SoftWalls in 2D

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1 Introduction

This document gives an outline of a general 2D softwalls approach. We assume the initial speed is known.

2 Step Bias

Suppose the aircraft is travelling at a constant speed s. Let θ denote the aircraft's heading angle, and let $\dot{\theta}_p$ be the pilot's control input, i.e. the desired rate of change in heading angle. At that speed, the aircraft has a minimum-safe turning radius r_{min}. This contrains the paths at which the aircraft can bank right or left as in figure 1.

Now suppose we wish to prevent the aircraft from crossing a boundry. As the aircraft approaches the boundry, one of minimum-turning-radius paths will interesect with the boundry. As long as the other path has not yet interestected the boundry, the aircraft can still avoid crossing the boundry by turning along this path. When the other path intersects the boundry, turning along this path until one of the paths no longer intersects the boundry will prevent the aircraft from crossing the boundry.

If the actual rate of change in aircraft heading angle be $\dot{\theta}$, and we limit this value to the safe range $[-s/r_{min}, s/r_{min}]$, we can view this controller as follows:

Let θ_s, be the softwalls-generated control signal. We calculate $\dot{\theta}$ from

$$\dot{\theta} = limit_{[-s/r_{min}, s/r_{min}]}(\dot{\theta}_p - \dot{\theta}_s,$$

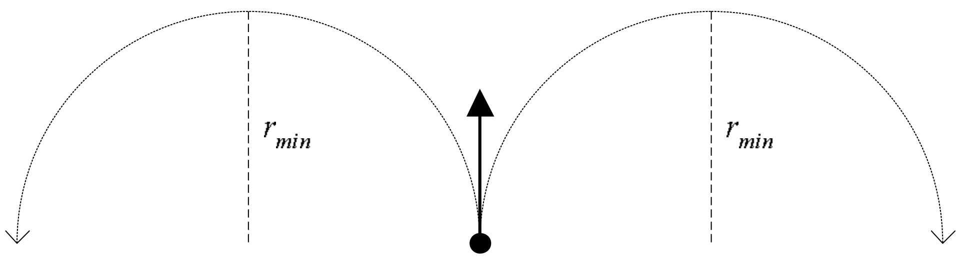

Figure 1: The dot represents the aircraft, which is moving along the center path. The arc paths representent turns at the minimum turning radius.

where

$$limit_{[a,b]}(u) = \begin{cases} b & \text{if } u > b, \\ a & \text{if } u < a, \\ u & \text{otherwise.} \end{cases}$$

Assuming $\dot{\theta_p}$ is limited to $[-\dot{\theta_M}, \dot{\theta_M}]$, which corresponds to the limits of the flight yoke, we can choose $\dot{\theta_s} = \dot{\theta_M} + s/r_{min}$ to force the aircraft to turn right at the maximum turning radius, irrespective of pilot input. Similarly $\dot{\theta_s} = -\dot{\theta_M} - s/r_{min}$ will force the aircraft to turn left.

By applying the appropriate θ_s to the input, the softwalls algorithm (the path/boundry-interestection algorithm) can garauntee the plane to never crosses the boundry.