GREY CORP **CONSULTANCY SERVICES**

Grey Corp

Drone based Sensor Platforms

Grey Corp Research and Innovation

What are Drones?

Grey Corp

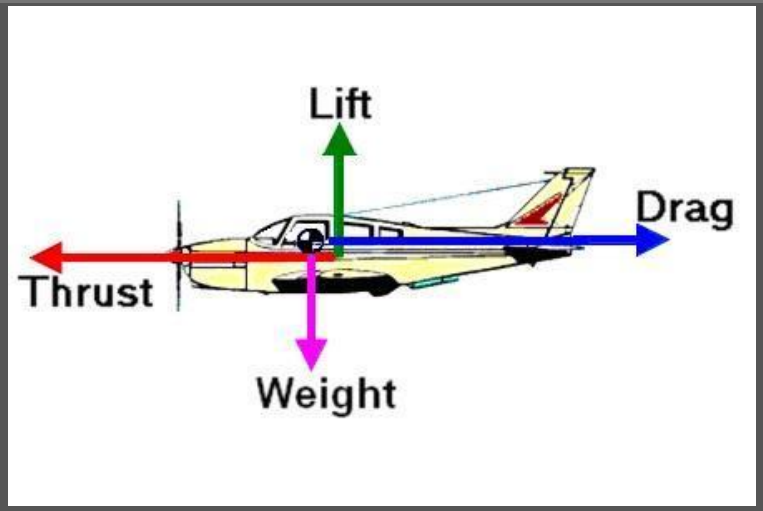
- Unmanned Aerial Vehicle (UAV)
  - Any aerial vehicle without a human on-board
  - Remotely controlled by a human operator OR
  - Controlled by onboard computers
- UGV/AGV
  - Unmanned/Autonomous Ground Vehicle
- UUV/AUV
  - Unmanned/Autonomous Underwater Vehicle

Types of Drones

Grey Corp

Four Forces of Flight

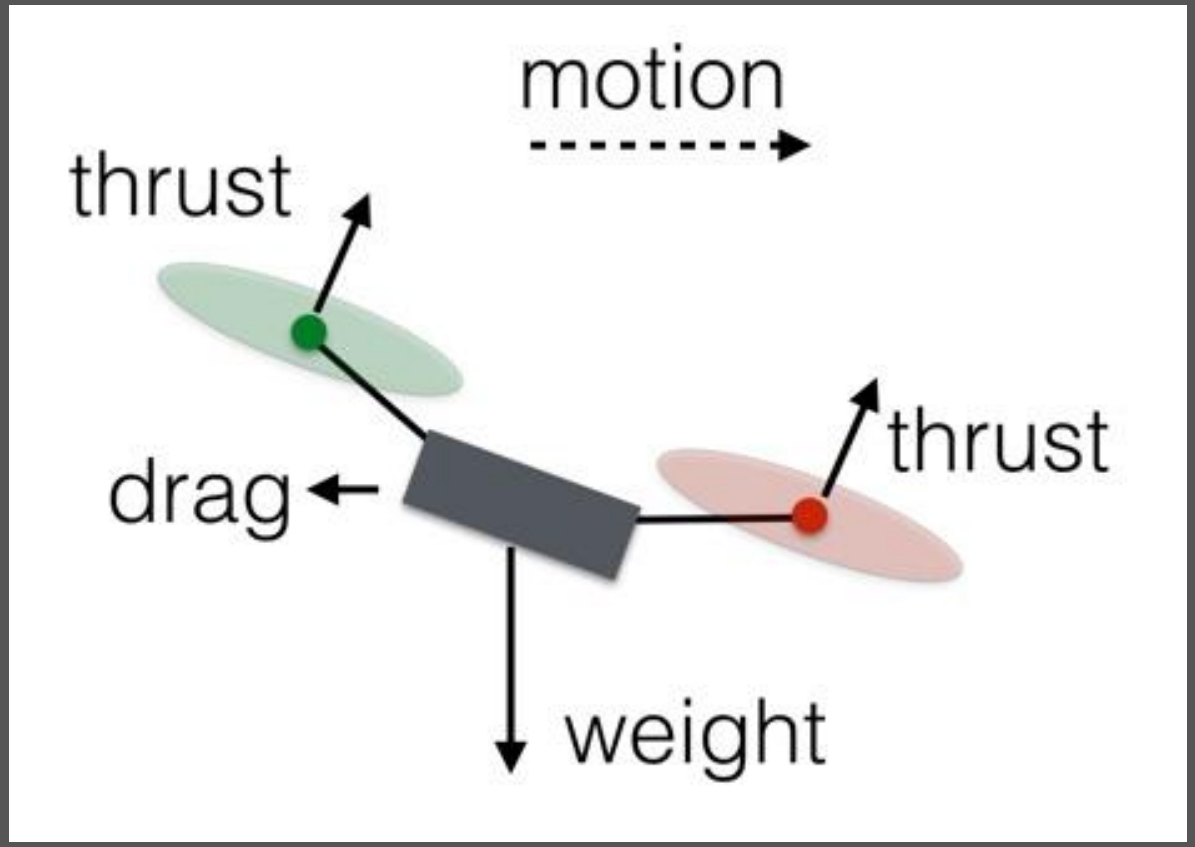
Grey Corp



- Thrust: A force that moves aircraft forward
  - Needs to overcome drag (frictional force)
  - Produced by the engine
- Lift: A force that “lifts” the aircraft up
  - Needs to overcome weight
  - Created by airflow over wings

How does a Drone Fly?

Grey Corp



Components of a Drone - 1

Grey Corp

Frame

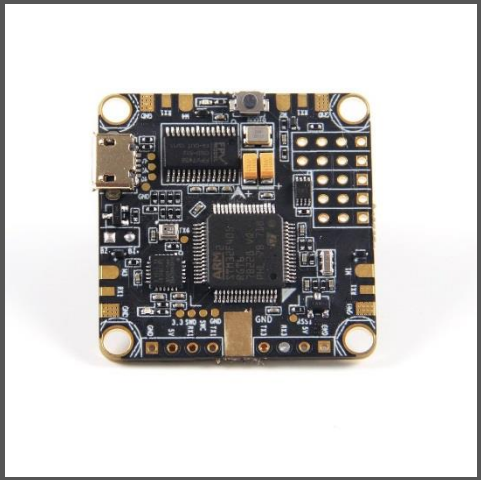
Motor

Speed Controller

Propeller

Components of a Drone - 2

Grey Corp



Flight Controller

Radio Transmitter

Radio Receiver

Battery

Components of a Drone - 3

Grey Corp

Telemetry Module

Camera

Video Transmitter

Video Receiver

Components of a Drone - 4

Grey Corp

Ground Control Station

Components of a Drone - 5

Grey Corp

OSD

- Monitor vital stats of drone
- Battery voltage
- Current draw
- ESC temperature
- Pitch & roll values
- Radio signal strength
- GPS signal strength
- Altitude, speed, heading
- Distance to next waypoint
- Distance to home

Sensors in a Drone - 1

- Accelerometer
  - Measures acceleration in all 3 axis
- Gyroscope
  - Measure angular rate in all 3 axis
- Compass
  - Determines heading
- GPS
  - Determines position based on GPS/GLONASS satellites
- Power module
  - Power supply to flight controller

Sensors in a Drone - 2

- Optical flow
  - More accurate landing
- Obstacle avoidance
  - Sense & avoid
- ADS-B
  - Broadcasts your position

Flight Control Algorithms

- PID (Propotional Integral Derivative) control
  - Closed loop control to stabilize the drone
- Inertial navigation
- Extended Kalman Filtering
  - Fuses all available measurements
  - Better error rejection
  - Non-linear state prediction
- SLAM
  - Autonomous navigation in GPS denied environment

Flight Modes

- Four controllable DoFs
  - Forward/backward, left/right, up/down, yaw
- Acro mode
  - Used by racing professionals
  - Gives more control over the drone
  - Uses least number of sensors for control
  - Less stable but high performance
- Stabilize
  - Flight controller (FC) just stabilizes drone
  - User controls all 4 DoFs
- Altitude hold
  - FC controls up/down
  - User controls 3 DoFss

Flight Modes

Grey Corp

- Loiter (position hold or hover)
  - FC controls all 4 DoF
- Autonomous
  - FC controlls all 4 DoFs
  - Drone takes-off, reaches a preset altitude
  - Drone navigates through a set of GPS waypoints at set speed
  - Drone returns to the launch point, lands

Safety Features

Grey Corp

- Redundant sensors
  - Accelerometers, gyros, compass and power supply
- Pre-flight and in-flight checks
  - Check all sensors and isolate faulty sensors and continue flight
  - Return to home or land in case of sensor failures
- Battery failsafe
  - Return to home in case of low battery voltage
- Radio failsafe
  - Return to home in case of radio signal loss
- GPS failsafe
  - Land in case of GPS signal loss
- Geo-fence
  - Return home if fence is breached

Typical Drone Specs

Grey Corp

- Small drones (like DJI Phantom)
  - Weight: 1.5 kg
  - Range: 2-3 km
  - Speed: 40 to 80 kmph
  - Endurance: 20 min
  - Payload capacity: 300 gms
- Racing drones
  - Weight: 750 gm
  - Range: 2-3 km
  - Speed: 150 to 200 kmph
  - Endurance: 5 to 15 min
  - Payload capacity: 100 gms

Applications of Drones

Grey Corp

Hobby Drones

- Fun & recreation
- Photography
- Racing

Commercial

- Surveillance
- Disaster response
- Agriculture
- Inspection
- Media
- Entertainment

Military

- Reconnaissance
- Attack

Agriculture

Grey Corp

- Crop health analysis
  - Estimation of nutition & water levels
  - Detection of pests & diseases
  - Estimation of height, count, acreage & yield
- Spraying fertilizers & pesticides
- Soil analysis

Infrastructure Inspection

Grey Corp

- Pipeline inspection
  - Cracks, leaks, corrosion
- Railway track inspection
  - Rails, sleepers, fishplates
  - Ballast, vegetation
- Wind turbine inspection
- Powerline inspection
- Rooftop inspection

Other Uses

Grey Corp

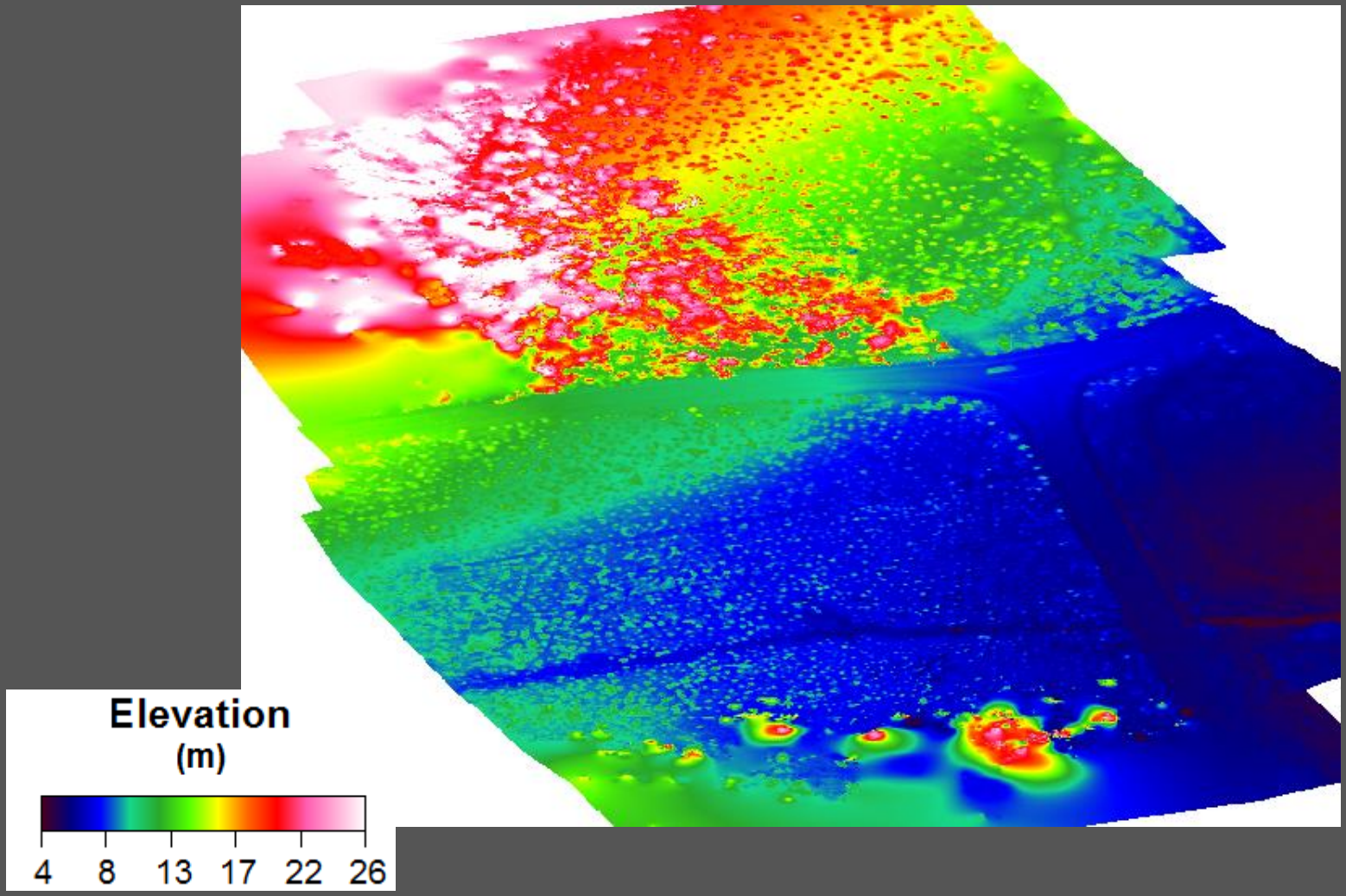
- Disaster response
- Assess damage
- Search & rescue

- Medical supplies delivery
- Blood, organs, first aid kits

- Package delivery

High Resolution Elevation Maps

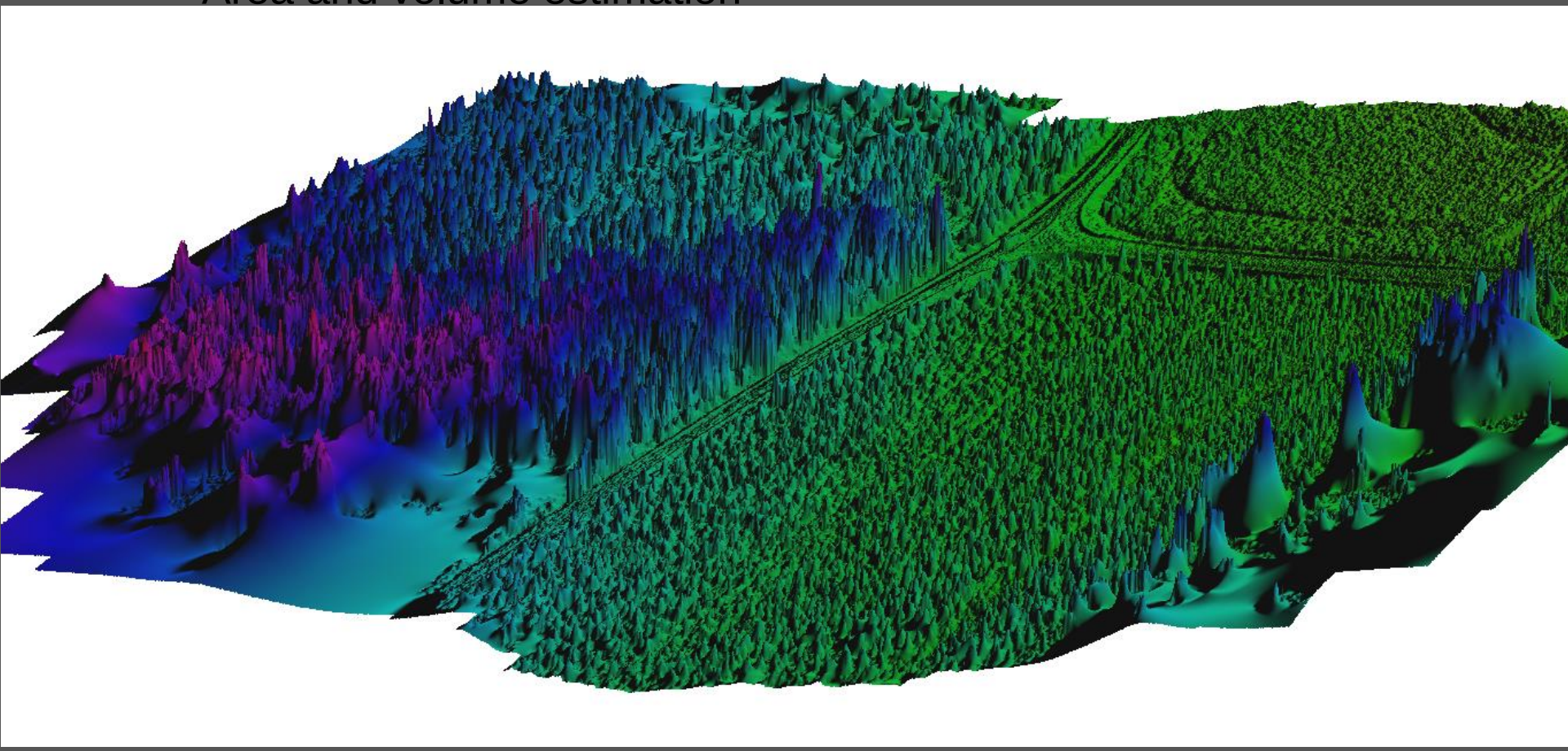
Grey Corp



3D Point Clouds and DSMs

Grey Corp

- Key forest figures
  - Tree count and height
  - Area and volume estimation

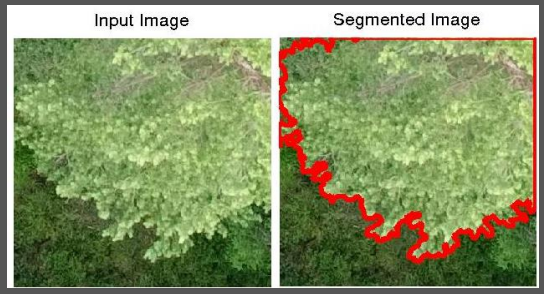


Estimating Crown Diameter

Grey Corp

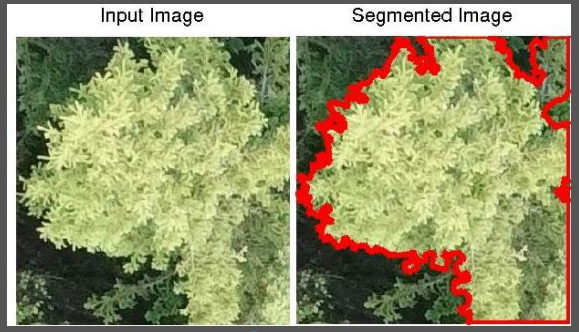
Grey Corp Algorithm approach overview example:

- The crown diameter estimation was performed through a process of continuous iterations of “fitting an ellipse” across the visible canopy of the target tree (*threshold of 1200 iterations were employed for the purpose*)
- The major axis of the ellipse for each tree was considered the diameter of associated crown.



Birch

Pine



Spruce

Species Recognition & Proximity Assessment

Grey Corp

Species identification: Coconut

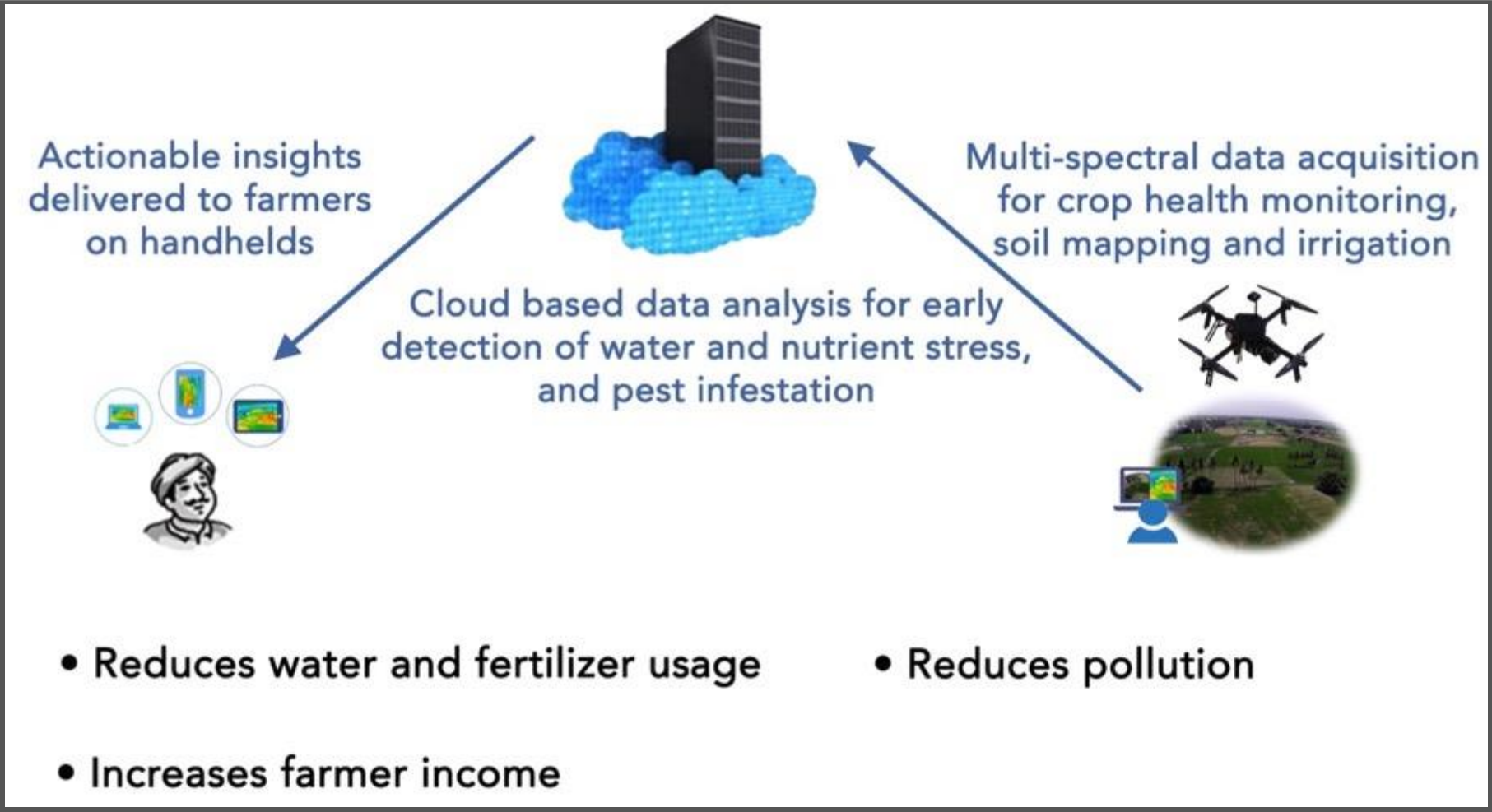
Road detection

Water area detection

- Deep learning algorithm for tree species identification and common infrastructure detection
- Proximity assessment

Drones for Precision Agriculture

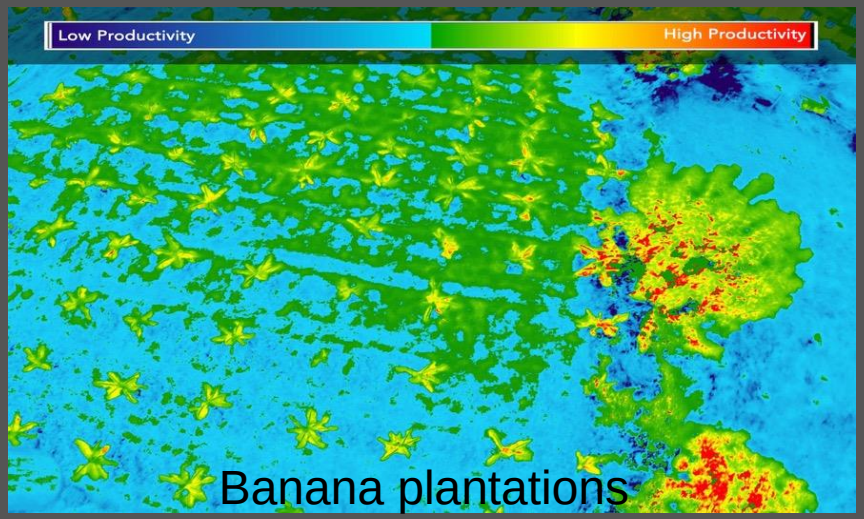
Grey Corp



- Reduces water and fertilizer usage
- Reduces pollution
- Increases farmer income

Crop Health Analysis

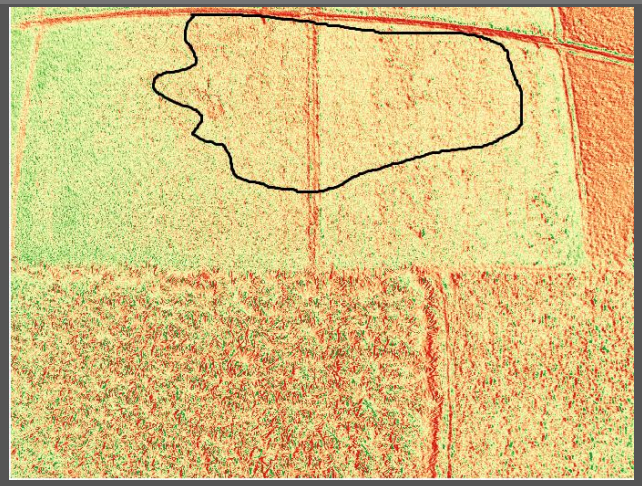
Grey Corp



- Multi-spectral and visual imagery acquisition using TCS drones
- Accurate crop health analysis using various crop health indices
- Early detection of nutrient deficiencies and other problems
- Advanced algorithms for species identification, population estimation and localization

Early Detection of Crop Health Problems

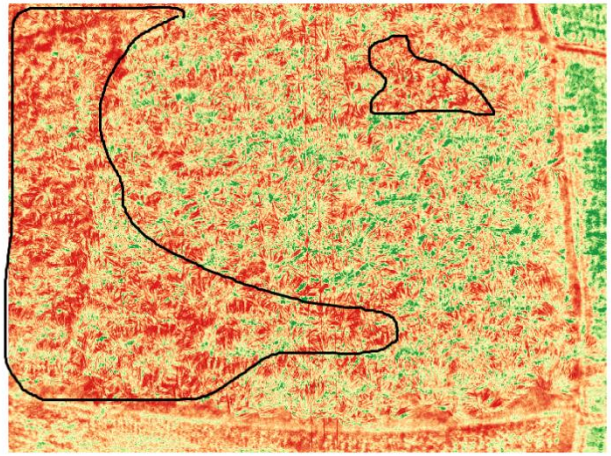
Grey Corp



Nitrogen deficiency in paddy

Productivity variations in paddy

Poor tillering in paddy



Productivity variations in sugarcane