Algorithm to Insert a Waypoint to Avoid an Obstacle

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Here is my description of an algorithm to add a waypoint to avoid an obstacle between two waypoints. My goal in the design of this algorithm is to make its implementation as simple as possible. Specifically, the algorithm should require only the implementation of a set of geometric functions. I think that we'll need to implement the following geometric operations.

1. Compute the equation of a line which goes through two points.
2. Compute the intersection between a line and a circle.
3. Compute the midpoint between two points.
4. Compute the equation of a line through a point with a particular slope.

I assume that we want the line between any pair of waypoints is at least distance b away from the obstacle. This is necessary because the vehicle's actual flight path is not precise. Right now we are setting b for an obstacle to be 20% of the radius of the obstacle.

Inputs: A sequence of two waypoints w1 and w2. One obstacle which is between the two waypoints.

Output: A sequence of three waypoints, w1, f, and w2. The path from w1 to f to w2 should avoid the obstacle.
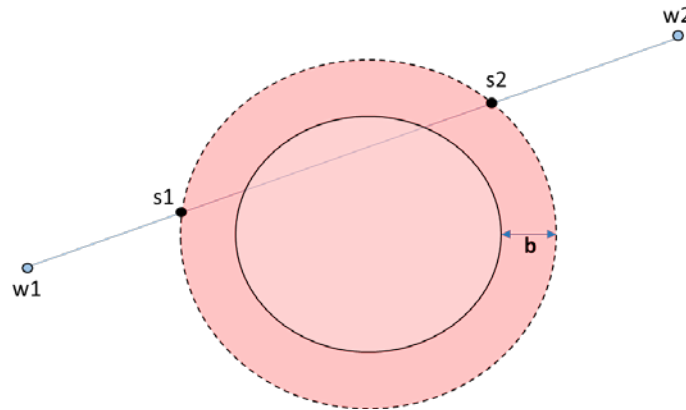

Figure 1: Waypoints, Obstacle, Safety Buffer

Figure 1 shows the two waypoints and an obstacle in between them. There are two pink circles in the figure. The inner circle is the obstacle and the outer circle has a radius which is b larger than the radius of the obstacle. The larger circle shows the **safety buffer** area which we need to avoid. The line between the waypoints intersects the safety buffer at two points labeled s1 and s2. The line segment connecting s1 and s2 is called the secant.
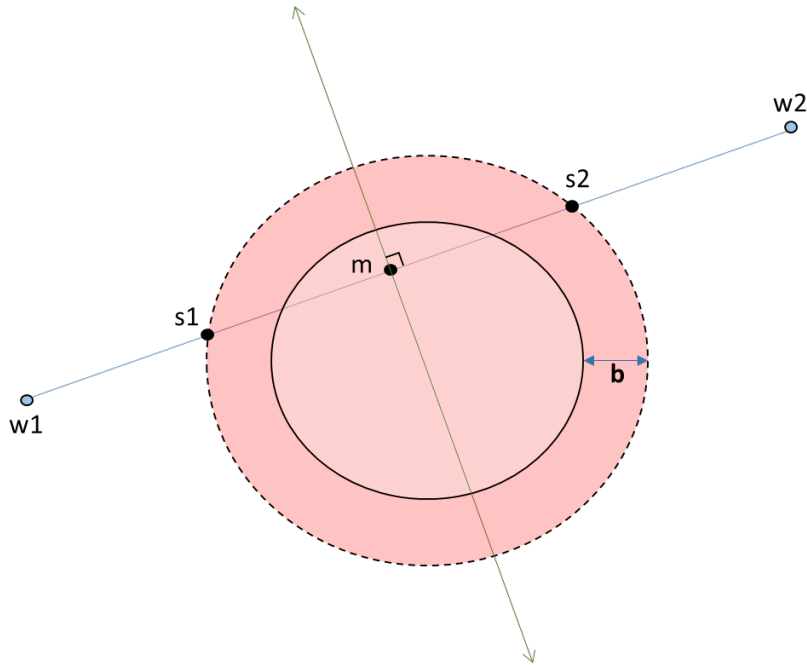
Figure 2: Perpendicular Bisecting Line

Once the points s1 and s2 have been determined, we need to find the line which bisects the secant line and is perpendicular to the secant. Figure 2 shows the midpoint m which bisects the secant line, and the green line passing through m is the perpendicular line which bisects the secant. The new waypoint which we will select to avoid the obstacle will be located on this perpendicular bisecting line.
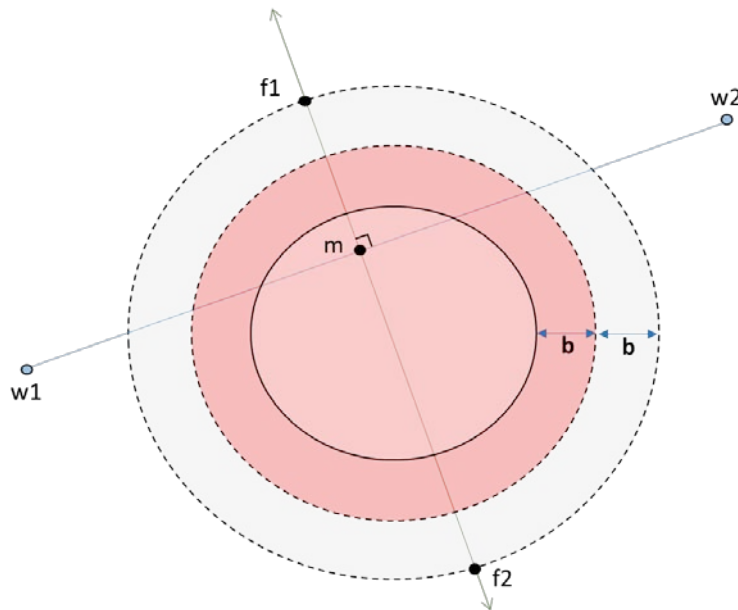

Figure 3: Avoiding waypoints, intersection with outer circle

We will identify two potential waypoints to allow us to avoid the obstacle. Both potential avoiding waypoints will be on the perpendicular bisecting line, but they will be on opposite sides of the obstacle. By identifying one potential waypoint on each side of the obstacle, we can choose which side of the obstacle we want to fly around. The two potential waypoints must be some distance outside of the safety buffer region in order to be sure that the lines between adjacent waypoints remain entirely outside of the safety buffer region. For this region define a larger circle, shown in Figure 3, whose radius is b larger than the radius of the safety buffer. The two points where the perpendicular bisecting line intersects the larger circle are the two potential avoiding waypoints. These two points are labelled f1 and f2 in Figure 3.
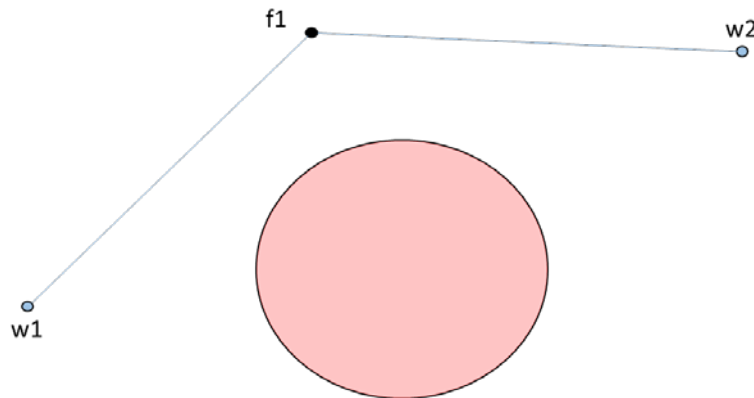

Figure 4: Avoiding waypoint f1 inserted

Once f1 and f2 have been located, one of these two points needs to be chosen as the new waypoint to be inserted in the sequence between w1 and w2. For now we will choose this randomly. Figure 4 shows the final result of choosing f1 as the new waypoint.