Fast Local Planner for Autonomous Helicopter

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Abstract:
- A system for identifying and navigating to safe landing zones for robotic helicopters. Our system will consist of a module that looks at the whole environment and evaluate the different possible landing zones, a module that plans the best route to the chosen landing area, and a collision avoidance system. This project focuses on designing the third component, a local obstacle avoider.

Fajen and Warren’s Control Law:
- The rotational acceleration is calculated based on the current rotational velocity \( \dot{\phi} \), the angle \( \psi_g \) and distance \( d_g \) to the goal as well as the angle \( \psi_o \) and distance \( d_o \) from obstacles:

\[
\ddot{\phi} = -b\dot{\phi} - \sum_{i=1}^{n} k_o \left( \psi_o \right) \left( d_o \right)^2 - \sum_{i=1}^{n} k_g \left( \psi_g \right) \left( d_g \right)^2 + \sum_{i=1}^{n} \left( -k_n \psi_n \right) \left( d_n \right)^2 + \sum_{i=1}^{n} \left( -k_r \psi_r \right) \left( d_r \right)^2
\]

- Subtract a proportion of the current rotational velocity
- Add up all obstacles
- Distance to obstacle
- Subtract the angle between the current heading and heading to goal
- Angle between the current heading and heading to the obstacle

Avoiding Obstacles:
- The red obstacle pushes the heading away while the blue goal pulls the heading towards itself.
- The two red obstacle’s push is cancelled out.
- The red obstacle’s closer position gives it more push than the blue goal.
- Cycle life: Data from sensor and planner are translated into a map of obstacles and goals. The map is at the same time calculating new poses.

Testing:
- Maps of pre-programmed red obstacles and green goals. The yellow arrow marks the starting point.

Experimental Results:
- Ex. 1 – 3 paths to 3 different goals
- Ex. 2 – Navigating multiple obstacles
- Ex. 3 – Paths to 3 goals
- Ex. 4 – Another Obstacle Type

Conclusions:
- Fajen and Warren’s control law does a fairly good job of planning out paths.
- My system has trouble with large numbers of obstacles and goals that are near obstacles.
- Many problems can be solved by tweaking the constants within the formula.

1. Fajen and Warren’s Control Law is described in their paper “Behavioral Dynamics of Steering, Obstacle Avoidance, and Route Selection”