

Overview of UAV REIS

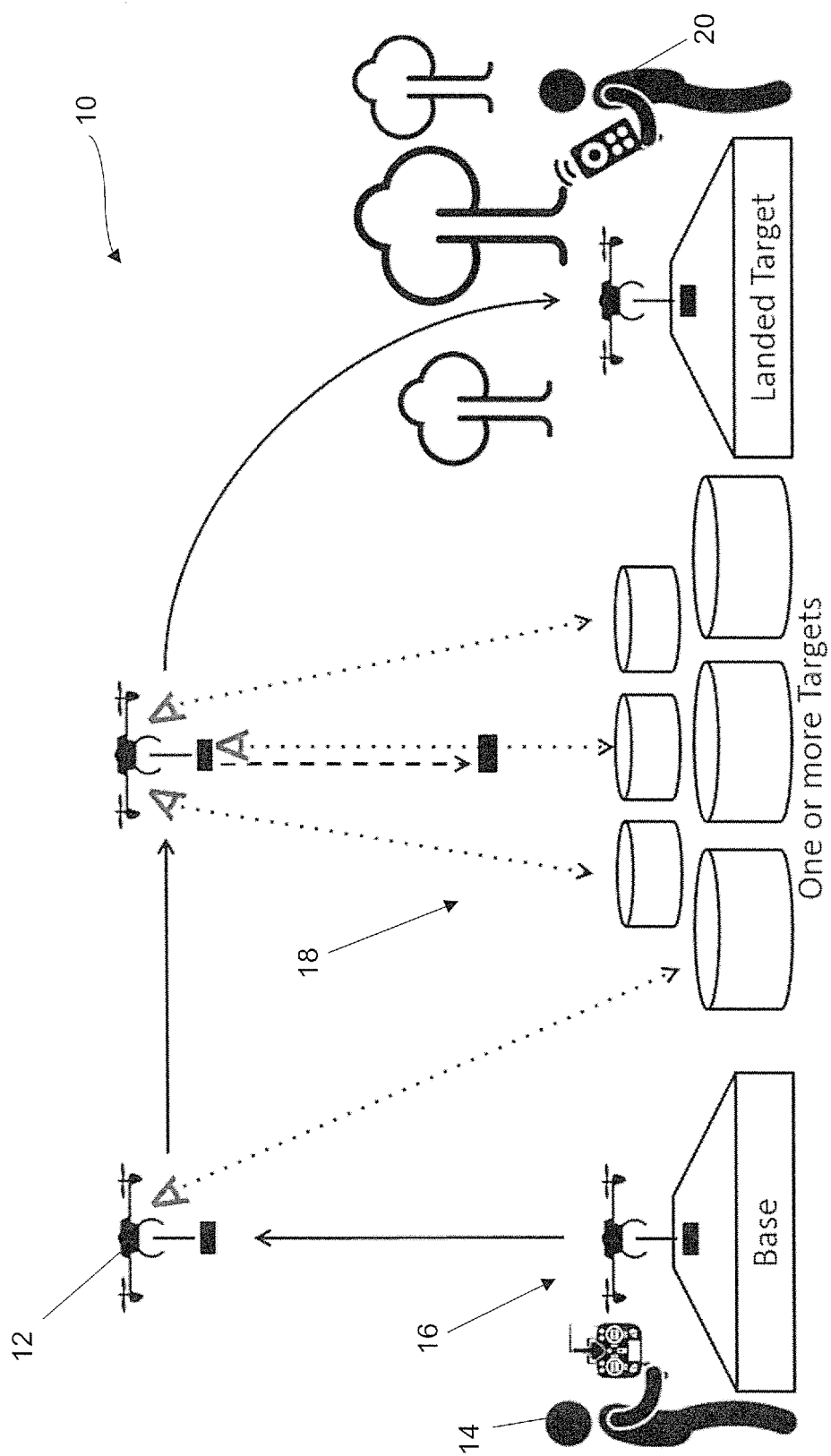


Fig. 1

Flowchart: Generate Flight Path

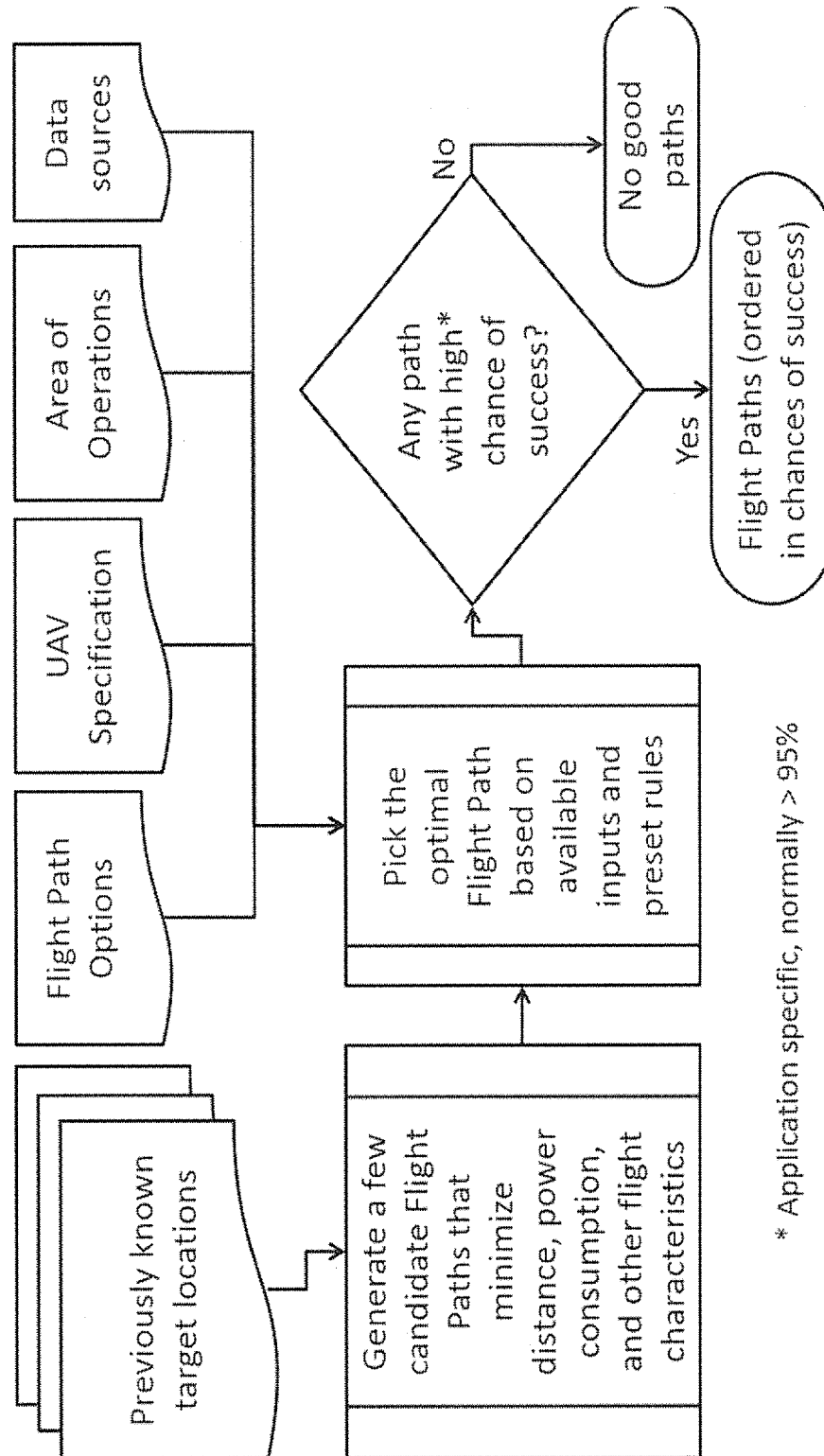


Fig. 2

Flowchart: Machine Learning (1/2)

- Initialization

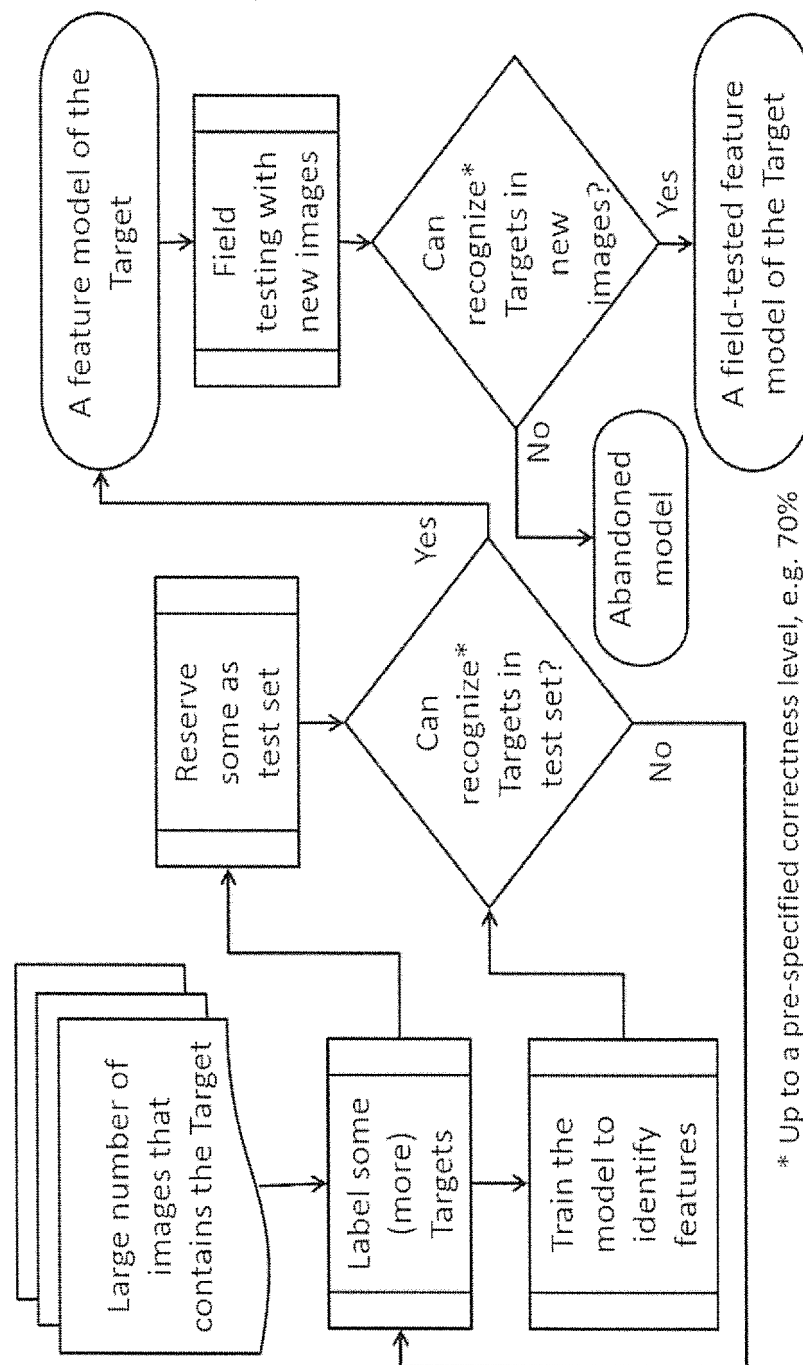
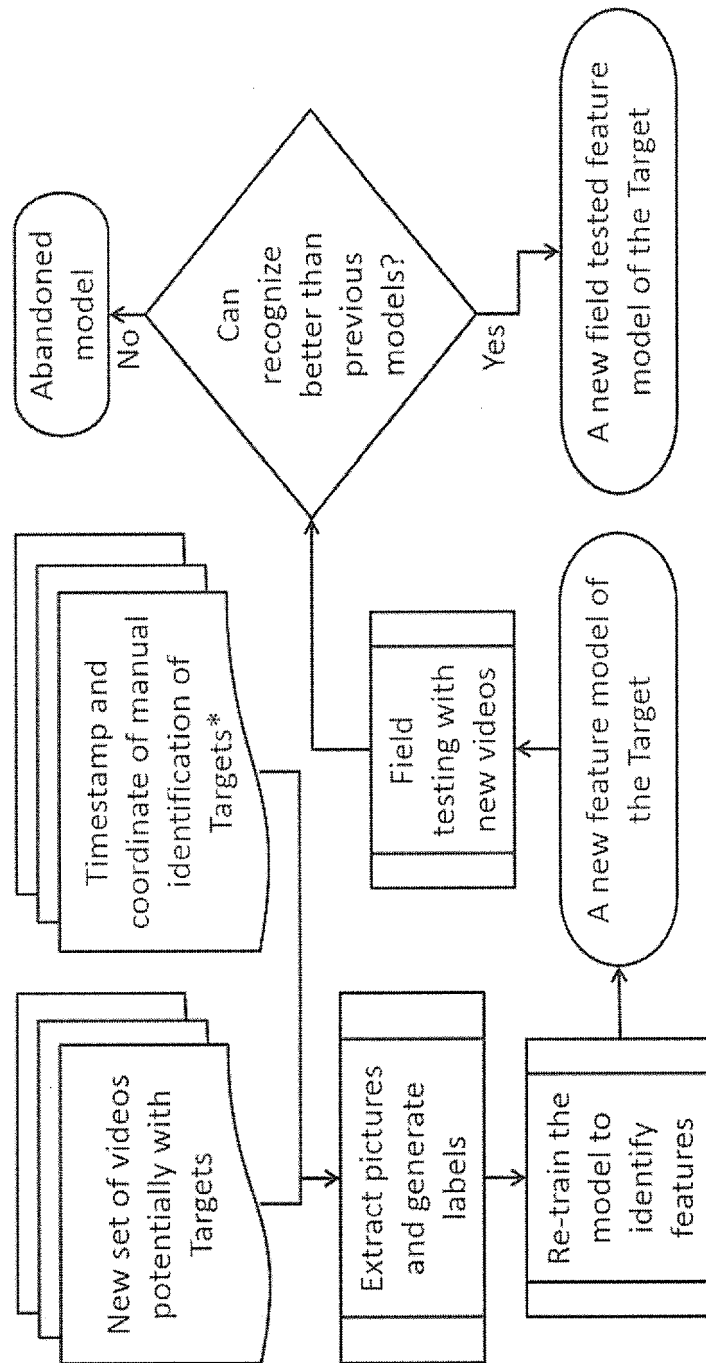


Fig. 3a

Flowchart: Machine Learning (2/2)
- Collaborative Incremental Model Improvement



* Recorded during Manual Operations when UAV Pilot specifies the Target

Fig. 3b

Flowchart: Detect Target

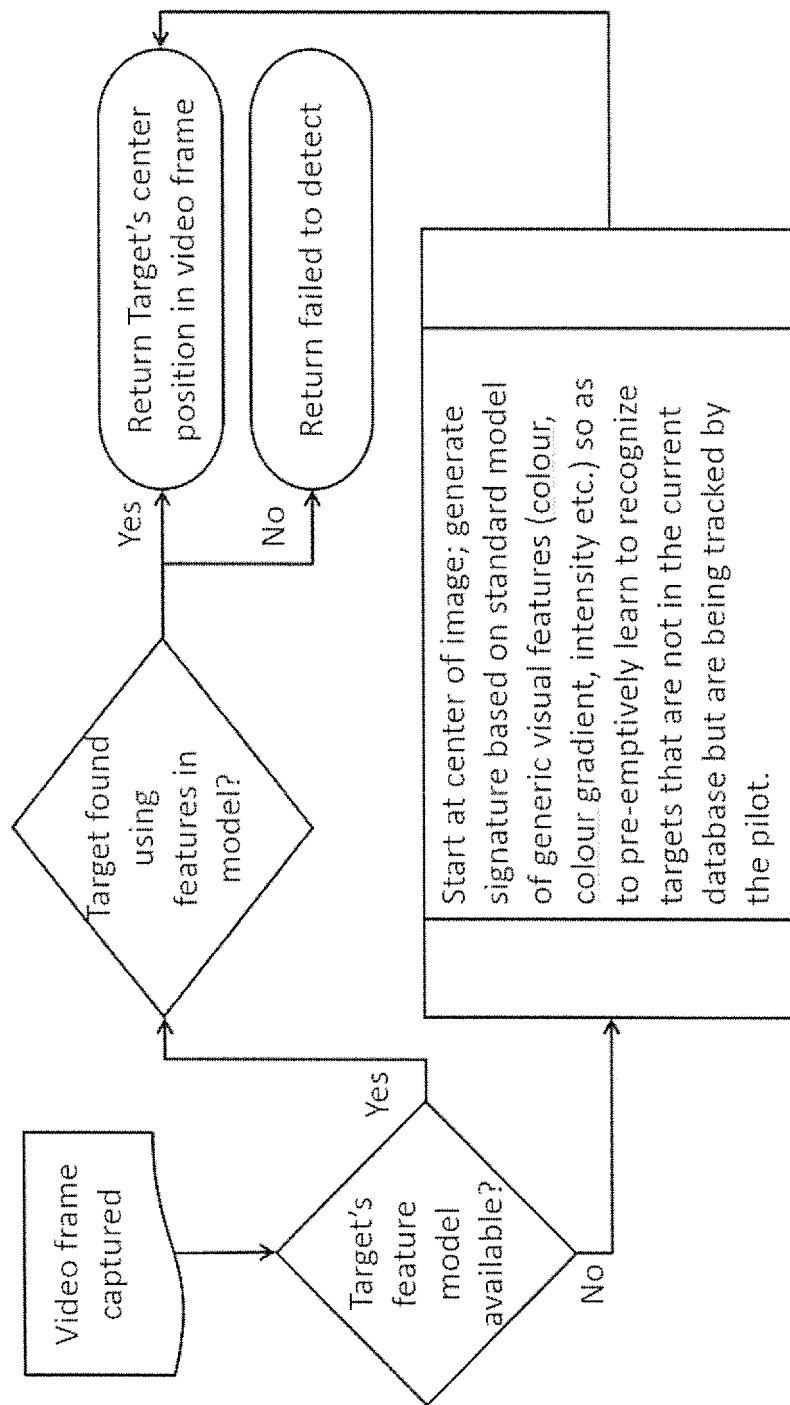


Fig. 4

Flowchart: Camera "Track" mode

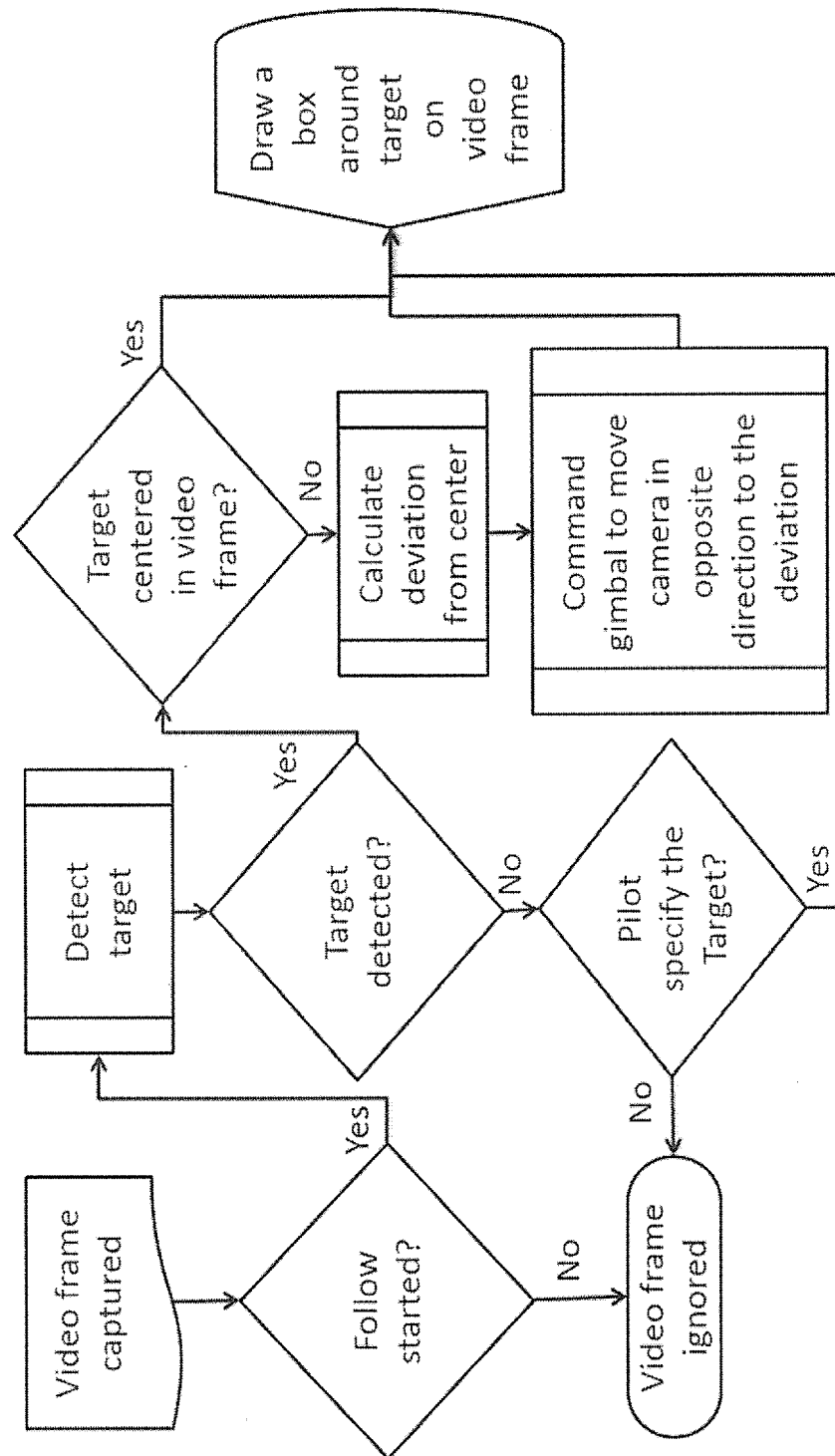


Fig. 5

General Plantation Terms

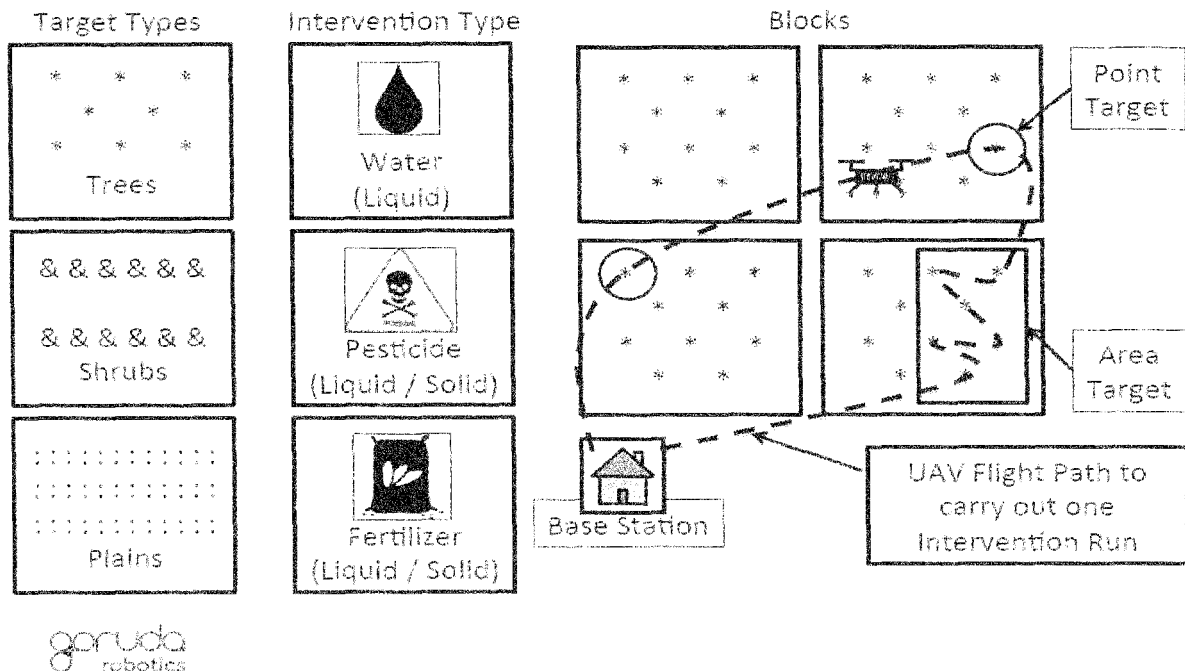


Fig. 6

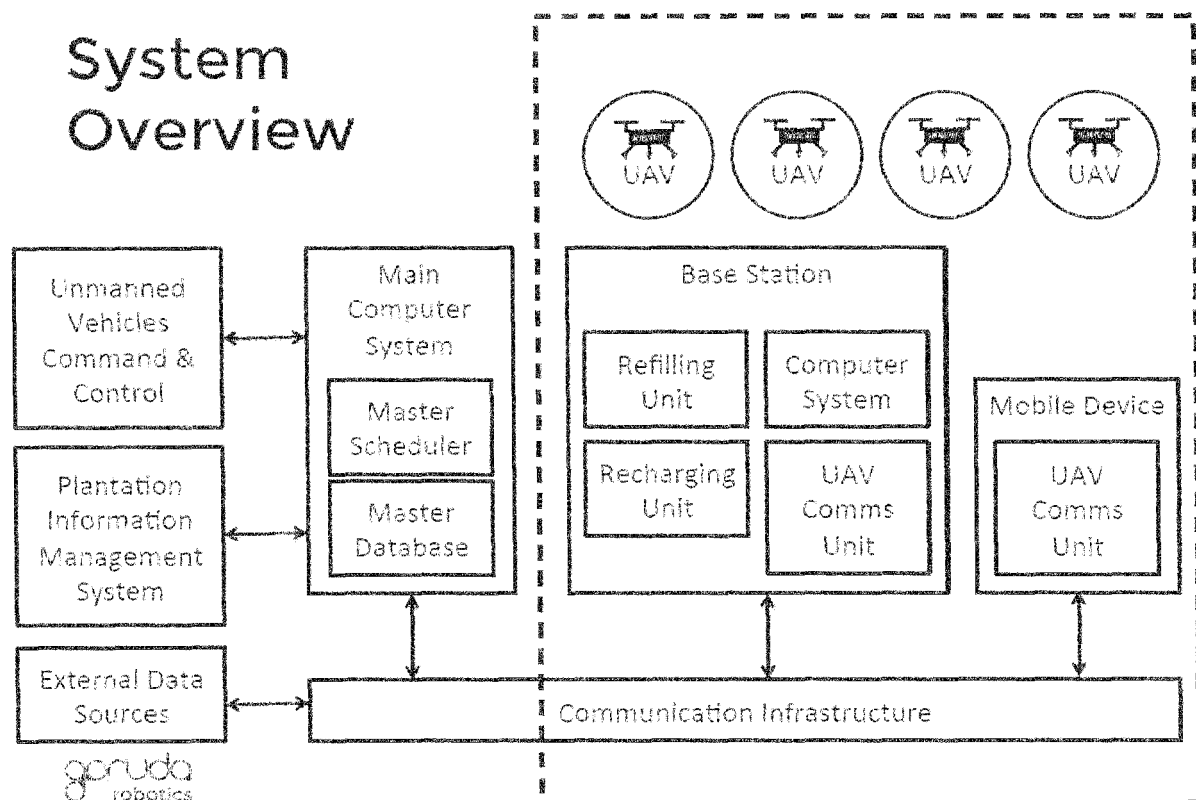


Fig. 7

Master / Local Scheduler architecture

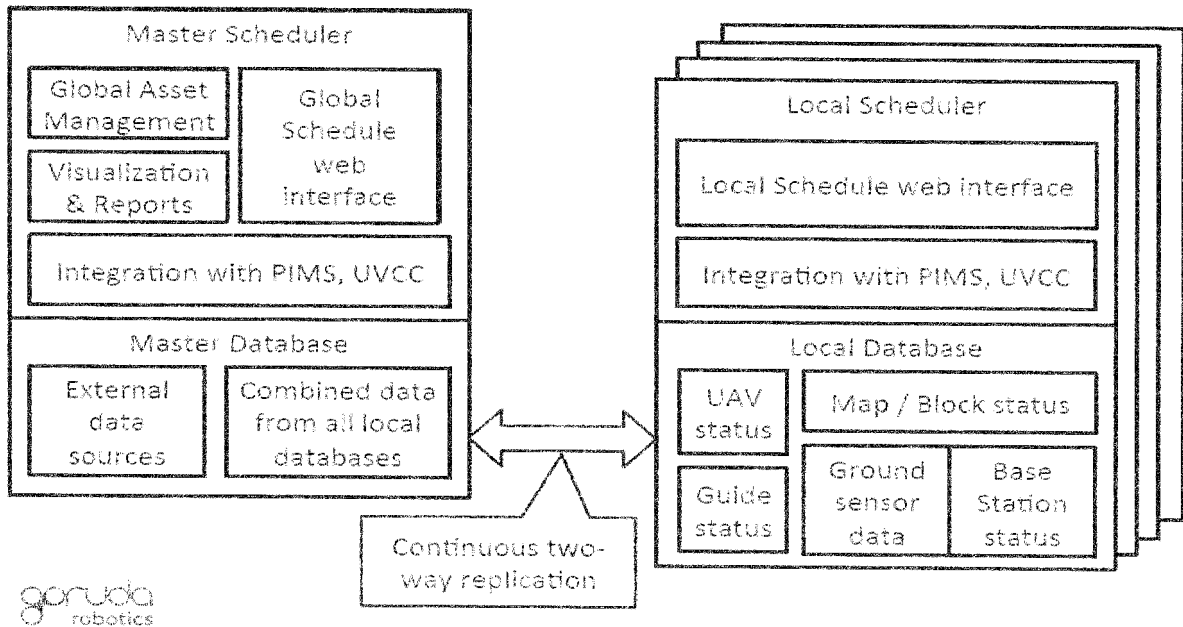


Fig. 8

Structure of UAV

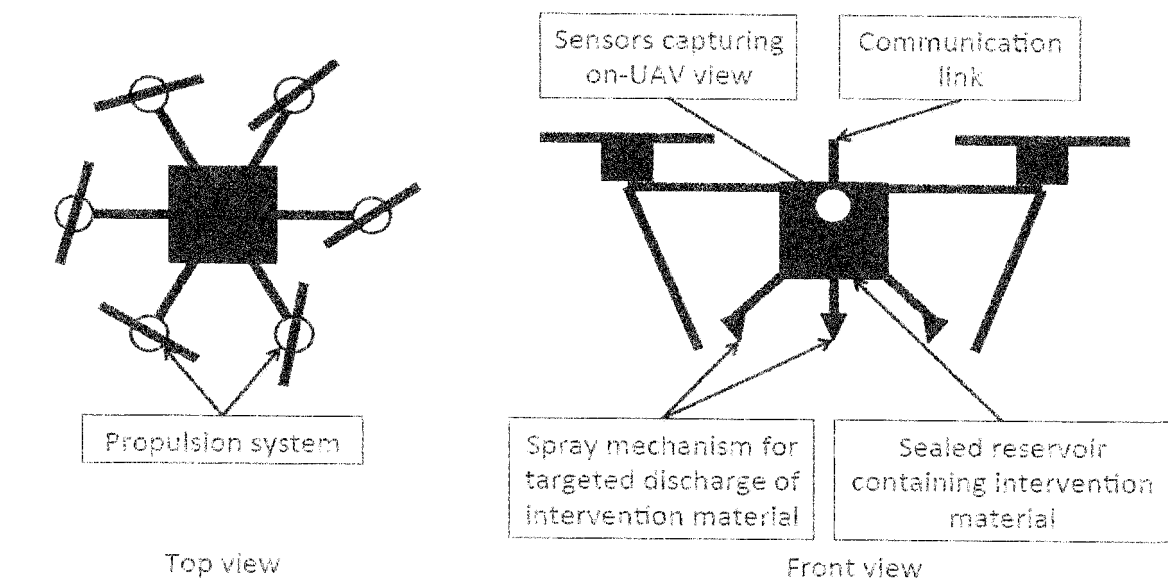


Fig. 9a

9/21

Structure of Spray/Dispersal System

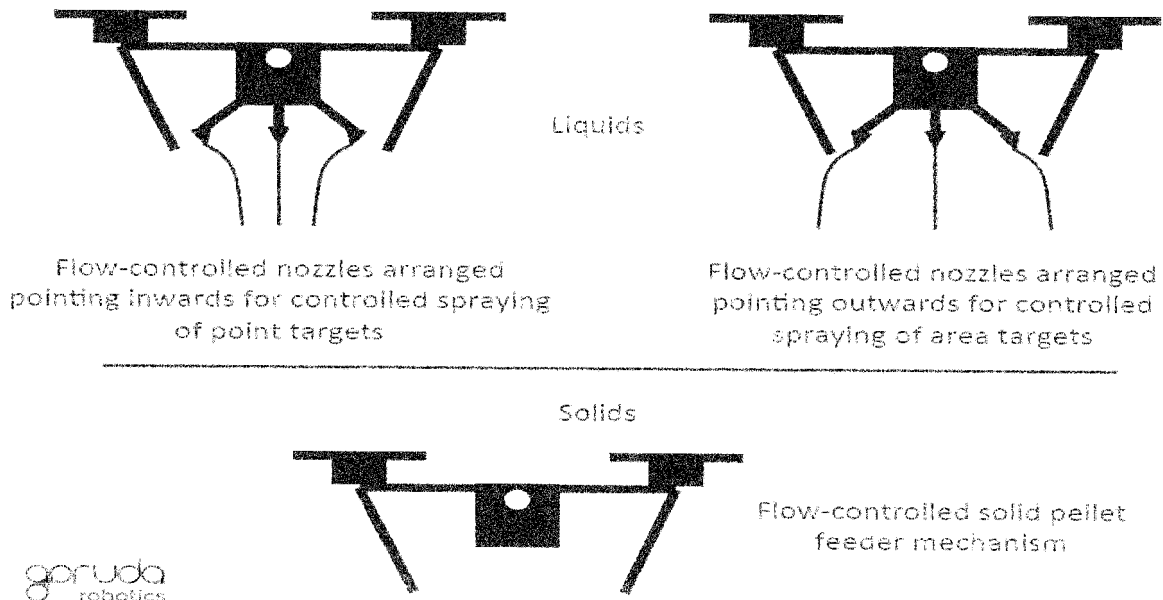


Fig. 9b

Structure of Reservoir

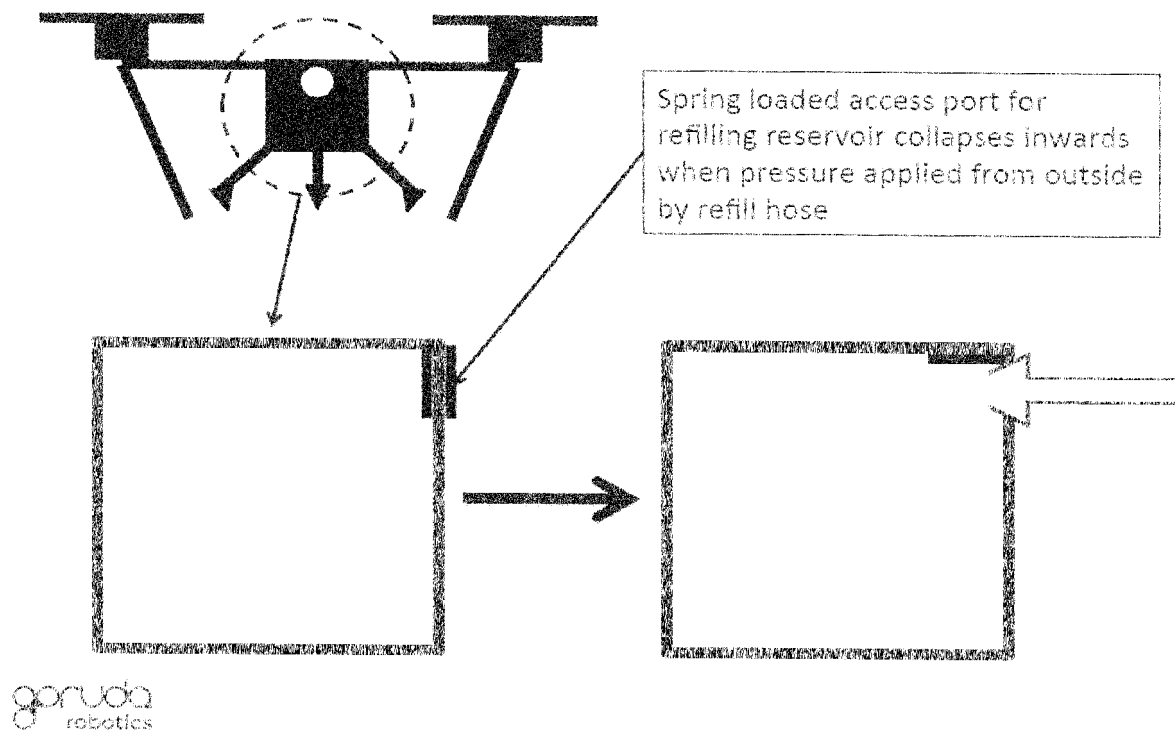


Fig. 9c

10/21

UAV Localization with Camera

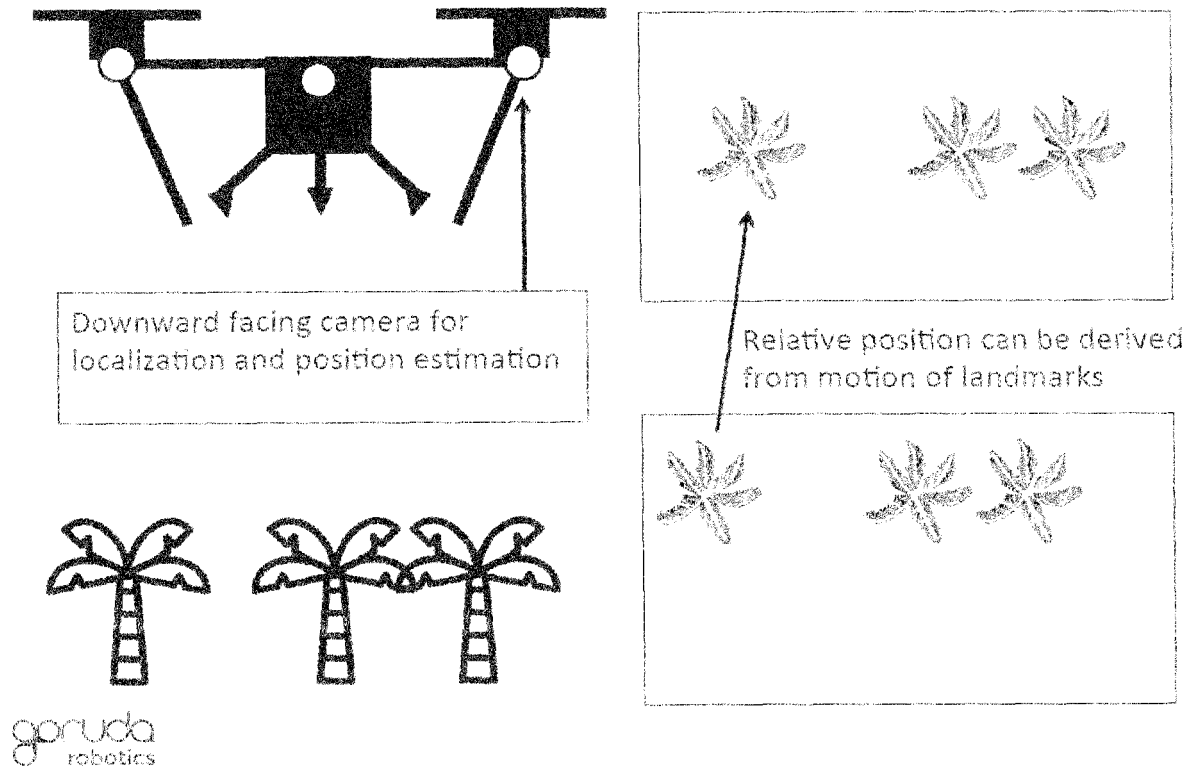
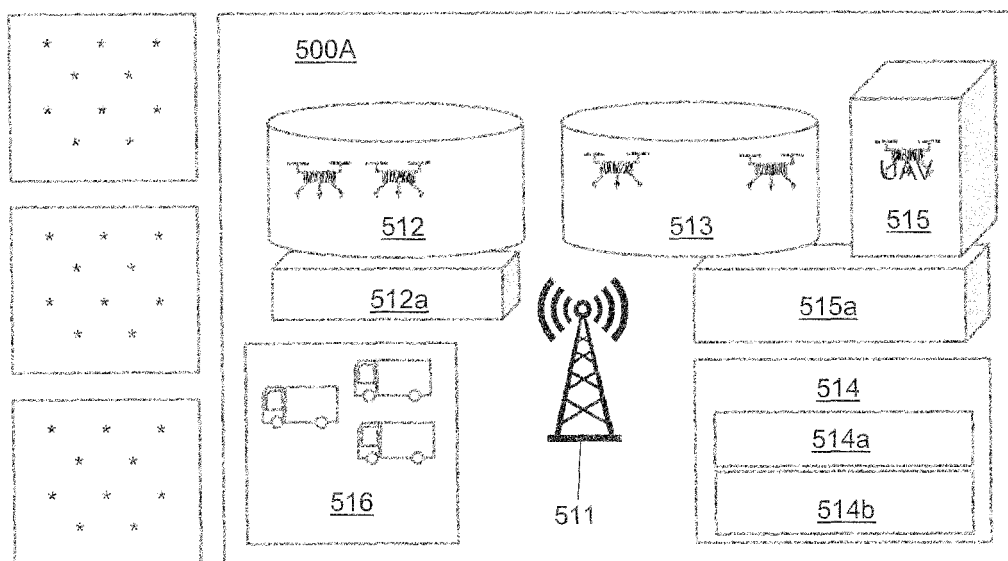


Fig. 10

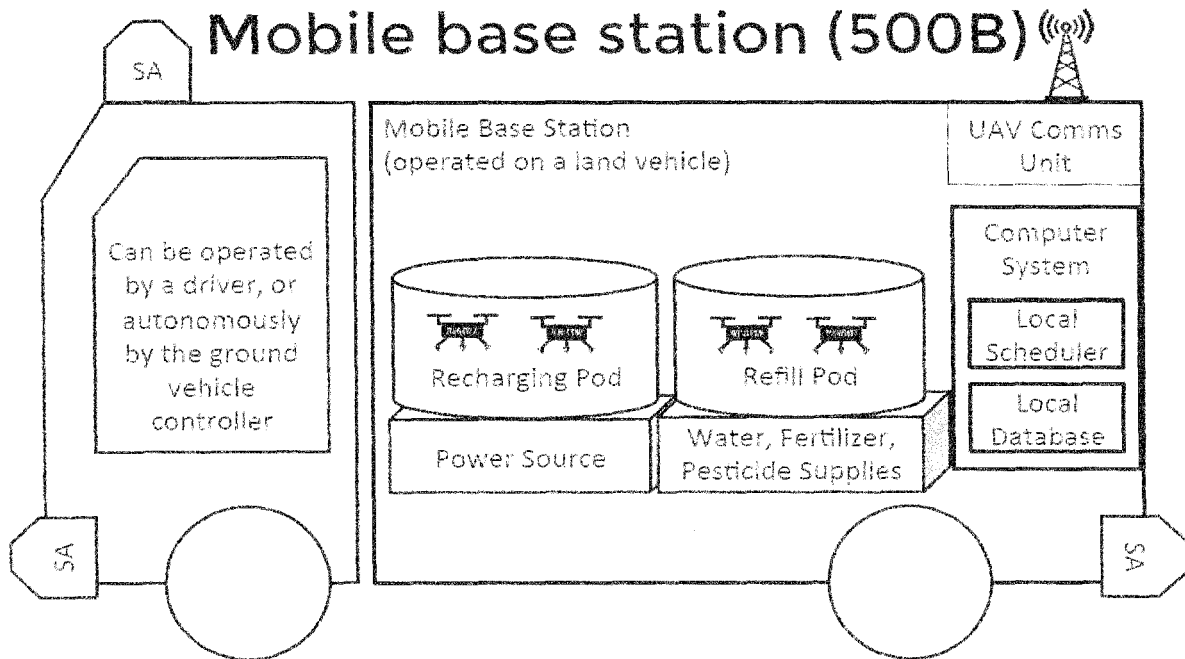
Static base station (500A)



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Fig. 11

11/21



SA: Object detection sensors, used with a Sense and Avoid system when driven autonomously

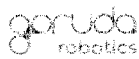
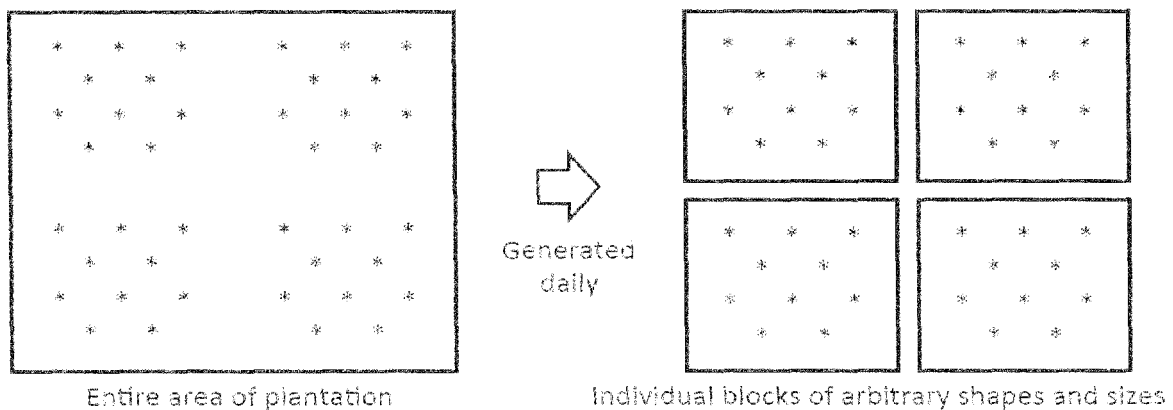


Fig. 12

Dynamic block partitioning



Goal of partitioning algorithm: minimum number of blocks, considering

1. UAV endurance and communications limitations
2. Mobile base station's capacity limitations given required no. of Intervention run
3. Geographical limitations – arterial roads and mobile base station deployment sites

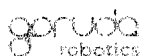


Fig. 13

12/21

Computer System Architecture

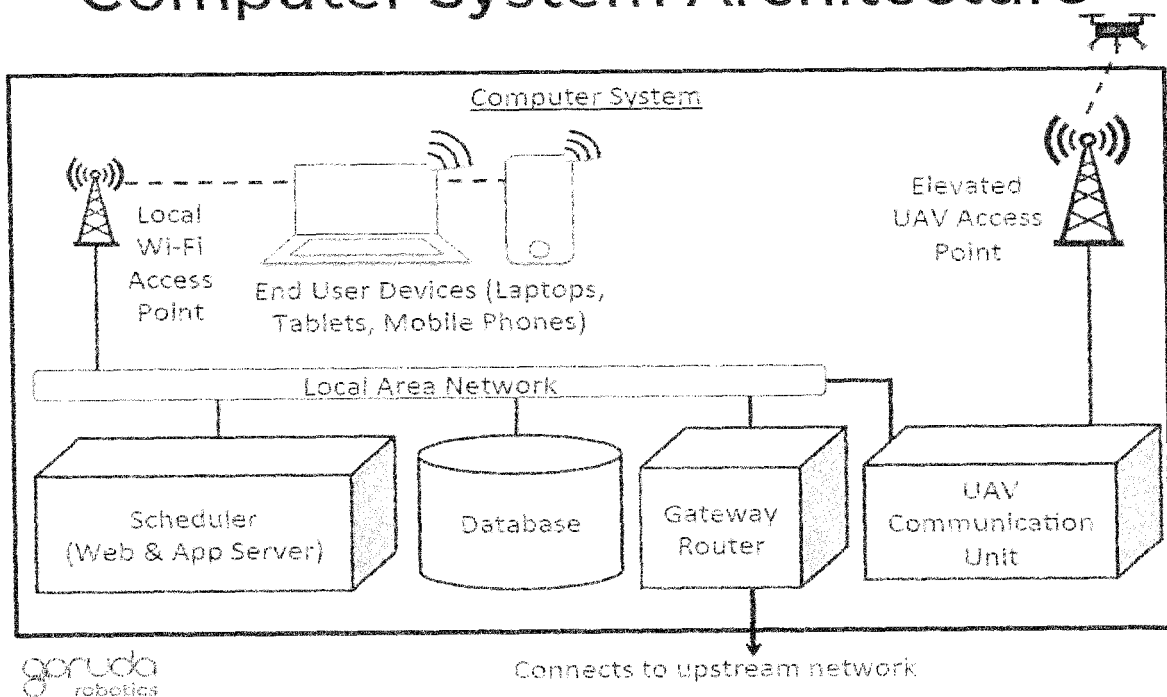


Fig. 14

Computer Network Architecture

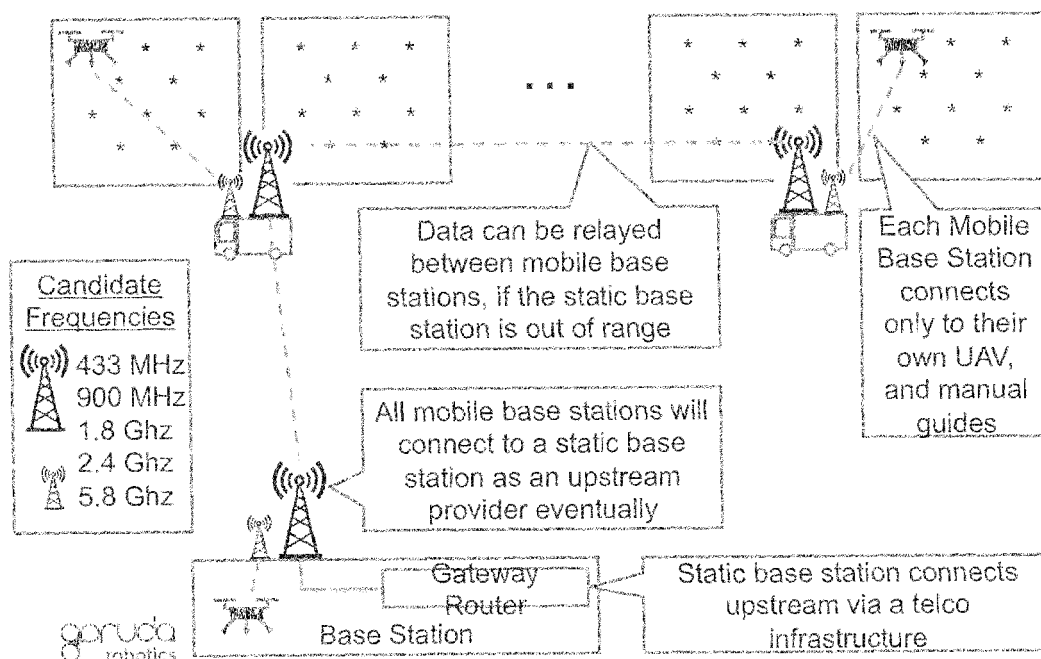
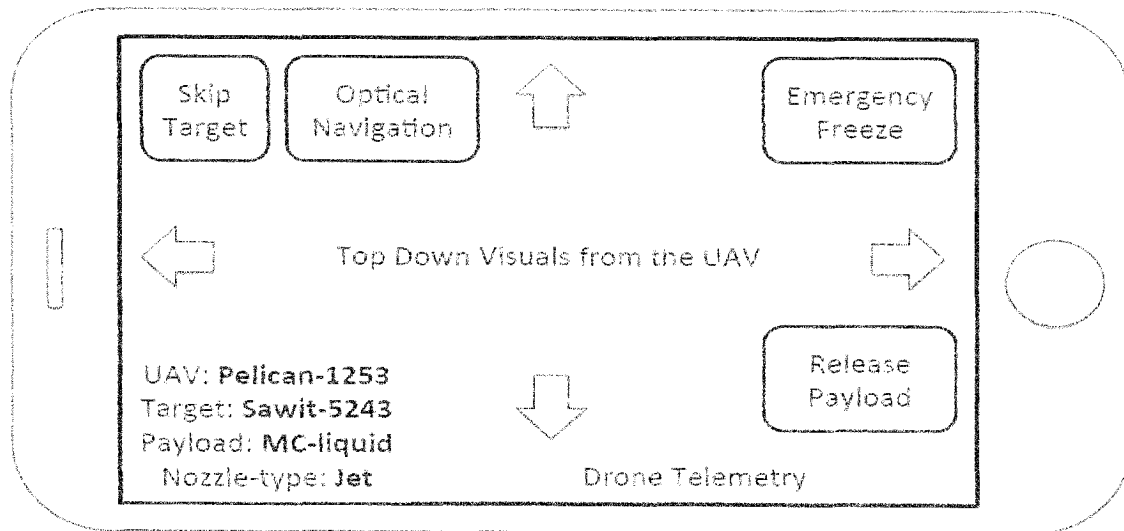


Fig. 15

13/21

Manual Guidance Interface (mobile application)



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Fig. 16

Sample request form filled in by the arborist in PIMS

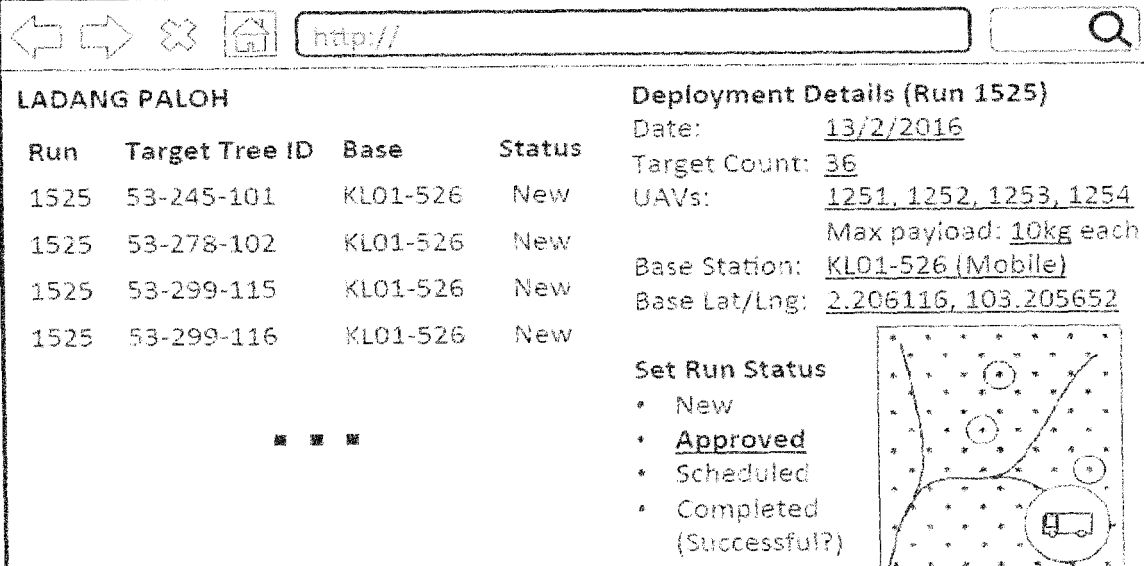
The screenshot shows a web-based form titled "LADANG PALOH". On the left, there is a map with a grid of asterisks and three circles highlighting specific trees. On the right, there is a section titled "Target (to be completed by Arborist)" with the following fields: "Request Date: 13/2/2016", "Tree ID: 53-245-101", "Intervention Type: Dribble onto tree crown", "Product 1: Imidacloprid 0.15 L", "Product 2: Cythrin 0.15 L", and "Total Volume: 1.2 litres (including water)". Below this, there is a "Notes to local guides" section with the text: "If the mixture comes seeping out of the bottom of the tree (not dribbling down the outside) then you can be sure it has enough." At the bottom, there are two buttons: "Add Target" and "Set Repeated Schedule".

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Fig. 17

14/21

Scheduler Interface



LADANG PALOH

Run	Target Tree ID	Base	Status
1525	53-245-101	KL01-526	New
1525	53-278-102	KL01-526	New
1525	53-299-115	KL01-526	New
1525	53-299-116	KL01-526	New

Deployment Details (Run 1525)

Date: 13/2/2016
 Target Count: 36
 UAVs: 1251, 1252, 1253, 1254
 Max payload: 10kg each
 Base Station: KL01-526 (Mobile)
 Base Lat/Lng: 2.206116, 103.205652

Set Run Status

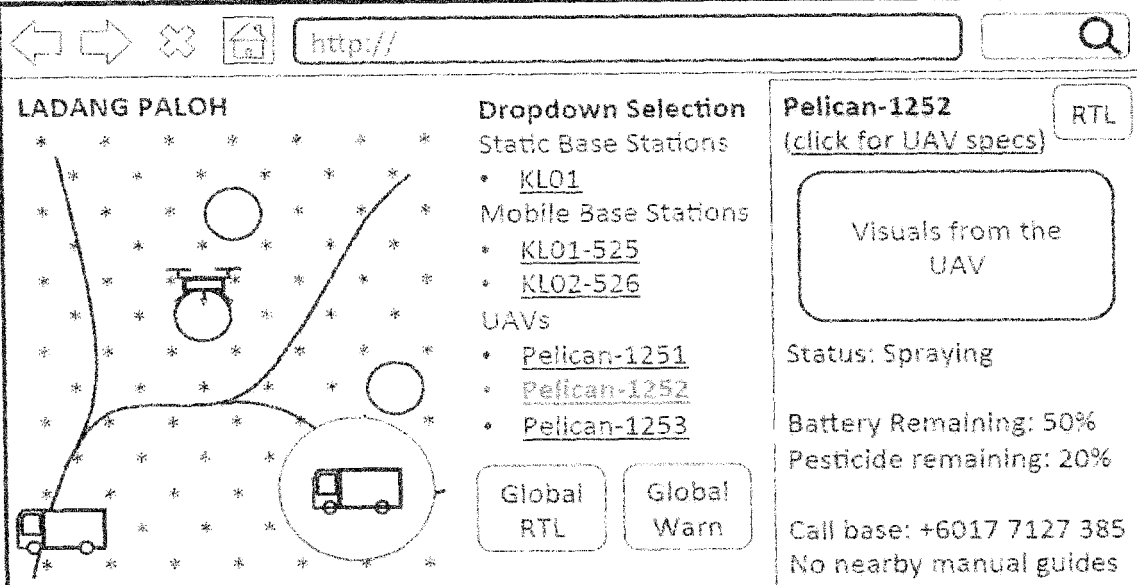
- New
- Approved
- Scheduled
- Completed (Successful?)

Map view showing a field with a vehicle icon and a path.

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Fig. 18

Unmanned Vehicle Command and Control Interface (UVCC)



LADANG PALOH

Map view showing a field with a vehicle icon and a path.

Dropdown Selection

Static Base Stations

- KL01

Mobile Base Stations

- KL01-525
- KL02-526

UAVs

- Pelican-1251
- Pelican-1252
- Pelican-1253

Pelican-1252 (click for UAV specs) RTL

Visuals from the UAV

Status: Spraying

Battery Remaining: 50%

Pesticide remaining: 20%

Call base: +6017 7127 385

No nearby manual guides

Global RTL Global Warn

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Fig. 19

15/21

Airspace Management

National maximum altitude from sea level for UAV flights (part of ICAO class G airspace)

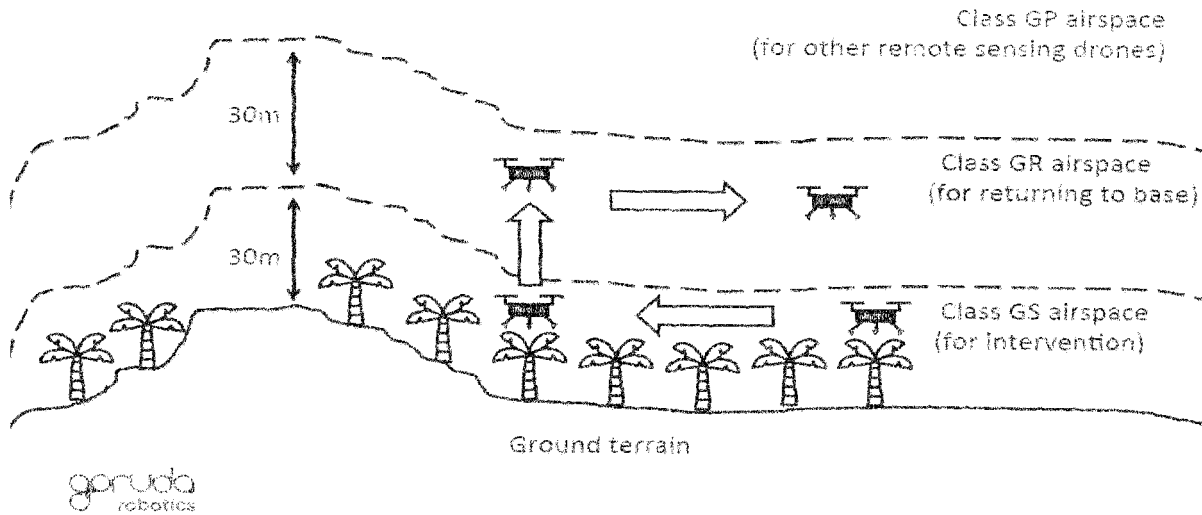


Fig. 20

Air Traffic Control

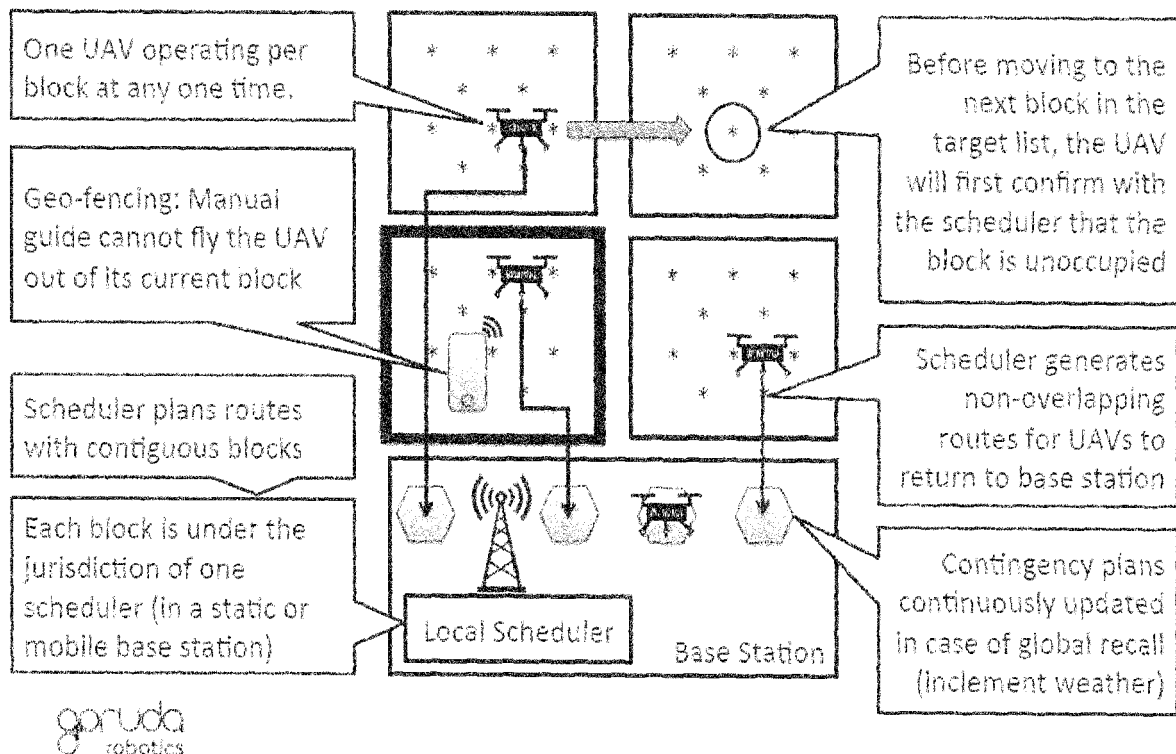


Fig. 21

16/21

Ground Traffic Control

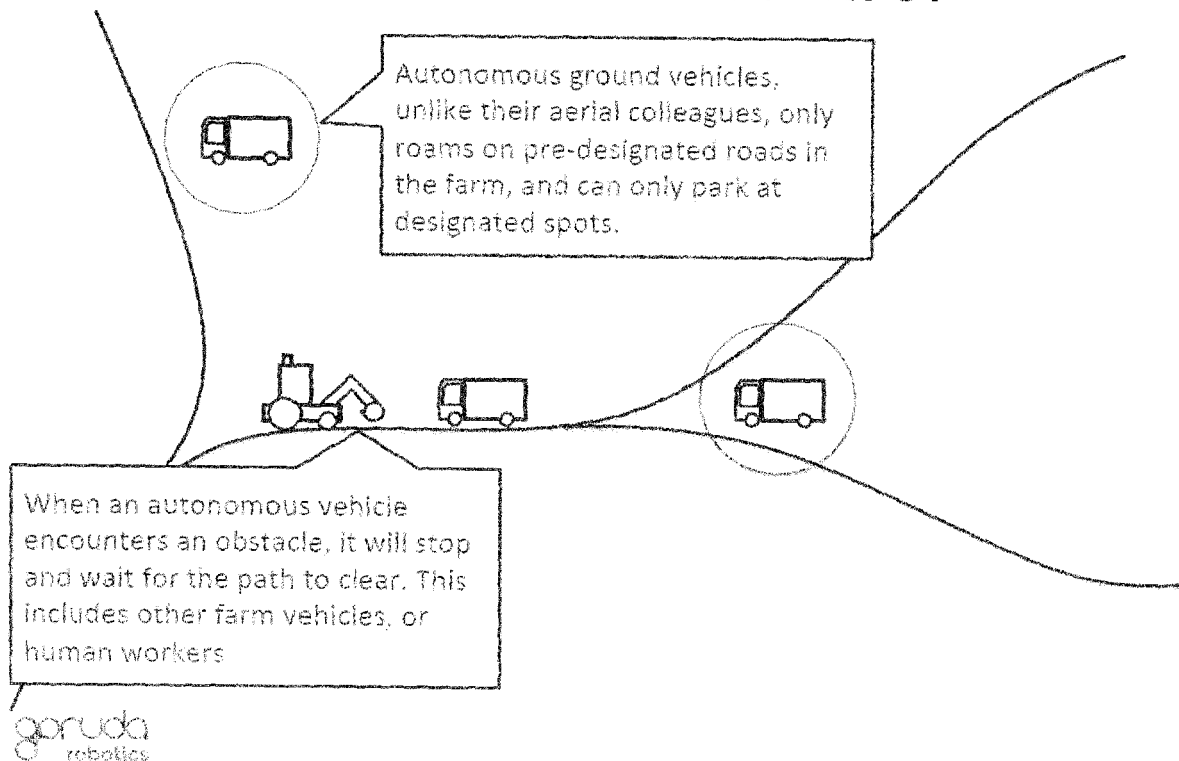


Fig. 22

Operations workflow overview

- For each day {
1. Grab target list from PIMS
 2. Partition blocks and generate schedule for MBS / UAVs to tackle all targets
 3. Deploy MBS with pre-charged UAVs to designated location
 4. Load up UAVs, perform intervention runs
 - 4.1 Generate optimal flight path, fly
 - 4.2 If manual guidance is available, follow manual guide prior to intervention
 - 4.3 In usual cases, use camera to find and fine tune aim prior to intervention
 - 4.4 Intervene, report back to base station
 5. Collect status of each intervention (success/failed, auto/intervened)
 6. Retreat to Static Base
 7. Perform maintenance for all equipment, charge UAVs
 8. Software generate reports, continuous syncing of data to Master in HQ
 9. Data fed to learning algorithms to improve
- }

Fig. 23

17/21

UAV workflow overview

(illustrated for 1 UAV doing 1 job)

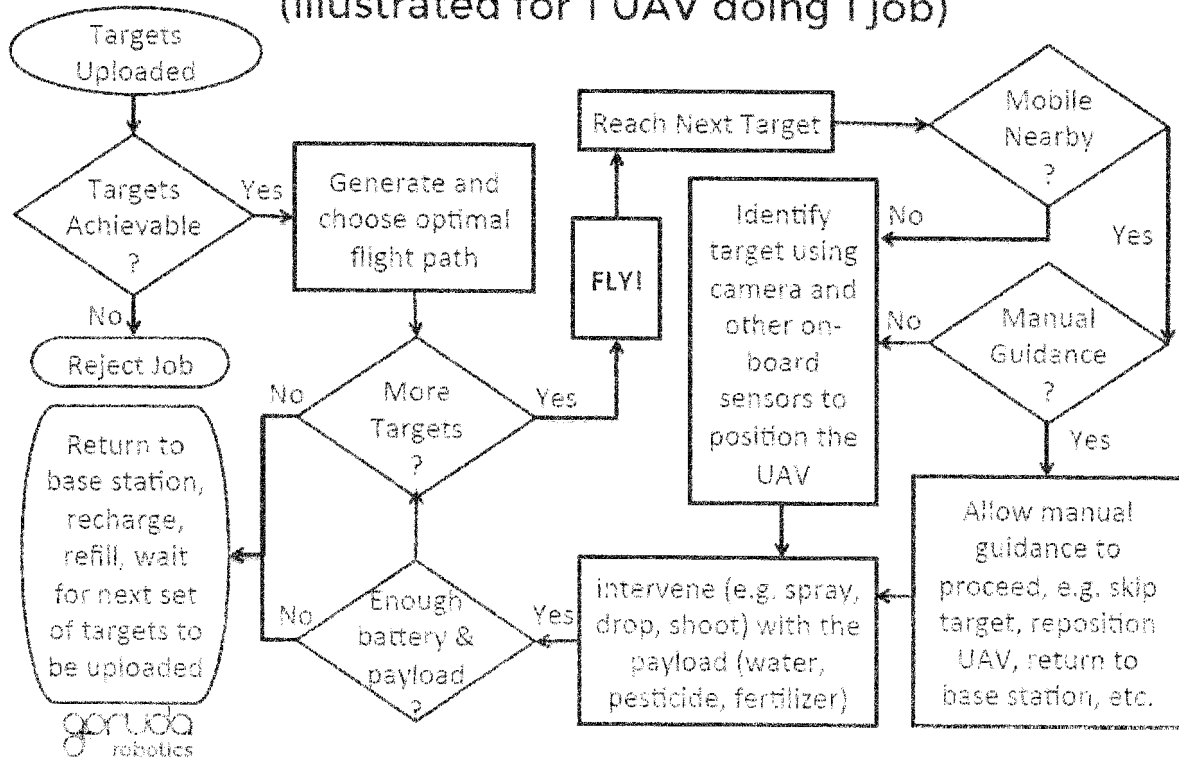


Fig. 24

Generate flight path and pick optimal path

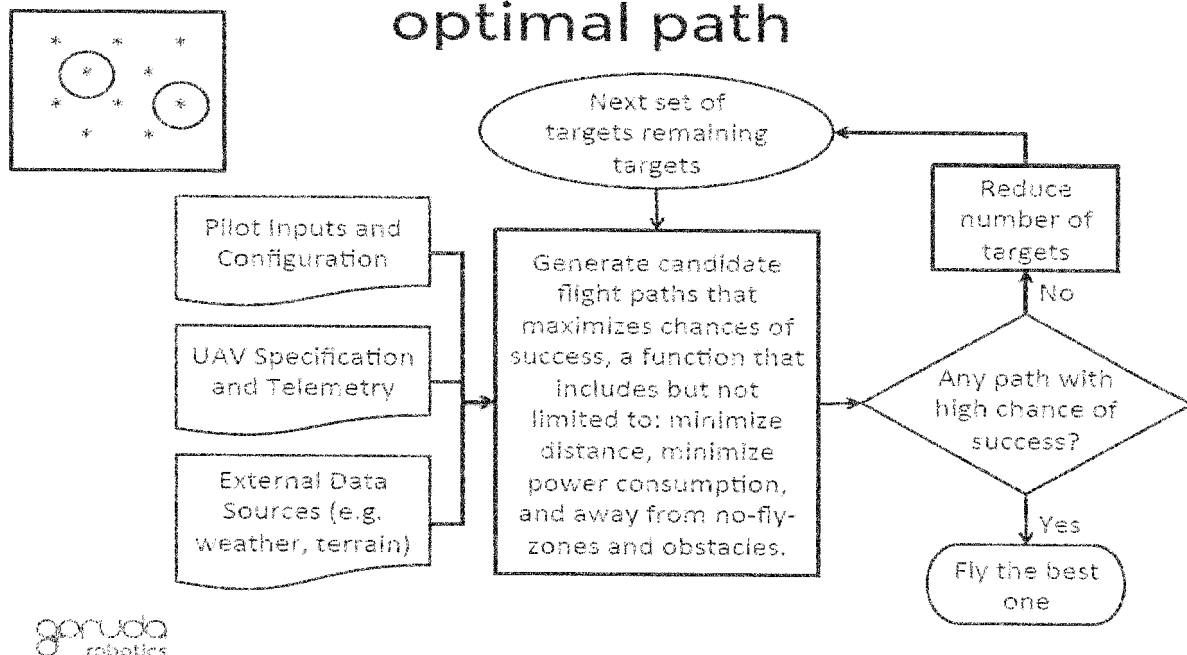
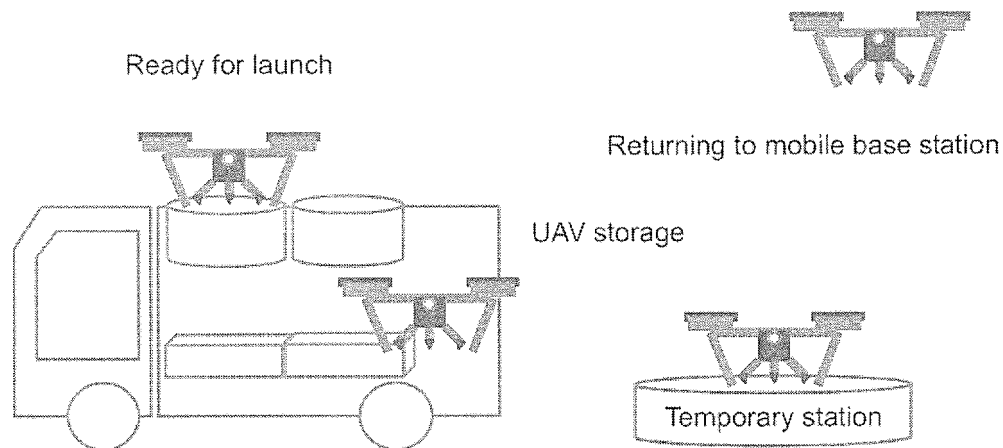


Fig. 25

18/21

UAV launch and recovery from base station



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Fig. 26

Visual target detection

```
Upon arrival at designated Lat / Long {  
  1. Capture image, crop center if needed  
  2. Use the learned model to detect target, and shift the position  
    2.1. If multiple targets detected, move horizontally to the closest one  
    2.2. If target is too small, consider moving closer downward  
    2.3. If no targets are detected / targets too big , move further upwards  
  3. Repeat 1 and 2 until the calculated correction is smaller than a threshold  
  4. Perform the intervention step  
}
```

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Fig. 27

19/21

Manual guidance step

Upon arrival at designated Lat / Long {

1. Mobile notified for workers in the area
 2. If one of the mobile app request to control, the rest will not be able to control
 3. Guidance provided by the controlling app heeded unless
 - 3.1. UAV hit the virtual geofence between blocks
 - 3.2. UAV ran low on battery
 4. Guides nudges the UAV until the FPV view of the target crop in screen center
 5. Perform the intervention step
- }

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Fig. 28

Real-time corrections made from mobile device

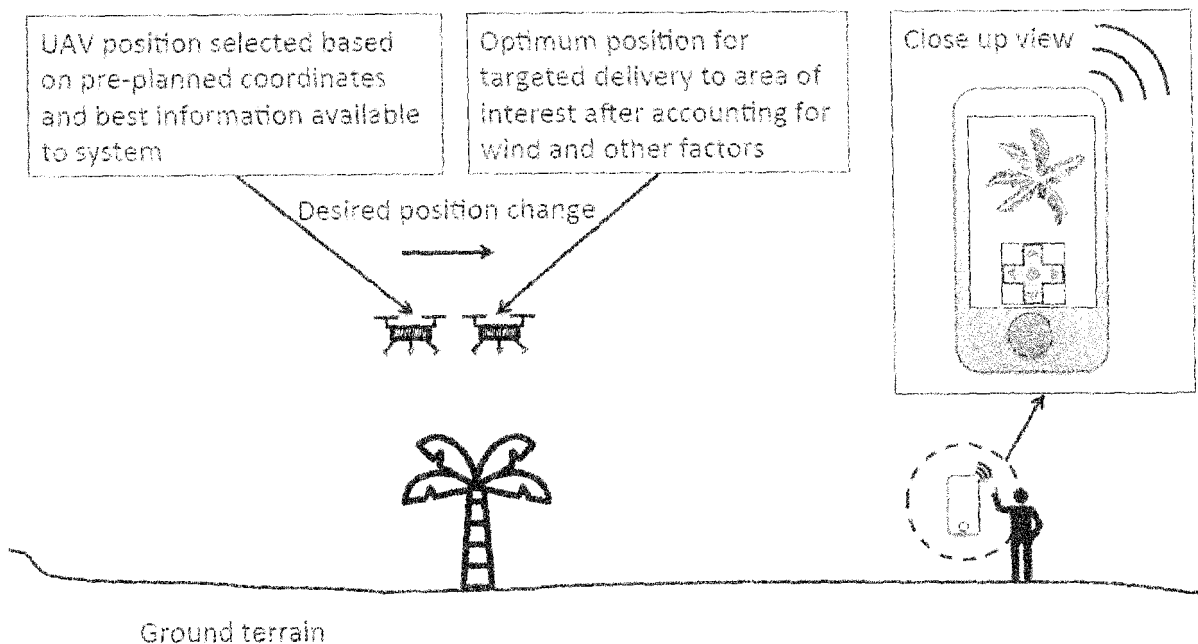


Fig. 29

Intervention step

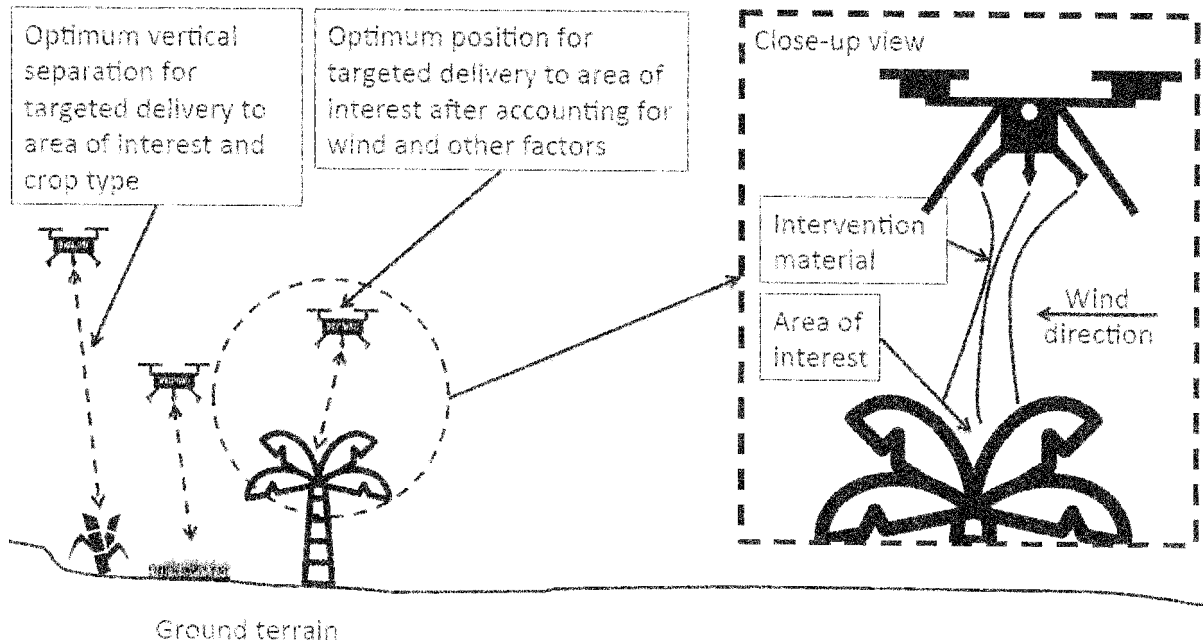


Fig. 30

Automated refilling of UAV reservoir at base station

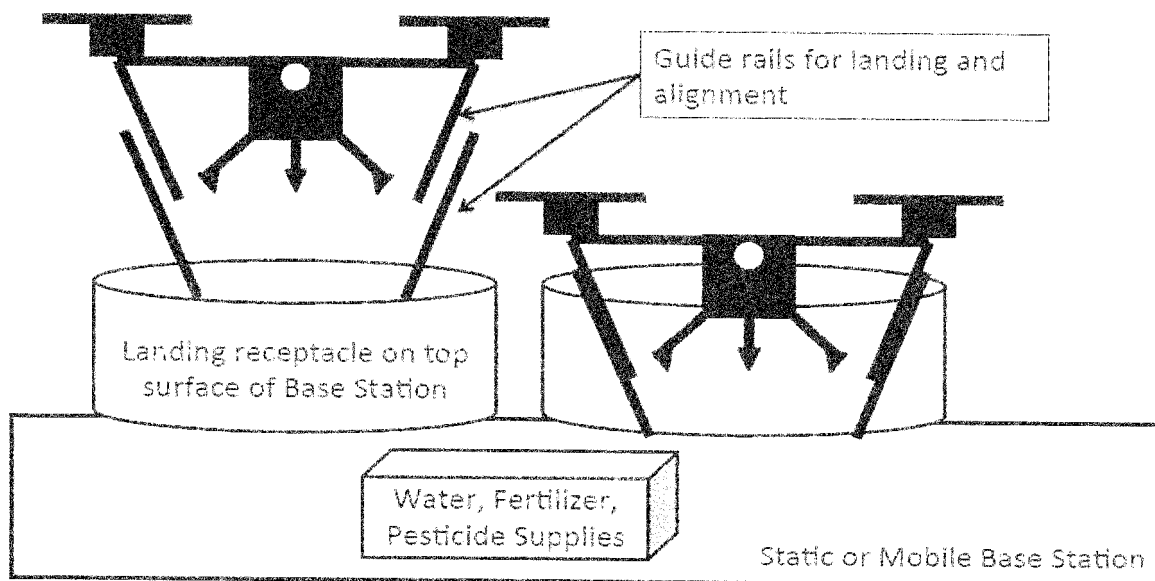
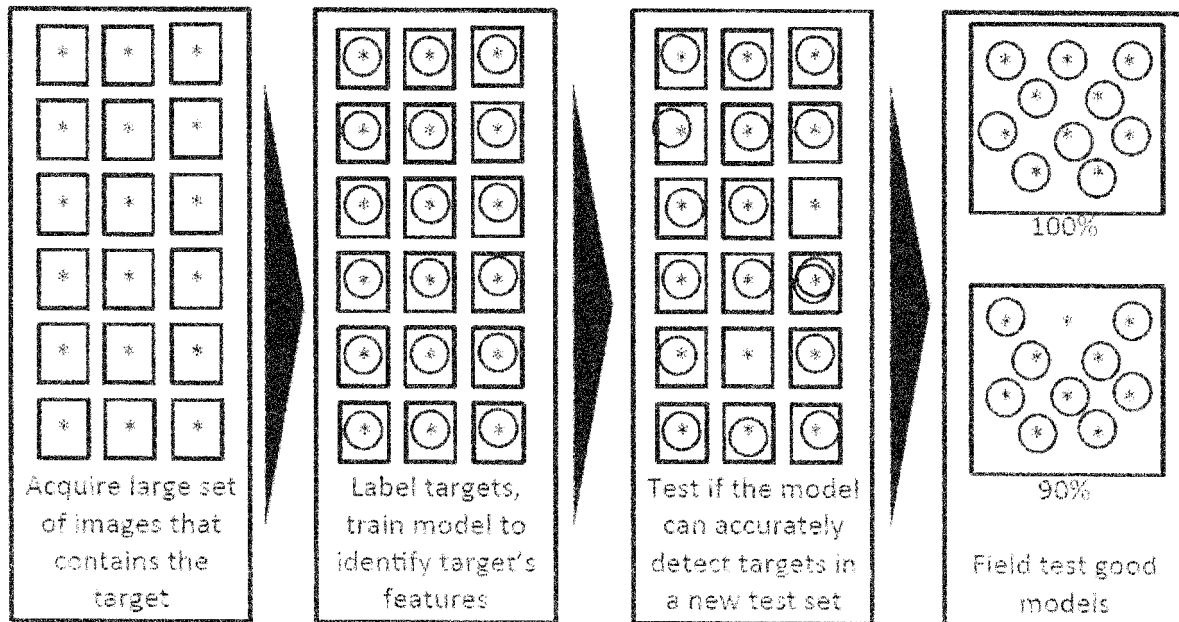


Fig. 31

Recognize targets using Machine Learning techniques



← Repeat multiple times for each target type, select the model with the highest accuracy →

Fig. 32