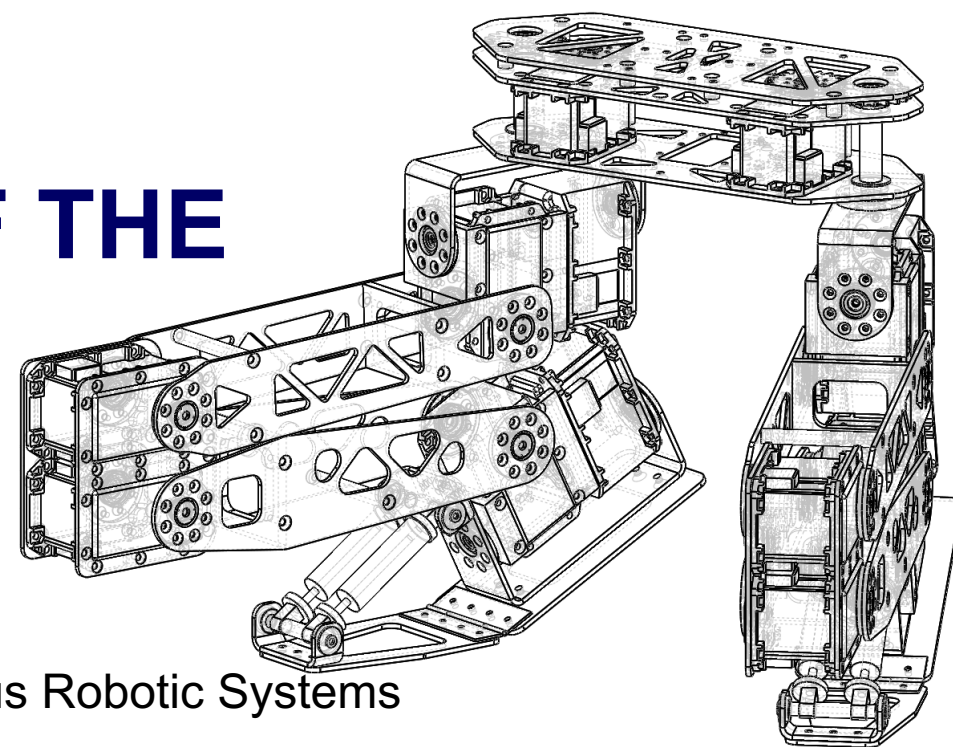




# St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences

## MECHANICAL LEG DESIGN OF THE ANTHROPOMORPHIC ROBOT ANTARES

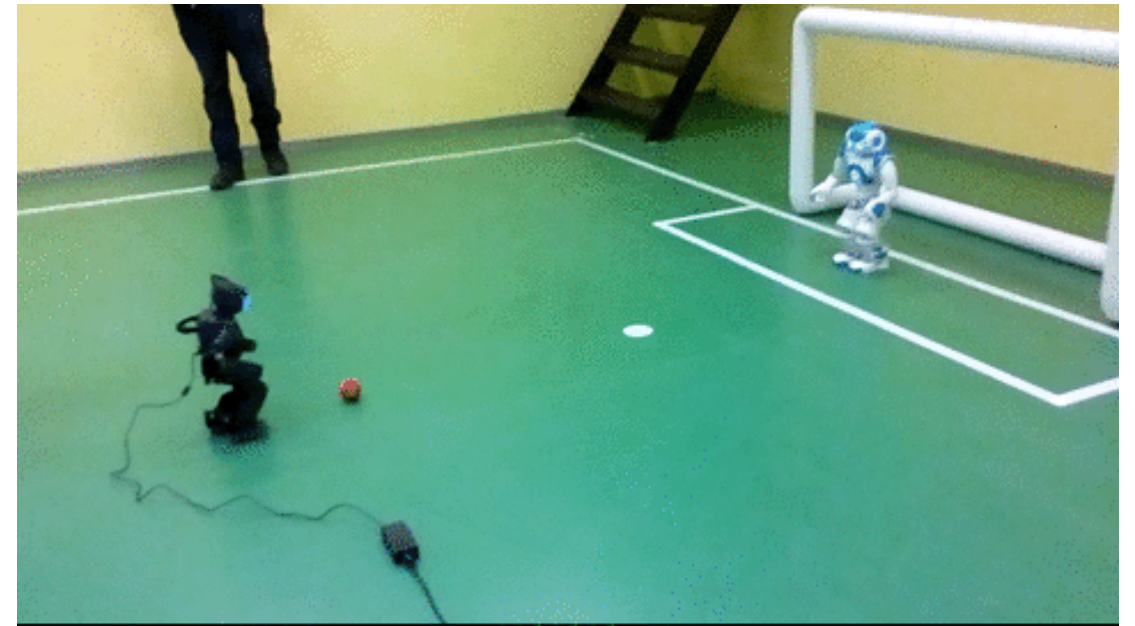


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Budapest, Hungary

# Development of Anthropomorphic Robots

- ▲ Among problems, which developers of mobile general-purpose and special-purpose robots face nowadays, are issues of robot's flotation ability on the rugged terrain, autonomous movement and control of kinetic equipment.
- ▲ A lever-hinge system of human and animals mobility, created by nature, is the most adapted to the natural earth's surface and is suitable for use during movement of the anthropomorphic robot.
- ▲ The development of the rational structure of legs of the robot Antares is based on the analysis of existing design solutions to the construction of lever-hinge mechanisms of legs of anthropomorphic robots and features of the lower extremities of the human.





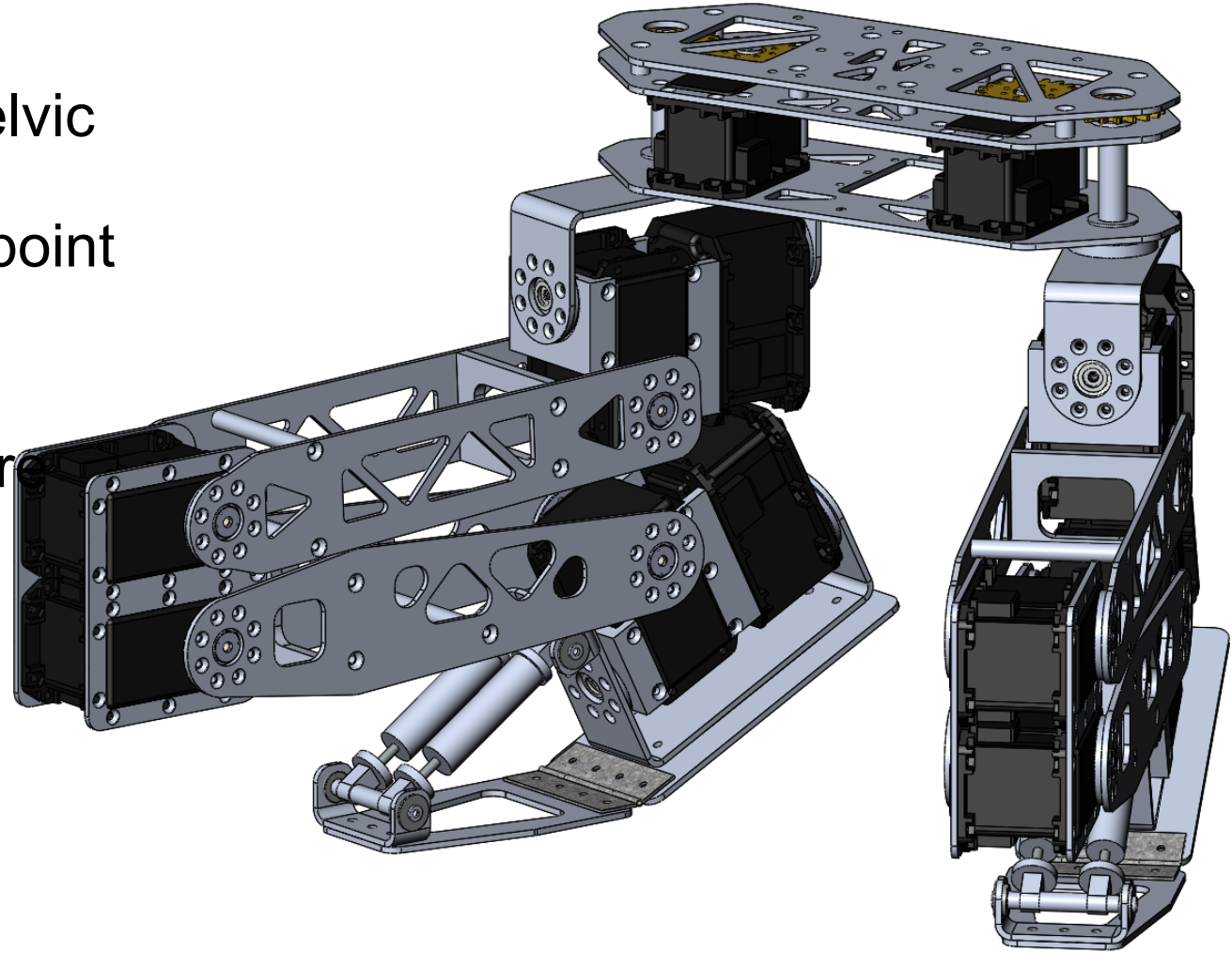
# Existing Anthropomorphic Robots

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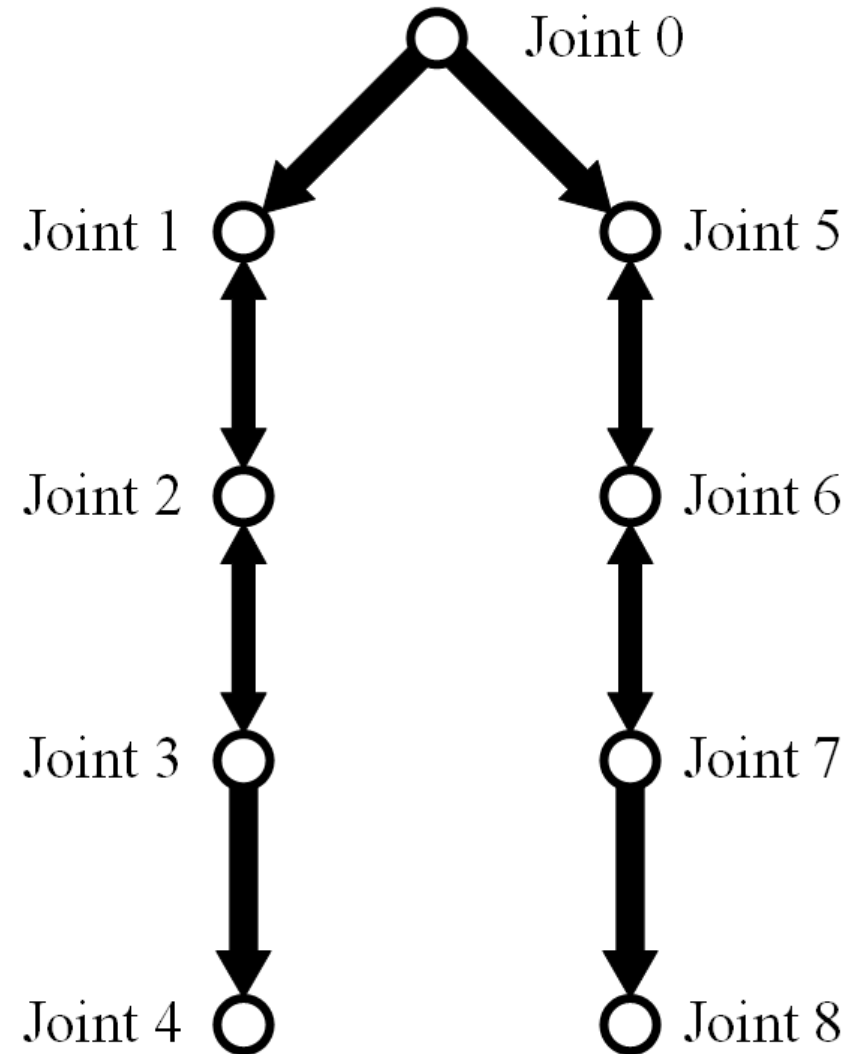
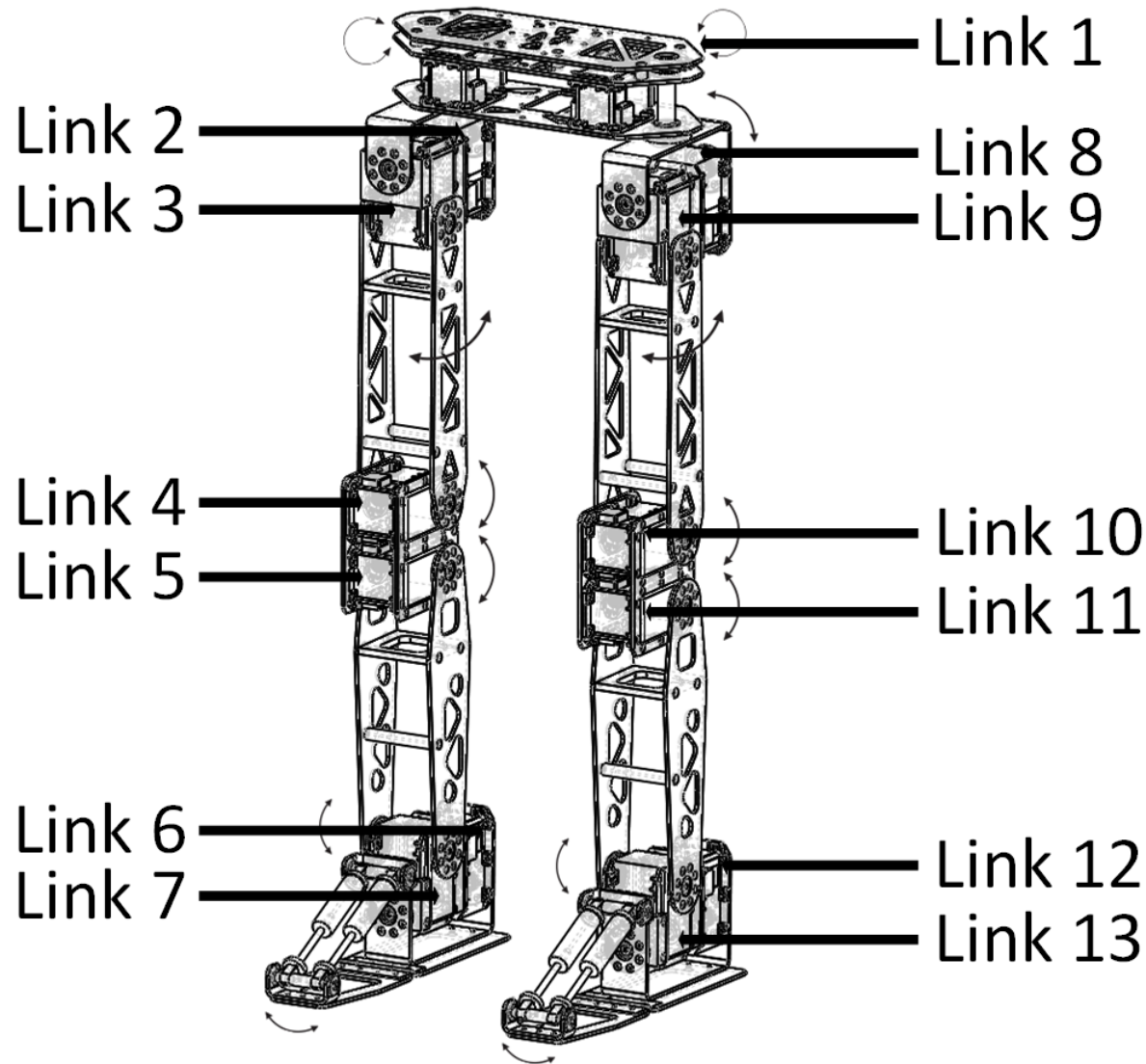
Characteristic	Poppy	Darwin-OP
Height, cm	84	45.5
Weight, kg	3.5	2.9
<b>Angles movement parts of the "legs" of the robot:</b>		
<b>Ankle joint</b>	No roll angle and pitch angle ranges from 43 degrees up, down to -45 degrees	
<b>Knee-joint</b>	The stroke from 0 to 130 degrees	
<b>Hip joint</b>	Next is from 87 degrees forward and 87 back. The deflection angle in the side outside is 26 degrees and the inside leg to the nearest 5 degrees, and the possibility of structural legs deviation is 28 degrees	
<b>The joint of the body and legs</b>	18 may outwards and inwards by 5 degrees	

# Overall Design of the Legs

- ▲ Total structure of legs includes pelvic joint and two identical leg joints consisting of simpler attachment point to the pelvic, hip, knee, lower leg, ankle and foot units.
- ▲ Joints of robot pelvic and legs were developed in accordance with the proportions of the human body, adjusted for assumed growth.

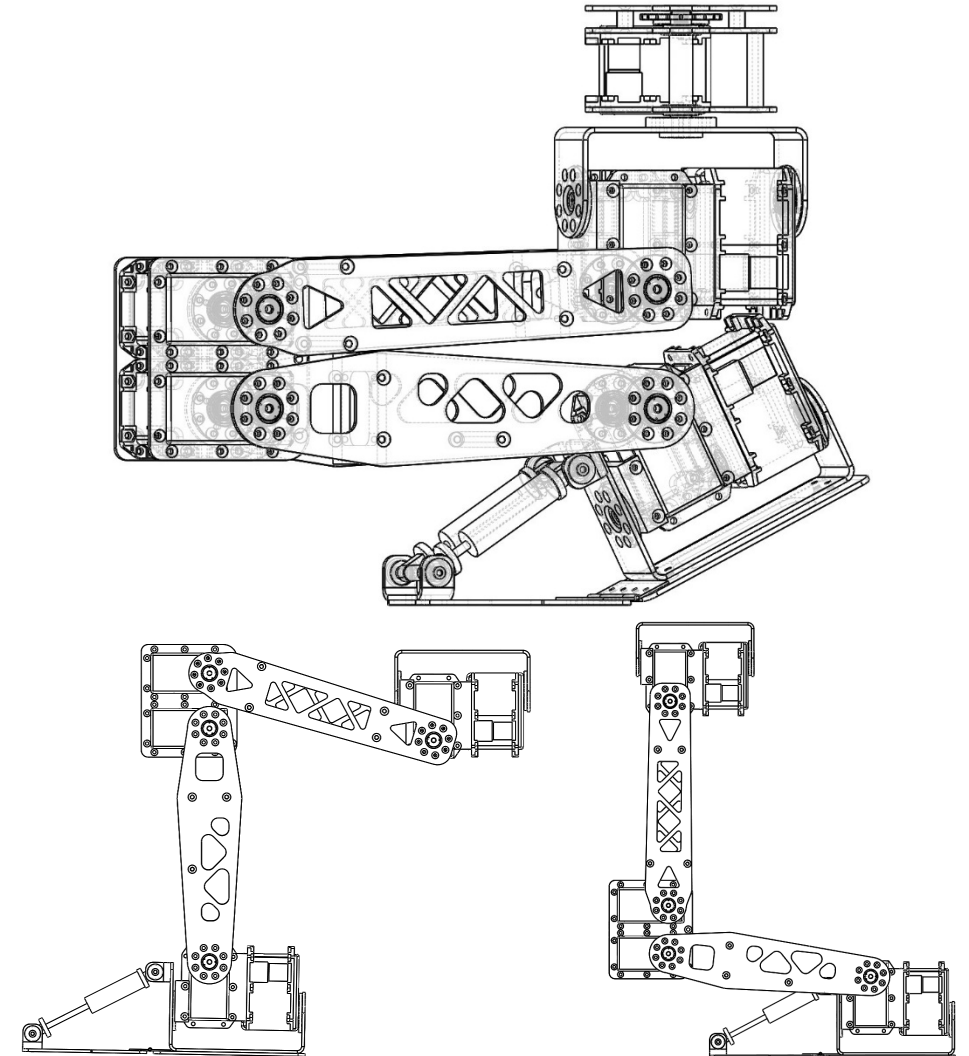


# Kinematic Scheme and Tree Graph



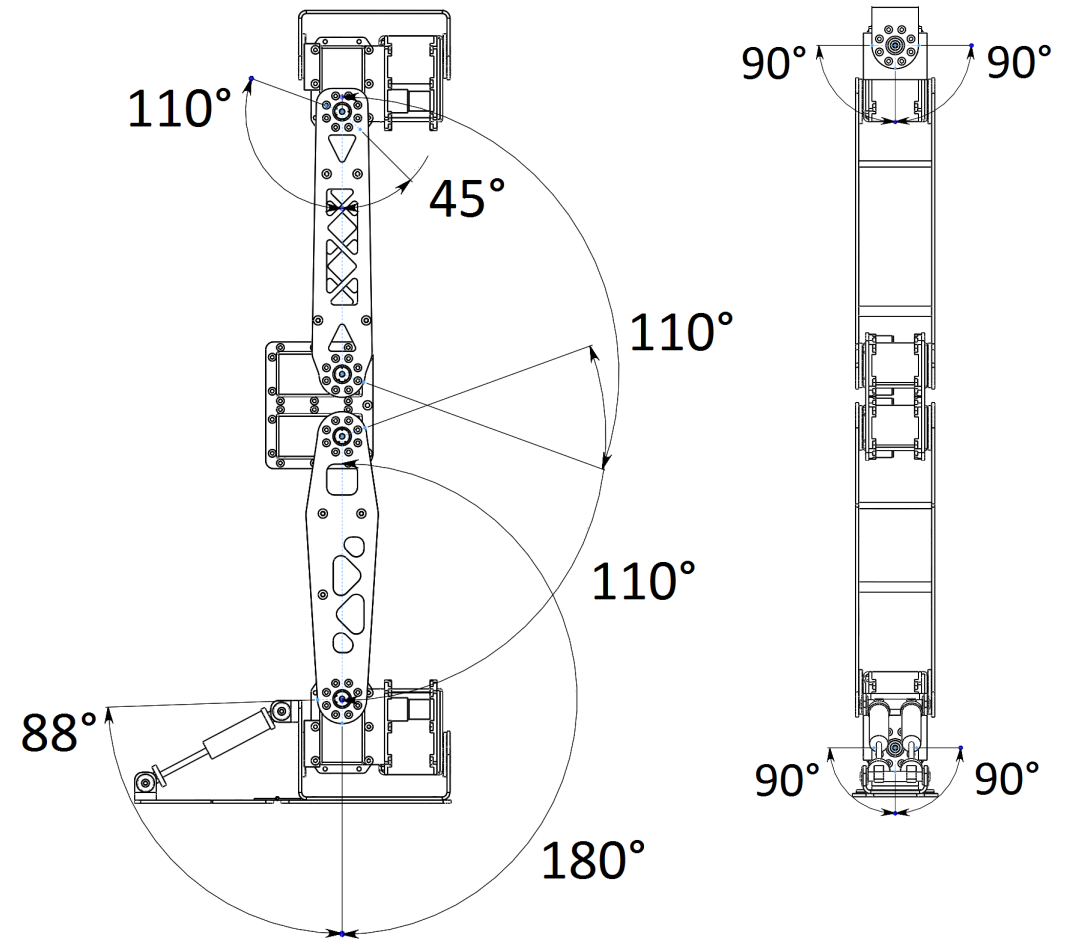
# Leg Joint Design

- ▲ Through the use of twin-engine layout in the knee a separate leg joint is obtained, which interacts with neighboring upper and lower leg joints, allowing them to be independent of each other when bending.
- ▲ The given design complicates the calculation of the kinematics of the robot motion, but provides more complex movements.
- ▲ Another advantage of this unit is that it facilitates design engineering of the above-mentioned joints of the upper and lower legs.



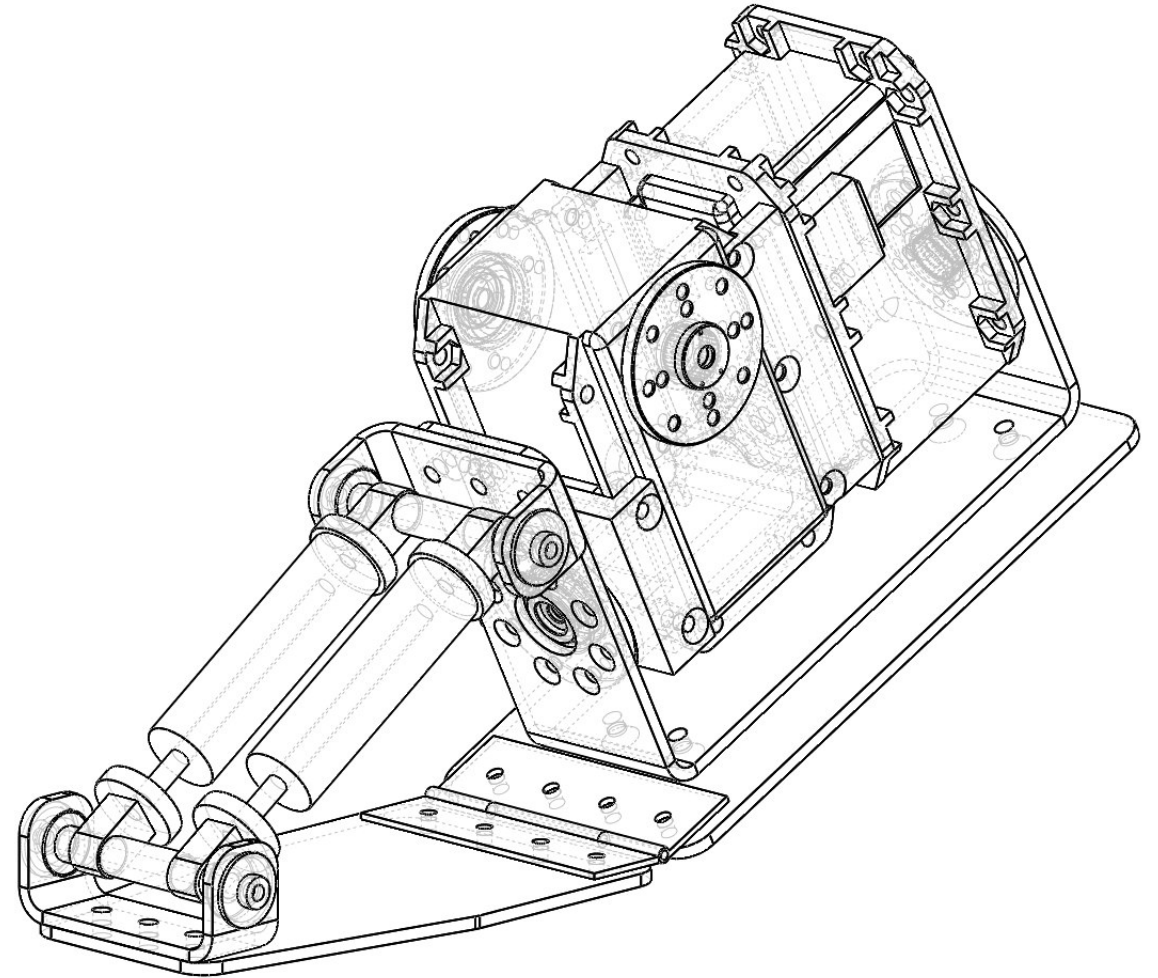
# The Angles of Rotation Feet

- ▲ The leg construction provides large steering angles for the motors, which ensures greater flexibility and ductility of the joint compared with the mentioned analogs.
- ▲ The angle of the foot position changes: eversion is  $90^\circ$  and inversion is  $90^\circ$ .
- ▲ Pelvic mechanism allows the robot to rotate each leg at  $360^\circ$  around its axis; however, at this stage we limited it up to  $270^\circ$ , since there was no need for such a large range of rotation.



# Foot Joint Design

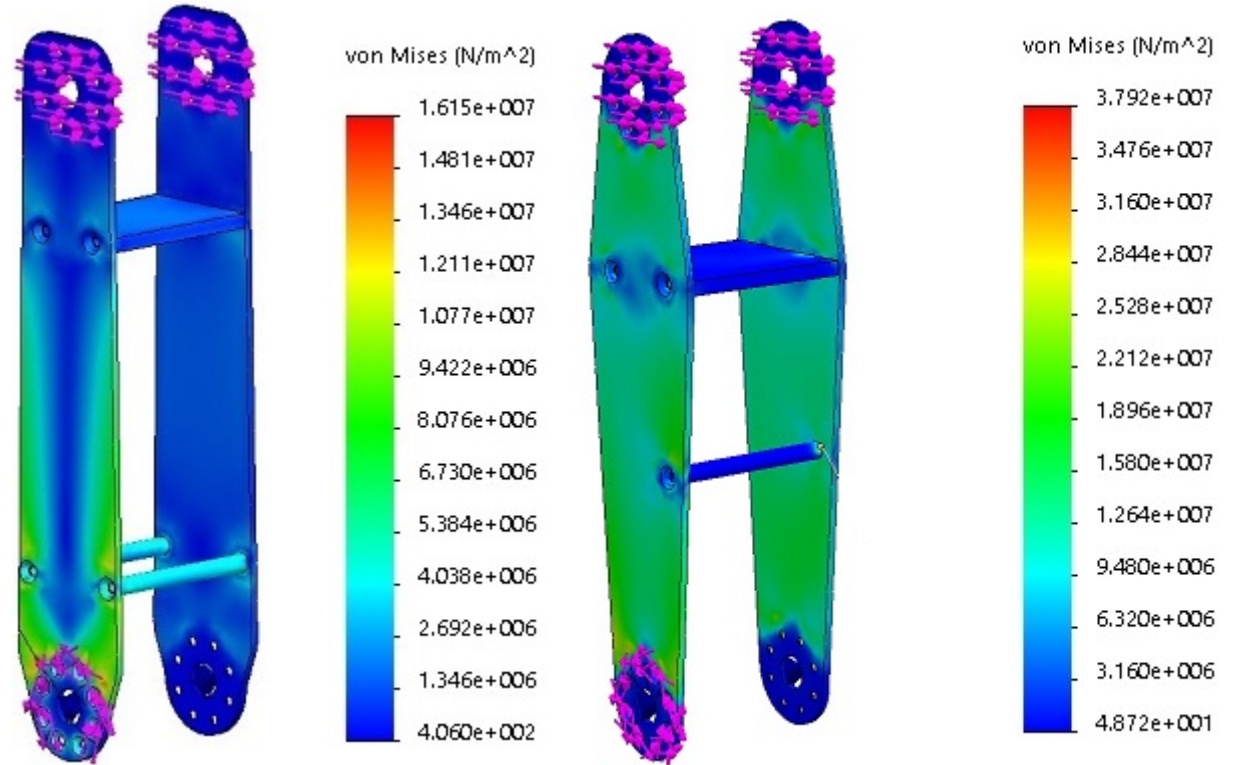
- ▲ The foot consists of two segments joined by a hinge and a pair of hydraulic shock absorbers which provide a passive foot bend within 26 degrees when moving.
- ▲ This solution combined with the performance of the remaining joints of the leg allows us to make robot movements more similar to the human gait.





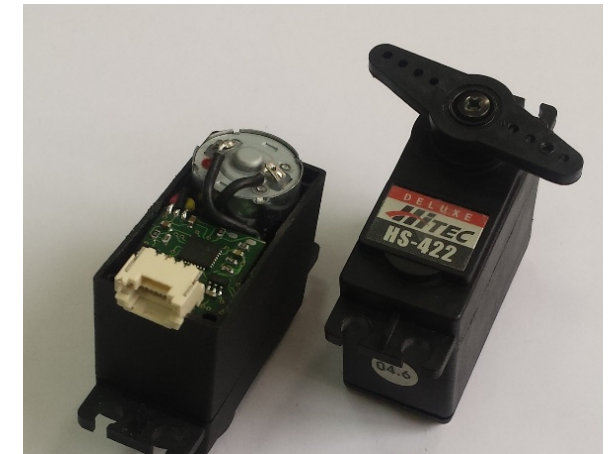
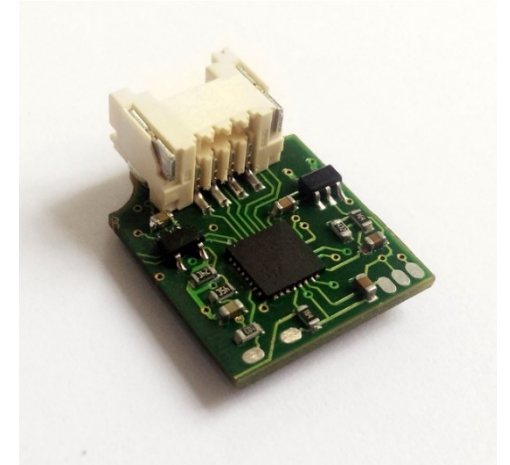
# Rugged Construction

- ▲ The analysis of the structure showed that all of the individual parts, assemblies and key elements of the robot are quite strong and able to withstand the load much higher than the estimated weight of the robot prototype equal to 8 kilograms.
- ▲ Modelling of the load of 1000 Newtons on the nodes of hip and shin is shown.



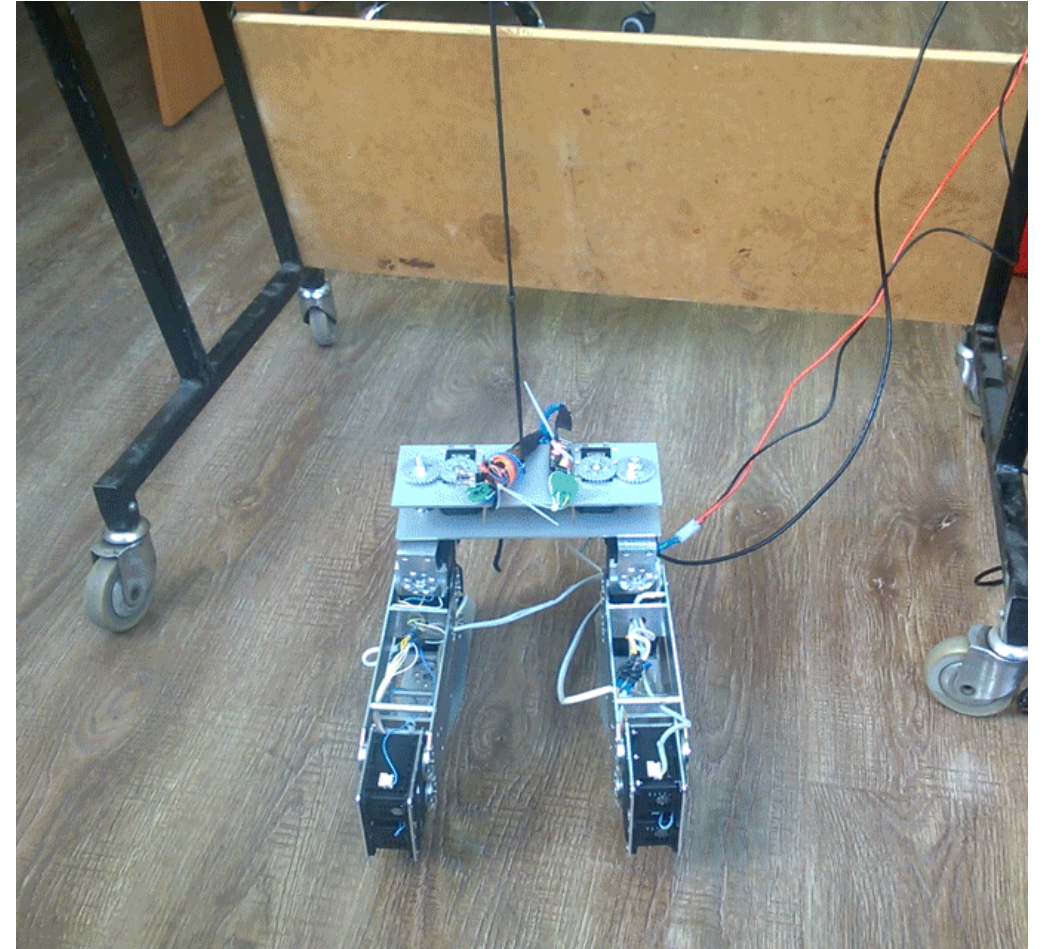
# Servo

- ▲ Apart from the pelvic mechanism responsible for axial rotations of legs and being a separate unit, in the legs structure we applied actuators Dynamixel MX-64.
- ▲ Each Dynamixel has a unique ID for connection to the common data line, supports the connection TTL, RS485 and others, can be connected to the common control bus; available LED or emergency shutdown (torque-off) functions may be set to predetermined values of temperature, current and voltage.
- ▲ These actuators can be adjusted to move more smoothly.
- ▲ Dynamixel servos can be controlled from a PC or a microcontroller, which is a great advantage in the development of prototypes.



# Conclusion

- ▲ A two-motor layout, used in the knee, ensures higher joint power along with independent interaction with the neighboring upper and lower leg joints when bending.
- ▲ The electrical load on the main battery of Antares is reduced by the use of auxiliary batteries installed in the upper legs and powering the servos.
- ▲ The direct servo control is also performed by the auxiliary controllers responsible for the work of all six engines of the leg joints.

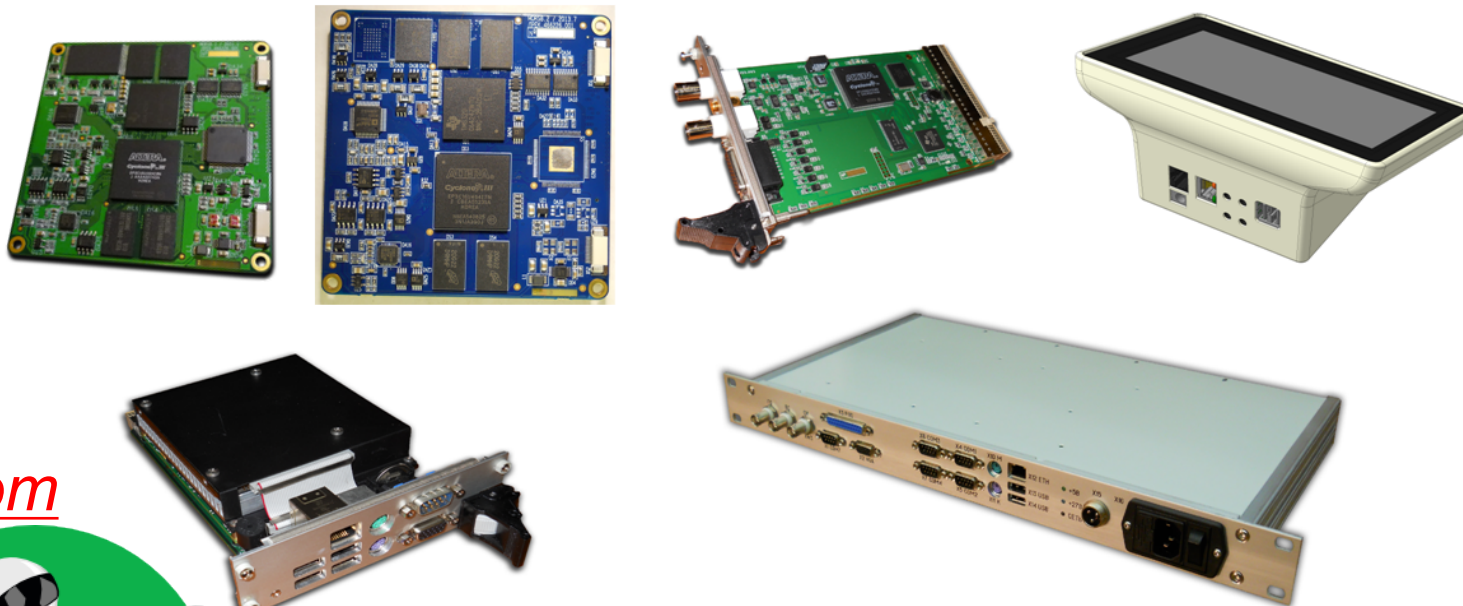


# Thank you for attention!

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