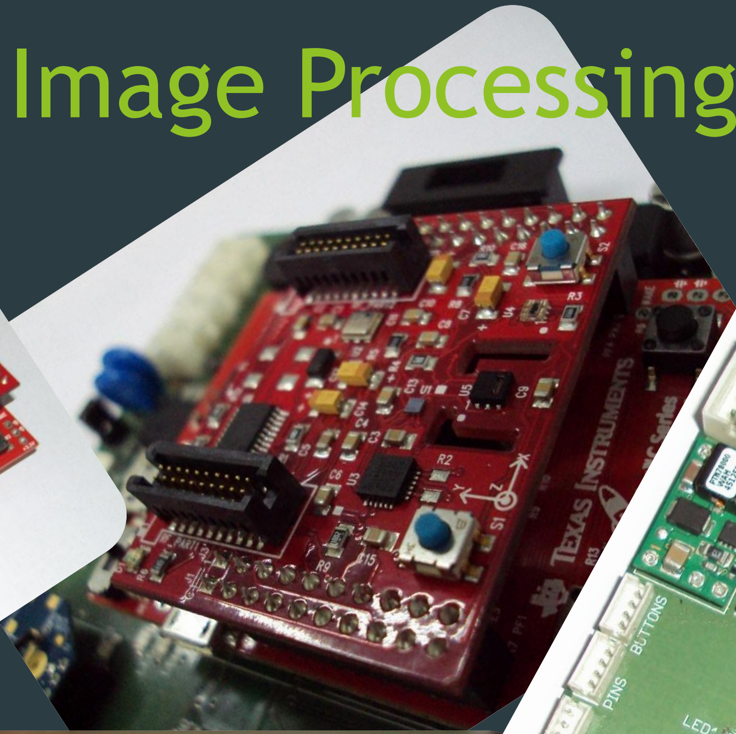
- Intel Atom Processor Board with 1.6Ghz Clock Speed (Single Core), 2GB RAM and 16GB SSD Memory.
- Linux Mint 13 is used as a supporting OS. It is a basic version of Ubuntu 12.04.
- Power of a desktop computer embedded within a size of 10cmX10cmX2cm. Small size is necessary for the humanoid robot's portability.
- Minimal Power consumption at just 4.5 Watts, ensuring a longer battery life.

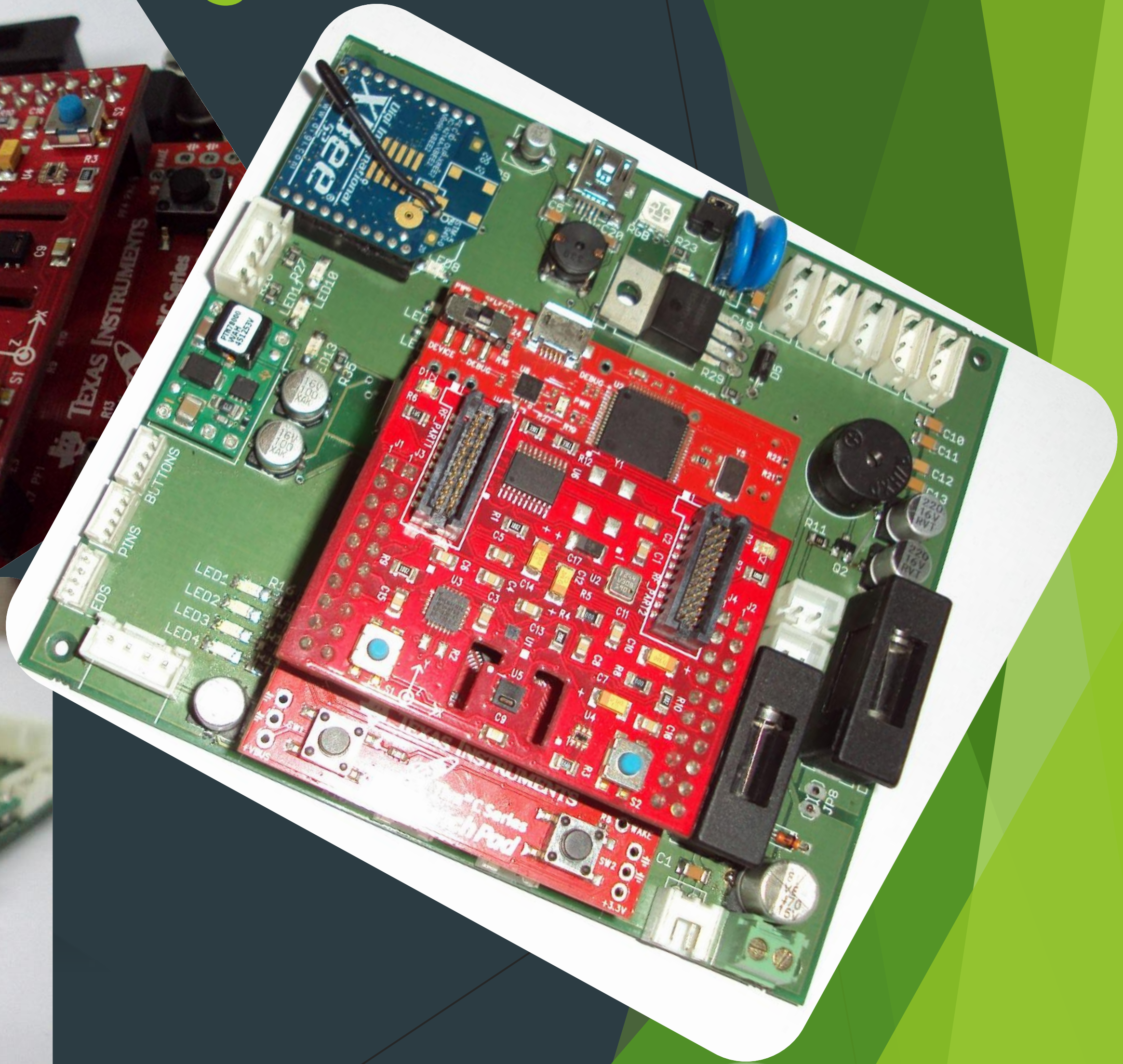
Left: Bare FitPC2i Motherboard

Right: Intel Atom inside its casing

Electronics and Image Processing

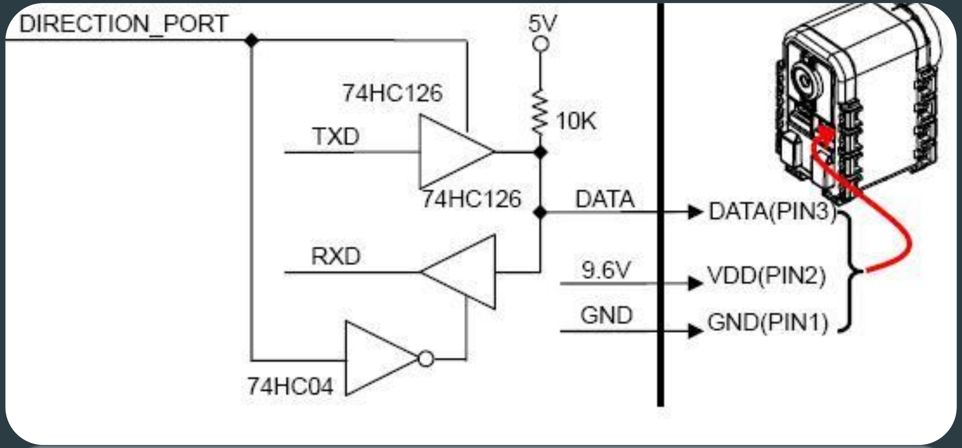


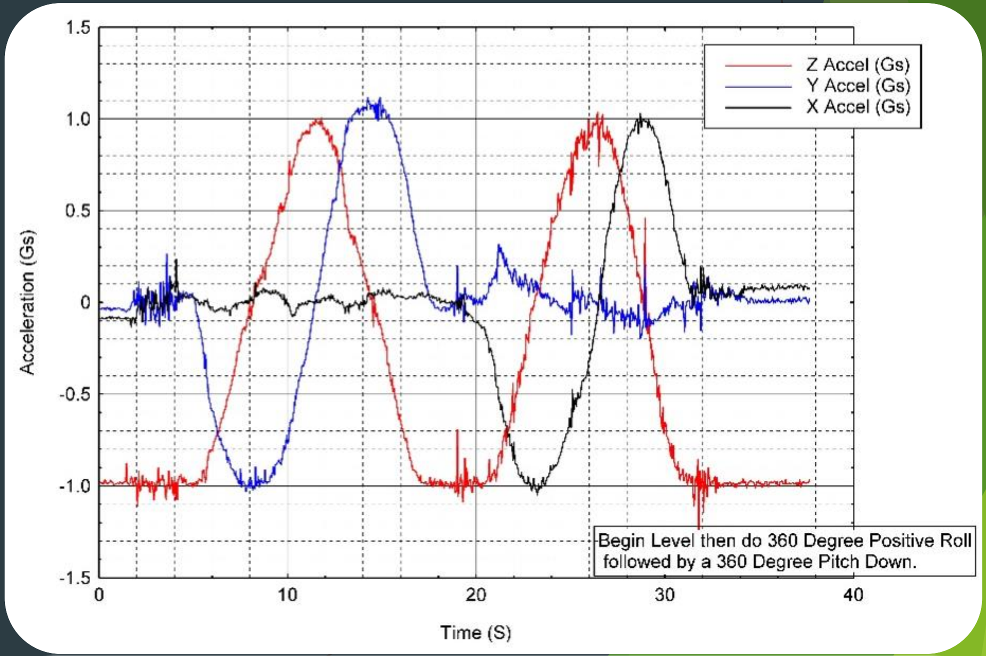




Electronics and Image Processing

- TIVA C Series used as to interface the main controller to the motors, sensors and other accessories like speakers and Camera.
- Dynamixel Half-Duplex Control circuit was designed and printed to control the Smart servo actuators.
- Integrated with SensorHub Booster Pack, with 9 Axis IMU. Advanced filters were used to obtain the values of Angular orientation and accelerations.

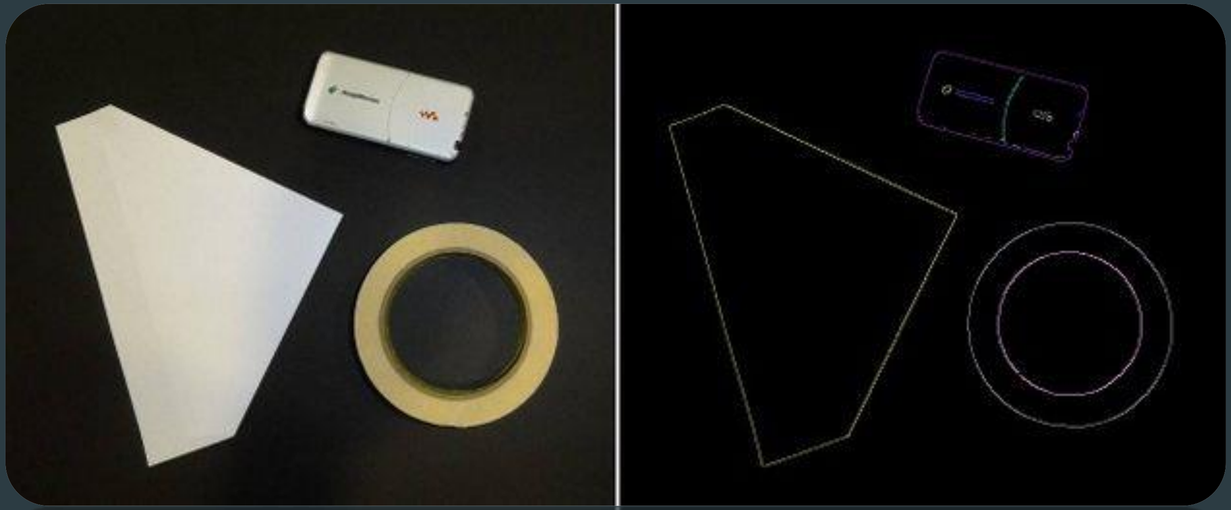




Half Duplex Circuit and Variation of Acceleration with Time (Right)

Electronics and Image Processing

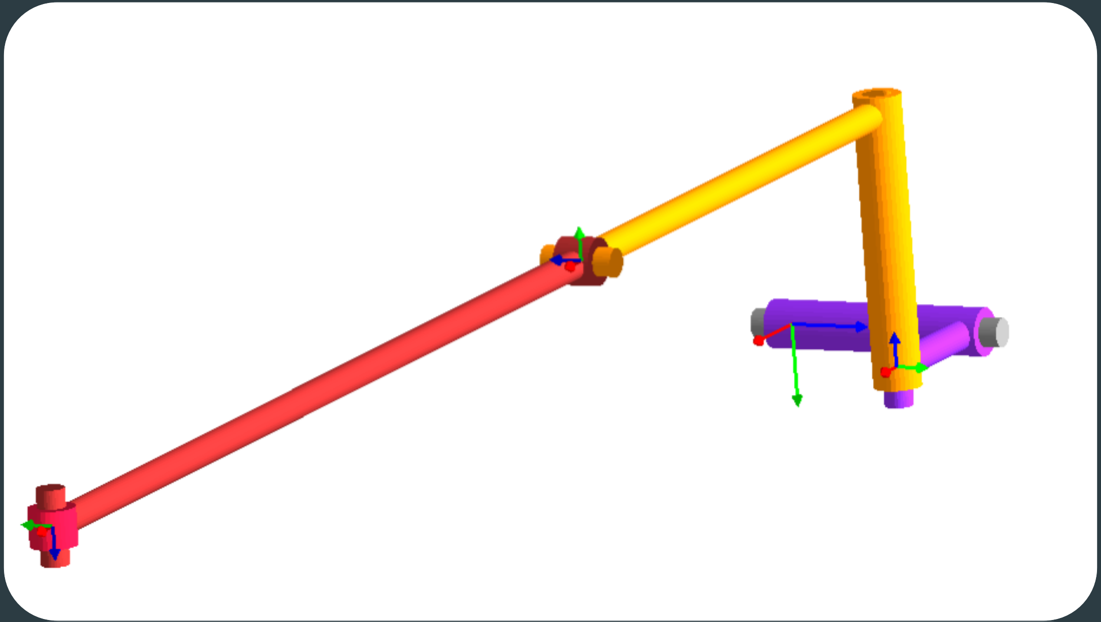
- Implemented Single camera distance detection using angular view of the camera mounted on head.
- Adaptive Thresholding was used to avoid the interference due to light disturbances and minor change in distances.
- Shape detection using contours was used for detection on unique shapes amongst others. This is used to differentiate the target position.



Shape detection using Canny Edge algorithm

Controls and Kinematics

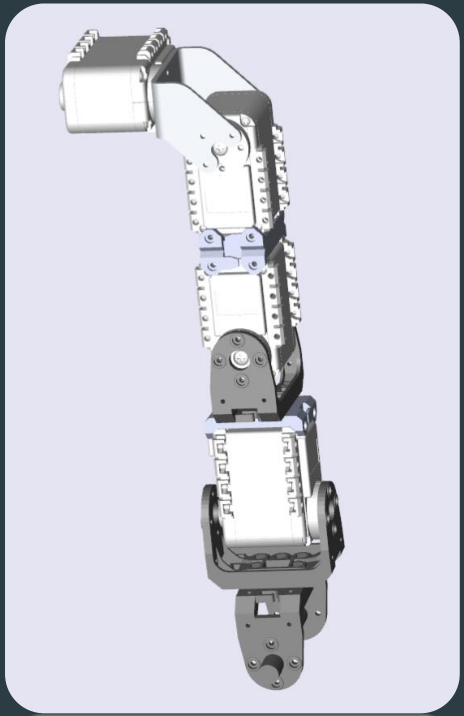
- Complete forward and inverse kinematics done in MATLAB. Inverse kinematics done by Constrained Minimization Algorithm.
- Path generation between the required points was done using spline fitting for smooth trajectories. Constrained motion was also achieved to limit the motion if required.



Analysis of DH Parameters and frames of the Arm

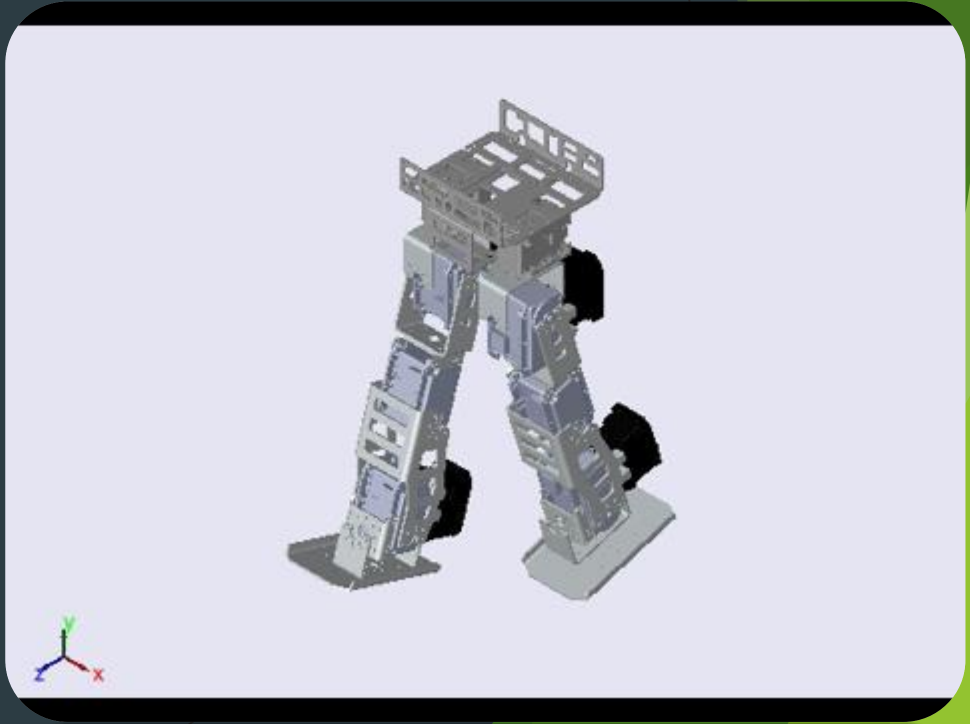
Controls and Kinematics

- Simulation of the robot arm was done in Simulink. The robot arm can write individual letters and words.
- Humanlike Gait design implemented in Simulink using CAD models. Zero-Moment Point method used for maximizing the stability while walking.
- Aim to use under-actuation to generate efficient gaits.



Simulink model and simulation of the robotic arm (Left)

Visualization of Walking gait in Simulink First Generation (Right)



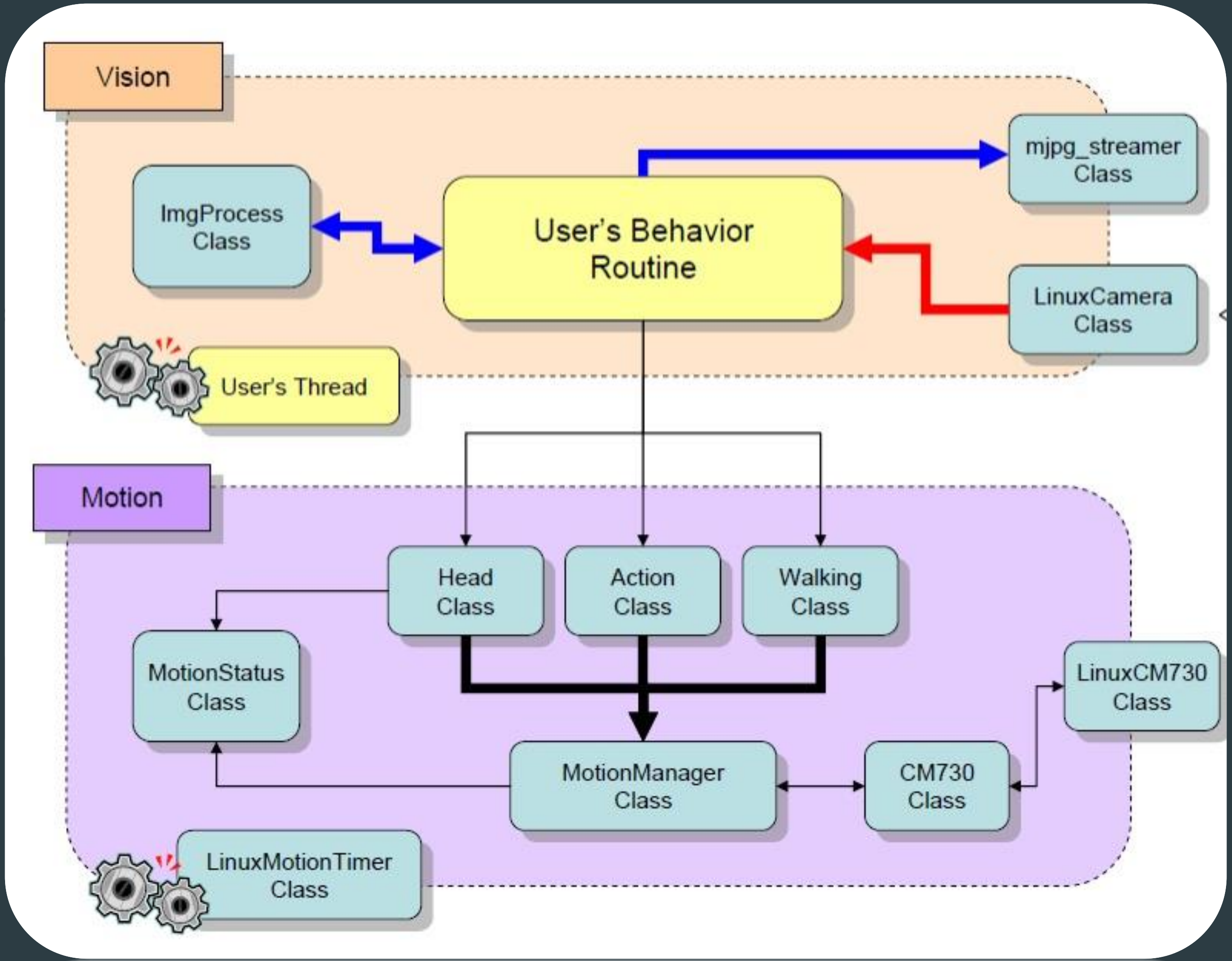
Controls and Kinematics

- Robot divided into 5 kinematic chains for analysis of forward and inverse kinematics : Head, Right Arm, Left Arm, Right Leg and Left Leg.
- Inverse kinematics done by Constrained Minimization Algorithm by constraining dynamic and kinematic constraints.
- Force Sensitive Resisters and Tactile Sensors used to calculate CG.
- Motors with different torque ratings placed at various joints in accordance with their torque requirements.

Software Design

- Implemented Robot Operating System on Ubuntu 12.04, to act as a main control platform between all hardware.
- Data input is published from sensors, Dynamixel Smart actuators, Wireless user input, Camera and Microphones.
- Data output is received in Main Class using and interpreted to make autonomous decisions about the motions like walking and action gaits.
- ROS Timers are used for scheduling the synchronous data output tasks to the sub-controller.
- UART class is used for interpreting the data from the hardware.

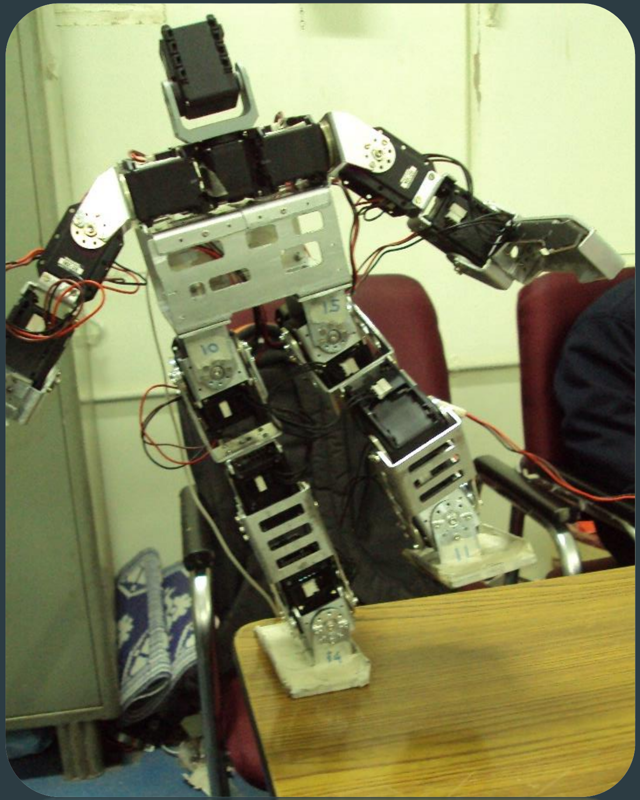
Software Design



Flow Control Diagram for the Software Design Process

CURRENT STATUS

- Swayat is currently fully assembled and being used for testing of various gaits.



Resources Needed

- Intel Atom Processor Board – FITPC2i Board
- Dynamixel MX64 Motors
- MakerBot Replicator 2X 3D Printer
- LCD Display for visual output
- Digital CRO
- Function Generator
- PCB Printer

Thank You

With regards,

Innovation labs, VNIT.