Using Optical Flow for Object Avoidance and Object Tracking

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Abstract

Most animals, including humans, use vision to track objects and to avoid obstacles. An artificial system with similar capabilities will have many practical applications. But most computer based vision systems require high computational power, complex vision algorithms, and sophisticated sensors. In this research, optical flow based novel approach was tested, which was inspired by the vision system of honeybees. This method reduced the computational load and used only a single low-resolution camera for obstacle avoidance and tracking.

The mathematical model for the optical flow was based on the pinhole model. A custom 3-D simulation framework was developed using Simulink and VRML, which was compared against the mathematical model. For velocities less than 30 ms^{-1}, the results of the simulations agreed with the mathematical model.

After the verification of the accuracy of the simulation framework, two models were simulated, a ground based robot with two degrees of freedom, and a flying robot with six degrees of freedom. Initial controller algorithms were based on the optical flow balancing models and were able to avoid obstacles. But they suffered from gap gravitating and overshooting at corners. Controller algorithms were developed in an iterative manner, and final fuzzy logic based algorithms prevent gap gravitating, was able to control the speed to make tight turns and was more efficient in avoiding obstacles.

The ground-based robot was tested with seven pre identified obstacle patterns with different orientations, colors, textures and light conditions and was able to avoid them with average accuracy more than 96 %. The flying robot, quadcopter, was tested for hovering capabilities and was able to reach stability in less than 4 seconds. Due to physical limitations, it was not possible to make extensive research on the physically build flying robot. But experiments were carried in the simulation. The robot was able to automatically reduce the speed with altitude similar to an airplane. It was also able to hover and to cruise at set speeds up to 30 ms^{-1}. It was also able to measure its rotation with respect to the ground.

The tracking experiments were conducted for single objects and multiple objects. The optical flow was used to detect the objects. When tracking the pendulum, the correlation between the theoretical period and the calculated period was as high as 0.996. The proposed method was able to evaluate the velocity of more than 10,000 points in a fluid flow by tracking small-suspended particles floating on it. In future, it may be possible to develop a mobile robot that can track a moving target while avoiding obstacles using optical flow.