Advanced shape for a robotic torque sensor

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Aim

Torque sensors are used to measure the interactive force acted on an end effector in order to reach higher quality results in manufacturing process, telemanipulation, in robots which use force control feedback. In this work we present the optimization design process of a 1DOF torque sensor of hydraulic quadruped robot (HyQ), Fig. 1.

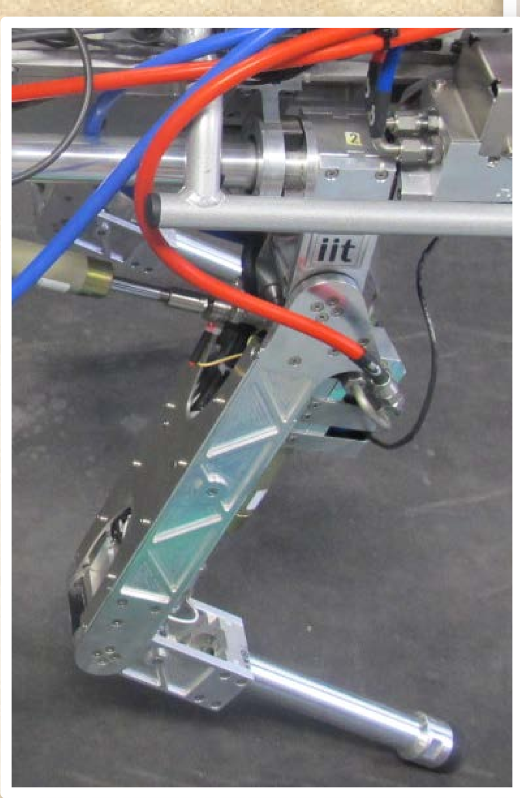


Figure 2 Torque sensor position

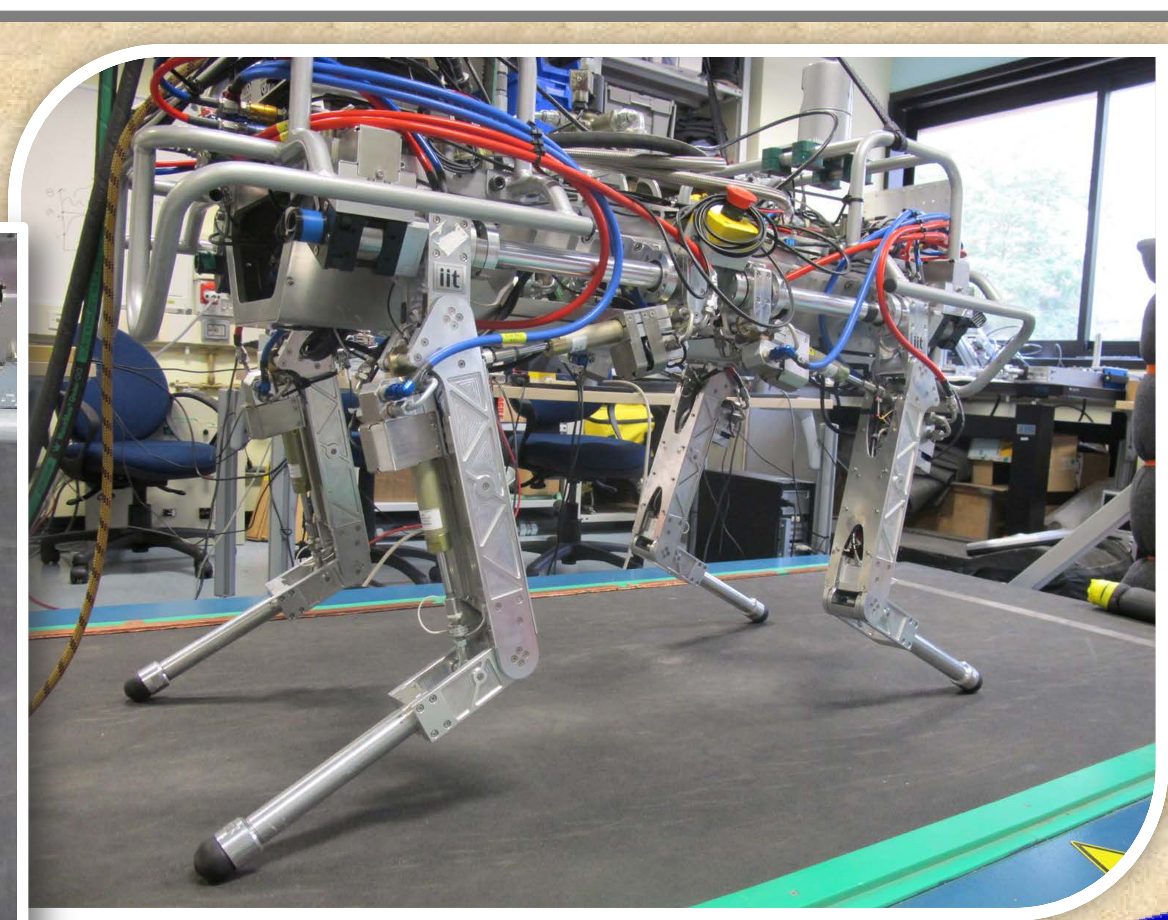


Figure 1 HyQ robot

Object

The object of our work is the **torque sensor of HyQ** (the Hydraulically actuated Quadruped designed in the Italian Institute of Technology), shown in Fig. 2. HyQ weighs about 70 kg, is 1 m long and 1 m tall with fully stretched legs. That platform is designed to perform high dynamic task like jumping, running, climbing, etc.

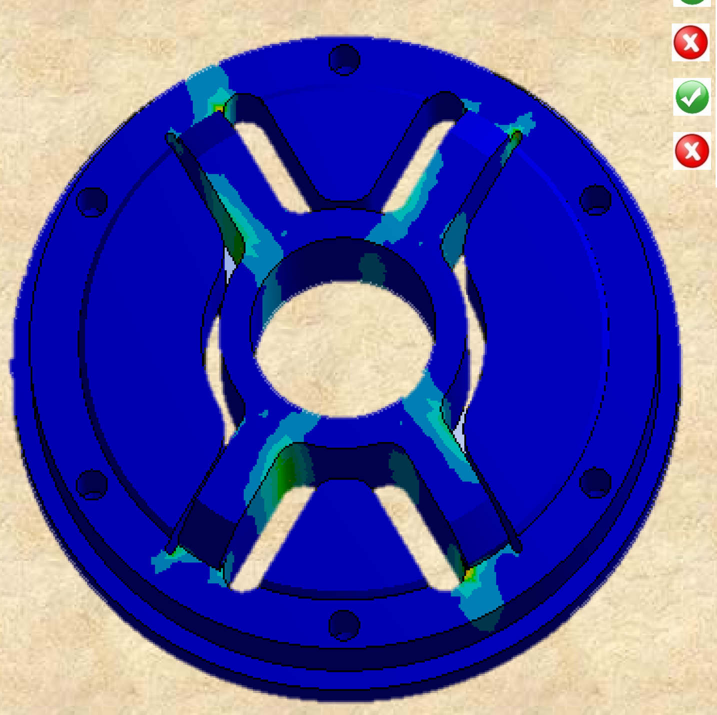
The actual version is able to perform both indoor than outdoor operations like: walking up to 2m/s, jumping up to 0.5m, balancing under ground disturbance .

In the future that robot can help man in all of the dangerous situation like earthquake, fire, etc.

Goal

- **Design a torque sensor with 40Nm of full scale**, that is the transmitted torque pick value to the leg by the motor.
- **Measuring within the strain gauge max value: ±0.01**, the operating field of the sensor.
- **Measuring within the strain gauge linearity: ±0.006.**
- **Planar surfaces to avoid offset in strain gauge measurement**. In case of non-planar surfaces a drift can influence the measures.
- **Easy positioning strain gauges**. The surfaces of positioning of the strain gauges must be easily accessible to allow all the operations of cleaning and bonding of the sensors in the assembly phase.
- **Bi-directionality**. The movements of the leg can be both in the clockwise direction than in counterclockwise , for this reason it is essential to have a sensor that has the same calibration factor in both directions.
- Elastic field of the material, in order to guarantee the complete recover of the deformation avoiding hysteretic phenomena.

- ✓ design a torque sensor with 40Nm of full scale;
- ✗ measuring within the strain gauge max value: ±0.01;
- ✗ measuring within the strain gauge linearity: ±0.006;;
- ✓ planar surfaces to avoid offset in strain gauge measurement;
- ✗ easy positioning strain gauges;
- ✓ bi-directionality;
- ✗ elastic field of the material.



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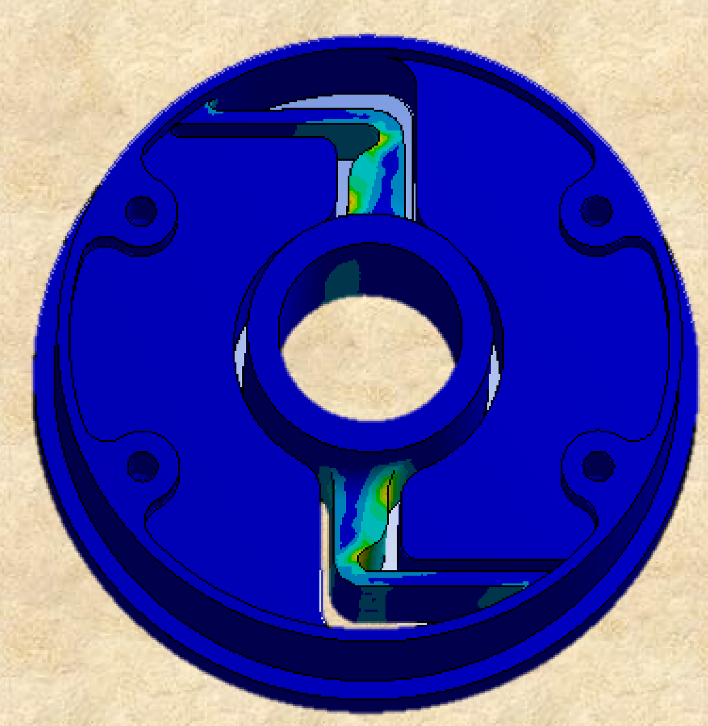

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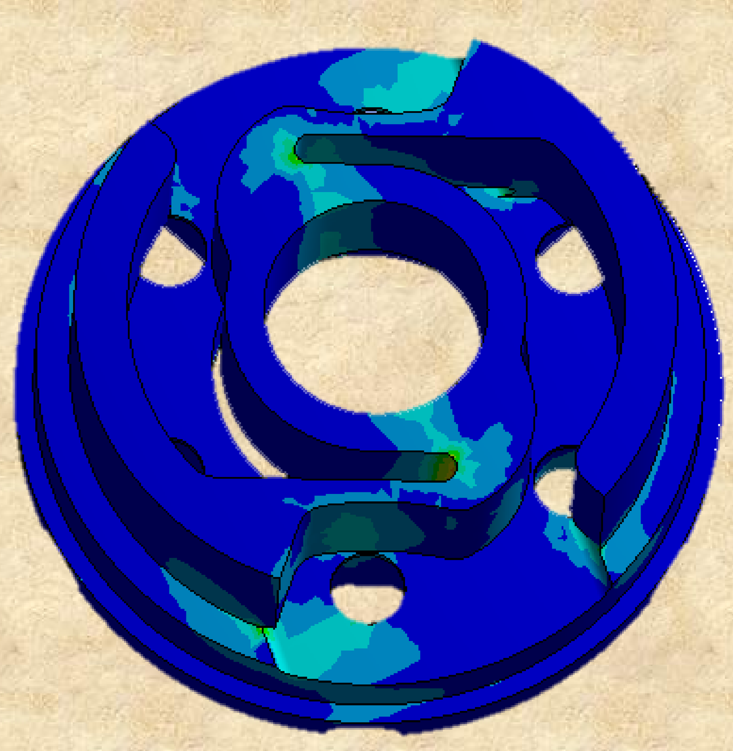

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Figure 3 Torque sensor

Conclusions

The design of the torque sensor in Fig. 3 was performed REDUCING COSTS AND TIME. Thanks to the FEM simulations (using Workbench) it was possible to investigate the behaviour of every single solution.

The step between one solution and the further was obtained by using a the rules of the building science , the refinement of the solution, instead, was carried out with Modefrontier simulations.

References

[1] C. Semini, N. G. Tsagarakis, E. Guglielmino, M. Focchi, F. Cannella and D. G. Caldwell, "Design of hyq–a hydraulically and electrically actuated quadruped robot," *Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering*, vol. 225, no. 6, pp. 831–849, 2011.