Agri-TYE

A DATA DRIVEN - PRECISION AGRICULTURE

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Why precision agriculture ?

Food requirements are expected to double by 2050 to meet the demands of the world population, but the amount of land fit for agriculture is shrinking.

Data-driven techniques, such as precision agriculture, could help meet the increased demand.

In this presentation, we will present Agri-TYE , an agricultural IoT system that uses a combination of unmanned aerial vehicles (UAVs) or tethered devices and wireless sensors to enable data-driven agricultural techniques. In doing so, we develop novel algorithms to maximize the coverage of UAV flights given limited battery power, to combine information from a UAV's video and ground sensor data, and, finally, to achieve cloud connectivity of the farm's monitoring system.

What should Microsoft do?

Microsoft should own the cloud for agriculture. In other words, it should be the default platform for hosting all sensor data, such as soil, tilling, irrigation, pesticides, etc. Microsoft should also be the platform for analyzing this data and providing feedback:

(i) real-time instructions to the farmers on how to improve yield based on sensor data processing in the cloud, and

(ii) Analytics to big companies on how their seeds/fertilizers/ equipment worked in different soil, water, weather, and other environmental conditions under various farming practices.

FARMBEATS

- Farmbeats video will be uploaded here

The FarmBeats Vision

Ag Services

Yield estimation

Precision Irrigation

Pest Infection

Fertilizer application

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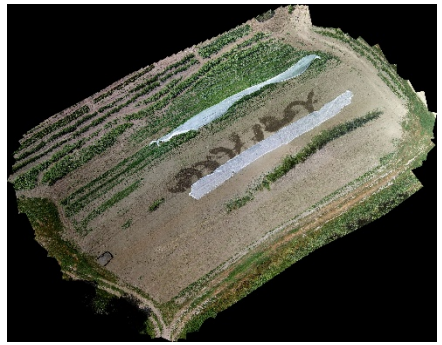
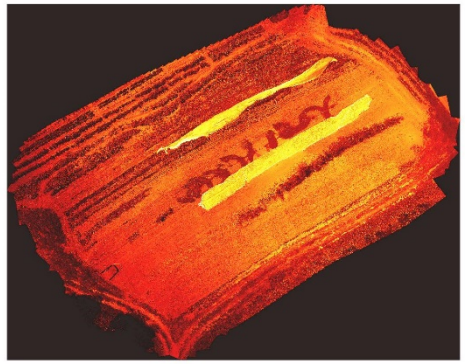
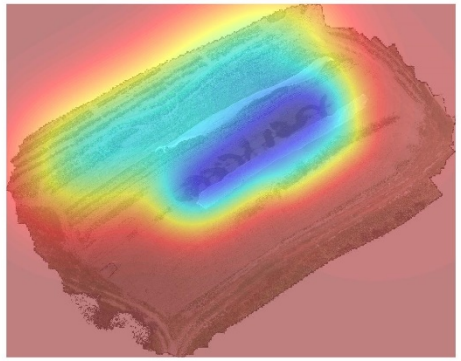
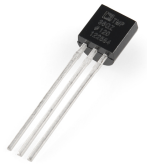
Spatio-temporal view of the farm

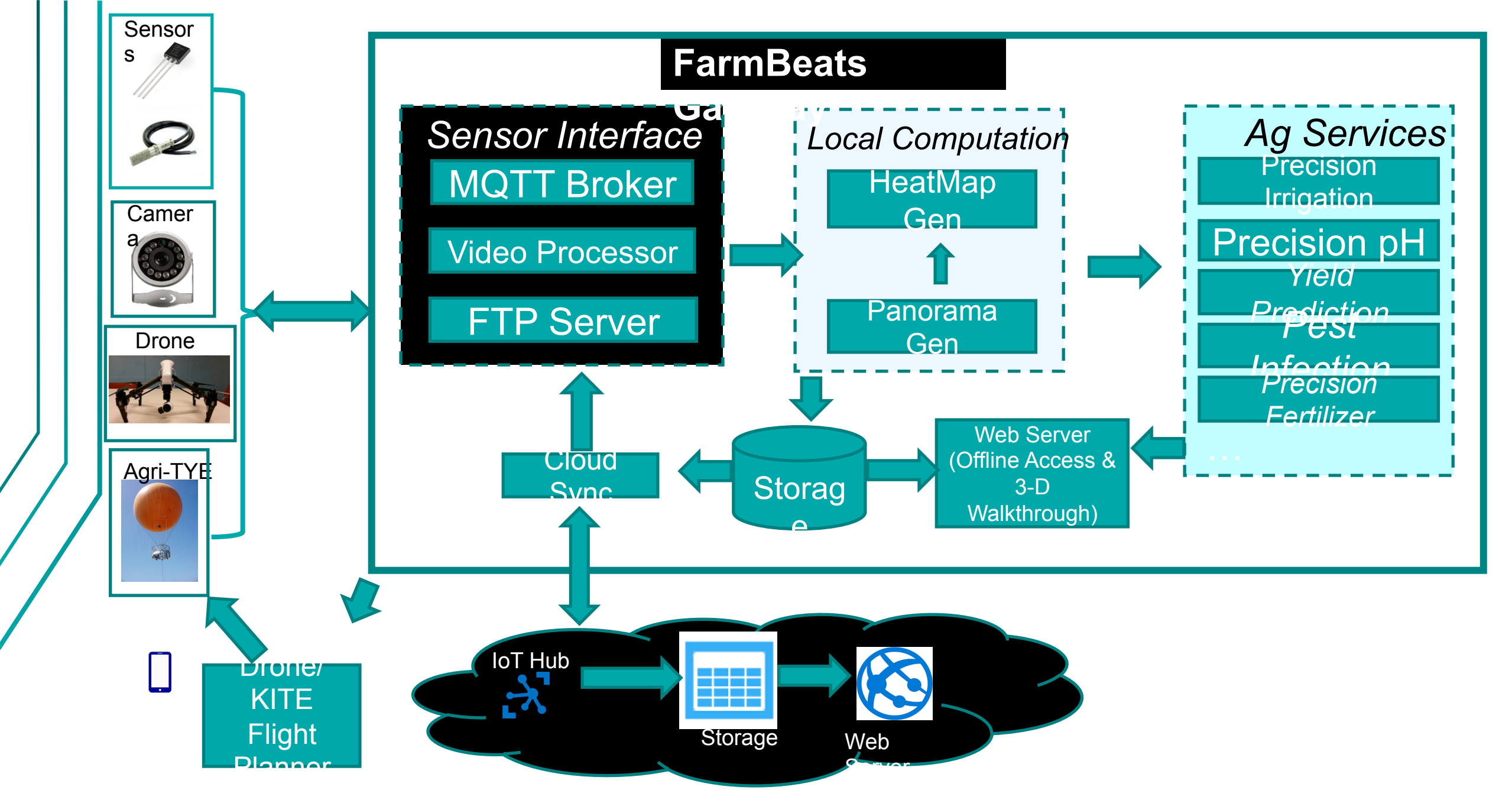






Sensors & UAVs

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Camer
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Drone
Agri-TYE
FarmBeats
Sensor Interface
MQTT Broker
Video Processor
FTP Server
Local Computation
HeatMap Gen
Panorama Gen
Ag Services
Precision Irrigation
Precision pH
Yield Prediction
Pest Infection
Precision Fertilizer
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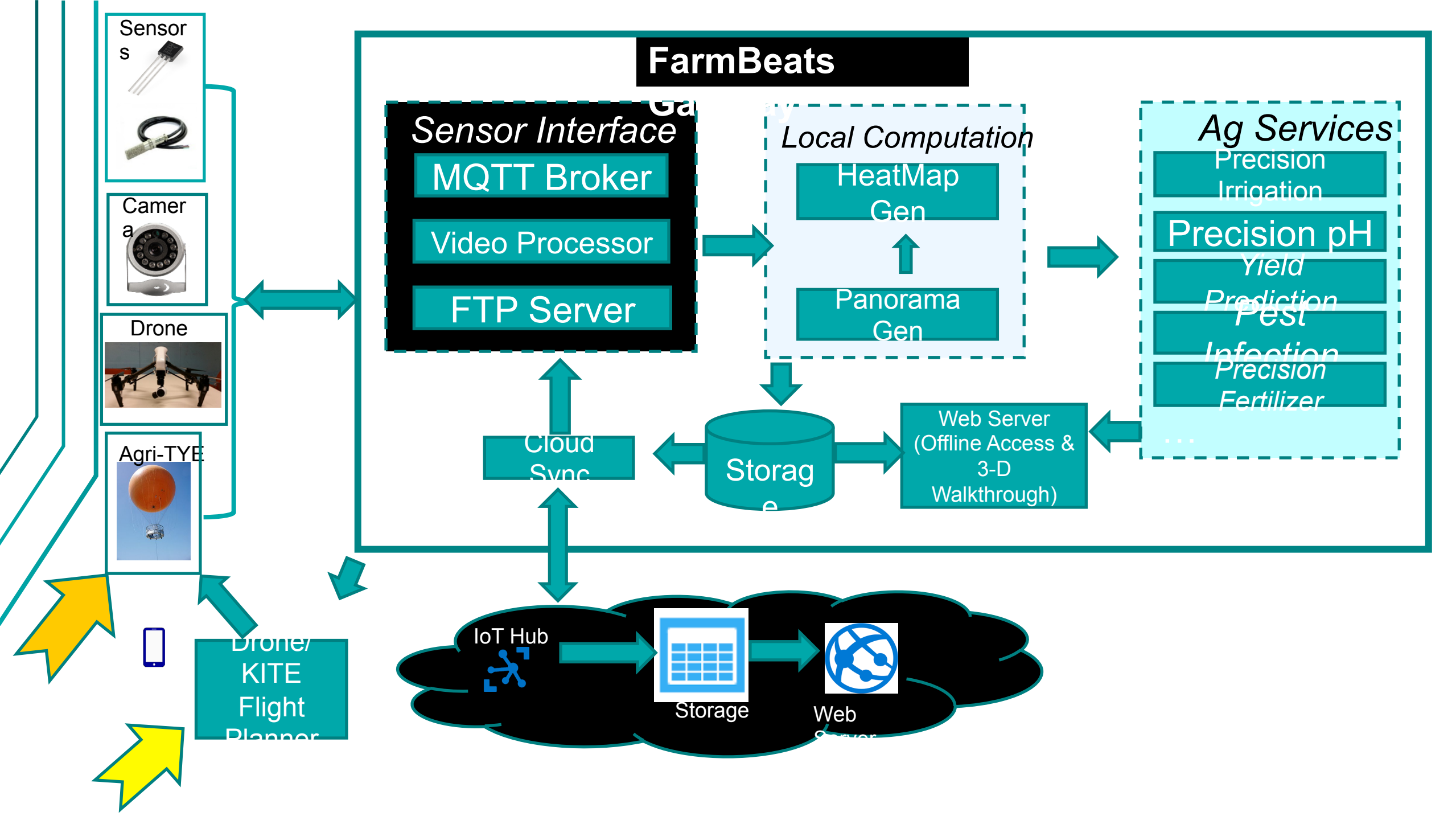
Web Server (Offline Access & 3-D Walkthrough)
IoT Hub
Storage
Web
KITE Flight Planner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IoT Hub
Storage
Web
Drone/
KITE
Flight
Planner

Summer: Back to Balloon flying

Why would MSR interns and researchers spend a summer flying balloons?

Overview

Build a UAV-based monitoring system, which clicks pictures from the entire farm and uploads it to the Microsoft cloud. The camera would upload the data to the cloud, where image analytics will reveal crop health.

The tethered device(GPS-equipped) combined with on-ground deployed sensors will map the entire field, and collect sensor data, which is then used to drive a variable rate algorithm for the amount of fertilizer, pesticides, or water to use, as well as for which seeds to sow and when , to monitoring crop health, to the final yield.

Long term Goal: Data Driven Agriculture

Specific examples of problems that can be tackled in the Indian context:

1) Drought notification
2) Damage estimation due to floods/cyclones for crop insurance and compensation
3) Effective water management in rainfed/dryland farming
4) Pest detection and infection prediction

All require collection of a data with high spatial and temporal resolution, followed up with analysis combining historic data (weather, past harvest, soil conditions, fertilizer/pesticide application, etc).

Architecture of the End to End System

Agri-TYE App

Real time Communication

Guidance App

Local Gateway

Sensor Network

Ag Service

End User (Eg. Farmer)

Agri-TYE

The IoT platform for Agriculture in India

We propose an low-tech yet powerful platform: Agri-TYE.

These are helium powered tethered devices that can go up to 100 feet, and are equipped with multi-spectral cameras.

High quality aerial images of farms form a adequate database for extracting most parameters of interest for enhancing agricultural productivity. For instance, to estimate the yield of a farm, identification of pests, estimation of moisture availability to plants based on images, etc.

They will provide an aerial view of the farm that can be streamed either to a PC in the farm or on the farmer’s phone.

In addition to monitoring, we will use the camera stream to develop vision algorithms to determine the health of the farm.

Agri-TYE

The IoT platform for Agriculture in India

Compared to drones, the Agri-TYE offer several advantages in India:

- No regulatory concern, since these are tethered. We would no longer need government exemptions. These can be deployed anywhere in the world, including India, where we don't expect favorable drone regulations in the coming years.
- Much cheaper. Based on my initial estimates, a tethered balloon that can carry up to 3 lbs and can go up to 200 ft can be assembled for less than 50 dollars (Compared to 1500 dollars for a low-end drone).
- No battery life concern. The helium needs to be refilled every few weeks. A drone's battery can only last 15 minutes using current technologies.
- Weather independent: They can remain afloat in rain or snow, compared to drones that we do not fly in the rain or windy weather.
- Low-tech: Can easily be adopted by farmers compared to the technical knowledge needed to fly drones

Components of our solution

- Hardware
  - Helium balloon
  - Tether
  - Payload holder

- Computing hardware
  - Smartphone/Hero Session on Balloon
  - Smartphone with Walker
  - Sensor Pad

Components (contd.)

- Connectivity
  - Between balloon phone and walker phone
  - Walker phone and sensor pad
  - Connectivity to the Cloud
- Software
  - App on the Balloon phone (Akshit)
  - App on the Walker phone (Avikalp)
  - Sensor pad embedded software (Apurv)
  - Data transfer code (Akshit)

Agri-TYE

The IoT platform for Agriculture in India

There are still three important follow-up questions:

(i) Why would farmers buy these cameras ?

(ii) How would the images be uploaded to the Microsoft cloud ?

(iii) How do we obtain aerial images given government regulations around drones ?

Block diagram of Balloon system

- Diagram with balloon, payload box hanging from balloon with dotted line showing smartphone inside, tether, stick figure of man holding tether and a smartphone. A small box on the ground next to the walker indicated as Sensor Pod.

Agri-TYE

The IoT platform for Agriculture in India

Project Aim

- Design , prototype and deploy hardware module for aerial photography and collecting farm data for precision agriculture.

- Study the feasibility of this platform with respect to how much time it can fly on one helium fill, the impact of wind, the effect of height, the size of the Agri-TYE, how many of them are needed for a given area, etc.

Agri-TYE

The IoT platform for Agriculture in India

Flight Module

It is basically a helium filled latex balloon (tethered) to which a hardware module carrying mobile phone / RasPI camera is attached .

What do we need to build one ?

- Helium Cylinder : 1.5 m^3 .
- Regulator , Teflon tape , Filling pipe with nozzle , Spanner .
- Weather Balloon : 150 g , PAWAN
- Mount , Phone .
- Tether rope with Winder .
- Stationery .
- HI-FLOAT.

Initial cost : Rs.15,000 ; Per deployment cost : Rs.1,500

Balloon

We use weather balloon , essentially made out of latex
PAWAN weather balloon – 150g

If inflated to Max burst diameter the balloon is capable

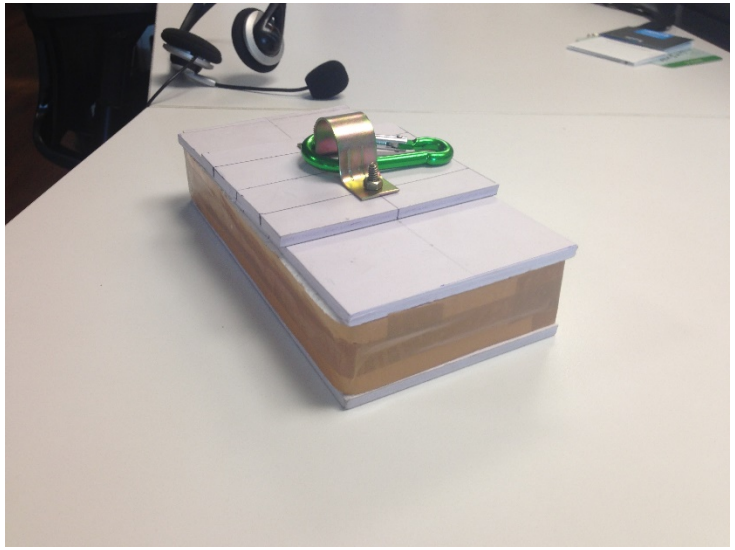
of carrying payload of 3kg . To achieve this 3.05 m^3 of

helium is required , which will cost up to Rs.3000 !!!

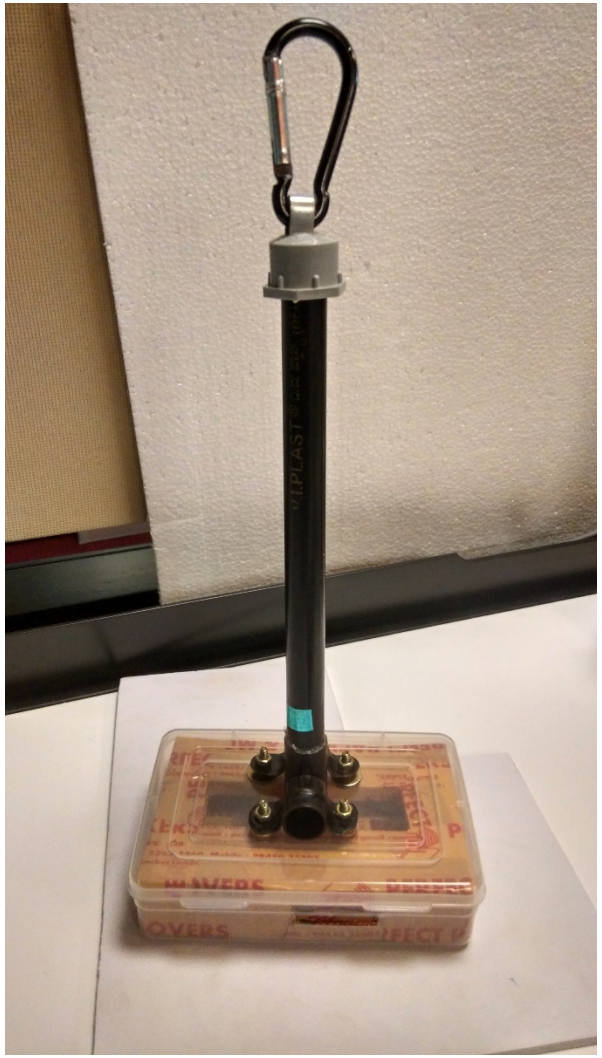
Latex balloon are porous , so helium eventually escape
So to solve this problem we use HI-FLOAT .

Payload and stabilization

Function of payload is to securely house mobile phone/RasPI and to attain stability , so that camera always faces downwards even being subjected to vibrations/jerks and to cool down the mobile/RasPI through cooling vents.



Payload and stabilization



Tether and Winder

To navigate and control the height of balloon, tether and winder are required .

Number of tether rope are available off-self :

Considering low weight to length ratio and strength

1) Spectra
2) Polyester
3) Polypropylene
4) Nylon

Duration of flight

- From our various trials , we draw a conclusion that single fill of helium to weather balloon -150g (with HI-Float) will last long for minimum 2 days carrying payload .

Height of flight

- We maintained about 40 – 80 ft to obtain images.

Height of flight is dependent on camera’s resolution and level of detailing required for analysis .

Helium

- Helium is the second lightest element ,because it is lighter than air , balloons are inflated with helium for lift. While hydrogen gas is more buoyant and highly flammable , helium has the advantage of being non-flammable.
- 1 ft^3 of helium gives lift of 28 gran
- Weight of payload

  Mobile + case + etc = 400 grams
- Weight of balloon : 150 grams
- Net weight = 550 grams

Diameter (feet)	Diameter (meters)	Volume (liters)	Lift (grams)	Lift (pounds)
1	0.3048	14.83	15.2	0.03
2	0.6096	118.62	121.7	0.27
3	0.9144	400.34	410.9	0.91
4	1.2192	948.96	973.9	2.15
5	1.524	1853.45	1902.2	4.19
6	1.8288	3202.76	3287	7.25
7	2.1336	5085.86	5219.7	11.51
8	2.4384	7591.72	7791.5	17.18
9	2.7432	10809.3	11093.7	24.46
10	3.048	14827.58	15217.7	33.55

To lift 550 grams of net weight and to have some +ve lift , the balloon should be inflated to 1.2 m diameter

Helium

- Volume of spherical balloon required to lift given weight at given pressure, temperature and altitude
- V = volume of balloon in cubic meters , T = 288 K
- $FB = W_{balloon} + W_{mount} + W_{harness\ \&\ platform} + W_{helium}$
- $W_{balloon}$ = (mass of balloon) x (g) = 4 π ($r2$) x (mass) x (9.81) = 123.3$r2$ N
- W_{mount} = (*mass of mount*) x (g).
- R_{He} = gas constant for Helium, g = acceleration of gravity
- W_{helium} = Ideal gas law =

  $=6.9589r^3$
- R_{air} = gas constant for air
- Force balance, the volume of the spherical balloon
- F_B = $=50.361r^3$ N
- Calculate ‘ r ’ and find volume using formula for sphere .

Helium cost and filling

- As our project is low cost alternative for drones in India , our focus is to attain certain height , acquire high resolution images , build lighter & secure payload and yet reduce the cost .
- 1.5m^3 of helium cylinder costs about Rs.1,500

Filling Proc

Deployment

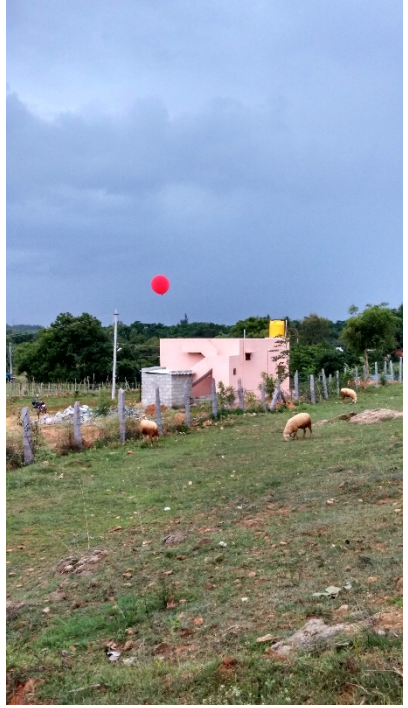
- First trail : Hebbal, Bangalo

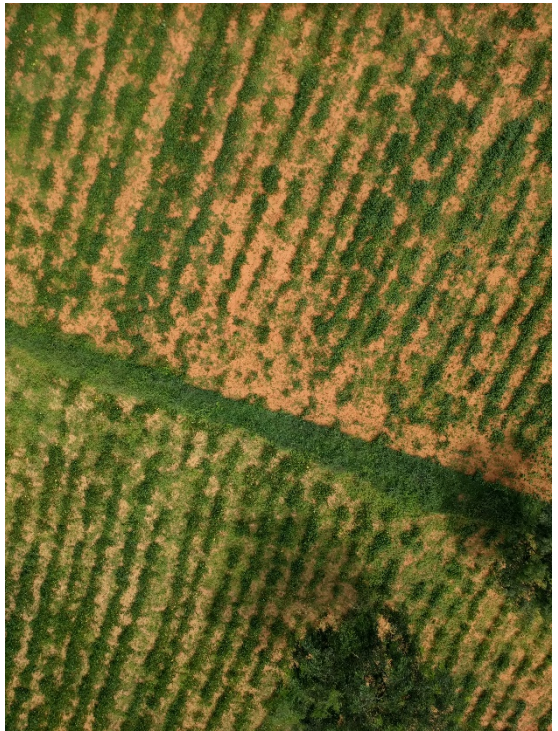
Deployment

- Second trail : Hebbal , Bangalore

Deployment

- Third trail : EIEO farm





Deployment

- Fourth Trail : TDU

Results

Results

Smart Phone as a Tethered Eye

Developing the Smartphone as a Platform

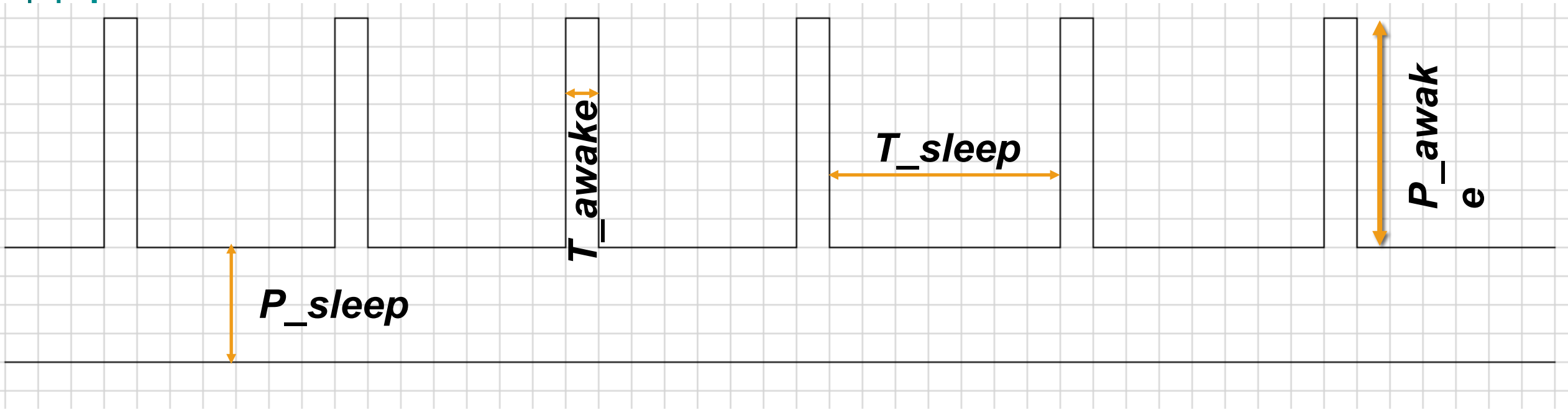
- Criteria for selection of a Smart phone (Android) as a platform
  - Commodity hardware and rapid decrease in price-performance
  - No additional overhead of developing custom hardware
  - Extensive API support for Android
- Challenges associated with using the Smart phone as a platform
  - Extensive Battery Drain
  - Connectivity Issues in the farm
  - Additional weight added due to unnecessary components (as opposed to a GoPro)

Battery Drain Challenge

- Major pressure points for the Battery
  - CPU (Central Processing Unit)
    - Short interval (in the order of seconds) for which images are being captured prevents the CPU from going to sleep so fast
    - Hold the CPU awake in locked screen conditions
  - Display
    - Major power consumer (in the order of Watts)
  - Network
    - Needs to be continuously on for transmitting/recording GPS data to the Guidance App
  - Camera
    - May cause excessive heating of the phone if continuously on

Modelling the Battery Drain Problem

The battery consumption by major pressure points can be modelled in the following manner



P_sleep : Sleep Power

P_awake : Awake Power Consumption

T_sleep : Set Time Interval for closing the camera

T_awake : Time image / video capture

Note : The model is in an ideal case approximation and not to scale

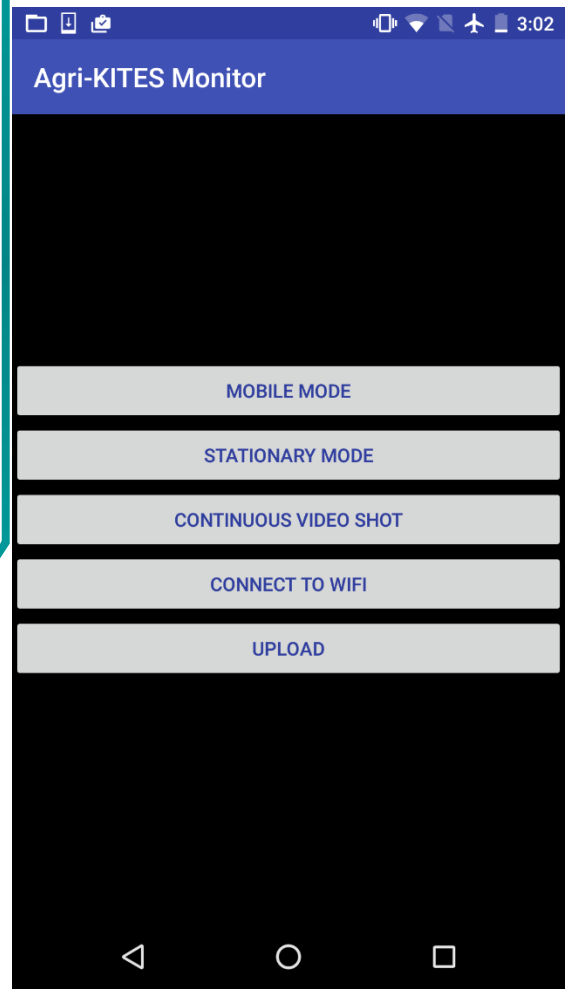
Techniques to improve the battery life

- Reduce P_sleep
  - Put phone in Airplane Mode
- Reduce P_awake
  - Screen off when taking pictures or video
  - GPS On only when needed
- Reduce T_awake/T_sleep
  - Reduce time to turn on camera
  - Turn off camera aggressively
  - Turn on camera only when needed

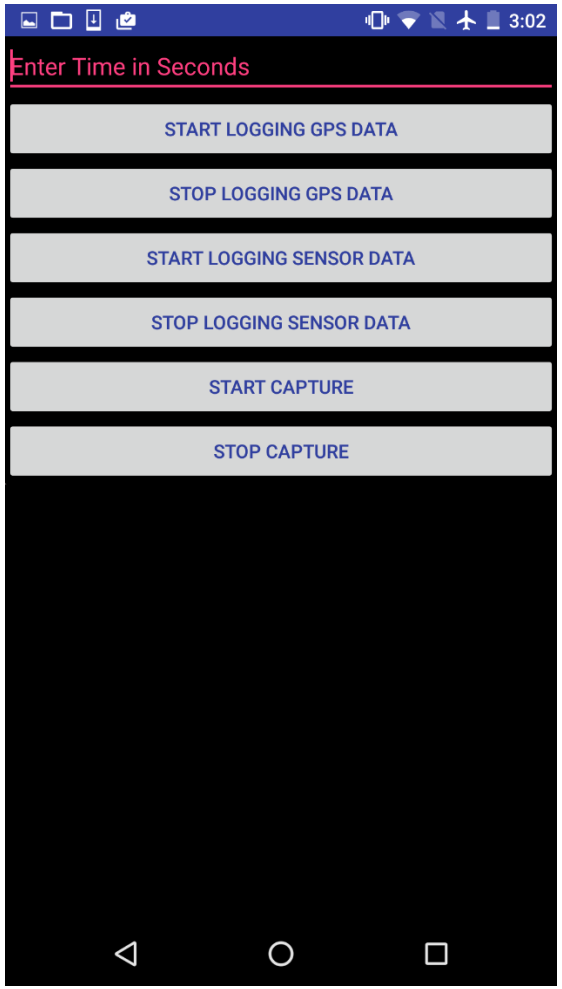
Description of the Mobile App

- Android Mobile App- Compatible with Lollipop (API 21) and above
- Operates in Two Modes – Mobile Mode & Stationary Mode
- Operation in Stationary Mode
  - Acts a surveillance/monitoring device
  - Takes burst for video for specified seconds for a given time interval
  - Does continuous video transfer to Ground Station for real time data
- Operation in Mobile Mode
  - Acts as a data gathering device tethered to the balloon
  - Takes images every specified seconds
  - Does bulk data transfer to the Ground Station after completion of the survey
  - Communicates with the Guidance Application for real time feedback

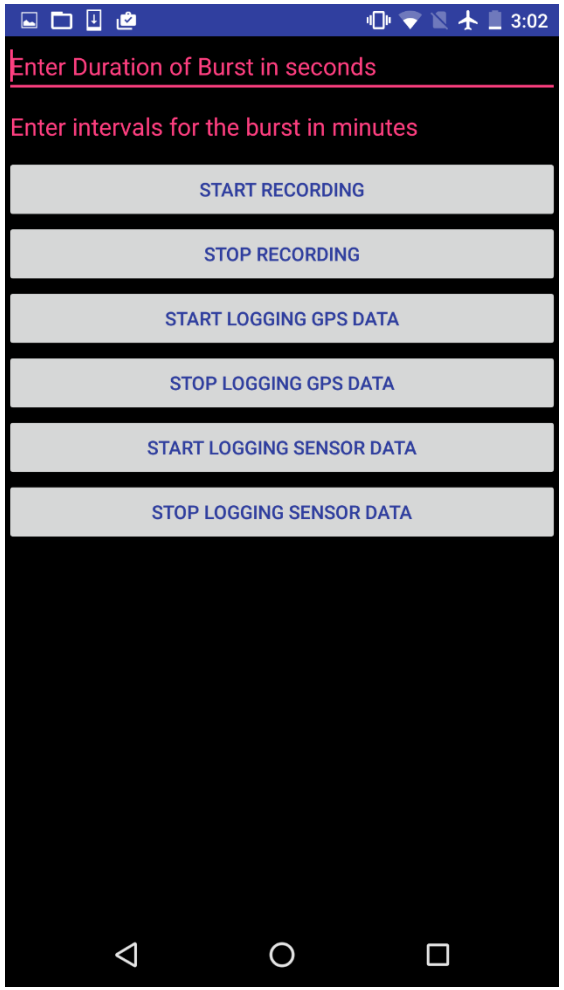
Interface of the Mobile Application



Interface for Mode Selection



Operation in Mobile Mode

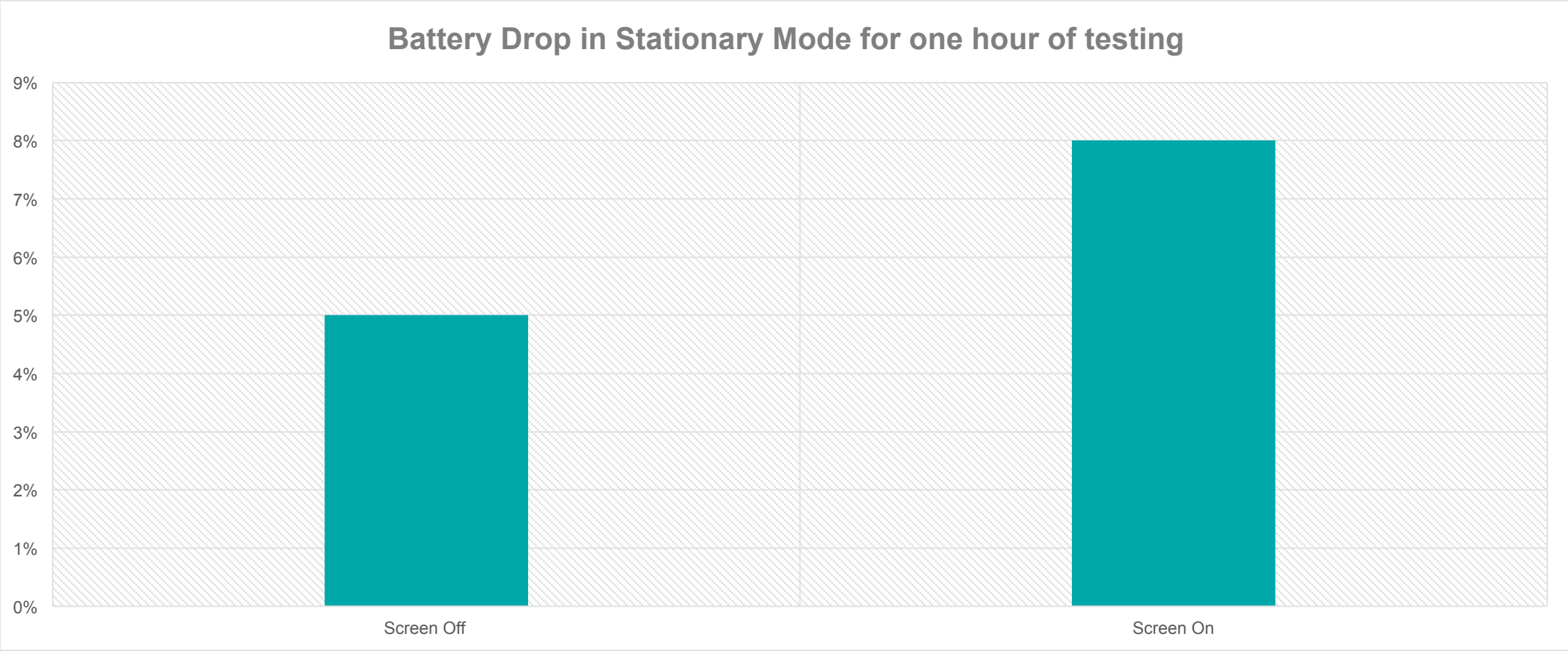


Operation in Stationary Mode

Comparison of Techniques in Stationary Mode & Mobile Mode

Techniques	Stationary Mode		Mobile Mode	
	Off the Shelf Phone	Rooted Phone	Off the Shelf Phone	Rooted Phone
Put phone in Airplane Mode	✓	✓	✓	✓
Screen Off when taking pictures/videos	✓	✓	✓	✓
GPS On Only when needed	✓	✓	✓	✓
Turn Off Camera Aggressively	✓	✓	✓	✓
Undervolt the CPU	×	✓	×	✓
Changing Screen	×	✓	×	✓

Battery Results in Stationary Mode

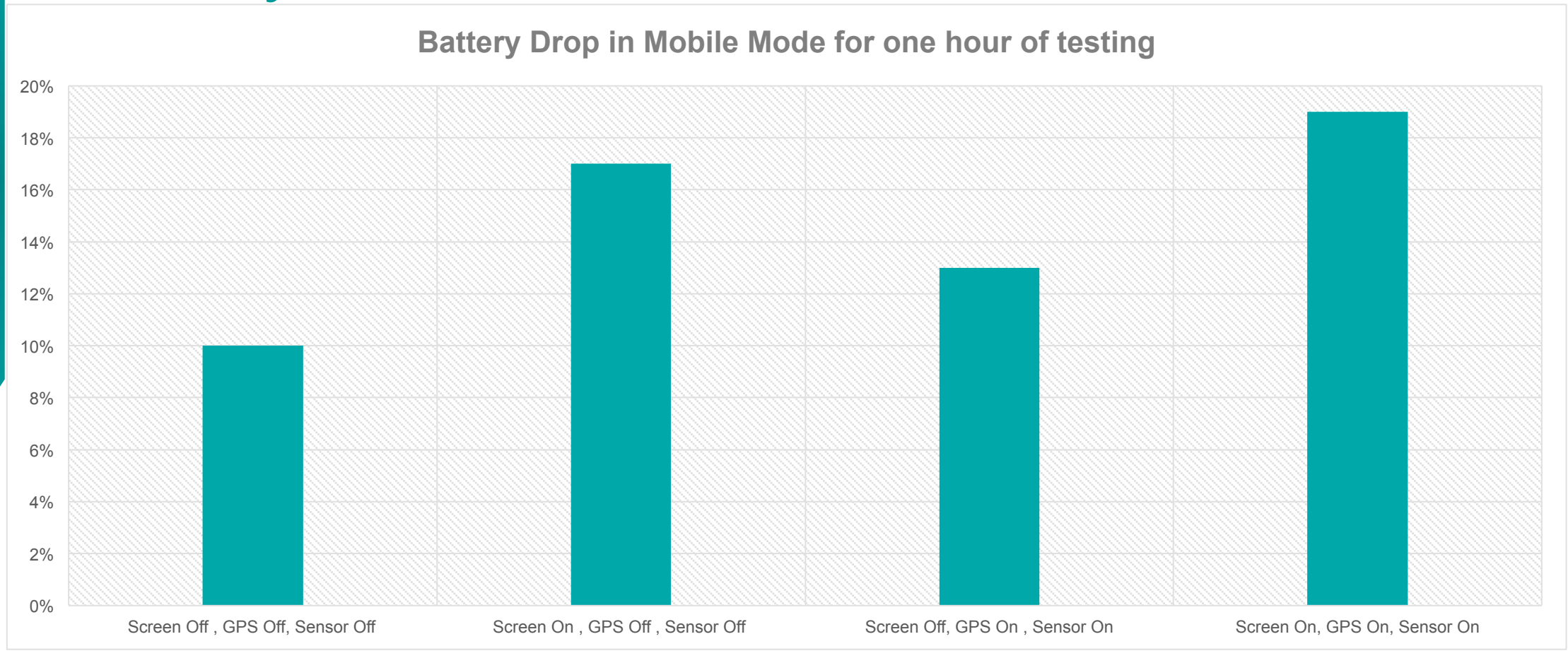


Camera : Duty Cycled
Sensor Logging : Off
Wifi : Duty Cycled

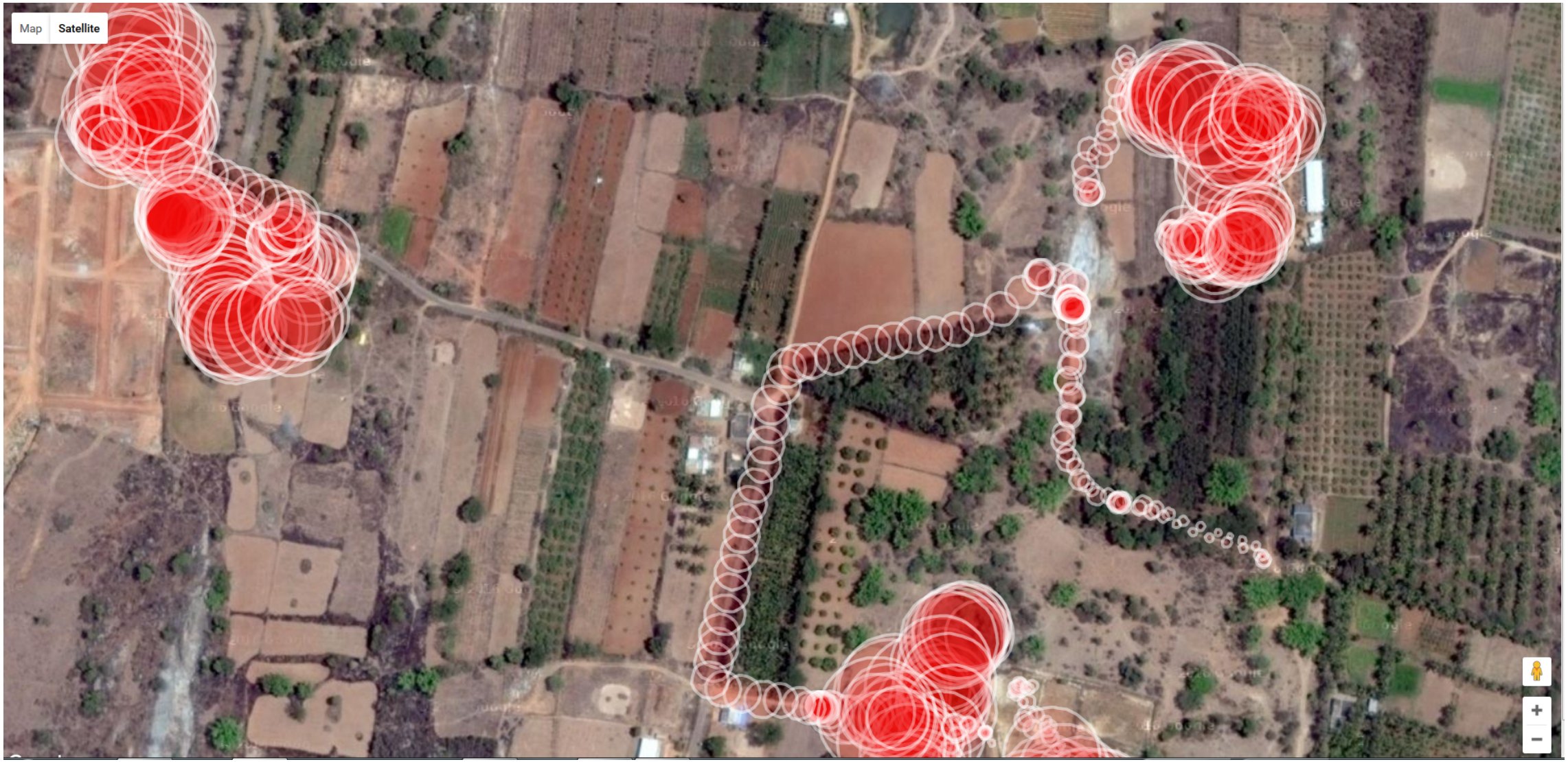
GPS Logging : Off

Airplane Mode : On

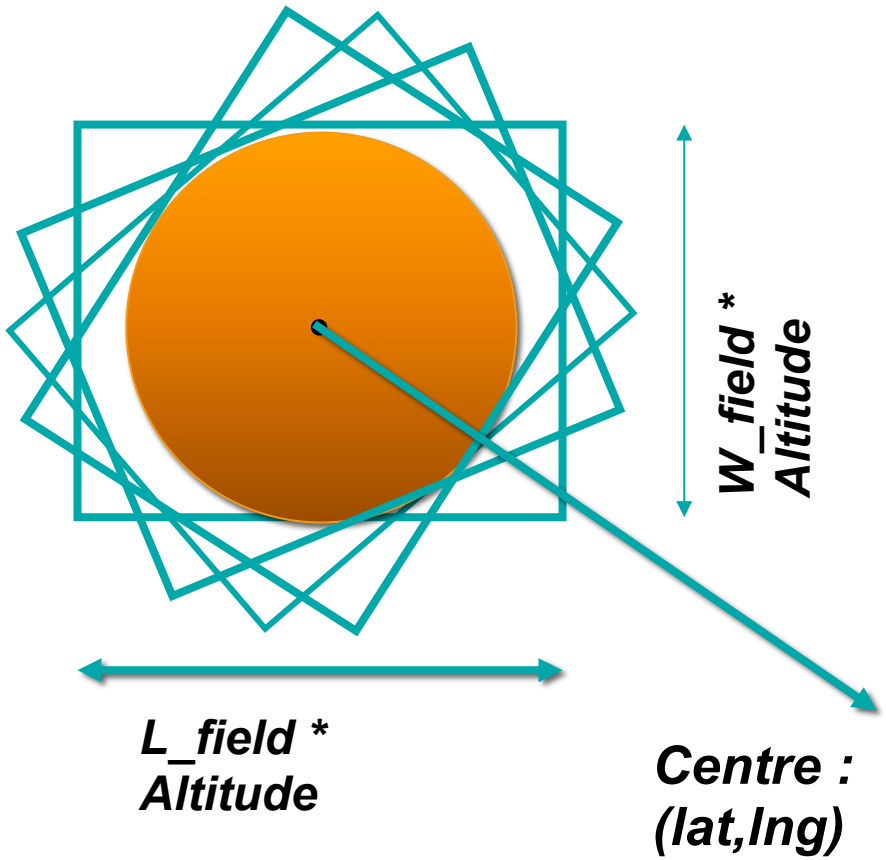
Battery Results in Mobile Mode



Visualization Tool for Farmer



Estimating the Covered Area



Top View as observed by the Camera

Getting a conservative estimate of the area covered by the camera for visualization and feedback to the Farmer

Focal Length	4.67 mm
Image Sensor Width	4.55 mm
Image Sensor Length	6.17 mm
Field of View Angle (Width)	51.94°
Field of View Angle (Length)	66.89°

Radius of the In circle is ***W_field * Altitude / 2***

Assumption : Camera Plane is parallel to the plane of the ground

Estimation of area coverage

- One fill of helium , the balloon stays afloat for 2 days.
- 20 mins of videos and 10 mins of cooling , which approx. covers area of 4,200 m^2 .
- 8 hours of survey in a day , then for 2days = 960 mins .
- Considering 20 mins video and 10 mins cooling , 32 video session can be captured in 2 days. If single session can cover 4,200 m^2 of area , then 32 sessions can cover 1,34,400 m^2 / 33.2 acre / 13 hectare.
- Cost : Approx. Rs.45 per acre of aerial imagery .

So above area can be covered in single deployment (2 days).

Hackathon 2016

//oneweek

Hackathon 2016

//oneweek

Hackathon 2016

//oneweek

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Vasuki

Deepak Vasisht

Zerina Kapetanovic

Hackathon 2016

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FarmBeats : IoT for Agriculture

Won 1st Place , Hackathon 2016 , Redmond.

Under Industries Category

Thank You