Project: Building a Controller

Rubric Points

Writeup / README

Implementing Controller

1. Implemented body rate control in C++.

Body rate controller is implemented in QuadController (lines 108-110). It is a proportional controller, which takes body rates and outputs moments:

```
V3F uPuQuR = (pqrCmd - pqr)*kpPQR;
```

Body rate controller takes into account the moments of inertia:

```
momentCmd = MOI * uPuQuR;
```

2. Implement roll pitch control in C++.

Roll pitch control is in QuadController (lines 140-157) The controller uses the acceleration and thrust commands, in addition to the vehicle attitude to output a body rate command:

```
float c = collThrustCmd / mass;
float r13c = -CONSTRAIN(accelCmd[0] / c, -maxTiltAngle, maxTiltAngle);
float r23c = -CONSTRAIN(accelCmd[1] / c, -maxTiltAngle, maxTiltAngle);

…

float bxDot = kpBank * (r13 - r13c);
float byDot = kpBank * (r23 - r23c);
```

The controller should account for the non-linear transformation from local accelerations to body rates:

```
pqrCmd[0] = (-r21*bxDot + r11 * byDot) / r33;
pqrCmd[1] = (-r22*bxDot + r12 * byDot) / r33;
```

Drone's mass is involved in calculation:

```
float c = collThrustCmd / mass;
```

3. Implement altitude controller in C++.

Altitude controller is in QuadController (lines 189-197). The controller uses both the down position and the down velocity to command thrust:

```
float hVelcmd = kpPosZ * (posZCmd - posZ) + velZCmd;
```

The drone's mass is accounted for calculating the thrust:

```
thrust = -mass * (hAccmd - 9.81f) / r33;
```

The thrust includes the non-linear effects from non-zero roll/pitch angles:

```
float r33 = R(2, 2);
```

The controller contains an integrator to handle the weight non-idealities presented in scenario 4:

```
integratedAltitudeError += (posZCmd - posZ)*dt;
float hAccmd = kpVelZ * (hVelcmd - velZ) + KiPosZ*integratedAltitudeError + accelZCmd;
```

4. Implement lateral position control in C++.

Lateral position controller is in QuadController (lines 238-252). The controller uses the local position and velocity to generate a commanded local acceleration:

```
V3F xyVelcmd = kpPosXY * (posCmd - pos) + velCmd;

V3F xyAccmd = kpVelXY * (xyVelcmd - vel) + accelCmd;
```

5. Implement yaw control in C++.

Yaw controller is in QuadController (lines 275-278). The controller is a proportional heading controller to yaw rate commands:

```
yawRateCmd = kpYaw * (yawCmdNormed - yawNormed);
```

6. Implement calculating the motor commands given commanded thrust and moments in C++.

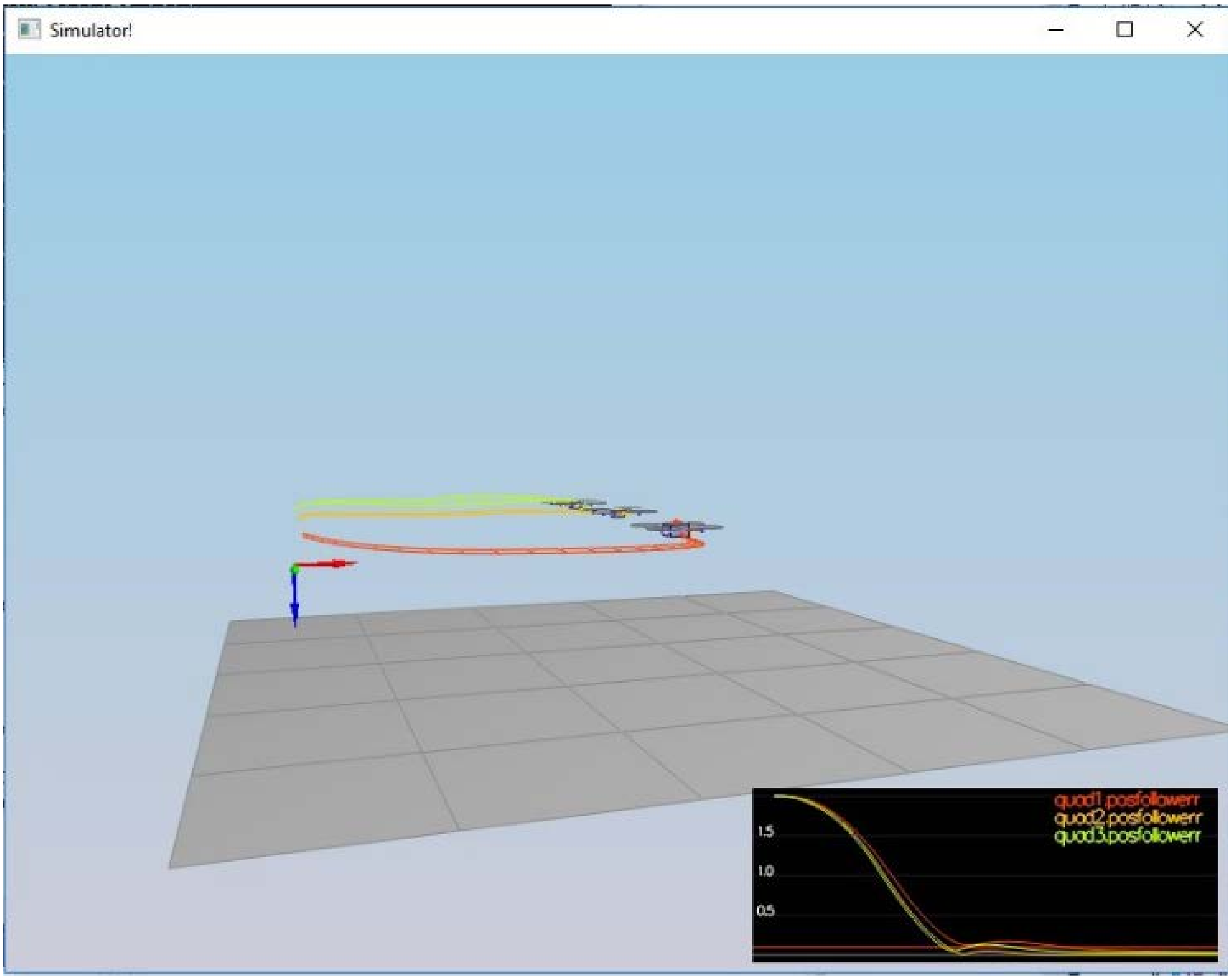
Motor commands calculation is in QuadController (lines 73-83). The thrust and moments is converted to the appropriate 4 different desired thrust forces for the moments:

```
cmd.desiredThrustsN[0] = (l*F*k - l * Mz + k * Mx + k * My) / (4 * k*l);
cmd.desiredThrustsN[1] = (l*F*k + l * Mz - k * Mx + k * My) / (4 * k*l);
cmd.desiredThrustsN[2] = (l*F*k + l * Mz + k * Mx - k * My) / (4 * k*l);
cmd.desiredThrustsN[3] = (l*F*k - l * Mz - k * Mx - k * My) / (4 * k*l);
```

Flight Evaluation

The controller is successfully able to fly the provided test trajectory and visually passes inspection of the scenarios leading up to the test trajectory.

An example. Controller in 4th scenario:


Simulator!
quad1.posfollowerr
quad2.posfollowerr
quad3.posfollowerr
1.5
1.0
0.5