HUMANOID ROBOTS – SENSORS AND ACTUATORS

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WHAT IS A SENSOR?

WHAT IS A SENSOR?

"… a sensor is a device, module, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor."

Wikipedia

WHAT IS A SENSOR?

“A mechanical device sensitive to light, temperature, radiation level, or the like, that transmits a signal to a measuring or control instrument.”

Dictionary.com

WHAT IS AN ACTUATOR?

WHAT IS AN ACTUATOR?

“An actuator is a component of a machine that is responsible for moving or controlling a mechanism or a system. An actuator requires a control signal and a source of energy.”

Wikipedia

WHAT IS AN ACTUATOR?

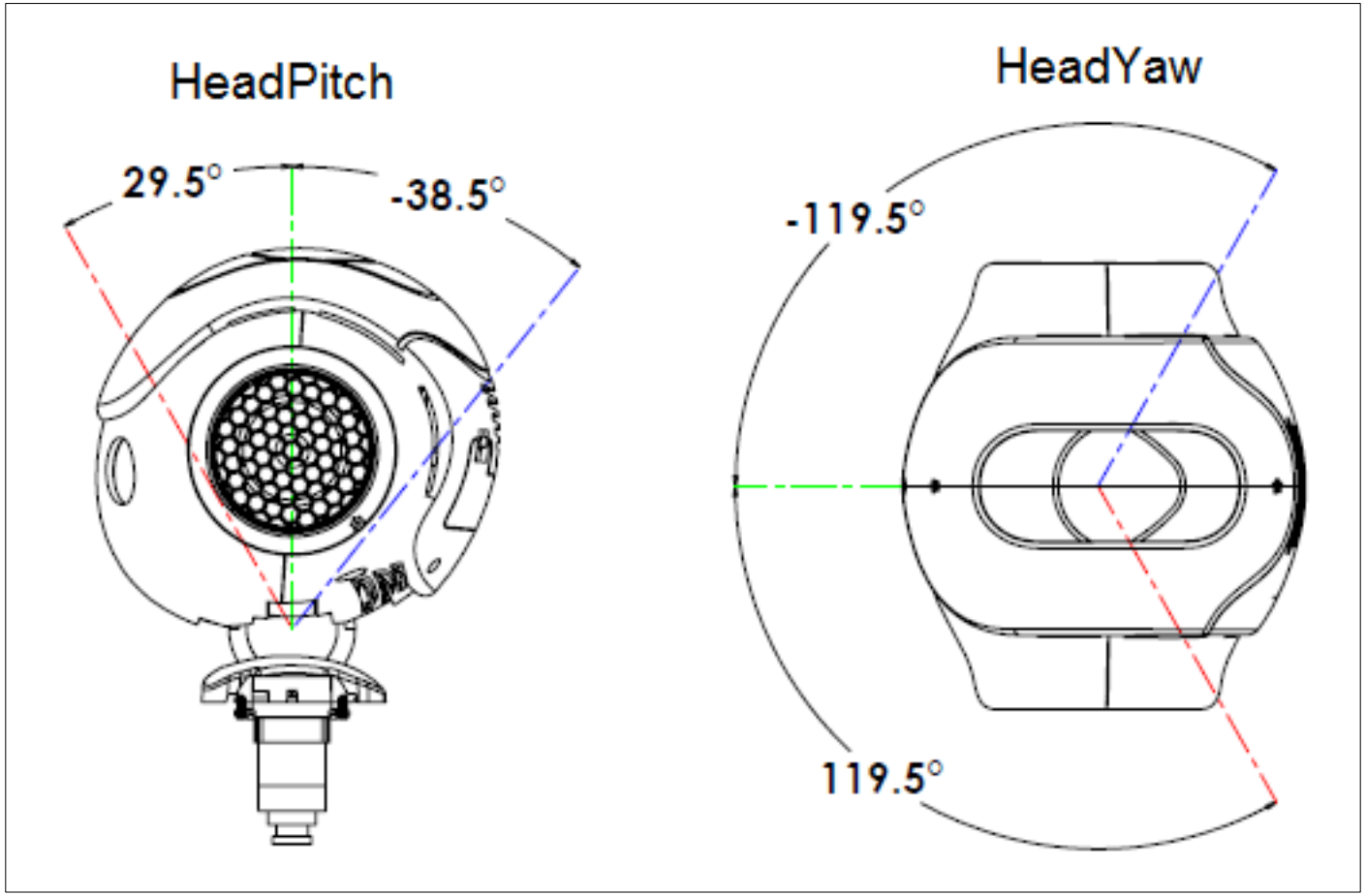
“A servomechanism that supplies and transmits a measured amount of energy for the operation of another mechanism or system.”

Dictionary.com

NAO’S HEAD

- how many joints?
- what kind of actuators?
- what kind of sensors?

NAO’S HEAD - JOINTS



NAO’S HEAD - ACTUATORS

- HeadYaw actuators
- HeadPitch actuators

NAO’S HEAD - ACTUATORS

- HeadYaw actuators
  - HeadYaw position actuator – value (rad)
  - HeadYaw hardness actuator – value (%)
- HeadPitch actuators
  - HeadPitch position actuator – value (rad)
  - HeadPitch hardness actuator – value (%)

NAO’S HEAD - SENSORS

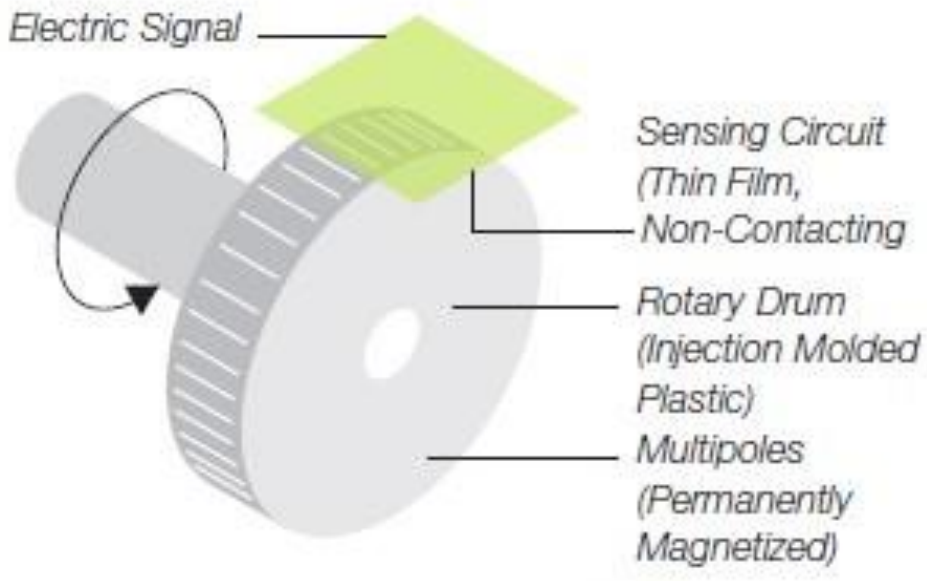
- HeadYaw sensors
- HeadPitch sensors

NAO’S HEAD - SENSORS

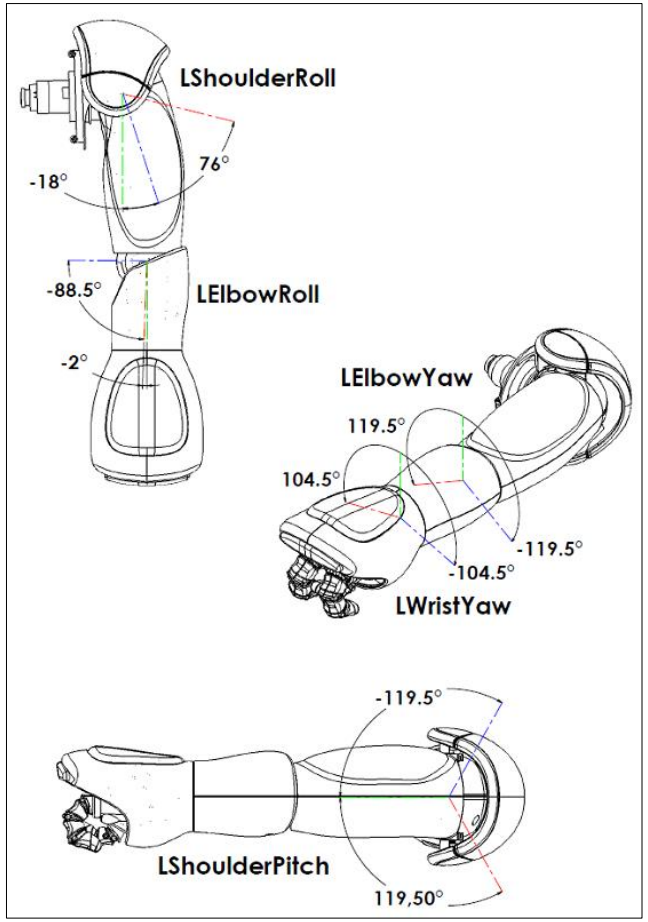
- HeadYaw sensors
  - HeadYaw position sensor – value (rad)
  - HeadYaw electric current – value (A)
  - HeadYaw temperature – value (°C)
  - HeadYaw temperature – status
- HeadPitch sensors
  - HeadPitch position sensor – value (rad)
  - HeadPitch electric current – value (A)
  - HeadPitch temperature – value (°C)
  - HeadPitch temperature - status

MAGNETIC ROTARY ENCODER

- uses magnetic fields to identify unique positions for the encoder
- With a magnetic encoder, a large magnetized wheel spins over a plate of magneto-resistive sensors. Just as the disk spins over the wheel causes predictable responses in the sensor, based on the strength of the magnetic field. The magnetic response is fed through a signal conditioning electrical circuit.



NAO’S LEFT ARM - JOINTS



NAO'S LEFT ARM - ACTUATORS

- LShoulderRoll
  - LShoulderRoll position actuator – value (rad)
  - LShoulderRoll hardness actuator – value (%)
- LElbowRoll
  - LElbowRoll position actuator – value (rad)
  - LElbowRoll hardness actuator – value (%)
- LElbowYaw
  - LElbowYaw position actuator – value (rad)
  - LElbowYaw hardness actuator – value (%)

NAO’S LEFT ARM - ACTUATORS

- LWristYaw
  - LWristYaw position actuator – value (rad)
  - LWristYaw hardness actuator – value (%)
- LShoulderPitch
  - LShoulderPitch position actuator – value (rad)
  - LShoulderPitch hardness actuator – value (%)
- LHand
  - LHand position actuator – value (rad)
  - LHand hardness actuator – value (%)

NAO’S LEFT ARM - SENSORS

- LShoulderRoll sensors
  - LShoulderRoll position sensor – value (rad)
  - LShoulderRoll electric current – value (A)
  - LShoulderRoll temperature – value (°C)
  - LShoulderRoll temperature – status
- LElbowRoll sensors
  - LElbowRoll position sensor – value (rad)
  - LElbowRoll electric current – value (A)
  - LElbowRoll temperature – value (°C)
  - LElbowRoll temperature - status

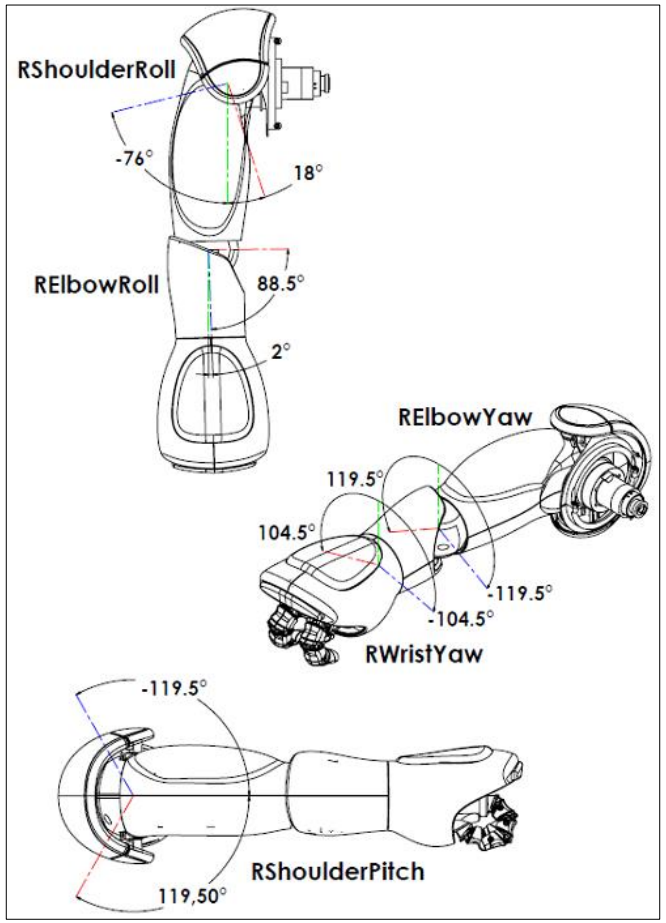
NAO’S LEFT ARM - SENSORS

- LElbowYaw sensors
  - LElbowYaw position sensor – value (rad)
  - LElbowYaw electric current – value (A)
  - LElbowYaw temperature – value (°C)
  - LElbowYaw temperature – status
- LWristYaw sensors
  - LWristYaw position sensor – value (rad)
  - LWristYaw electric current – value (A)
  - LWristYaw temperature – value (°C)
  - LWristYaw temperature - status

NAO’S LEFT ARM - SENSORS

- LShoulderPitch sensors
  - LShoulderPitch position sensor – value (rad)
  - LShoulderPitch electric current – value (A)
  - LShoulderPitch temperature – value (°C)
  - LShoulderPitch temperature – status
- LHand sensors
  - LHand position sensor – value (rad)
  - LHand electric current – value (A)
  - LHand temperature – value (°C)
  - LHand temperature – status

NAO’S RIGHT ARM - JOINTS



NAO’S RIGHT ARM - ACTUATORS

- RShoulderRoll
  - RShoulderRoll position actuator – value (rad)
  - RShoulderRoll hardness actuator – value (%)
- RElbowRoll
  - RElbowRoll position actuator – value (rad)
  - RElbowRoll hardness actuator – value (%)
- RElbowYaw
  - RElbowYaw position actuator – value (rad)
  - RElbowYaw hardness actuator – value (%)

NAO’S RIGHT ARM - ACTUATORS

- RWristYaw
  - RWristYaw position actuator – value (rad)
  - RWristYaw hardness actuator – value (%)
- RShoulderPitch
  - RShoulderPitch position actuator – value (rad)
  - RShoulderPitch hardness actuator – value (%)
- RHand
  - RHand position actuator – value (rad)
  - RHand hardness actuator – value (%)

NAO’S RIGHT ARM - SENSORS

- RShoulderRoll sensors
  - RShoulderRoll position sensor – value (rad)
  - RShoulderRoll electric current – value (A)
  - RShoulderRoll temperature – value (°C)
  - RShoulderRoll temperature – status
- RElbowRoll sensors
  - RElbowRoll position sensor – value (rad)
  - RElbowRoll electric current – value (A)
  - RElbowRoll temperature – value (°C)
  - RElbowRoll temperature - status

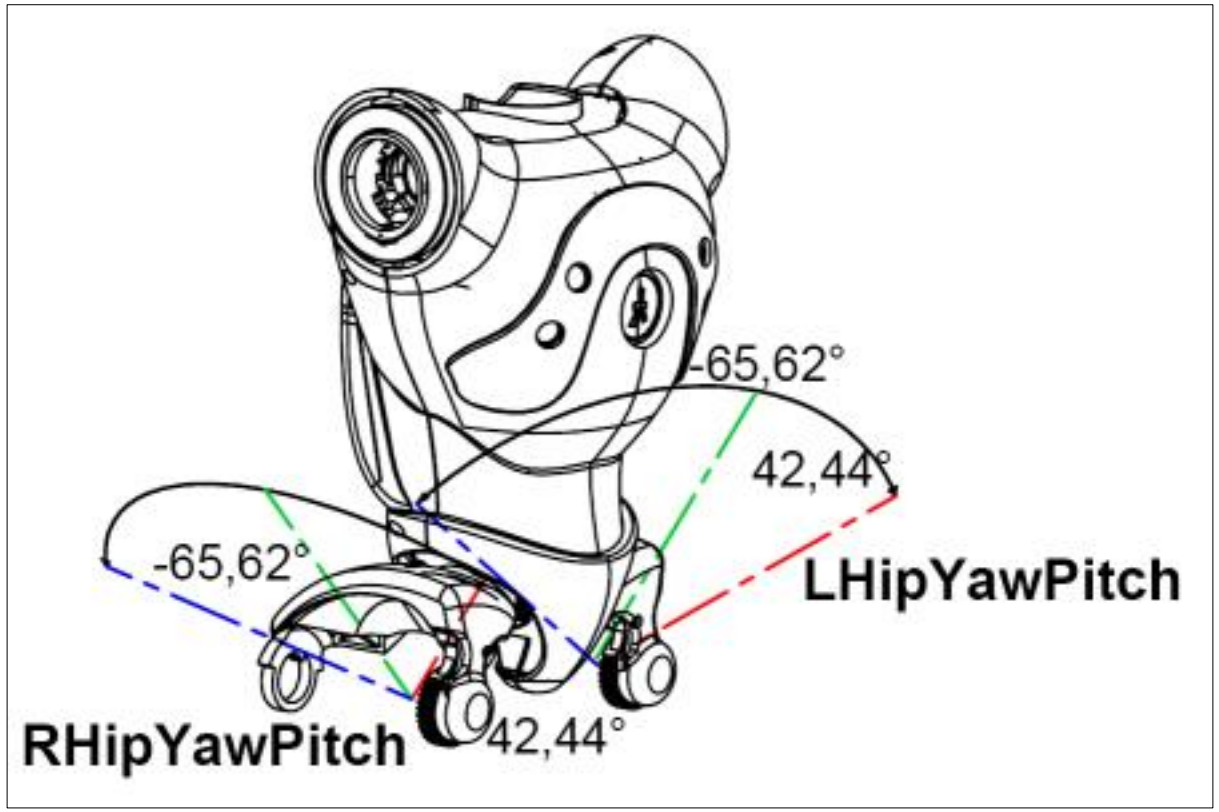
NAO’S RIGHT ARM - SENSORS

- RElbowYaw sensors
  - RElbowYaw position sensor – value (rad)
  - RElbowYaw electric current – value (A)
  - RElbowYaw temperature – value (°C)
  - RElbowYaw temperature – status
- RWristYaw sensors
  - RWristYaw position sensor – value (rad)
  - RWristYaw electric current – value (A)
  - RWristYaw temperature – value (°C)
  - RWristYaw temperature - status

NAO’S RIGHT ARM - SENSORS

- RShoulderPitch sensors
  - RShoulderPitch position sensor – value (rad)
  - RShoulderPitch electric current – value (A)
  - RShoulderPitch temperature – value (°C)
  - RShoulderPitch temperature – status
- RHand sensors
  - RHand position sensor – value (rad)
  - RHand electric current – value (A)
  - RHand temperature – value (°C)
  - RHand temperature – status

NAO’S PELVIS - JOINTS



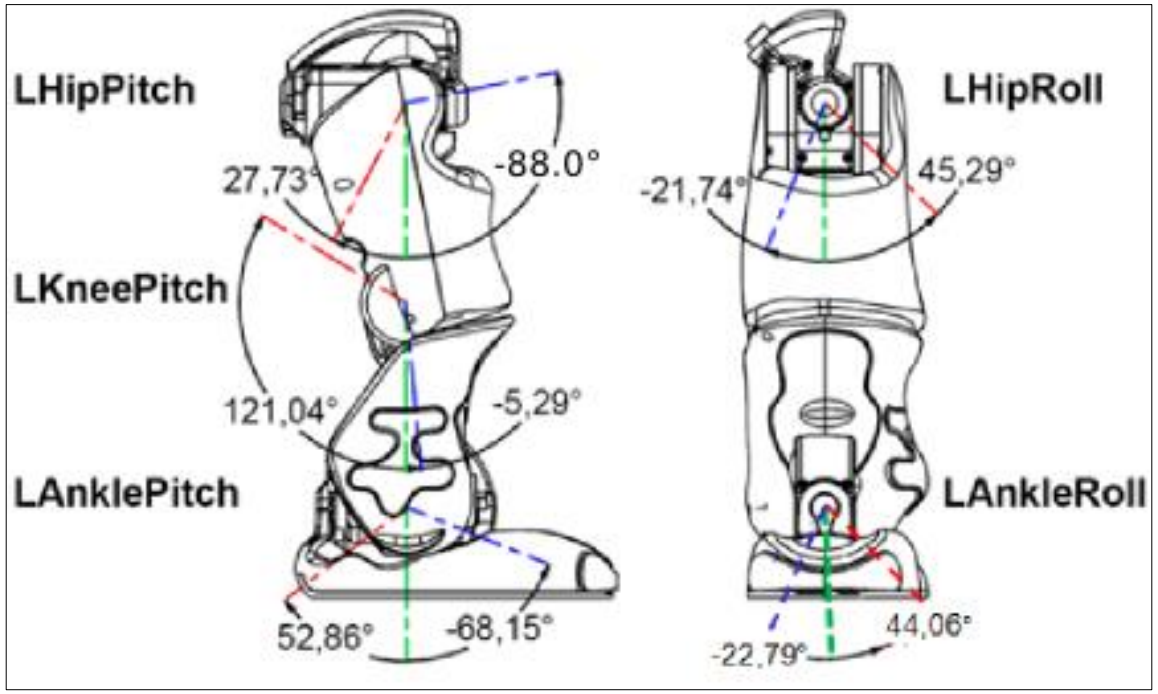
NAO'S PELVIS- ACTUATORS

- LHipYawPitch
  - LHipYawPitch position actuator – value (rad)
  - LHipYawPitch hardness actuator – value (%)
- RHipYawPitch
  - RHipYawPitch position actuator – value (rad)
  - RHipYawPitch hardness actuator – value (%)

NAO’S PELVIS - SENSORS

- LHipYawPitch sensors
  - LHipYawPitch position sensor – value (rad)
  - LHipYawPitch electric current – value (A)
  - LHipYawPitch temperature – value (°C)
  - LHipYawPitch temperature – status
- RHipYawPitch sensors
  - RHipYawPitch position sensor – value (rad)
  - RHipYawPitch electric current – value (A)
  - RHipYawPitch temperature – value (°C)
  - RHipYawPitch temperature - status

NAO’S LEFT LEG - JOINTS



NAO’S LEFT LEG - ACTUATORS

- LHipPitch
  - LHipPitch position actuator – value (rad)
  - LHipPitch hardness actuator – value (%)
- LKneePitch
  - LKneePitch position actuator – value (rad)
  - LKneePitch hardness actuator – value (%)
- LAnklePitch
  - LAnklePitch position actuator – value (rad)
  - LAnklePitch hardness actuator – value (%)

NAO’S LEFT LEG - ACTUATORS

- LHipRoll
  - LHipRoll position actuator – value (rad)
  - LHipRoll hardness actuator – value (%)
- LAnkleRoll
  - LAnkleRoll position actuator – value (rad)
  - LAnkleRoll hardness actuator – value (%)

NAO’S LEFT LEG- SENSORS

- LHipPitch sensors
  - LHipPitch position sensor – value (rad)
  - LHipPitch electric current – value (A)
  - LHipPitch temperature – value (°C)
  - LHipPitch temperature – status
- LKneePitch sensors
  - LKneePitch position sensor – value (rad)
  - LKneePitch electric current – value (A)
  - LKneePitch temperature – value (°C)
  - LKneePitch temperature - status

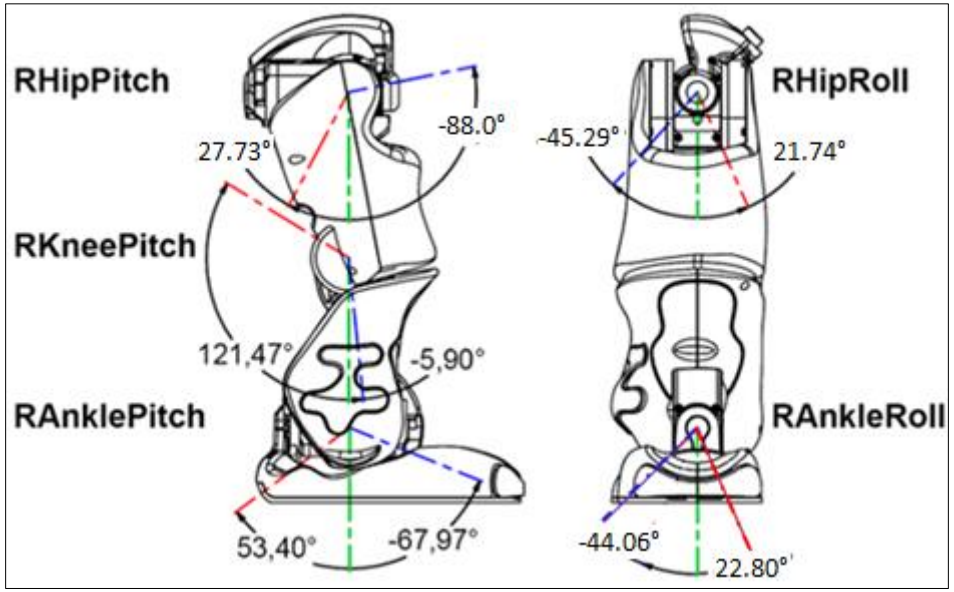
NAO’S LEFT LEG - SENSORS

- LAnklePitch sensors
  - LAnklePitch position sensor – value (rad)
  - LAnklePitch electric current – value (A)
  - LAnklePitch temperature – value (°C)
  - LAnklePitch temperature – status
- LHipRoll sensors
  - LHipRoll position sensor – value (rad)
  - LHipRoll electric current – value (A)
  - LHipRoll temperature – value (°C)
  - LHipRoll temperature - status

NAO’S LEFT LEG - SENSORS

- LAnkleRoll sensors
  - LAnkleRoll position sensor – value (rad)
  - LAnkleRoll electric current – value (A)
  - LAnkleRoll temperature – value (°C)
  - LAnkleRoll temperature – status

NAO’S RIGHT LEG - JOINTS



NAO’S RIGHT LEG - ACTUATORS

- RHipPitch
  - RHipPitch position actuator – value (rad)
  - RHipPitch hardness actuator – value (%)
- RKneePitch
  - RKneePitch position actuator – value (rad)
  - RKneePitch hardness actuator – value (%)
- RAnklePitch
  - RAnklePitch position actuator – value (rad)
  - RAnklePitch hardness actuator – value (%)

NAO’S RIGHT LEG - ACTUATORS

- RHipRoll
  - RHipRoll position actuator – value (rad)
  - RHipRoll hardness actuator – value (%)
- RAnkleRoll
  - RAnkleRoll position actuator – value (rad)
  - RAnkleRoll hardness actuator – value (%)

NAO’S RIGHT LEG- SENSORS

- RHipPitch sensors
  - RHipPitch position sensor – value (rad)
  - RHipPitch electric current – value (A)
  - RHipPitch temperature – value (°C)
  - RHipPitch temperature – status
- RKneePitch sensors
  - RKneePitch position sensor – value (rad)
  - RKneePitch electric current – value (A)
  - RKneePitch temperature – value (°C)
  - RKneePitch temperature - status

NAO’S RIGHT LEG - SENSORS

- RAnklePitch sensors
  - RAnklePitch position sensor – value (rad)
  - RAnklePitch electric current – value (A)
  - RAnklePitch temperature – value (°C)
  - RAnklePitch temperature – status
- RHipRoll sensors
  - RHipRoll position sensor – value (rad)
  - RHipRoll electric current – value (A)
  - RHipRoll temperature – value (°C)
  - RHipRoll temperature - status

NAO’S RIGHT LEG - SENSORS

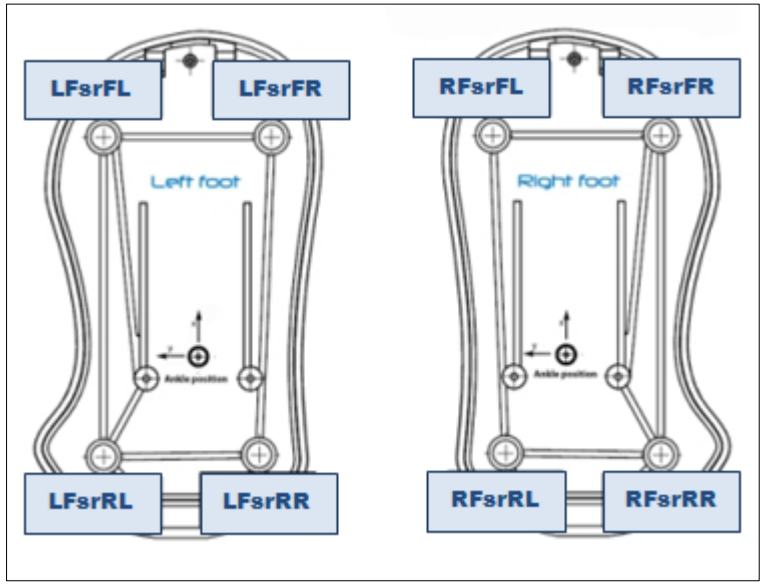
- RAnkleRoll sensors
  - RAnkleRoll position sensor – value (rad)
  - RAnkleRoll electric current – value (A)
  - RAnkleRoll temperature – value (°C)
  - RAnkleRoll temperature – status

WHAT OTHER SENSORS?

- force sensitive resistors
- inertial
  - gyroscope
  - angle
  - accelerometer
- touch sensors
- sonars
- switches

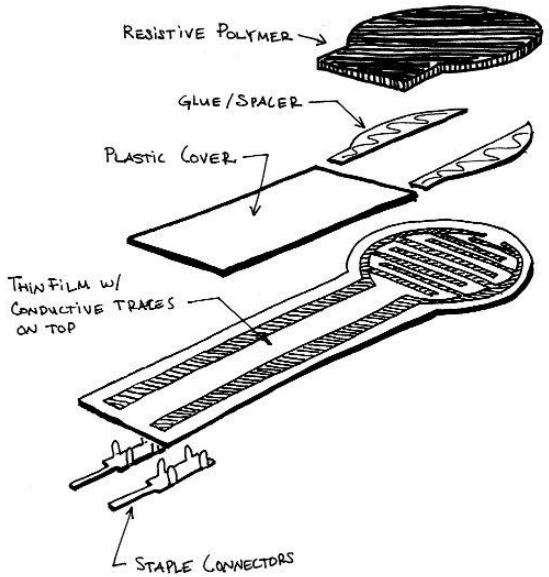
FORCE SENSITIVE RESISTORS

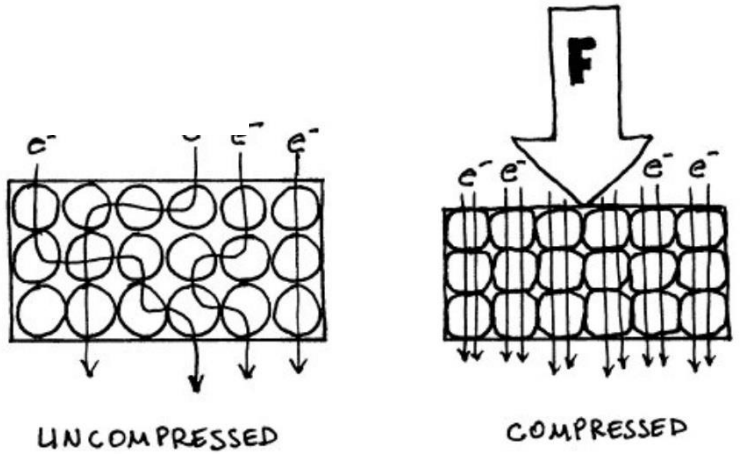
- these sensors measure a resistance change according to the pressure applied
- the FSRs located on the feet have a working range from 0 N to 25 N



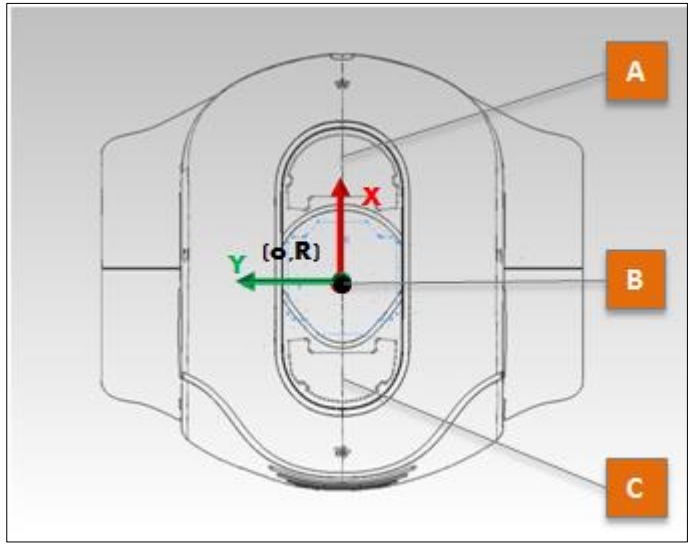
FORCE SENSITIVE RESISTORS

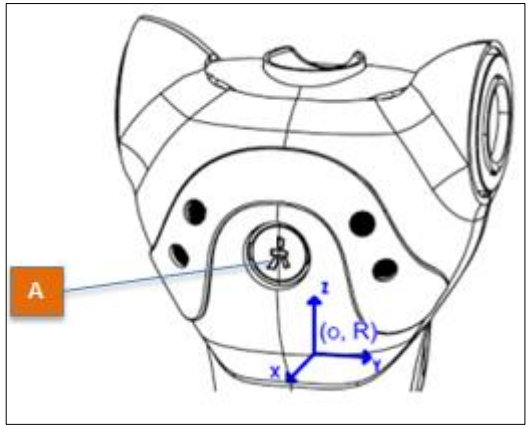
- The force sensing resistor is generally supplied as a polymer sheet or ink which is applied as screen printing. Both the electrically conducting and non-conducting particles are present on this sensing film.
- If force is applied to a surface of sensing film, then the particles touches the conducting electrodes and thus resistance of the film changes.

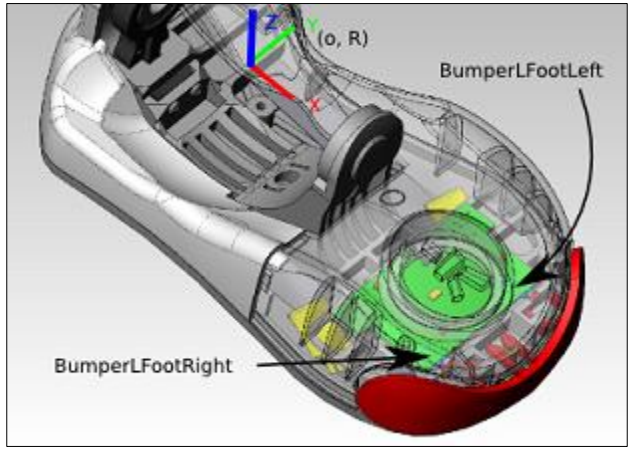


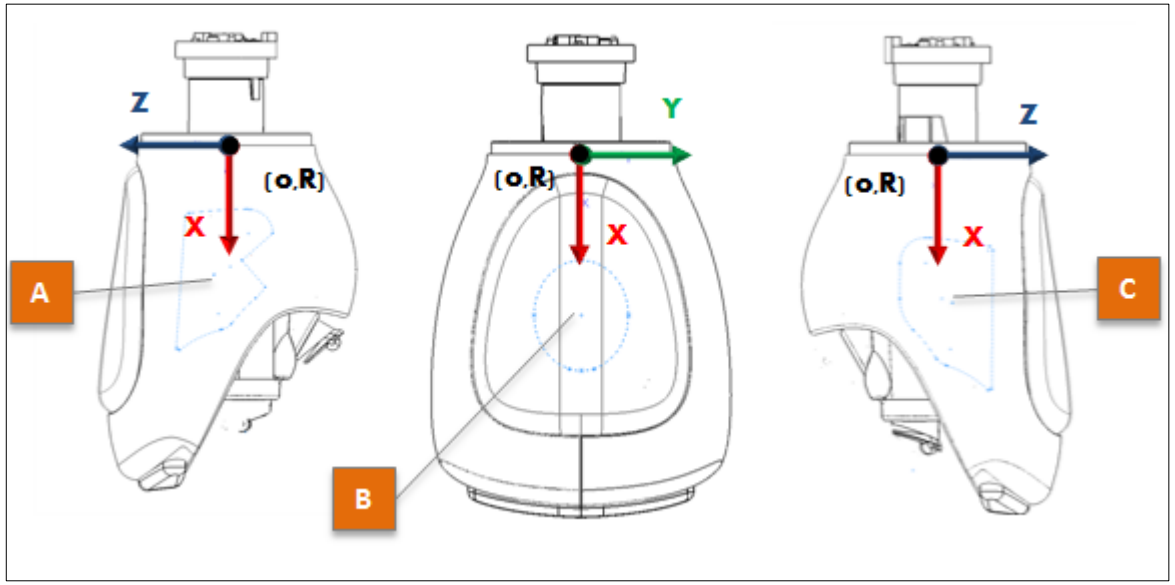


TOUCH SENSORS



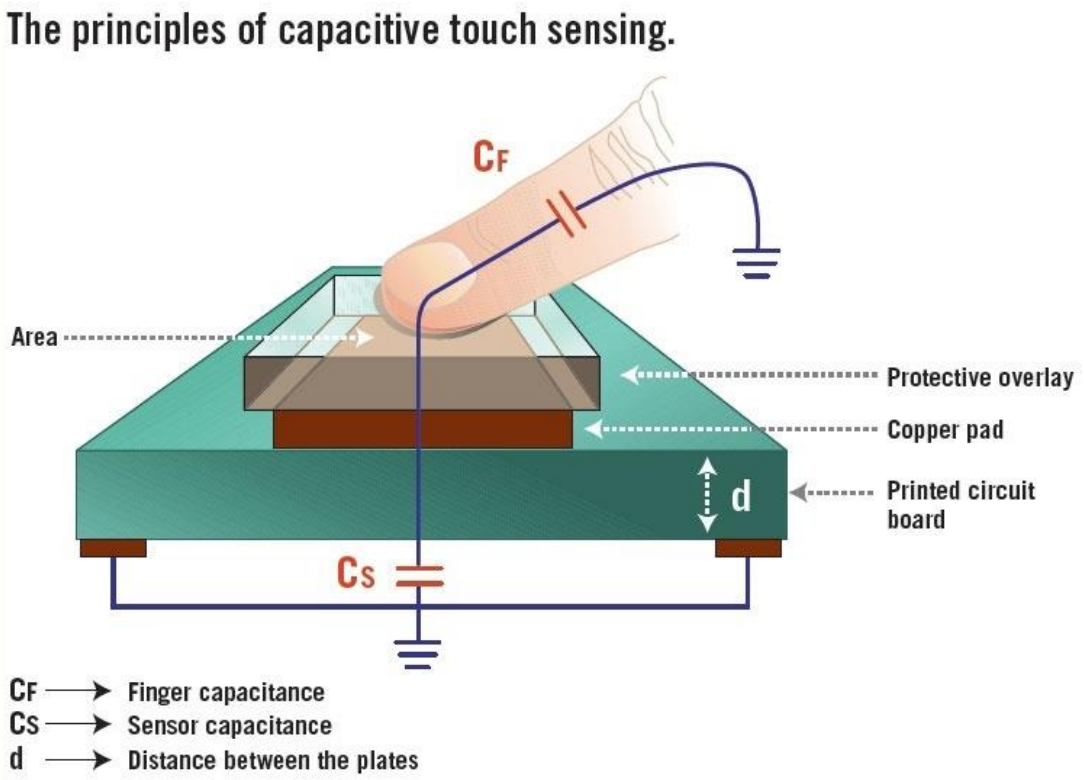




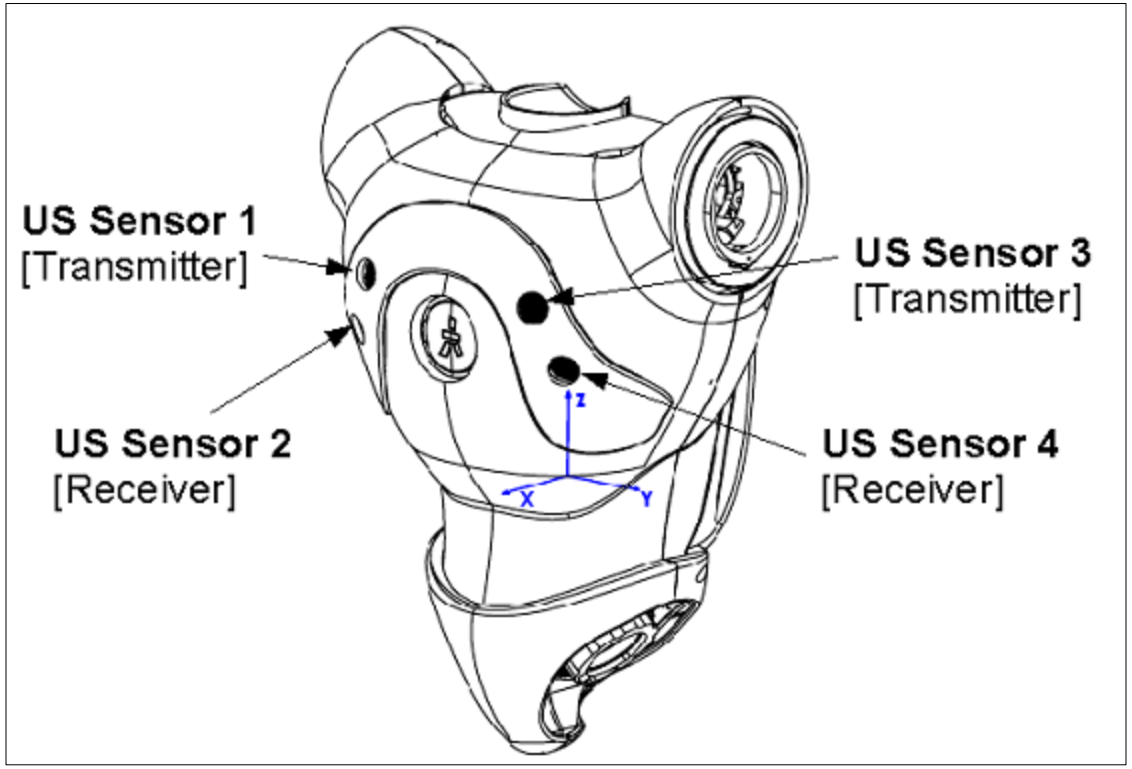


CAPACITIVE TOUCH SENSORS

- In capacitive touch sensors, the electrode represents one of the plates of the capacitor.
- The second plate is represented by two objects: one is the environment of the sensor electrode which forms parasitic capacitor CS and the other is a conductive object like a human finger which forms touch capacitor CF.
- The sensor electrode is connected to a measurement circuit and the capacitance is measured periodically.
- The output capacitance will increase if a conductive object touches or approaches the sensor electrode. The measurement circuit will detect the change in the capacitance and converts it into a trigger signal.

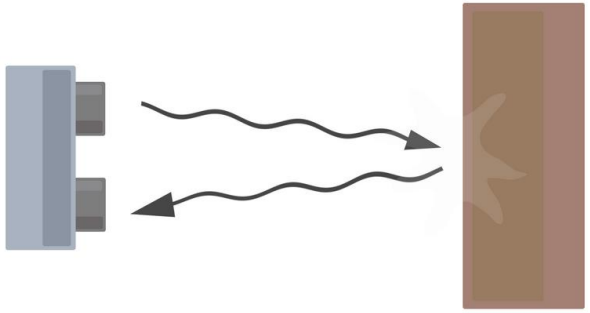


SONARS


US Sensor 1
[Transmitter]
US Sensor 2
[Receiver]
US Sensor 3
[Transmitter]
US Sensor 4
[Receiver]
Z
X
Y

SONARS

- An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves.
- It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back.
- By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.



$$distance = \frac{speed\ of\ sound\ \times time\ taken}{2}$$