Project Proposal - Flappy Bird

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March 2024

The primary challenge in Flappy Bird is to navigate a bird through a series of pipes or obstacles by tapping the screen to make it flap and ascend, while competing against a constant force of gravity and consistent forward momentum. The bird must avoid collision with the obstacles while maintaining a stable flight trajectory. The main objective of this optimization is to create an obstacle avoidance algorithm which is able to accurately navigate the bird safely through the obstacles.

A potential cost functional is:

$$J[\mathbf{u}] = \int_t^{t_f} f(u(t))\,dt + \phi(t_f, y(t_f))$$

where $f(u(t))$ is a cost on the control which guides it to appear like various instantaneous taps. This could be represented in a form such as $f(u(t)) = u(t)^2 - u'(t)^2$, where $u(t) = sin(10t) + cos(-10t)$.

$\phi(t_f, y(t_f))$ adds an endpoint cost to the functional to keep the bird ending in between the two pipes. This could be in the form $\phi(t_f, y(t_f)) = \exp\left(-\frac{(y(t_f)-(P_u+P_l)/2}{\sigma^2}\right)$, where P_u and P_l represents the y locations of the upper and lower pipe.

Our state equation is:

$$\begin{bmatrix} x(t) \\ y(t) \\ \dot{x}(t) \\ \dot{y}(t) \end{bmatrix}' = \begin{bmatrix} k \\ \dot{y}(t) + u(t) \\ 0 \\ -9.8 \end{bmatrix}$$

where k is a constant horizontal velocity.

We will utilize the following mathematical tools:

- Obstacle Avoidance Lab
- Pontryagin Maximum Principle
- Bang-Bang Problems