Non linear control of ARIES: A pendulum driven explorer sphere

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Method

- ARIES design and prototyping
- Kinematic and dynamic modelling
- Sliding mode control (SMC) design [3]
- Complete simulation in Simulink
- Embedded control on ARIES with ROS

Objectives

We use a group of independent spherical robots named ARIES powered by a cylindrical drive pendulum and designed with lunar exploration mission requirements. A nonlinear control strategy is being developed to guide the robots along various trajectories.

Conclusion and future work

The early stage of the study demonstrates that model-based control is mandatory. We select SMC for trajectory control which showed good performances but heavy chattering. To cope with that, our current SMC using the Exponential Reaching Law (ERL) will be soon tested on the field.

Dynamic modelling of ARIES

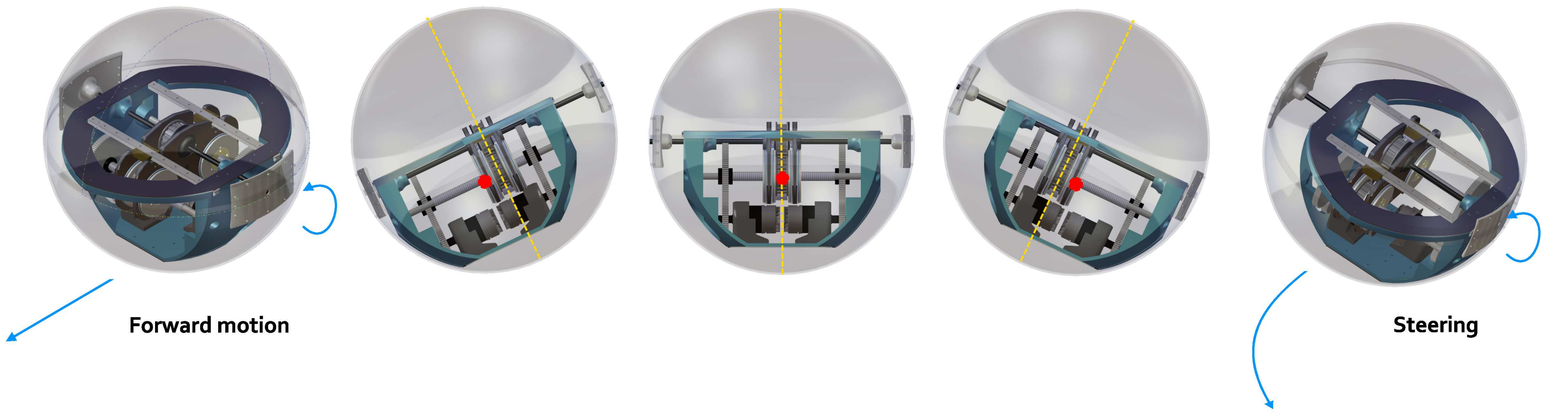
Decoupled dynamic [2]

$$M(q(t))\,\ddot{q}(t) + V(q(t), \dot{q}(t) = Q$$

Complete dynamic

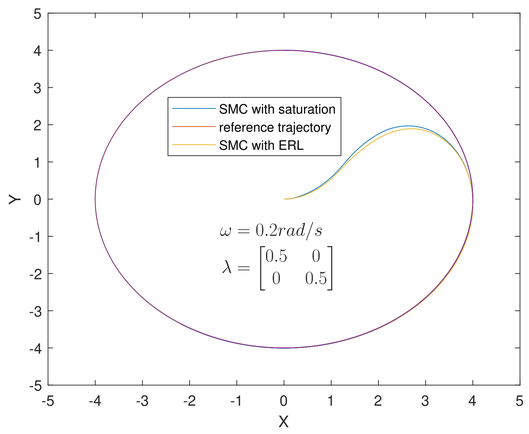
$$M(q(t))\,\ddot{q}(t) + V(q(t), \dot{q}(t) = Q + A^t\,\lambda$$

Motion of ARIES: steering and rolling [1]

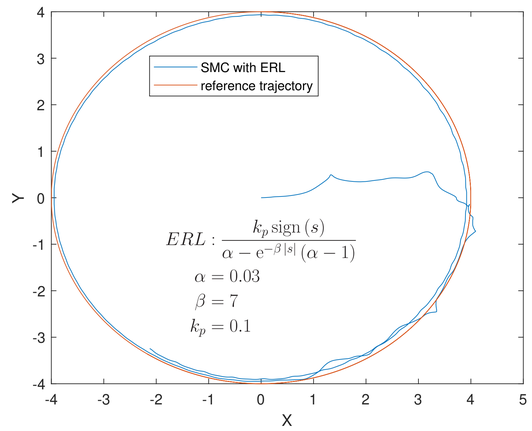


ARIES [1]

Trajectory tracking using sliding mode control



Decoupled dynamic



Complete dynamic

References

[1] Bruno Belzile and David St-Onge. Aries: Cylindrical pendulum actuated explorer sphere. *IEEE/ASME Transactions on Mechatronics*, 27(4):2142–2150, Aug 2022.

[2] Erkan Kayacan, Zeki Y. Bayraktaroglu, and Wouter Saeys. Modeling and control of a spherical rolling robot: A decoupled dynamics approach. *Robotica*, 30(4):671–680, 2012.

[3] Seyed Mehdi Mozayan, Maarouf Saad, Hani Vahedi, Handy Fortin-Blanchette, and Mohsen Soltani. Sliding mode control of pmsg wind turbine based on enhanced exponential reaching law. *IEEE Transactions on Industrial Electronics*, 63(10):6148–6159, Oct 2016.

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