Design of a Quadcopter for Winning the Jerry Sanders Creative Design Competition

System Engineering & Operations Research, George Mason University

Jordan **Bramble**, Ibtsam **Khan**, Harold **Merida**

Background:

Competition Objective: Compete with other robots by placing colored cones onto pins to control territories.

The Jerry Sanders Creative Design Competition, sponsored by Advanced Micro Devices, and named after their former CEO, is a yearly competition in robotics held at the University of Illinois Urbana-Champaign. The 2014 competition was held March 14th – 15th. Multidisciplinary teams of engineering students nationwide, participate in a game like competition for two days with robots they've designed and constructed. Each year the competition challenges change and require teams to develop innovative mechanisms for successfully scoring points. Each year the competition challenges change and require teams to develop innovative mechanisms for successfully scoring points.

The competition takes place in a 2000 square foot arena (44.7 x 44.7 ft). For airborne robots, a sloping net is hung above the course that is always approximately 6 feet above the arena floor. The goal of the competition is fostering innovation and creativity within robotics and promoting the engineering disciplines. In this last year's competition, 26 teams from six different universities participated in the competition, attempting to pick up cones and place them on pins in order to score points.

CONTACT

Jordan **Bramble**
Email: jbramble@masonlive.gmu.edu
Ibtsam **Khan**
Email: ikhan5@masonlive.gmu.edu
Harold **Merida**
Email: hmerida@masonlive.gmu.edu

Description of Competition

Competition Rules

- Each match will
  - be seven (7) minutes long
  - consist of four or fewer robots
- The team's color cone is the topmost in the stack of cones for control of a territory
- Teams cannot attempt to control a territory unless it would be contiguous

Scoring

- Airborne robots have a constant 3x multiplier when scoring cones
  - 5x multiplier for autonomous
- For each contiguous powered territory controlled at the end of match:
  - First level– 10 points
  - Second level – 30 points
  - Third level – 40 points
- Every ten (10) seconds that a team controls:
  - First level territory – 1 point
  - Second level territory – 3 points
  - Third level territory – 5 points

Mission Requirements

1. The Quadcopter shall have greater than 50 percent likelihood of winning the competition and at least a 70 percent likelihood of advancing to final round.
2. The Quadcopter shall have be able to pick up and carry cones, with a mean time of 30 seconds, in order to place them on territories throughout the course.
3. The Quadcopter shall maintain 7 minutes of flight time

Design Requirements

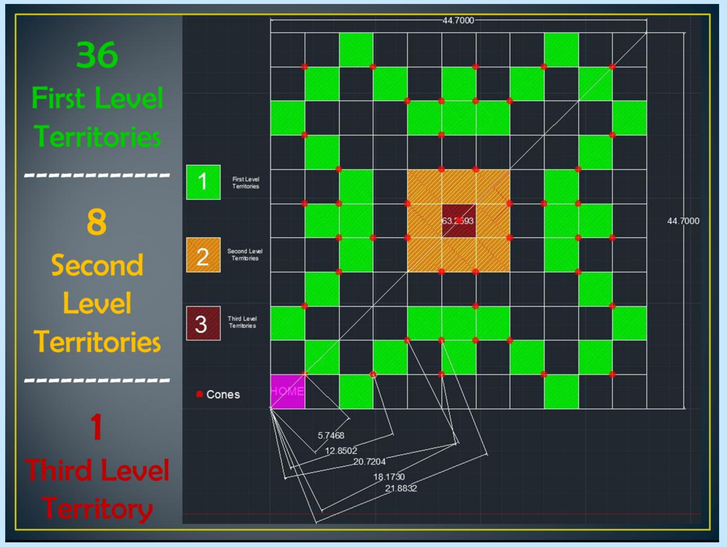
1. The Quadcopter shall fit within a 3'x3'x3' cube.
2. The Quadcopter shall weigh no more than 15lbs.
3. The Quadcopter shall be equipped with a FPV camera.
4. The Quadcopter shall have a mechanism for picking up Adams Saucer cones.
5. The Quadcopter's propellers shall be guarded such that they cannot damage the netting above the course.

Design of Experiment

Experiment 1- Horizontal Velocity
- Three distances
  - 20.5 feet, 30.7 feet , 47.7 feet
- 36 Trials per distance, 108 trials total

Experiment 2- Vertical Velocity
- Three vertical distances
  - 2.5 feet, 4.5 feet , 5.5 feet
- 20 Trials per vertical distance, 60 trials total
- 4.5 Feet data used in simulation

Course Layout



Quadcopter Alternatives Weighted Value Matrix

		DC Drones		A.R. Parrot	
	Category Weight	Score	Weighted	Score	Weighted
Technology	3	4	12	2	6
Quadcopter Weight	4	3	12	4	16
Flight time with Max Payload	5	5	25	0	0
Carrying Capacity	5	5	25	1	5
Cost	3	3	9	4	12
Camera	3	4	12	3	9
Total Score:			95		48

Category Weight:

5	Very High Importance
4	High Importance
3	Medium Importance
2	Low Importance
1	Very Low Importance
0	Not Importance

Score Scale:

5	Excellent
4	Good
3	Average
2	Poor
1	Very Poor
0	Does not meet the requirement

Equations of Quadcopter Dynamics

$$rpm_{ideal} = \left(\frac{2}{\pi}\right)^{1/2\omega} \left(\frac{g^{3/2}m^{3/2}}{\alpha D\sqrt{\rho}}\right)^{1/\omega}$$

RPMs generated under a given thrust ω , and α are power coefficients given by the propeller manufacturer ω= 3.2, α = .015 for APC 11x4.5 propellers

$$P = IV = \alpha \times rpm^{\omega}$$

$$Time(mins) = \frac{BatteryCapacity}{I} \times 60$$

Motor/Battery Performance Matrix

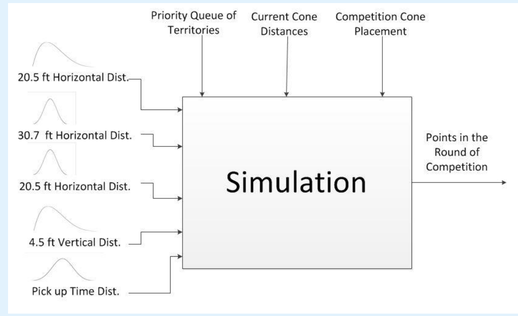
Motor (Kv)	Battery (mAh)	Mean amps (4x)	Flight Time (min)
850	5000	6.97	11.95
1100	5000	15.91	5.24
1220	5000	22.16	3.76
850	10000	6.97	23.9
1100	10000	15.91	10.48
1220	10000	22.16	7.52

Method of Analysis/Simulation Design

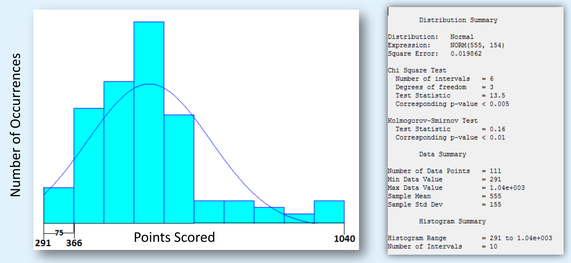
Model Assumptions

- Teams will attempt to enter the third territory as soon as possible
- The teams' paths will not come into contact until level two
- No team will sabotage another team
- Cone transportation takes about 30 seconds, and is normally distributed.

Simulation Diagram



Simulation Results



Average Points Scored per Round: **555 points**
Standard Deviation: **154**

2014 Competition Results

- Highest Single Round Score was 932 points for first place, 430 points for second place.
- Winning team averaged 866 points per round
- 80% chance of runner up, only 2% chance of victory

Recommendations

- To win the competition quadcopter needs to be designed with:
  - Mechanism that picks up cones quicker
  - Implementation of autonomy
- Reduce mean time to pick up and place cones from 30 seconds to 6 seconds.