CSE 634: Revised Project Proposal

Due on Autumn 2011

Prof. James W. Davis 9:30

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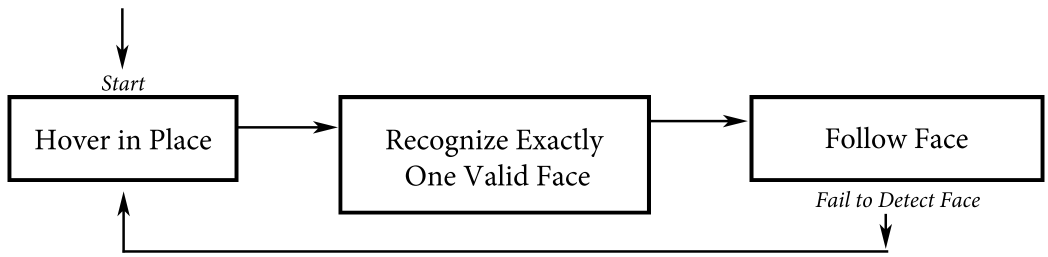
Proposal

We propose to fly a toy quadrotor to recognize and follow the faces of group members using machine vision techniques introduced in class. The toy quadrotor includes a 320 by 240 pixel color web cam and a Linux wireless network interface by which we may receive the web cam video feed and send simple flight commands from a laptop computer. The quadrotor is small, safe, and stable enough to be flown in class, but we will also prepare work based on recorded video in the case that the quadrotor fails unexpectedly.

Figure 1: Final Drone Flight State Transition Diagram



Our live demonstration features untested computer vision algorithms to pilot a possibly unstable flying robot to be developed in under three weeks. Thus, we propose to bound the risk of a live demonstration by first preparing foundational *Base Flight* presentation which we extend to prepare a second, more advanced *Goal Flight* presentation. The *Base Presentation* is simple but sufficient, and we complete and video record this Presentation by the second week. Meanwhile, we individually prepare a cascade of more ambitious sub-projects which more throughly fulfills the intended theoretical computer vision emphasis of this class. Near the deadline, and we compile the successful subprojects into an coherent *Goal Flight* presentation as summarized above.

This split proposal grants us the flexibility to add, abandon, or substitute subprojects without hindering core project progress or risking a failure in the live demonstration, and it includes all group members in substantial computer vision work. In the event of an intractable complication, for example, total drone failure, we will still be able to present a video demonstration of the flying drone while striving to produce a more ambitious demonstration which we can confidently and reasonably propose to complete by the project deadline.

Outline

- **Project idea**: quadrotor object and face video tracker
- **Data source**: streaming color 320x240 pixel video from embedded quadrotor video camera over local WiFi network connection
- **Development and Code**: quadrotor video feed processing and pilot software in C++.
- **Evaluation**: the quadrotor successfully follows the intended face or object.
- **General Team Rolls**:
  - Michael: Video Analysis and Computer Vision
  - Andrew: Project Management and Flight Control
  - Daniya: Algorithms and Theory

Test Flight: Stationary Follow

This flight is not intended to be a sufficient final presentation.
To be completed by November 13th by Andrew.

We propose to track and follow a green object while hovering above one location for at least three minutes. To achieve this, the computer vision techniques that we expect to use includes background subtraction, simple threshold object detection and noise filtering. The quadrotor will attempt to keep the green object in the center of its view at a stable distance by rotating and lifting while hovering in place. These algorithms will be written in C.

Subgoal

Record sufficient corpus of training video to begin independent work. This video may be recorded both with the drone camera and with other cameras; for example, an iPhone video camera.

1. Detect single green object from video frame. Find centroid.
2. Compute (x,y) vector from object to center of frame.
3. Convert (x,y) vector to (rotate, lift) drone flight commands.
4. Follow green object until commanded to land from computer.

Base Flight: Dynamic Follow

To be completed by November 20th by Andrew.

We propose to track and follow one green ball in flight for at least three minutes. The quadrotor will attempt to keep the green object in the center of its view at a stable distance and will compensate for the angular tilt and instability as the quadrotor pitches. To achieve this, we extend the *Test Flight* with computer vision techniques including moment calculation, object scaling, and simple object tracking. When the quadrotor does not detect the green ball, it will hover in place. These algorithms will be written in C.

1. Select first green ball to enter video frame. Ignore all other similar shapes (e.g. flat green frisbee)
2. Compute (x, y, z) vectors (z is distance to tracked object) from expected ball size.
3. Convert (x,y,z) vector to rotate, lift, pitch flight commands given the current tilt of the drone.
4. Follow green ball until commanded to land from computer.

Subprojects

To be completed by November 24th as listed individually.
Individual project components may be programmed using C, C++, OpenCV, or Matlab.

Michael

1. Skin Detection: select skin regions from color video frame
2. Face Detection: select face regions from set of candidate skin regions. Determine approximate distance from drone to face.

3. Face Recognition: given a sufficiently large face-like object, confirm that it is a face and recognize it as one of the three group members.

4. End Face Detection: given a selected region that previously contained a face, detect when that face has been sufficiently obscured in order to halt tracking.

Daniya

1. Object Track: Given a region, track that region frame to frame. Compute this efficiently enough to be used in real time.

2. Tracked object trajectories: Given a selected object, compute the smoothed motion trajectory of that object.

3. Matching trajectories: Given a smoothed trajectory, match that trajectory to a model trajectory: shake up-down or shake left-right.

Goal Flight: Recognized Face Follow

To be completed as a team by November 27th.

We propose to integrate the work completed in the Subprojects into the final "Goal Flight" demonstration as described in the Proposal section. Subprojects that are incomplete or produce results too unreliable to safely use in a live demonstration will be presented using slides in a brief concluding presentation. We will also prepare video recording of the goal flight which we may show if the drone cannot be flown in class during the presentation due to, for example, drone failure.

1. Hover in place.

2. Wait until exactly one identified face has been detected for at least three frames. If the drone detects any other faces in the scene, or if the face detected is not recognized as one of the group members, then continue to hover in place.

3. Begin following the recognized face using object tracking.

4. When tracked object is no longer detected as a face, stop following and hover in place.

5. Go back to 1.