# A cost-effective, agile and robus quadruped robot

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad


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*Image courtesy: a.ANYmal(©Anybotics and ETH Zurich) b.Spot(©Boston Dynamics) c.Laikago(©Unitree Robotics) d.MIT mini-cheetah(©MIT Biomimetic robotics lab)*

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# Motivation

- Legged robots, especially Quadruped robots are increasing in demand, especially by various defense agencies due to their ability to traverse rough terrain that is too rocky, sandy, muddy, snowy and wet for existing conventional vehicles.*
- They can be very useful in case of a fire, in case of natural disasters like earthquakes, for surveying high radiation areas, for detecting a leakage in a toxic areas like a nuclear power plant, underground operations in mines, defense, surveying in wildlife reserves, etc.

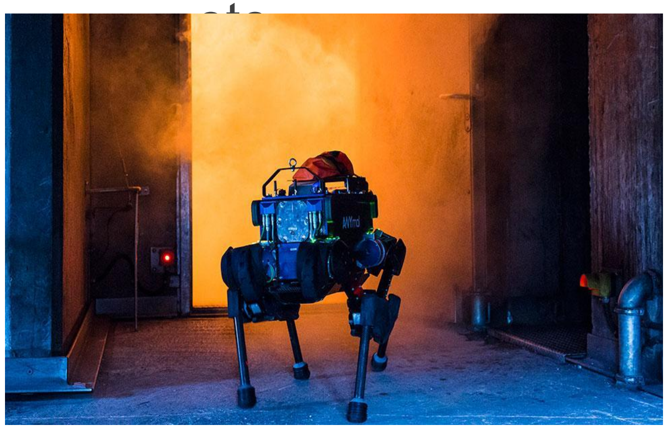




*Image courtesy:-https://rsl.ethz.ch/robots-media/anymal.html*

* *Raibert, Marc(2010):Dynamic Legged robots for rough terrain*

# Objective

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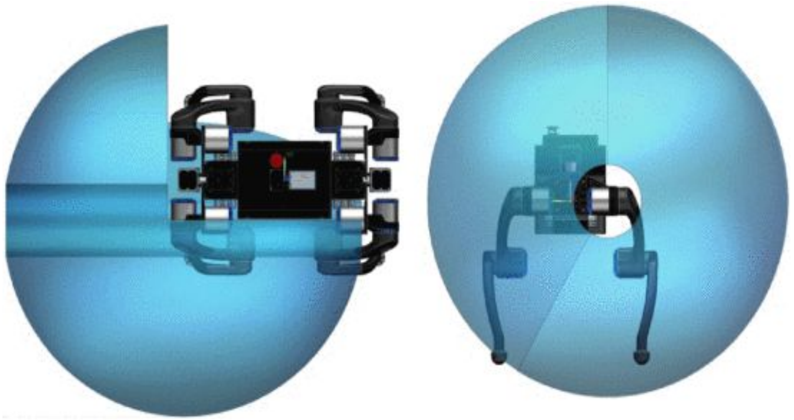
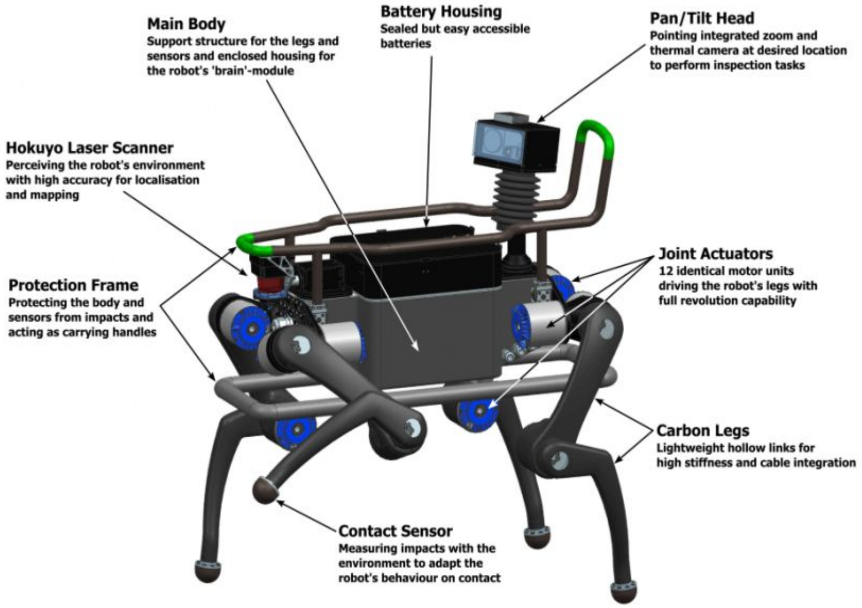
I plan to make a quadruped robot which is quadrupedal but not in a conventional sense. Quadruped robots are more stable in mobile movement than legged or biped robots* but they face several difficulties while locomotion like:-

- ❖Travelling down through a tunnel or through a gap which is smaller than the robot's minimum achievable height for locomotion.

- ❖Crossing an obstacle of a certain height in its way by possibly jumping or by any other means.



*Range of motion for ANYmal ©Marco Hutter*




*Main components ©Marco Hutter, ANYbotics*

- ❖ Travelling through a narrow gap like that of between two closely packed walls.

**Note:-**Only about half the Earth's landmass is accessible to wheeled and tracked vehicles, yet people and animals can go almost everywhere on foot. *Ref:- Raibert, Marc(2010):Dynamic Legged robots for rough terrain*

**At average speeds, they tend to form a stable tripod and their COG is maintained nearly at the center of their torso and at a lower level than bipeds.*
***Ref:-**Bekey, George A. (2005). Autonomous robots: from biological inspiration to implementation and control. Cambridge, Massachusetts: MIT Press*

# Proposed method

I thought of a design which could tackle all these problems effectively and also enable the robot  move swiftly in rough terrains. For the objectives mentioned, I’m planning the robot to:-

1. Sway down through a tunnel or a narrow gap by reconfiguring itself as shown in the next slide.

2. It could take support of any of the three major joints (of the torso)and cross the obstacle.

3. As the robot is planned to have a small girth, it should be able to crosee narrow gaps by reconfiguring itself.

***Image:-****BigDog is able to walk up and down 30 inclines, trot at speed up to 1.8m/s, carryover 153 kg of payload, walk through forest, snow, recover balance after sliding on ice or after kicks from the side*

*Ref:-* M. Raibert, K. Blankespoor, G Nelson and R. Playter, "Bigdog the rough-terrain quaduped robot", *Proc. 17th International Federation of Automation Control Seoul Korea 2008*

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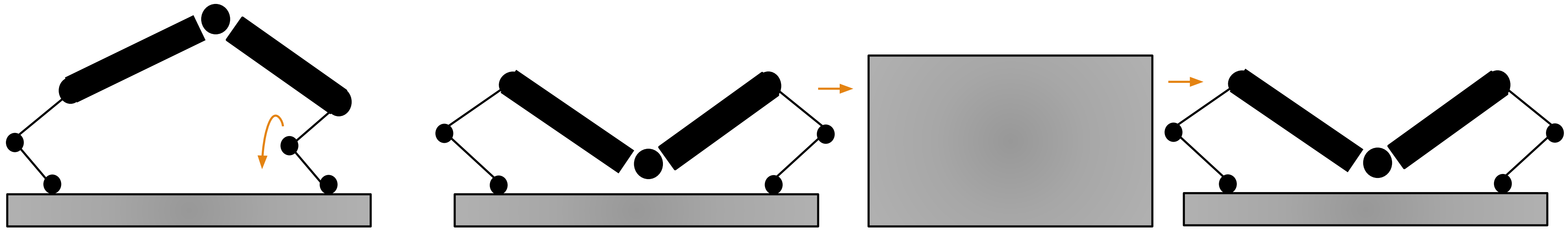
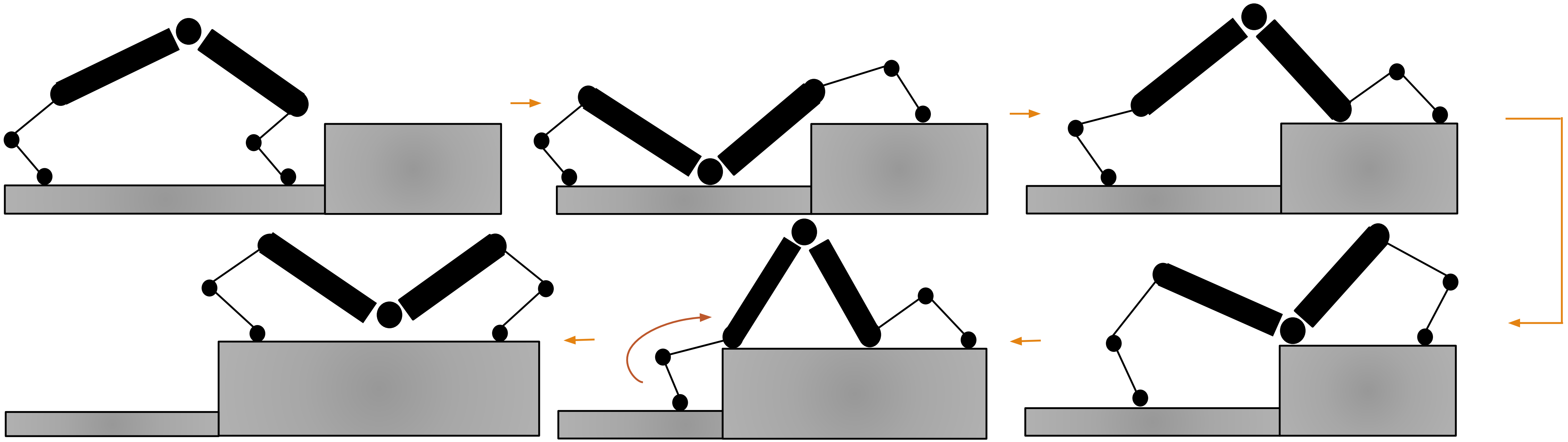
## Going down through a tunnel



## Climbing up an obstacle



# Targeted equipment and specifications + Budget Considerations

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## *Sensors:*

*1.Vision-based/perception sensors:-*

- **Stereo camera:-** Intel Realsense T265 (includes two fish-eye sensors, an IMU and a VPU where we can run SLAM algorithms directly). (around Rs.17k)

Dimensions:-108*25*13mm
Link:-https://www.intelrealsense.com/tracking-camera-t265/

- **Depth camera:-**Intel Realsense D435(wide field of view and upto 10m range,Realsense SDK 2.0) (around Rs.12k)

Dimensions:-90*25*25mm
Link:-https://www.intelrealsense.com/depth-camera-d435/

- **TOF cams/ LiDARs:-**Not necessary in this case

*2.Heading sensors:-*

- **IMUs/gyros:-** In the Realsense T265, BMI055 IMU is already integrated

*3.GPS:-* will not use as of now, beacons can be used alt.


*Realsense T265 ©Realsense*

*Realsense D435©Realsense*


*The MESA Swissranger* is a great cam because of high data rate for point cloud mapping and visual odometry*
*http://wiki.ros.org/swissranger_camera


*Hokyu laser rangefinders© Hokuyo*

*4.Wheel/motor sensors/actuators:-*

- **Motors:-** The Faulhaber series 3272 motors(32mm d, 72mm l) would be a good choice ( link:-https://www.faulhaber.com/en/products/series/3272cr)(actuators for KFE joint are not decided yet) (4*Rs.3k)
- **Gearbox:-**Series 32/3 are compatible with the given motor (link:-https://www.faulhaber.com/en/products/series/323/)
- **Wheel encoders:-** CUI Devices' AMT-102 rotary encoder at each moto (link:-https://www.cuidevices.com/product/resource/amt10.pdf)(4*Rs.1400/-)

*5.Other sensors like thermal imaging sensors or gas sensors can also be added*

## *Controllers:-*

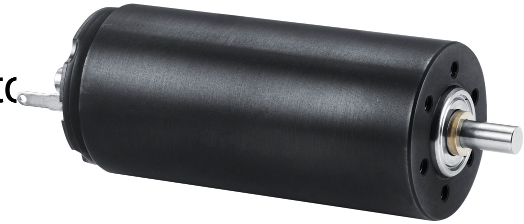
- **Microcontrollers:-**STM32F407G-DISC1 Development Board by STElectronics-Can be used for respective joint-level control in each actuator.(4*Rs.1500/-)

(link:-https://www.st.com/en/microcontrollers-microprocessors/stm32f4-series.html)

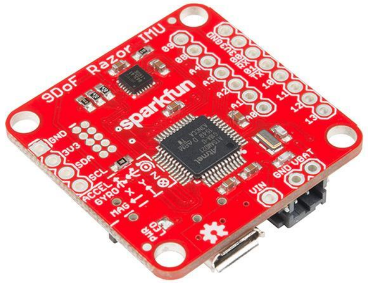
- **IMU(additional):-** Can be placed along all the actuators(Rs.2706/-)

(link:-https://www.sparkfun.com/products/14001)

AMT-102 wheel encoders with 0.25 deg. Accuracy(©CUI)



Faulhaber series 3272 motors(©Faulhaber)




9DOF Razor IMU ©Sparkfun

STM32 series microcontroller©digi-key India

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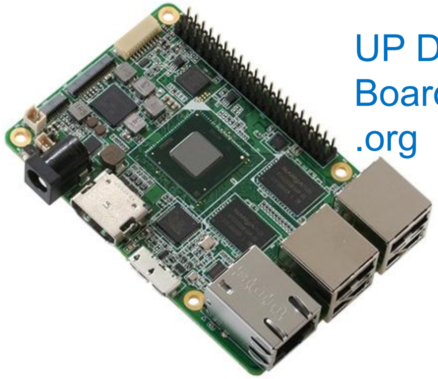
## *Computing:-*

Available options:-

- ASUS Tinker Board (link:-https://www.asus.com/us/Single-Board-Computer/Tinker-Board/) (Rs.5k)
- UP Developer Board with Intel® Atom™ x5-Z8350 Processor SoC (link:-https://www.aaeon.com/en/p/up-board-computer-board-for-professional-makers/) (Rs.7k)

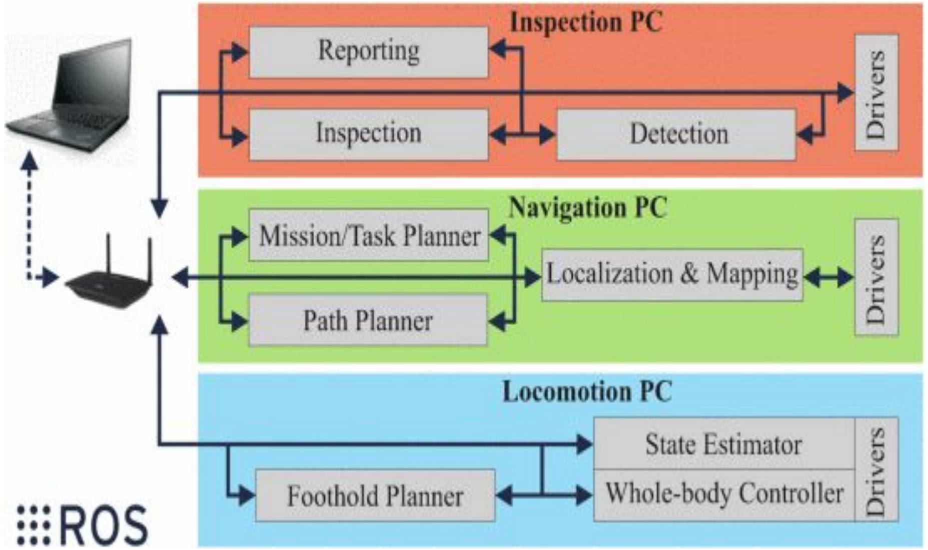
ASUS Tinker board ©ASUS



UP Dev. Board©UP-Bo .org

## *Software:-*

- **Operating system:-**Ubuntu Linux 20.04
- **Simulation:-**MATLAB Robotics and ROS Toolbox for design and simulation (links:https://www.mathworks.com/matlabcentral/fileexchange/68542-robotics-toolbox-for-matlab, https://www.mathworks.com/products/ros.html)
- Localization framework and navigation using ROS Melodic Morenia and some other available Python APIs (link:-http://wiki.ros.org/melodic)



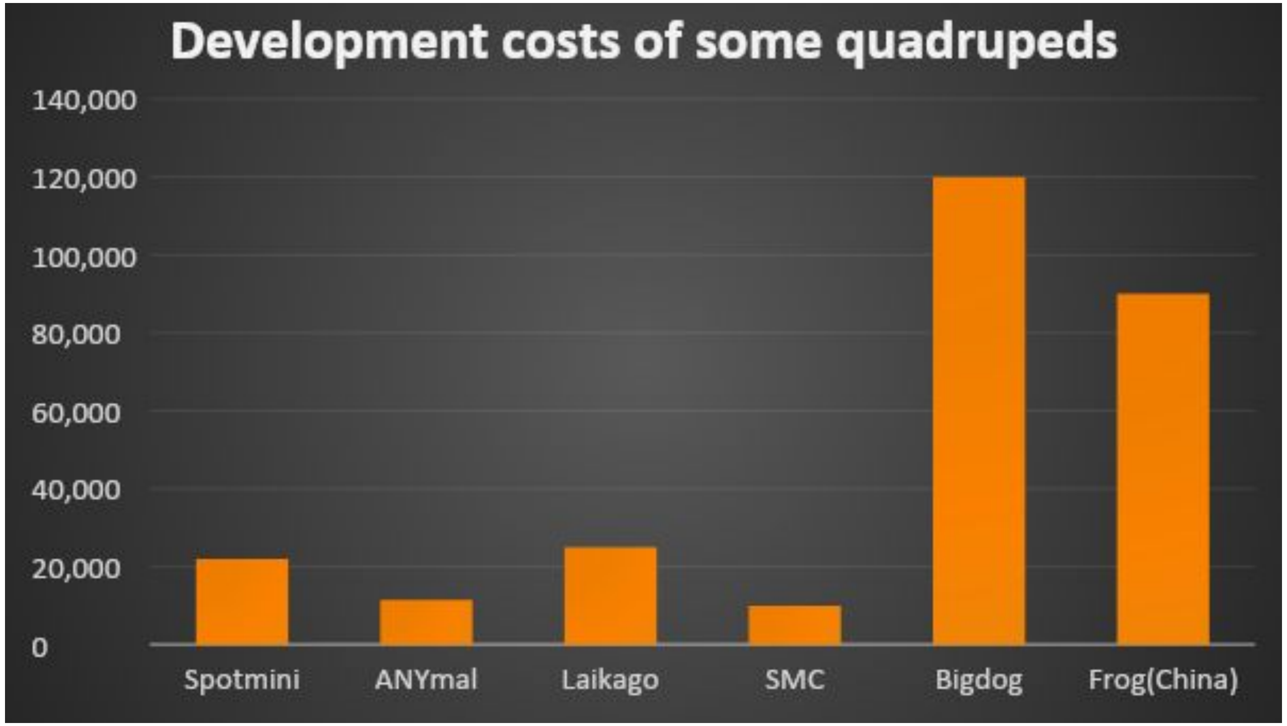
# Materials and Power source:-

- Carbon fibre rods
- Rubber grippers for legs
- Plastic protectors
- Note:- Batteries are not decided yet as I don't have a rough idea of power consumption

Small dia. Cf rods ©robu.in

| Components | Est. cost |
|---|---|
| Sensors | Rs. 17k |
| Wheel Encoders/actuators | Rs.12k+ Rs5.6k +Rs.3k |
| Controllers | Rs.6k (+ Rs.10.8k) |
| Main Computer | Rs.7k |
| Software | - |
| Materials | Not known |
| Batteries | Not known |
| Est. budget(as of now) | Rs.50.6k (+Rs.10.8k) |

(Cost is mentioned in US$)



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# THANK YOU!