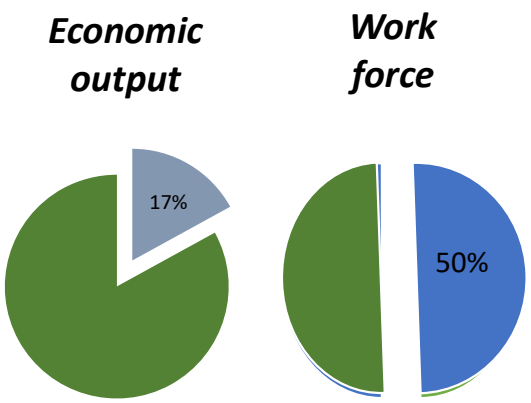
Agriculture, Aviation, AI

Kota Harinarayana

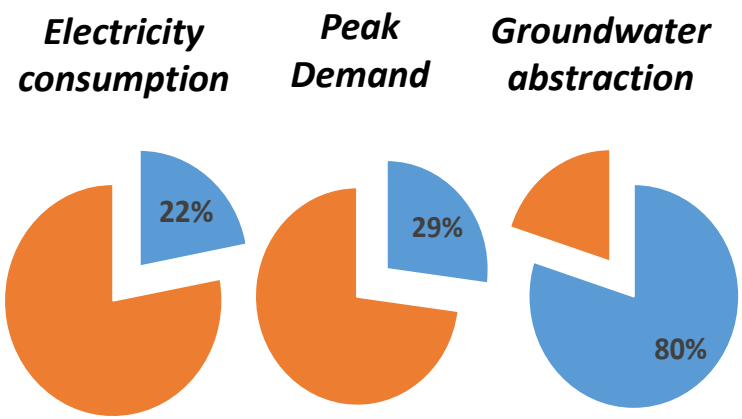
YSR Memorial Lecture at RGUKT,8th July,2022

OVERVIEW | INDIAN AGRICULTURE

Responsible for

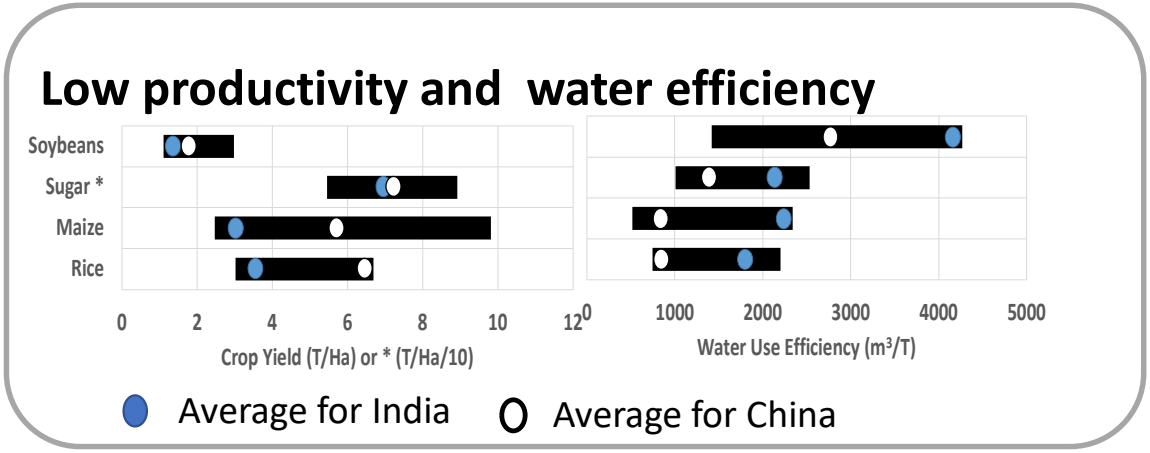


Consumes



Source : SCORESS,FARM HAND LTD

Indian Agriculture

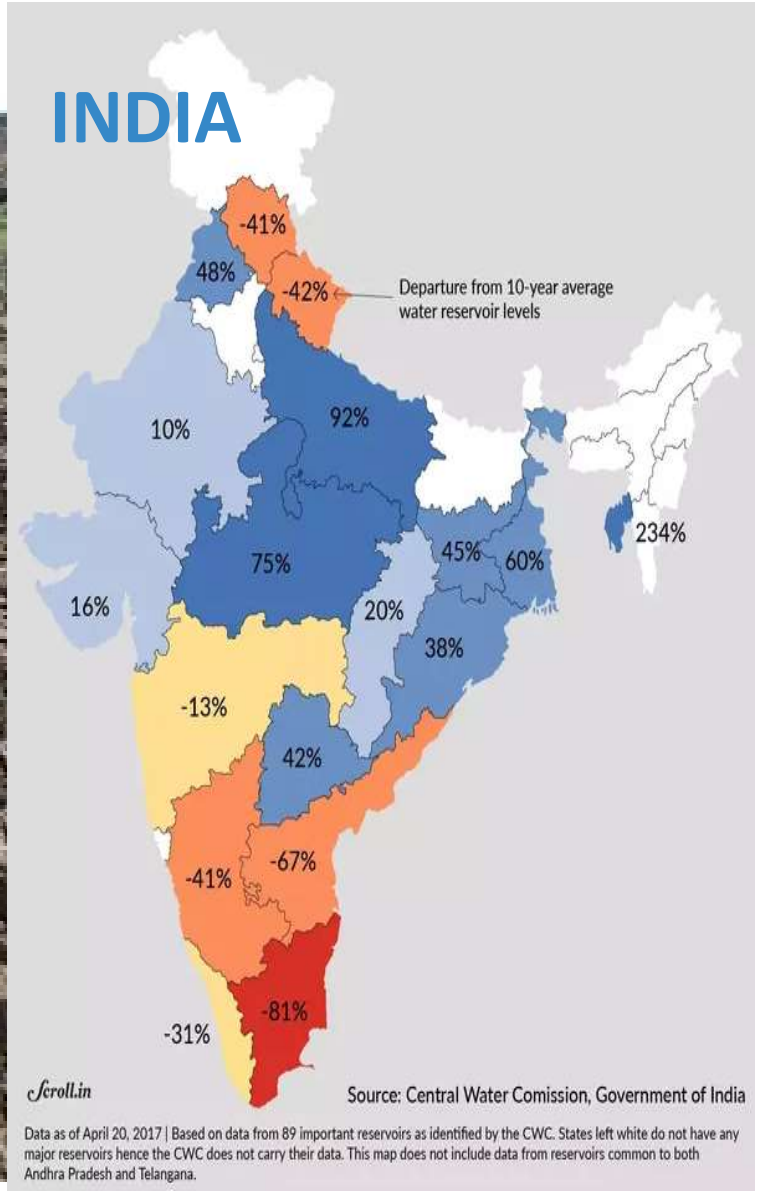


Source: SCORRES FARM HAND LTD, Auroville

Existing Farm Practices

- The practices in India have a very traditional bearing and have not significantly changed over time. The good-old methods relying on rains as per heavenly calendar are becoming irrelevant in the face of changing climate.
- The eco-system that a present farmer is exposed to is not favorable either. Availability of information on quality of inputs (water, fertilizers and soil) is often absent or inaccurate. This results in virtually blind use of input resources with very poor understanding of their impact on the crop yield.
- It should also be noted that predicting weather over tropical regions is fundamentally more difficult and much harder if the projections are to be made over smaller regions.
- Forecasting weather over 100 acres is next to impossible and as such environmental conditions as input can hardly be used.


DEPARTURE FROM
10YEAR
AVERAGE WATER
RESERVE LEVELS


INDIA
-41%
48%
-42%
Departure from 10-year average water reservoir levels
10%
92%
234%
45%
60%
75%
16%
20%
38%
-13%
42%
-67%
-41%
-81%
-31%
scroll.in
Source: Central Water Comission, Government of India
Data as of April 20, 2017 | Based on data from 89 important reservoirs as identified by the CWC. States left white do not have any major reservoirs hence the CWC does not carry their data. This map does not include data from reservoirs common to both Andhra Pradesh and Telangana.

Indian Agriculture-ISSUES

- **Scarcity of Water**
- **Low Crop Yield**
- **Inadequate Crop Quality**
- **Excess application of Water, Fertilizer, Pesticides etc**
- **Rapid changes in weather & Environment**
- **Farmer Indebtedness**

Source : Scope of AI & ML in Indian Agriculture, Anupama Namburu, Acharya Nagarjuna univ

Technology Intervention—Precision Agriculture

- Increasing the productivity, enhancing the income of the small farmer and ensuring sustainable agriculture are vital in a country like India.
- This can be achieved with application of emerging technologies in the sector to maximize production

Precision agriculture is the technology that enhances farming productivity.

- It prepares the land for farming,
- ensures equally fertile vegetation across the field,
- monitors plantations during in season growth,
- detects early onset of pests and diseases.
- It also ensures application of farm input in right amount, at right time, at right location through harvest and post harvest processes

Precision agriculture involves

- remote sensing,
- use of geographical information system (GIS),
- global positioning system (GPS),
- image processing to determine soil nutrient composition, early detection of pests/diseases, application of farm inputs like fertilisers, herbicides, water etc.

Precision Agriculture

Precision agriculture can be defined as "the application of modern information technologies to provide, process and analyze multisource data of high spatial and temporal resolution for decision making and operations in the management of crop production" (National Research Council, 1997).

From: Global Food Security, 2016

How of Precision Agriculture

Precision agriculture relies upon specialized equipment, software and IT services. The approach includes accessing real-time data about the conditions of the crops, soil and ambient air, along with other relevant information such as hyper-local weather predictions, labor costs and equipment availability. Predictive analytics software uses the data to provide farmers with guidance about crop rotation, optimal planting times, harvesting times and soil management.

Sensors in fields measure the moisture content and temperature of the soil and surrounding air. Satellites and robotic drones provide farmers with real-time images of individual plants. Information from those images can be processed and integrated with sensor and other data to yield guidance for immediate and future decisions, such as precisely what fields to water and when or where to plant a particular crop

Source : Global Food Security,2016

Precision Agriculture & Small Farms

In the past, precision agriculture was limited to larger operations which could support the IT infrastructure and other technology resources required to fully implement and benefit from the benefits of precision agriculture. Today, however, Mobile apps, smart sensors, drones and cloud computing makes precision agriculture possible for farming cooperatives and even small family farms.

Tools For Precision Agriculture

- **Precision Agriculture Aviation (PAA) technologies for remote sensing**

- **Artificial Intelligence technologies for data analysis & interpretation**

- **When combined together are are proving to be major tools for precision agriculture**

Agriculture Aviation- Remote sensing Technologies

- The existing agricultural remote sensing technologies are classified into (a) satellite, (b) aircraft, (c) unmanned aerial vehicle (UAV)/Drone platforms
- *Satellite based:* Satellite based remote sensing technologies are widely used to provide guidance in global agricultural production. In India also this is in use for the last two decades. Indian agricultural scientists have done a lot of work using satellite images. The image processing and data processing has been a major challenge in the practice of agriculture. Features of images from vegetation need to be extracted, segmented and finally fed into model. **The processes are slow, suitable for overall assessment but not useful to a small farmer**
- *Aircraft based remote sensing:* Aircraft based remote sensing is flexible and versatile for fields to be imaged at variable altitudes depending on the spatial resolution required. While these technologies are better than satellite based systems, **however are not within the reach of small farmers**
- *UAV based remote sensing:* UAVs offer one of simple construction, low cost operations and maintenance, a compact and light weight foot print; simple to operate and high flexibility as a remote sensing platform**. The UAV based systems are ideally suited for small farms prevalent in India.**
- ***UAV based Aerial Spraying Technologies****:* Spraying is a critical agricultural aviation service that provides rapid response to sudden pest outbreaks. Unmanned agricultural aviation spraying has the advantage of low labour operational costs with no damage to crops or soil physical structure. UAV based aerial spraying technology is proving to be a boon especially for small and medium sized farms.

An Eye in the Sky for Agriculture : The Drone Revolution

DRONES & AGRICULTURE : A MATCH MADE IN HEAVEN

Types of Drones: Multirotor

- Vertical take-off and landing
- Fly slowly and hover
- Lower speed & endurance

Types of Drones: Fixed Wing

- Higher speed & endurance
- Cannot fly slowly or hover
- Cannot take-off & land vertically

Types of Drones: Hybrid

- Vertical take-off & landing
- Higher speed & endurance
- More complex & expensive

Types of Drones: Nano to Mega









Components of a Drone - 1

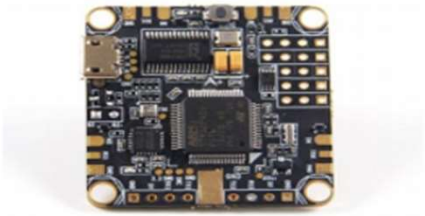
Frame

Motor

Speed Controller

Propeller

Components of a Drone - 2



Flight Controller

Radio Transmitter

Radio Receiver

Battery

Components of a Drone - 3

Telemetry Module

Camera

Video Transmitter

Video Receiver

Components of a Drone - 4

Ground Control Station

* Images downloaded from multiple websites

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

- 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

- 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

Applications of Drones

Hobby Drones

- Fun & recreation
- Photography
- Racing

Commercial

- Surveillance
- Disaster response
- Agriculture
- Inspection
- Media

Military

- Reconnaissance
- Attack

Agriculture

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

Drones for crop spraying

EFFECT OF USAGE

- Unmanned aerial vehicle (UAV) sprayer does not need a runway
- Drones can take off and land vertically.
- Flying at low altitude of several meters, the crop-spraying can be controlled
- Drones are suitable for all kinds of complex terrain, crops and plantations of varying heights.
- Precise and accurate crop spraying ensures the best coverage and application of your fertilizers or pesticides on your lands.

Drone developed by General Aeronautics for crop spraying

Trials conducted with ICAR-CPCRI

General Aeronautics
INNOVATION IN AVIATION

Trials conducted with PAU

General Aeronautics
INNOVATION IN AVIATION

Trials conducted with ICAR-NRRI

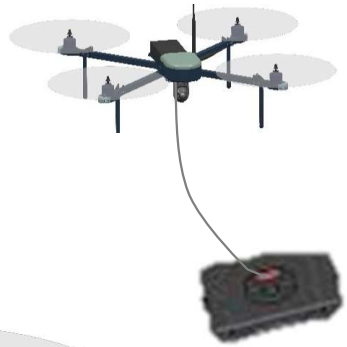
- No phytotoxicity related issues observed up to 4 ltr/acre dosage. Quantity of pesticide was as per CIB &RC instruction
- No major drift was observed
- Uniform Droplet distribution observed
- Project ongoing towards detailed evaluation over entire crop cycle

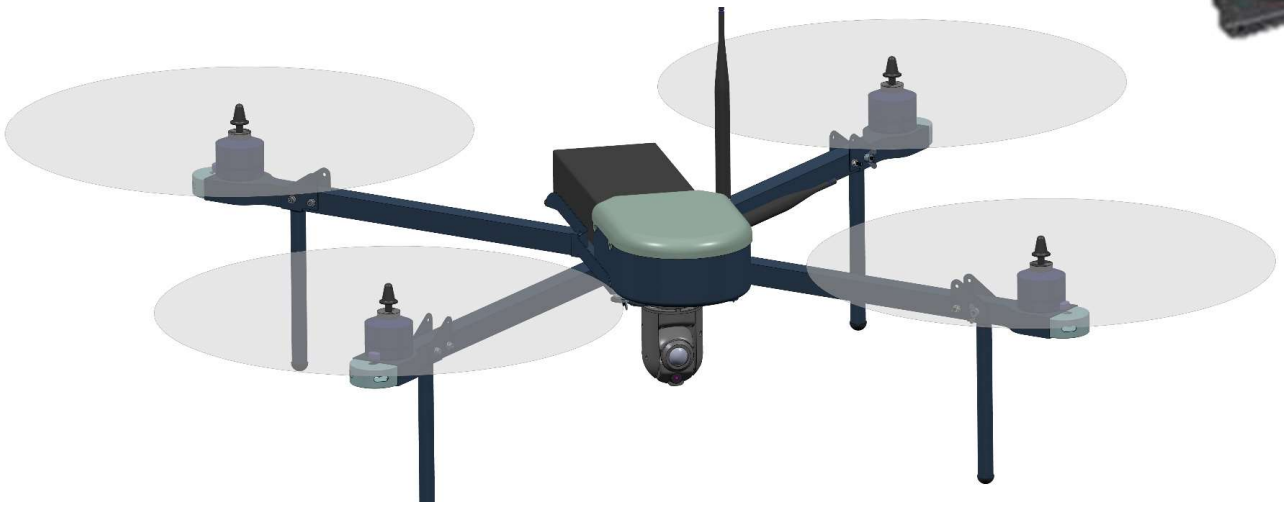
General Aeronautics

GA-3: Multi-copter

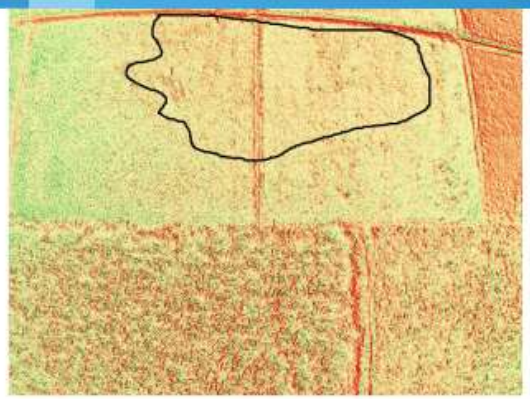
Requirements

- **> 40 min Endurance**
- **> 4 km Range**
- **> EO & IR Camera**
- **VTOL**
- **Box to Launch < 10 mins**

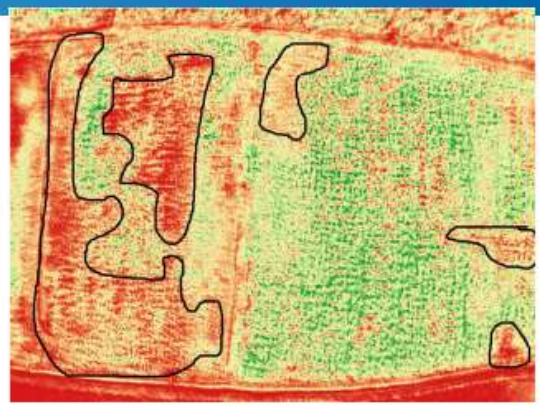




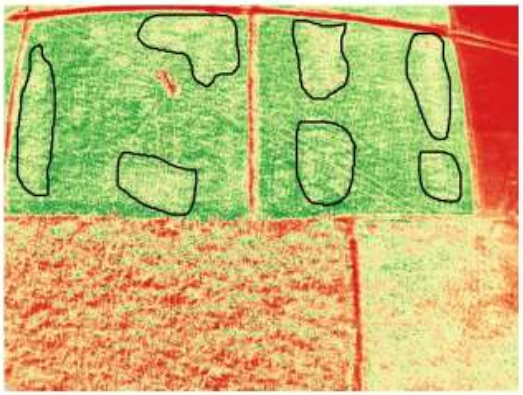
Early Detection of Crop Health Problems



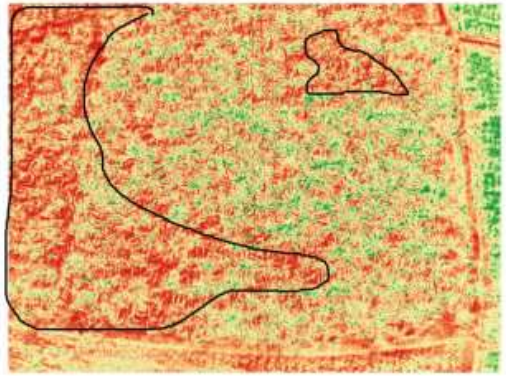
Nitrogen deficiency in paddy



Productivity variations in paddy



Poor tillering in paddy

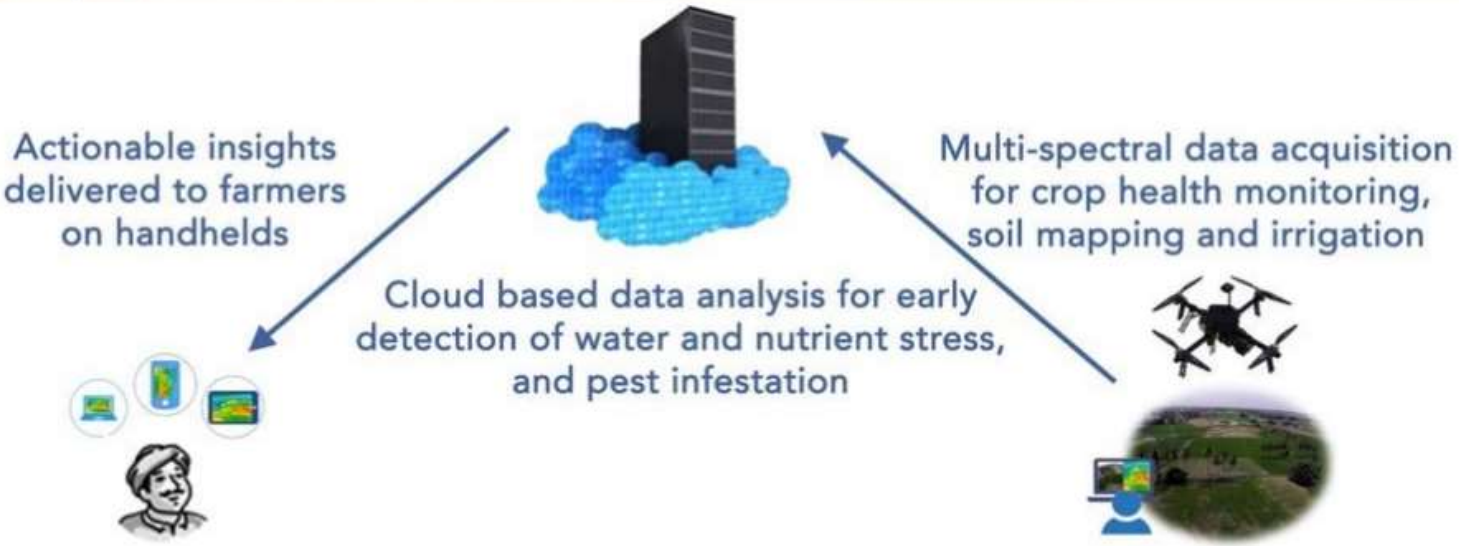


Productivity variations in sugarcane

Benefits of UAVs– Case Study from Sri Lanka

- The ability of UAVs/Drones to hover over fields with sensing devices promises many benefits to the farmers
- Recently International water management institute carried out trials in Sri Lanka with a near field infrared sensor (NIR). The trials showed how NIR can give early warning of problems any where in the field.
- It was observed that a drone with NIR camera could identify stress in a plant 10 days before it becomes visible to the eye.
- When a plant goes into stress due to water or fertilizer shortage or because it is being attacked by a pest, photosynthetic activity decreases and that affects the chlorophyll. That is what NIR can detect but human eye cannot see until it s more advanced.
- 10 days warning could prevent large scale crop losses.

Drones for Precision Agriculture



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

Image Processing

- Image processing is an important area in agriculture
- Traditional image processing techniques
    - * Image preprocessing
    - * Image segmentation
    - * Feature extraction
    - * Image classification
- These processes are cumbersome, time consuming & cost is high

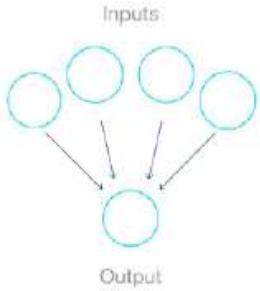
Image Processing- Advent of AI

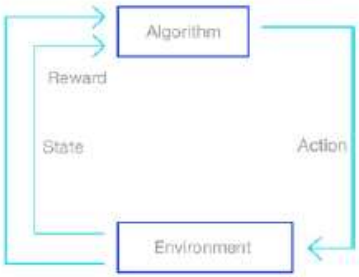
The newly-developed technology delivers this information using RGB (red, green, blue) cameras, a standard accessory carried by drones. The drone flies about 20 metres above land, capturing one image of a section of a crop field every two seconds. This data is then processed offline and modelled into useful information through deep learning—all without the additional cost of a multispectral camera.

Artificial intelligence: A definition
AI is typically defined as the ability of a machine to perform cognitive functions we associate with human minds, such as perceiving, reasoning, learning, and problem solving.
Machine learning: A definition
Most recent advances in AI have been achieved by applying machine learning to very large data sets. Machine-learning algorithms detect patterns and learn how to make predictions and recommendations by processing data and experiences, rather than by receiving explicit programming instruction. The algorithms also adapt in response to new data and experiences to improve efficacy over time

What is AI & ML

Understanding the major types of machine learning





	Supervised learning	Unsupervised learning	Reinforcement learning
What it is	An algorithm uses training data and feedback from humans to learn the relationship of given inputs to a given output (eg, how the inputs "time of year" and "interest rates" predict housing prices)	An algorithm explores input data without being given an explicit output variable (eg, explores customer demographic data to identify patterns)	An algorithm learns to perform a task simply by trying to maximize rewards it receives for its actions (eg, maximizes points it receives for increasing returns of an investment portfolio)
When to use it	You know how to classify the input data and the type of behavior you want to predict, but you need the algorithm to calculate it for you on new data	You do not know how to classify the data, and you want the algorithm to find patterns and classify the data for you	You don't have a lot of training data; you cannot clearly define the ideal end state; or the only way to learn about the environment is to interact with it

Source :An executive's guide to AI, Mckinsey Analytics

Machine Learning (ML)
& Deep Learning (DL)

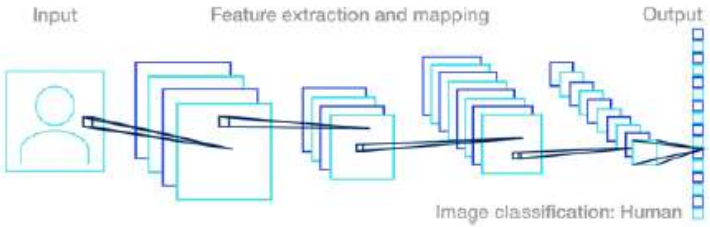
- Machine learning is most popular technique used for analysis of images
  - * K-means; Support Vector Machines (SVM)
  - * Artificial neural net works (ANN) etc etc
- The recent technique for image processing is Deep Learning (DL). Deep Learning provides high accuracy, out performing existing ML techniques
- DL how ever needs large data for training which can be generated using Drones/UAVs

Deep Learning

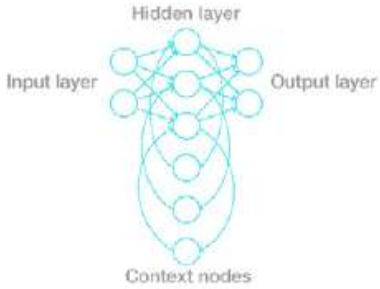
- Deep learning is a type of Machine learning that can process a wide range of data sources, requires less data processing by humans, and can often produce more accurate results than traditional machine learning approaches.
- In deep learning interconnected layers of software based calculators known as “ neurons “ form a neural net work.
- The net work can ingest vast amount of input data and process them through multiple layers that learn increasingly complex features of data at each layer.
- The net work can make a determination about the data, learn if it’s determination is correct, and use what it has learnt to make determination about new data.
- For example ,once it learns what an object looks like, it can recognize the object in a new image

Understanding the major deep learning models and their business use cases[4]

Convolutional neural network

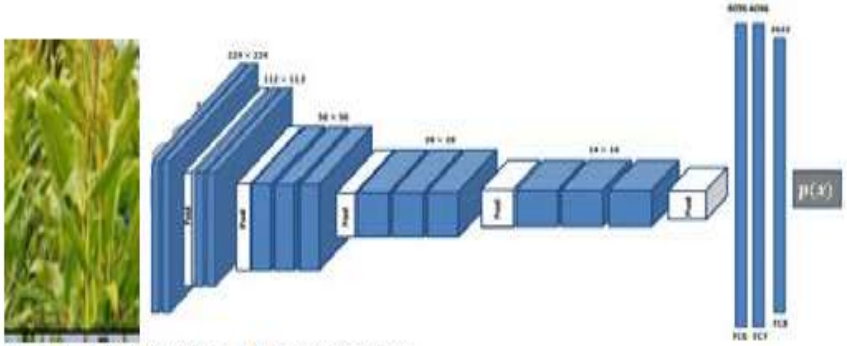


Recurrent neural network

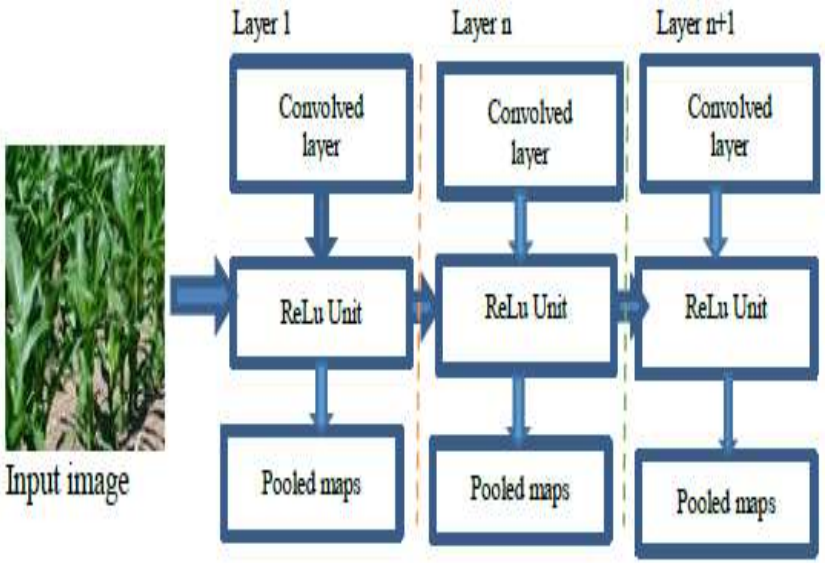


	Convolutional neural network	Recurrent neural network
What it is	A multilayered neural network with a special architecture designed to extract increasingly complex features of the data at each layer to determine the output	A multilayered neural network that can store information in context nodes, allowing it to learn data sequences and output a number or another sequence
When to use it	When you have an unstructured data set (eg, images) and you need to infer information from it	When you are working with time-series data or sequences (eg, audio recordings or text)

Source : An Executive's guide to AI,Mckinsey Analytics



CNN model architecture



Overall framework of CNN

Ref : convolution neural net works in precision agriculture for plant recognition and classification

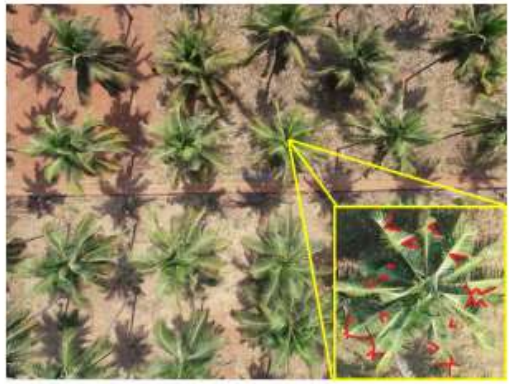


Fig. 1. UAV captured RGB image at 40 m altitude in summer season. Inset: Rhinoceros beetle made 'V-shape' cuts marked using red color for SFM.

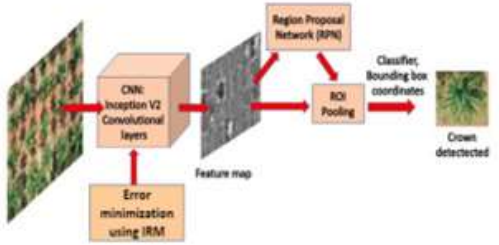
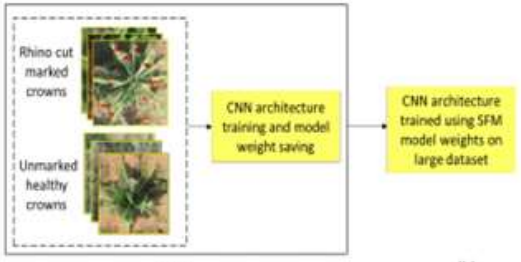


Fig. 3. Proposed Crown detection architecture using IRM framework.



Methods	Total dataset annotations	Precision (%)	Recall (%)
Proposed IRM crown localization	**9427**	**97.30**	**92.0**
M Zakharova (2017)	500	71.0	93.0
Steven P. et. al. (2018)	3798	97.31	88.58

. Comparison of proposed IRM crown detection model performance on private data with different coconut crown detection methods.

Team Work with members from CPCRI, IIIT,Bangalore & General Aeronautics

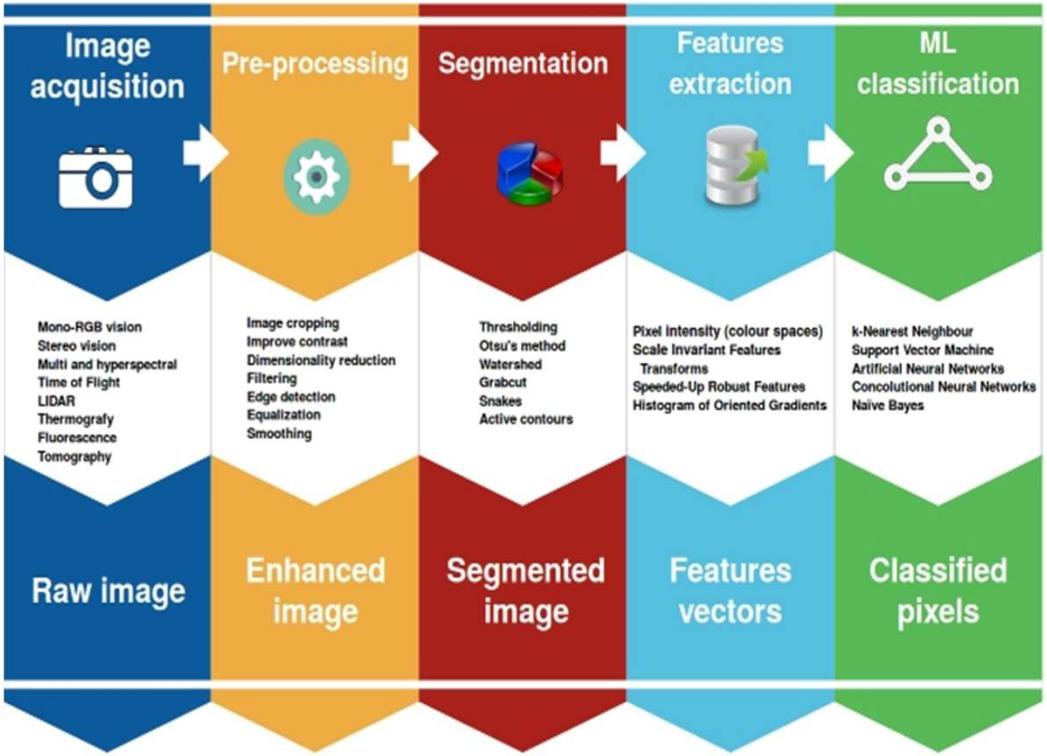
Source : Neelam Sinha,ICASSP,2021

PLANT PHENOMICS

Plant phenotyping is the comprehensive assessment of complex plant traits such as growth, development, tolerance, architecture, yield, and the basic measurement of individual quantitative parameters that form the basis for more complex traits .

Computer vision and machine learning methods are the primary drivers for the development of high-throughput models for the quantification of plant phenotypes like leaves, roots to name a few.

Basic workflow in computer vision–based plant phenotyping



(i) Identification, (ii) Classification, (iii) Quantification (iv) Prediction

Field Phenomics

- Phenotyping in the field allows researchers to observe and measure phenotypic data in large quantities from remote sensors in the air and on the ground under variable environmental conditions.

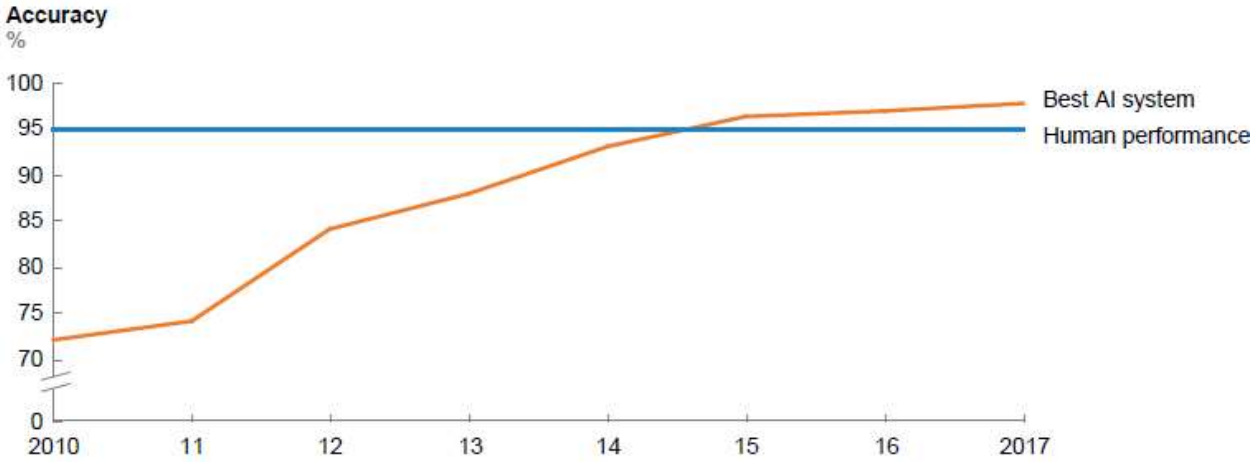
- Ground based Sensor Network

- UAV for Aerial Imaging

WHY AI NOW

A convergence of Algorithmic advances, data proliferation and tremendous increase in computing power and storage propelled AI from hype to reality

The ability of AI systems to recognize objects has improved markedly to the point where the best systems now exceed human performance



SOURCE: ImageNet Large Scale Visual Recognition Challenge; McKinsey Global Institute analysis

[9] Olga Russakovsky et al., "ImageNet Large Scale Visual Recognition Challenge," *International Journal of Computer Vision*, volume 115, issue 3, December 2015.

GOI's Policies on drones & app in Agriculture

- The Gov considers UAVs can be significant creators of employment and economic growth due to their reach, versatility, and ease of use, especially in India's remote and inaccessible areas and envisions India as a possible global drone hub by 2030.
- Government is promoting the use of 'Kisan Drone' for **crop assessment, digitization of land records, spraying of pesticides and nutrients** .
- Government Promotes Drone use in Agriculture – Financial Support Being Extended Under 'Sub-Mission on Agriculture Mechanization'

  Agriculture Ministry to provide grant up to Rs. 10 lakhs to agricultural institutes for purchase of drones

  Custom Hiring Centers set up by Cooperative Society of Farmers, FPOs and Rural entrepreneurs to also get financial assistance for purchase of drones

  Subsidized purchase would make drones more accessible to the common man and will encourage domestic drone production


Thank you