

ArduPilot Object Avoidance

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Version 1.0

Agenda

1. Existing sensor based object avoidance
2. Dijkstra's Path Planning
3. Bendy Ruler
4. Issues & Next Steps
5. Path Planning Systems Overview

Simple Avoidance (aka Stopping)

Vehicle stops before it hits something using a “sensor based approach”.

Raw sensor data is used to create a mini-fence around the vehicle.

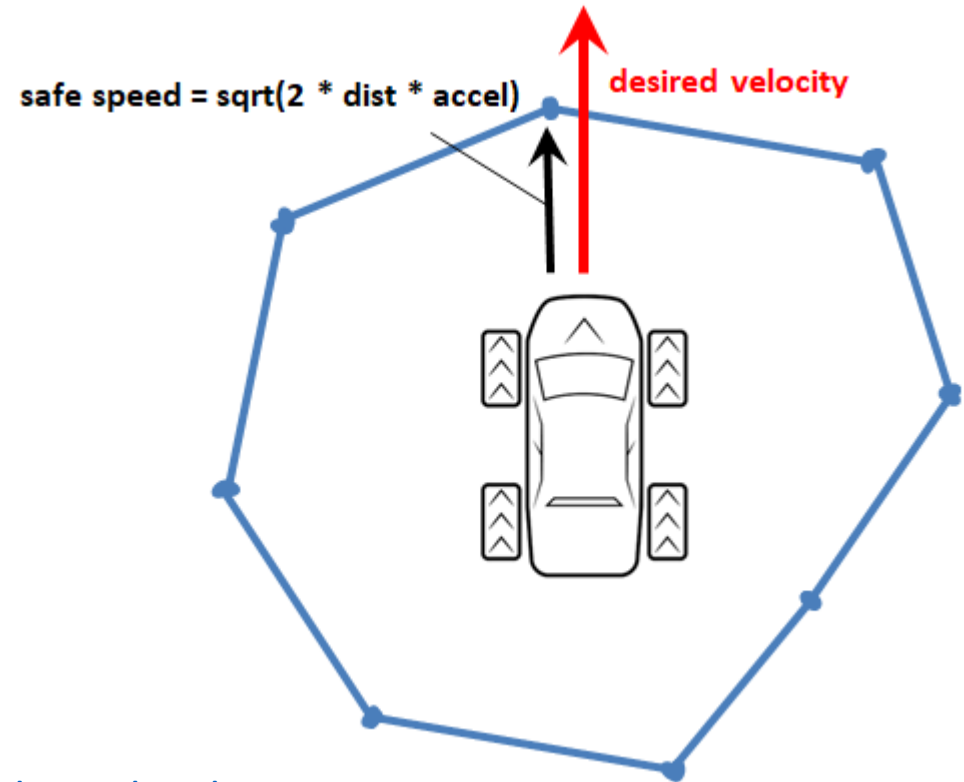
The desired velocity is shortened so the vehicle **stops** before hitting things.

Copters can **slide** around objects by slightly rotating the desired vector.

<https://ardupilot.org/copter/docs/common-simple-object-avoidance.html>

Copter: https://www.youtube.com/watch?v=BDBSpR1Dw_8

Rover: <https://www.youtube.com/watch?v=ho9mIVwhgHA>



Simple Avoidance Issues

1. Sensor based with no “memory”. In the future we will store the mini fence for a few seconds
2. Mini fence is in “body frame” so we need fast update rate or stopping is jerky. Will move to “earth frame”
3. Vehicle does not back away from close objects
4. Not enabled in Auto mode (for Copter) because vehicle could get stuck

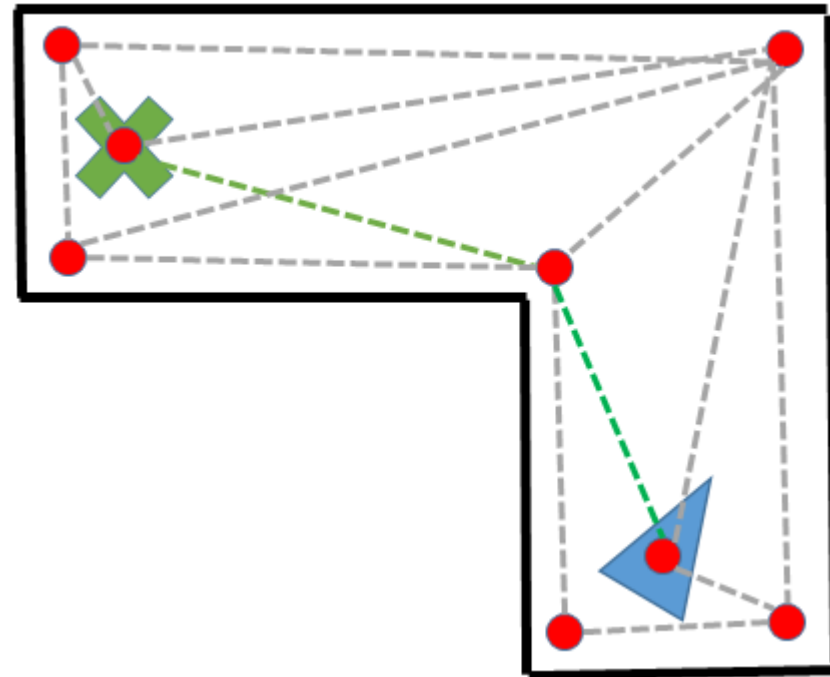
Dijkstra's Path Planning

Creates an array of “safe points” including the origin, destination and fence points (both stay-in and stay-out)

Iteratively calculates the distance of all paths and then picks the shortest.

<https://ardupilot.org/copter/docs/common-oa-dijkstras.html>

SITL video: <https://youtu.be/GAmNaDTzy3Q?t=36>



Dijkstra's Issues

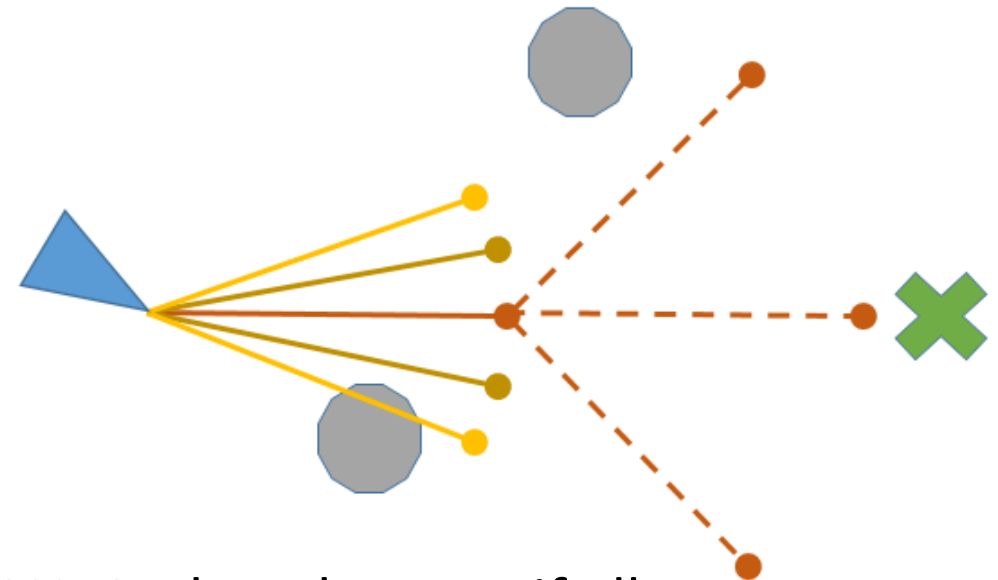
1. Dynamic obstacles not supported (i.e. no lidar support)
2. Spline waypoints not supported
3. Bug in memory allocation that limits how many safe points can be handled. Fixed in Copter-4.0.4, Rover-4.1 (thanks Sid!)

Bendy Ruler Path Planning

A “ray” based approach in which we probe 360° around the vehicle for a direction that best heads towards the destination and also has the largest margin from obstacles and fences

A second probe is done in 3 directions.

The length of the probe comes from OA_LOOKAHEAD but shortens if all directions have low margins from obstacles.



<https://ardupilot.org/copter/docs/common-oa-bendyruler.html>

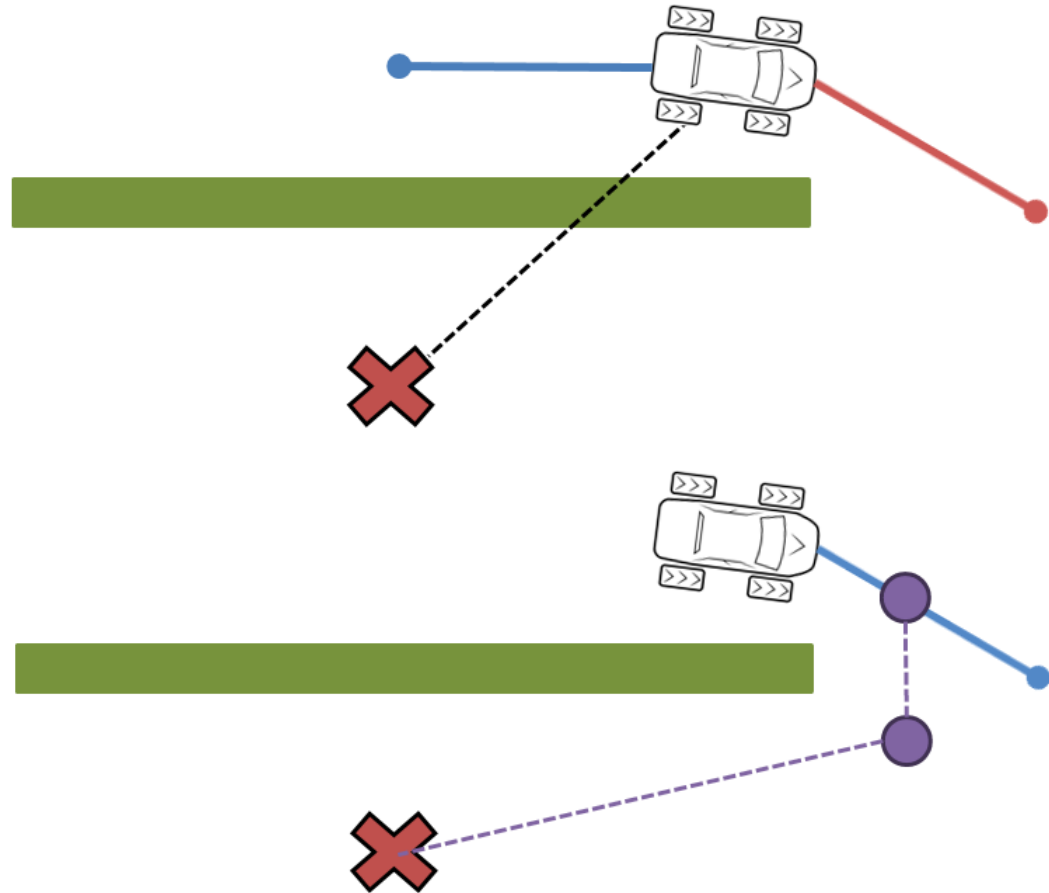
Copter: <https://youtu.be/SPu0a23FGKc>

Rover: <https://youtu.be/EOKYLpXnD1A>

Bendy Ruler Issues & Next Steps

Sometimes cannot get around obstacles wider than the probe length.

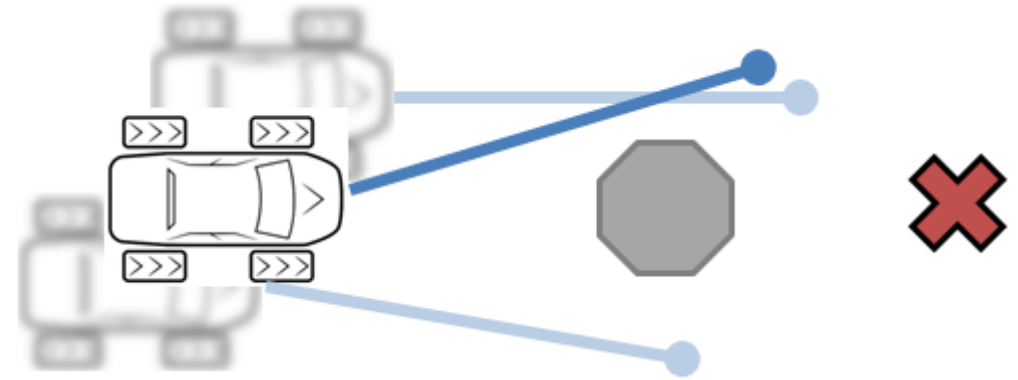
Maybe we should use Bendy and Dijkstra's together?



Bendy Ruler Issues & Next Steps

May be hesitant as it changes its mind about which way to get around an obstacle.

Wanders instead of taking a straight, confident path around an obstacle.



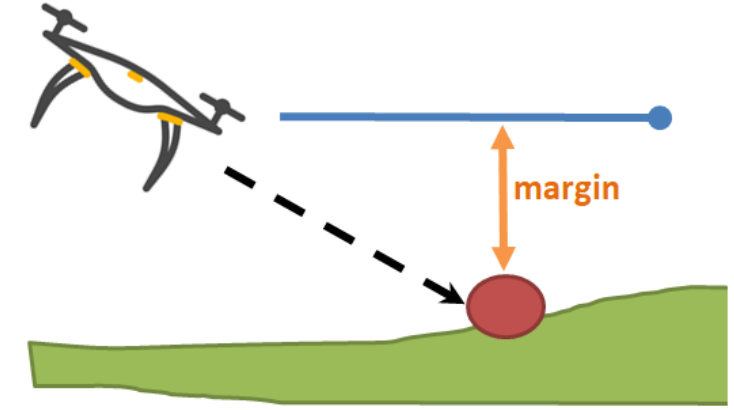
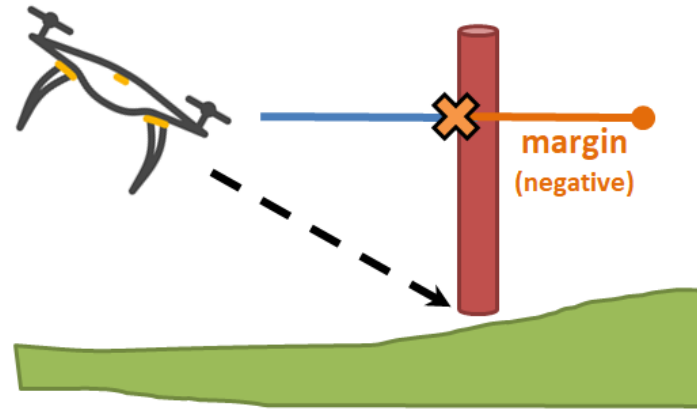
It may help to:

1. improve position estimation accuracy (better GPSs?)
2. stick with a target unless the new targets provide a significant improvement
3. Probe from the previous line segment instead of current position

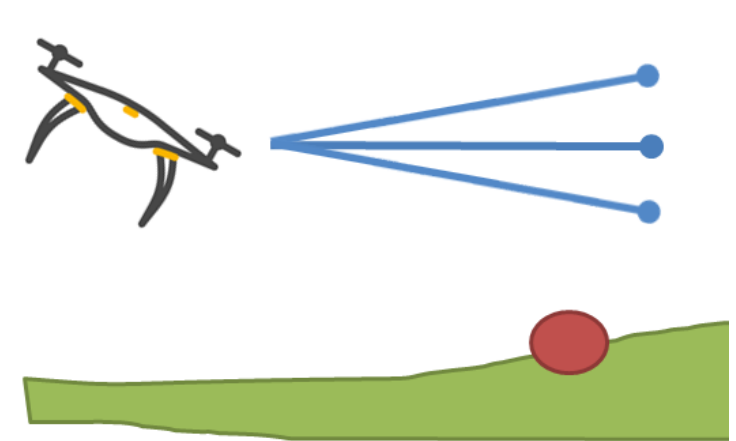
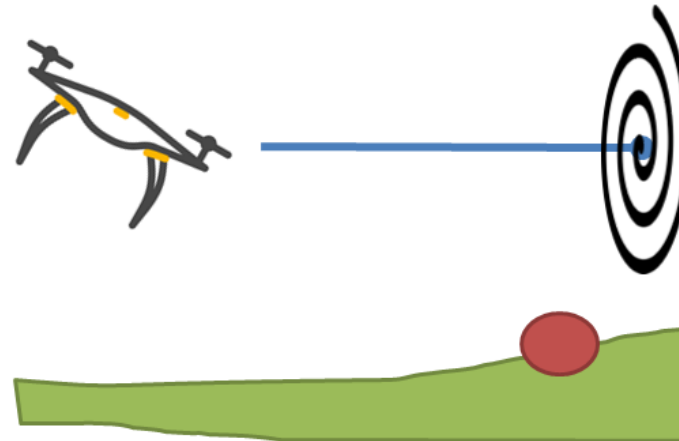
Example Rover video: <https://youtu.be/E0KYLpXnD1A?t=186>

Bendy Ruler Issues & Next Steps

The ground may appear as obstacles especially when the vehicle leans over.



The object database and search algorithms should be made 3D

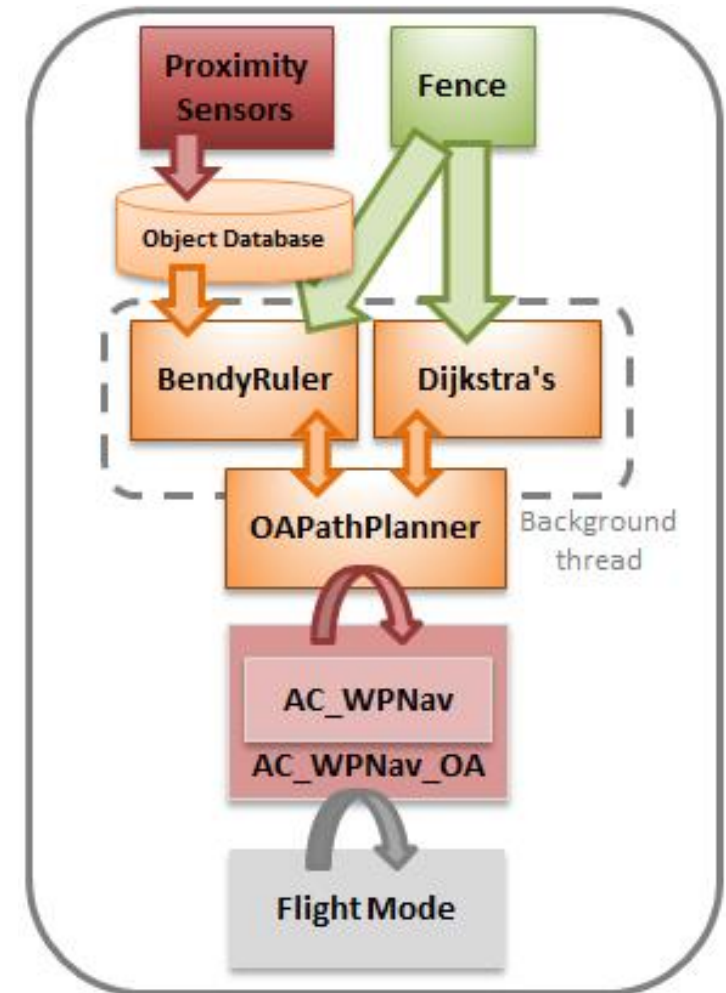


Path Planning System Overview

Proximity sensor data is converted to “earth frame” as it enters Object Database.

Navigation sends origin and destination to Path Planner which then asynchronously calls Bendy Ruler or Dijkstra.

Navigation library hides details of path planning from flight mode code.



Want to Help?

Relevant issues from the issues list are below, feel free to grab one!

[13215](#) : AC_Avoidance: BendyRuler and Object Database should work in 3D

[13016](#): AC_Avoidance: BendyRuler may provide a position target outside the fence

[12691](#): AC_Avoid: Dijkstra's should work with Spline waypoints

[11961](#): AC_Avoidance: resolve BendyRuler's hesitancy

[11945](#): AC_Avoidance: Object database should only be active when using BendyRuler

[11601](#): AC_Avoidance: vehicles using Dijkstra's may pass too close to fence

[11582](#): AC_Avoidance: Dijkstra's VisGraph should hold distances in meters

[11565](#): Rover: recovery from BendyRuler avoidance may impact fence

[11562](#): AC_Avoidance: add proximity sensor support to Dijkstra's

[11552](#): Copter: use terrain data for path planning (aka obstacle avoidance)

Developer Wiki: <https://ardupilot.org/dev/docs/code-overview-object-avoidance.html>

Thanks!



Thanks very much to EAMS Lab for their support!