Distributed Logistics in an Urban Setting Using Small Unmanned Aerial Vehicles

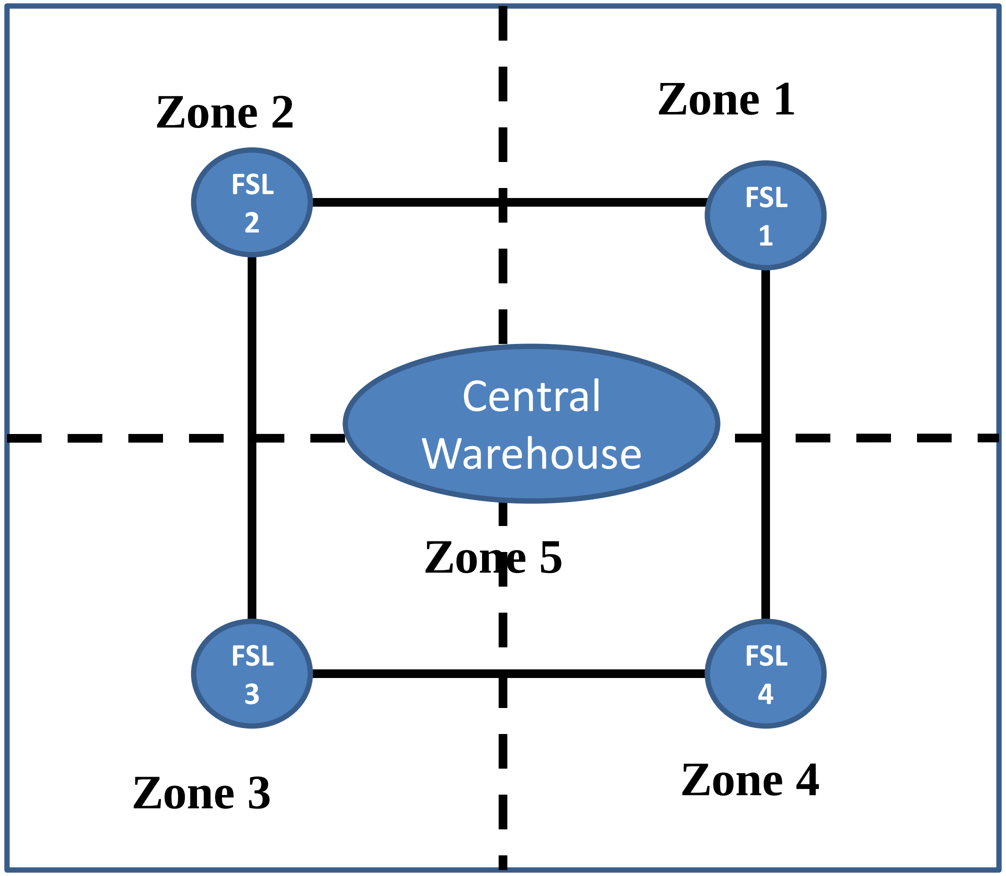
32nd Annual AHS International Student Design Competition (SDC)

Indian Institute of Science

Team Lakshya-IISc

Proposed solution:

- Urban area divided into 5 working zones
- Based on one Central Warehouse and four additional FSLs
- Two different RUAV configurations proposed for package delivery
- Advanced R-MAX helicopter for heavier packages and customized quadrotor for delivering lighter packages.
- Inventory-less maintenance and servicing inspired by additive manufacturing technology



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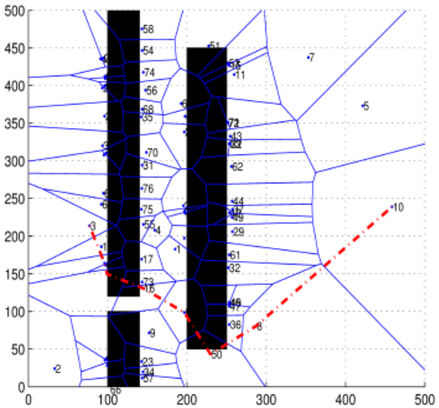

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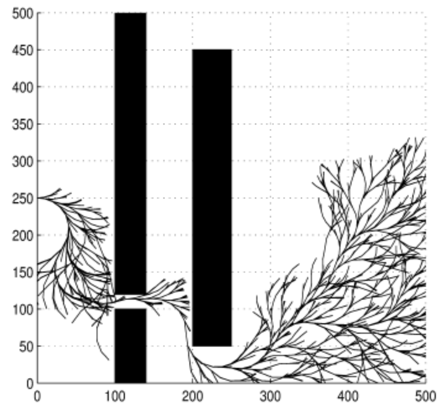

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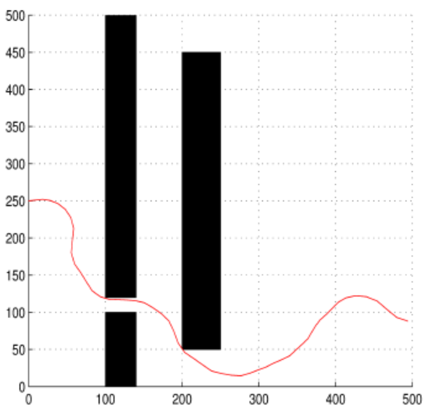

(c)

Modified RRT vertices distribution after 2000 iterations

Vehicle routing problem:

- Posed as generic multiple travelling salesman problem
- A genetic algorithm based approximate solution is used to plan the vehicle routing
- Motion planning and obstacle avoidance methodology, based on Rapidly Exploring Random Tree, is derived
- Zone sequence obtained using modified RRT

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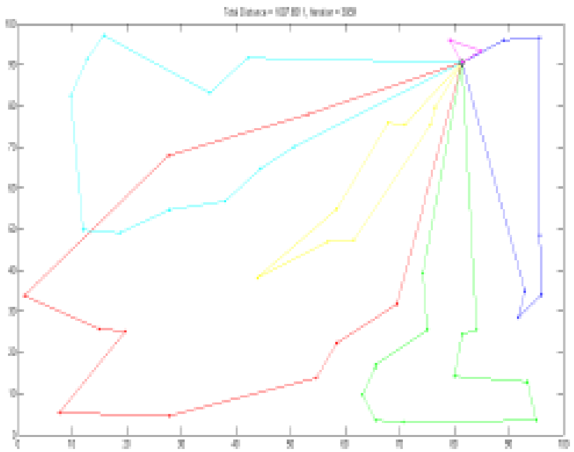
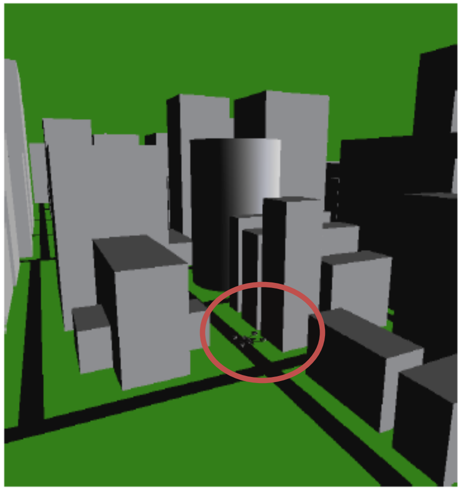
Obstacle avoidance and path planning simulation:

- Quadrotor Simulations based on OpenGl platform in a typical urban setting





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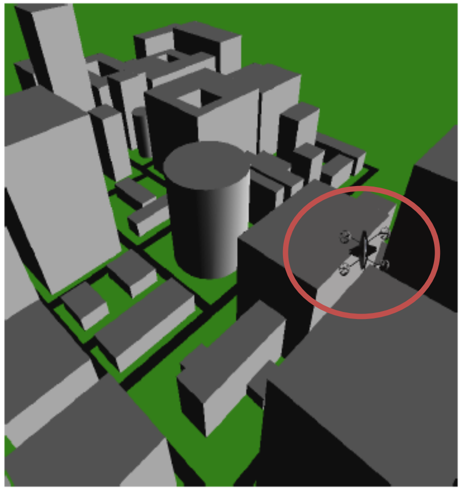

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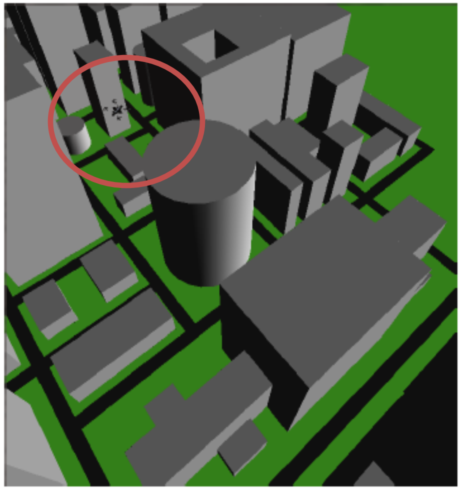

(c)

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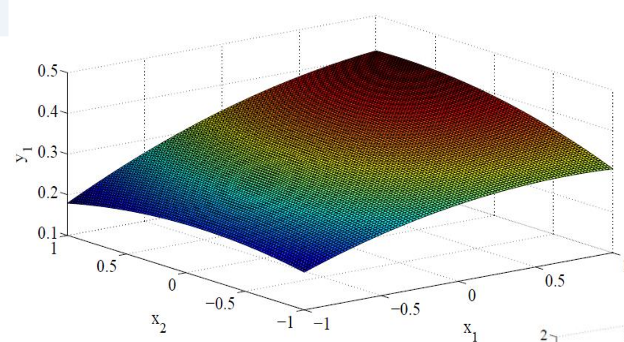
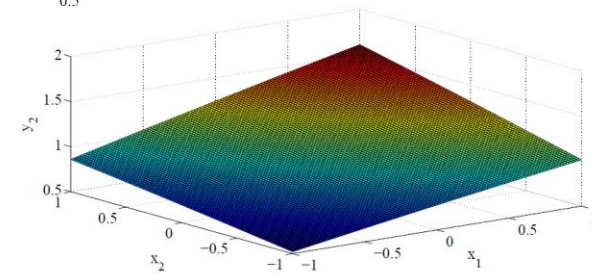
Optimal Design

- Over 10000 design points are explored from the design space
- Nonlinear analytical expressions are obtained which modeled the VAM analysis within less than 2% error.
- Multi-objective evolutionary optimization algorithm based on evolution of bats is employed.





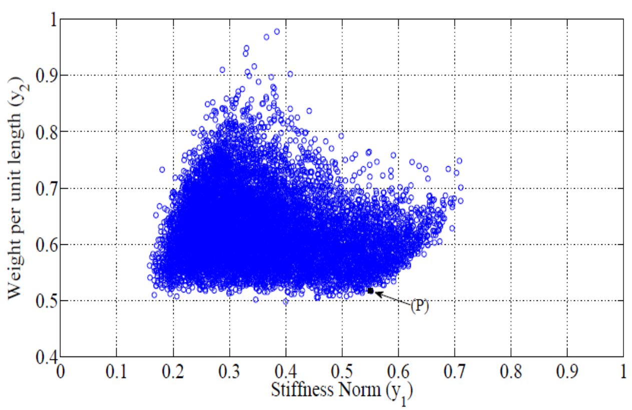


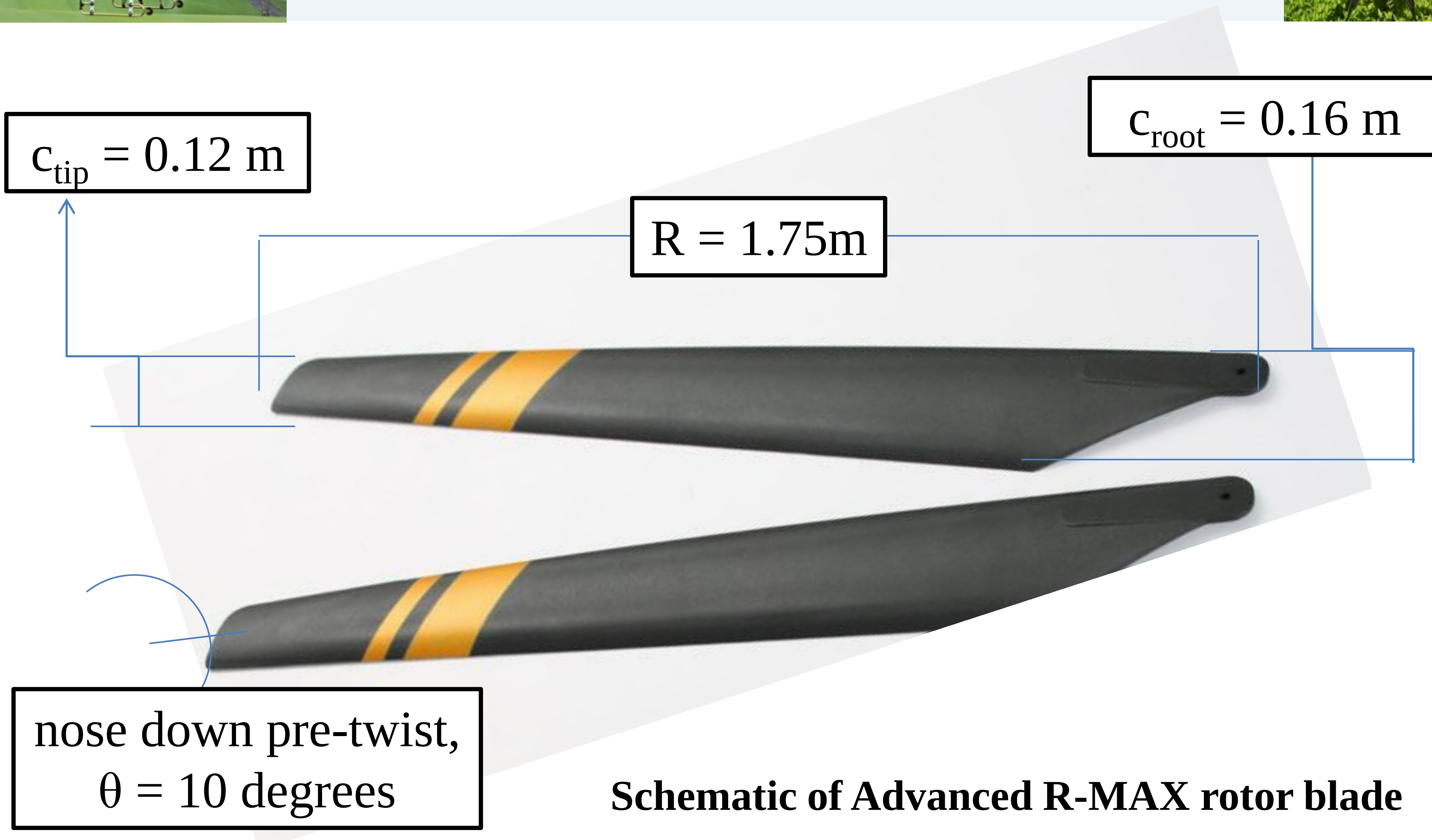
Table 4.10: Comparison between predicted response and VAM analysis for y_1 using MGB4P-OA

S.No.	x_1 Coded value	x_2 Coded value	x_3 Coded value	x_4 Coded value	y_1 RSM prediction	y_1 Analysis prediction	% Error
1	-1	-1	-1	-1	0.1917	0.1928	0.6
2	0	0	0	0	1.0000	1.0147	1.5
3	1	1	1	1	2.1285	2.1296	0.03
4	0	0	1	1	1.3900	1.3843	-0.4
5	1	1	-1	-1	0.4053	0.4134	2.0
6	-1	-1	0	0	0.5297	0.5239	-1.1
7	-1	1	0	1	0.8649	0.8640	-0.1
8	0	-1	1	-1	1.0363	1.0378	0.1
9	1	0	-1	0	0.3870	0.3784	-2.2
10	1	0	0	-1	1.2612	1.2585	-0.2
11	-1	1	1	0	1.1867	1.1895	0.2
12	0	-1	-1	1	0.2840	0.2846	0.2
13	1	-1	1	0	1.3495	1.3487	-0.1
14	-1	0	-1	1	0.2143	0.2158	0.7
15	0	1	0	-1	1.2018	1.1933	-0.7
16	0	1	-1	0	0.3250	0.3223	-0.8
17	1	-1	0	1	1.0021	1.0050	0.3
18	-1	0	1	-1	0.9501	0.9508	0.1

Advanced main rotor blade design:

- Advanced R-MAX main rotor design obtained using Taguchi method
- Design variables: main rotor blade length, plan-form, pre-twist and rotor speed
- Taguchi orthogonal arrays used to ensure robust design against variations in design parameters
- Robust design demonstrates 10% improved hover efficiency
- Efficient design methodology for initial sizing of main rotor

Advanced R-MAX Helicopter	Particulars
Main rotor diameter	3.5 m
Root chord length	0.16 m
Tip chord length	0.12 m
Rotor speed	760 rpm
Blade pre-twist	10 degrees
Max speed	41 kmph
Endurance	60 minutes
Cruise speed	22 kmph
Empty weight	64 kg
Payload	30 kg

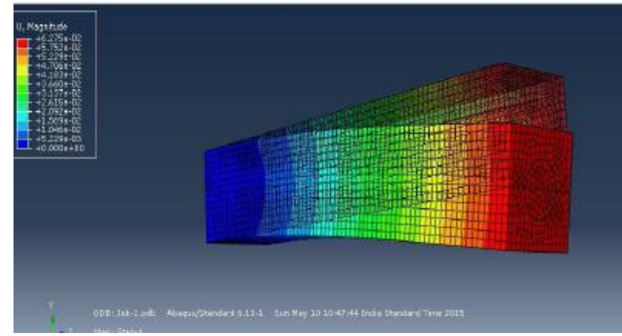


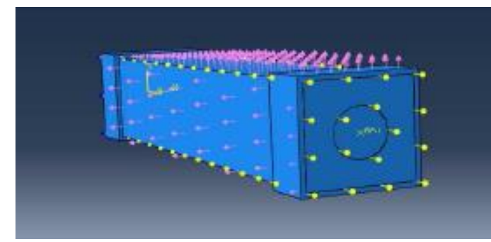
Schematic of Advanced R-MAX rotor blade

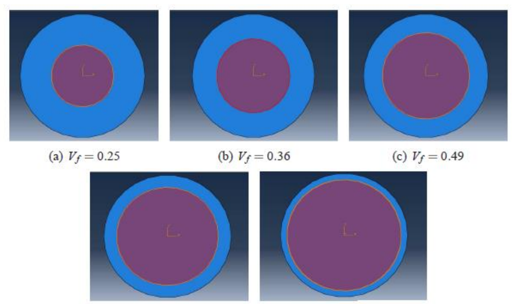
Energy Harvesting:

- Micromechanics based energy harvesting solution using piezo fiber composite

- Multifunctional material used in the design for smart composite structure.

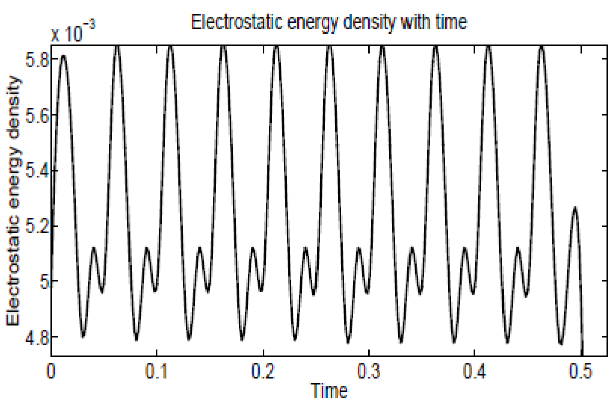






(a) $V_f = 0.25$ (b) $V_f = 0.36$ (c) $V_f = 0.49$

(d) $V_f = 0.64$ (e) $V_f = 0.81$



Homogenization based structural analysis for the proposed smart composite structure