* P1: title page
  + Welcome to my dissertation defense. The title of my dissertation is….
* P2: motivation
  + The application of attitude control and estimation is based on the increasing demand of autonomous vehicles, including vehicles in the space, vehicles under water…..
  + This dissertation mainly focuses on the attitude dynamics, which is the orientation of the vehicle.
  + **There are several different attitude representations other than SO(3), and it is interesting that these attitude representations actually effect the performance of the controller.**
* P3: parameterization of SO(3)
  + **The rotational motion of a rigid body has 3 degree of freedom**. At least 3 parameters are required to represent the attitude. And it turns out all of the minimal representations suffer from singularities. Certain attitude is not defined by RP and MRP. Or the singularity happens at Euler angles.
* P4: quaternions
  + To get grid of the issue of singularity. People turns to quaternions.
  + Quaternions consist of one scalar, and one vector can be applied to mechanics to 3D space.
  + From mathematic point of view, quaternions is also a manifold, called 3 sphere. And 3 sphere happens to be the covering manifold of SO(3). This implies two important facts: First, there is no singularity as S3 double covers SO(3). This is also the reason that quaternion representation is the most popular way in literatures and applications. Second, one attitude corresponds to two different quaternions.
* P5: rotation matrix
  + It is the manifold that model the rotational motion. **And it is highly redundant as you can see from the definition of SO(3), there are 9 elements subject to 6 constraints.**
  + It is understandable that people choose parameterizations to simplify attitude control problem.
* P6: geometric control and estimation
  + **There are techniques that can handle the singularity of Euler angles, and the ambiguity associated with quaternions. But these extra treatment make the control system design much more completed.**
* P7: dissertation outline
  + All of the control and estimation systems are developed and investigate based on this geometric approach.
* LOS1: motivation
  + The increasing demand for the low mass and low volume satellites
  + Darwin mission, 5 spacecraft work together as a large space inferometer
  + EDSN mission: Edison Demonstration of Smallsat Network
  + Relative positon control is nicely done by using GPS, but so far there is no ideal sensor can measure relative attitude directly.
* LOS2: control problem
  + Assume their position is given. We know the direction vector from one spacecraft to another spacecraft or to an object
  + If we use on-board optical sensors at spacecraft 2. Measuring the LOS to spacecraft 1
  + The s and b vectors actually are the same vector expressed in different coordinate frame
* LOS3: leader-follower scheme
* LOS4: problem formulation
  + This is attitude control problem, not an attitude estimation problem.
* LOS5: absolute attitude control
* LOS6: relative attitude tracking
* LOS7: error variables for relative attitude tracking
* LOS8: formation control between two spacecraft
* LOS9: relative formation tracking among n spacecraft
* LOS10: simulation model
* LOS11: simulation result
* LOS12: animation
* LOS13: velocity-free attitude formation control
* LOS14: conclusion
* Vel1: motivation
  + There are many different types of attitude controller, adaptive control, optimal control, control input saturation. These controllers have different features for different purposes. Generally, full-state is required.
  + In some conditions, angular velocity measurement is not available.
  + In the previous project, we use LOS directly control the attitude.
  + Instead of estimate the angular velocity, a damping term is created and this term has the same effect as angular velocity does.
* Vel2: estimate frame
  + We introduce an estimate frame.
  + Estimate error variables to describe the difference between estimate frame and the true body-fixed frame.
* Vel3: estimation problem
  + Governing equations are expressed with respect to the inertial reference frame.
* Vel4: observer design
  + Compact design
* Vel5: block diagram
* Vel6: proposition for the full-state attitude control
* Vel7: proposition for velocity-free attitude control
* Vel8: compare to literature
  + In the numerical simulation, we compare our observer with a recently published quaternion-based observer
  + First let’s put the attitude representation way and look at the performance of the observer.
  + Our observer is continuous and the literature has a switching logic in it.
  + Both of the design can achieve AGAS
  + The literature has the constraint on the inertial matrix.
* Vel9: simulation
* Vel12: conclusions
* Global1: motivation
  + Two conditions must be satisfied for GAS
  + First the equilibrium must be stable in the sense of Lyapunov, second, the region of attraction must be the entire configuration. In other words, convergence must be guaranteed for any initial condition.
  + It has been shown that it is impossible to achieve GAS in continuous attitude controller. The is because the topology of SO(3).
  + The best we can achieve is AGAS. You will always have unstable equilibrium.
  + Is this a big deal? Yes and No. It is not likely that the initial condition is right on that unstable equilibrium.
  + In literuatures, attitude observer has been studied intensively, and SO(3) has been used to develop attitude observer.
  + For continuous system, it is a dead end. Hybrid system is introduced to break the topology of SO(3).
* Global2: problem description
* Global3: estimation frame
* Global4: proposition for Mahony
  + We further analysis Mahony’s design.
* Global5: alternative of error function
  + Decompoase the matrix K to UGU transpose.
  + Why are we doing this? What is so special for the b vector?
* Global6: motivation of hybrid observer
* Global7: switching logic
* Global8: hybrid observer design
* Global9: hysteresis switching
* Global10: numerical integration
* Global11: geometric numerical integrator
* Global12: numerical examples
* Global13: experimental result