Methods section:

SINGULARITIES:

* Discussion on singularities and why they are a problem
  + Define singularities, (Quiver showing location)
  + Small regions of zero guidance
    - May not avoid obstacle in time
    - Could trap multi-rotor
  + Locating singularities and determining if they will be encountered
  + Plot magnitude in surface plot, identify singularities visually
  + Find the minimum of a magnitude function
    - Entire space
    - Evaluating entire space is costly and not necessary since singularity is only an issue if it lies along the UAVs flight path
  + Flight envelope
    - For a dubins vehicle a flight envelope for a time horizon t can be constructed which represents the possible locations of the UAV
    - Initial conditions at the edge of the flight envelope
    - Find singularities during flight
* Singularities identified, allows us to determine if they are a problem
* Circulation adds perpendicular component to repulsion accomplishing two things
  + 1) Modifies and possibly eliminates singularity
  + 2) Adds information on how to go around an obstacle instead of blindly pushing away
    - Side note, if strictly repulsive, guidance relies on the goal field for circumnavigation

* Construction of GVF for line (normalization, weights)
* Construction of GVF for obstacle (normalization, weights, decay function)
* Summing fields together to produce a path following and avoidance guidance

PATH FOLLOWING:

* GVF for path following
  + Normalization
  + Weights
  + Circulation function of velocity to prevent oscillation and reduce steady state error
* Dubins vehicle converging and following a path

AVOIDANCE:

* GVF for avoidance
  + Normalization
  + Weights
  + Decay function
* Summing attractive and avoidance fields together
  + Strictly repulsive field
  + Dubins vehicle following summed guidance (strictly repulsive)
* Selecting GVF parameters for obstacle avoidance
  + Goal is to optimize GVF to produce a guidance that minimizes the deviation from the original path while avoiding the obstacle
  + Determining parameters of greatest influence on performance
    - Decay function strength 2x goal field, eventually overpower goal guidance
    - Gradual and smooth transition to prevent abrupt heading command changes
    - Decay radius, how far out should field extend so UAV has adequate time to turn
    - Defining obstacle region, decay edge, and equal strength position
    - Obstacle radius must be no smaller than turning radius of UAV (needs justification)
    - Decay field radius should be larger for UAVs with greater velocities to allow more time to react to guidance
    - Gamma ratio and cost
    - Cost is a measure of how far the UAV deviates from the path
    - Evaluation of gamma ratio vs cost plot
      * Fix circulation
      * Fix gamma
      * Determine decay radius from uav turn radius
      * Combinations of decayR and uav turn radius for fixed gamma produce identical costs.
      * Relationship breaks down at velocities <=1
  + Circulation (adds information on how to circumnavigate)
    - Sign (LOS angle) to determine which direction to go around obstacle
    - Magnitude
  + Parameter solver
    - Find combination of gamma and circulation which minimizes deviation from the path when using gvf guidance
* Simulations
  + Obstacle centered on line
  + Obstacle off center
  + Multiple obstacles along line