Global Exponential Stabilization on $SO(3)$

Background:
The attitude control on the Special Orthogonal Group SO(3) is a long lasting problem that has received a broad interest during the last decades. Recent investigations focus on using differential geometric tools to design attitude control systems directly on the attitude configuration space SO(3); where the orientation of the rigid body is uniquely and globally rep- resented by a rotation matrix in SO(3). The available results obtained via smooth feedback are limited to almost global asymptotic stability, with slow convergence rates near some critical points. These limitations are mainly due to the topological nature of the closed compact manifold SO(3).

Methods:
An interesting hybrid framework involving synergistic potential functions has been developed by A. Teel and his collaborators, overcoming the topological obstruction to global stabilization on SO(3) and leading to global asymptotic stability results.

Results and Discussions:
Recently, we extended the synergistic hybrid control design approach and proposed a comprehensive framework for the design of hybrid control and estimation schemes providing stronger global exponential stability results. Our framework encompasses the use of either differentiable or non-differentiable attitude potential functions. A hybrid switching mechanism is employed to avoid the critical points or the singular points of each individual control law, when using smooth or non-smooth attitude potential functions, respectively. We provide new results on the design of the hysteresis gap that is necessary for the implementation the switching mechanism. We show that these control strategies guarantee global exponential stability results on SO(3); a result that was considered as the holy grail for many years.

Conclusion and Interdisciplinary reflection:
We strongly believe that our developed tools will not only benefit the area of

aerial vehicles engineering but also the robotics and biomedical engineering community. In fact, hybrid systems modelling arise from natural phenomena where both continuous and discrete events can be present.