UNIVERSITI PUTRA MALAYSIA
AGRICULTURE • INNOVATION • LIFE

Visual IoT (V-IoT) for Intelligent Agriculture

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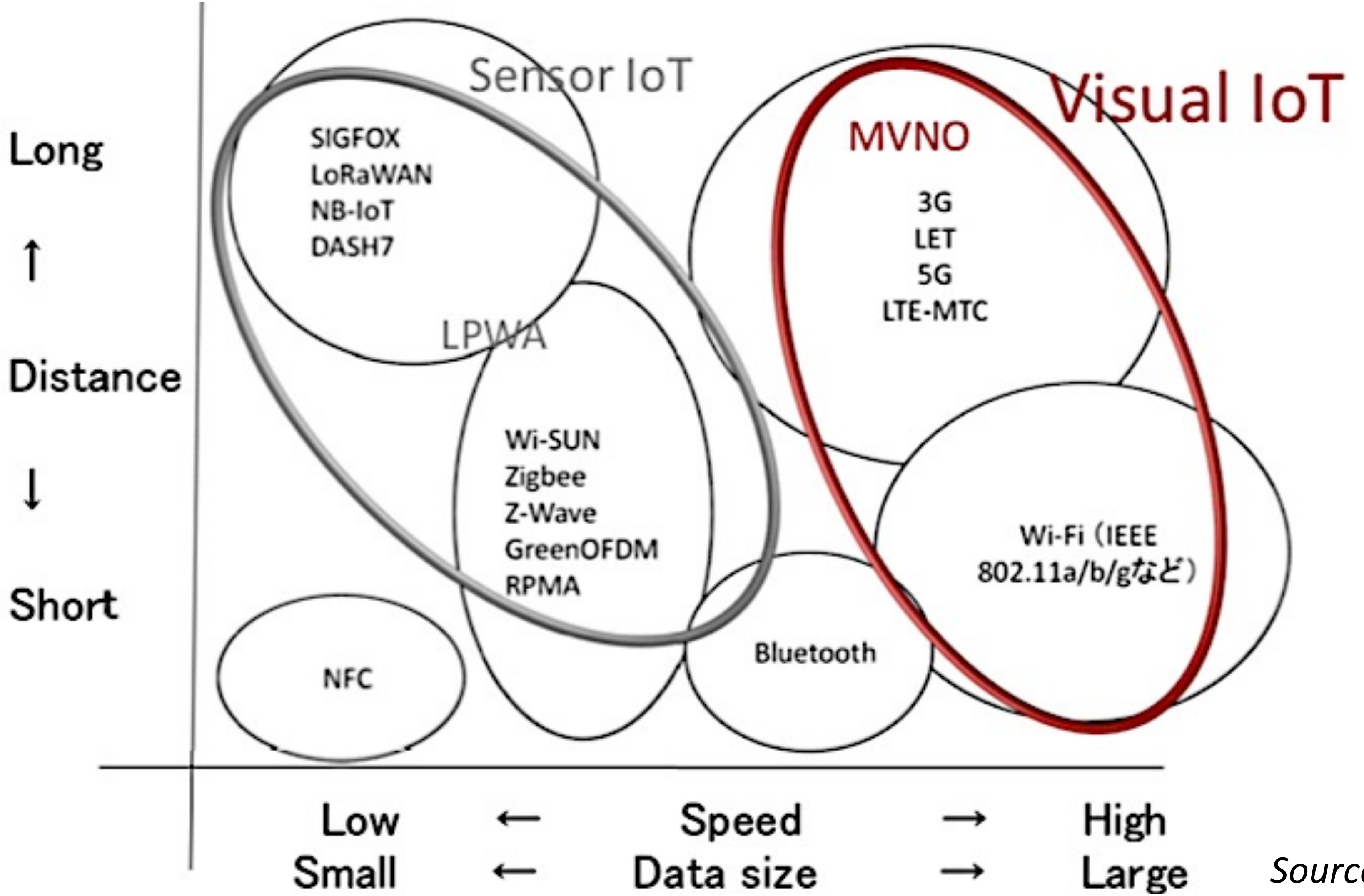
Introduction

- Widespread deployment of the Internet of Things (IoT) has changed the way network services are developed, deployed and operated.
- Recently, most advanced IoT devices are equipped with visual sensors, subsequently forming the so-called visual IoT (V-IoT).
- The V-IoT utilizes visual processing techniques due to the need for sensing and processing visual data which has direct impact on computational complexity, cost (data storage and processing) and efficiency of transmissions

How IoT evolves in Agriculture

Early algorithms → Machine Learning → Deep Learning

SMART AGRICULTURE



INTELLIGENT AGRICULTURE

Source: www.Apan.net

IoT Data Generation

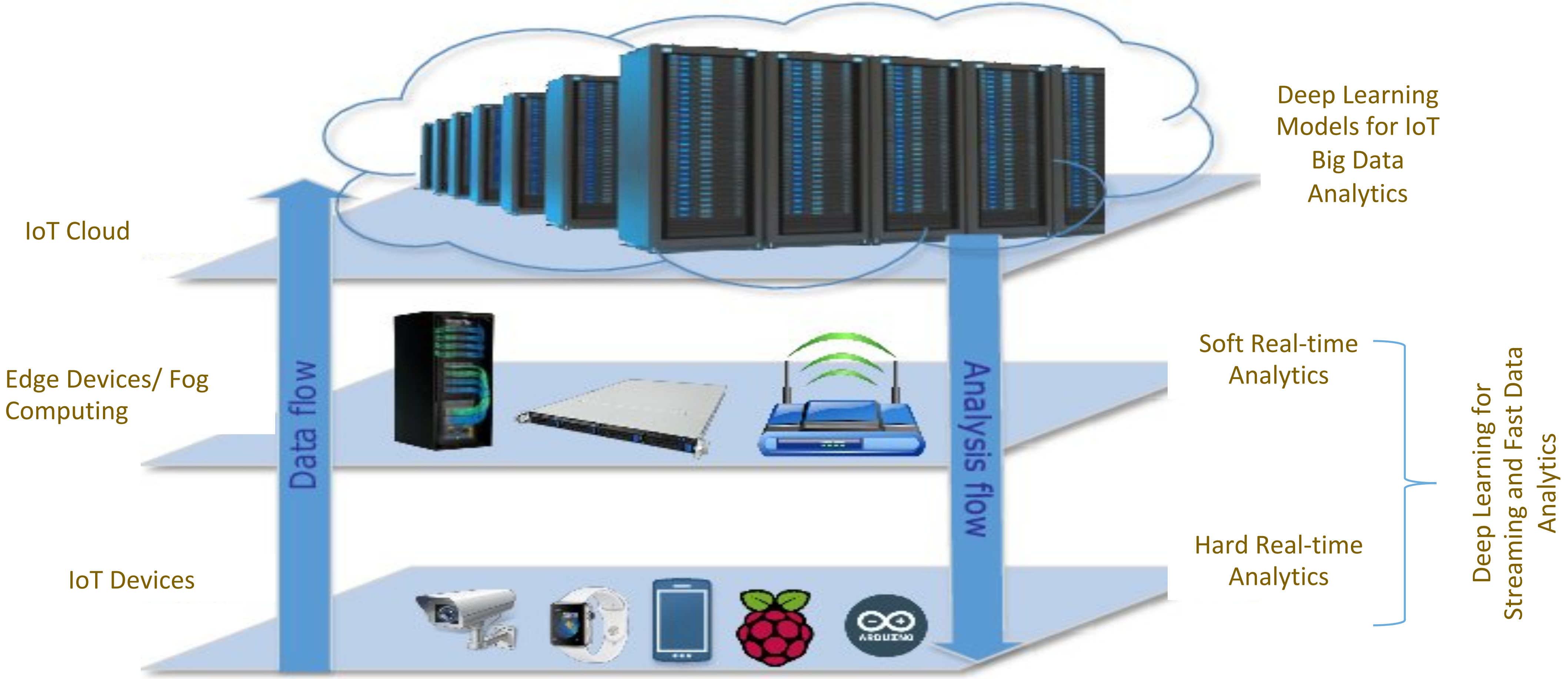


Figure 1: IoT data generation at different levels and deep learning models to address their knowledge abstraction. *Source: IEEE Communications Surveys & Tutorials*

Issues with current IoT adoption

- NB-IoT & LPWAN IoT is limited to serial/time series data
- Constraint on limited coverage of LPWAN IoT esp. in the terrestrial landscapes / propagation in foliage-rich areas
- Optimisation and configuration of transmission parameters such as spreading factor (SF) and data rate for LPWAN IoT to transmit 2D/3D data (images, video, sounds etc) are not a straight forward task
- 5G is paving a way for better transmission of massive IoT data

Objectives

The objectives of this project are:

- To develop an intelligent agriculture system based on Visual IoT (V-IoT) architecture;
- To evaluate the performance of the V-IoT framework in term of communication capability (latency, data rates and effective utilization of channels) using latest communication platform such as LTE/5G;
- To verify the proposed V-IoT architecture for intelligent agricultural applications in terms of analytical accuracy.

Methods & Project Planning

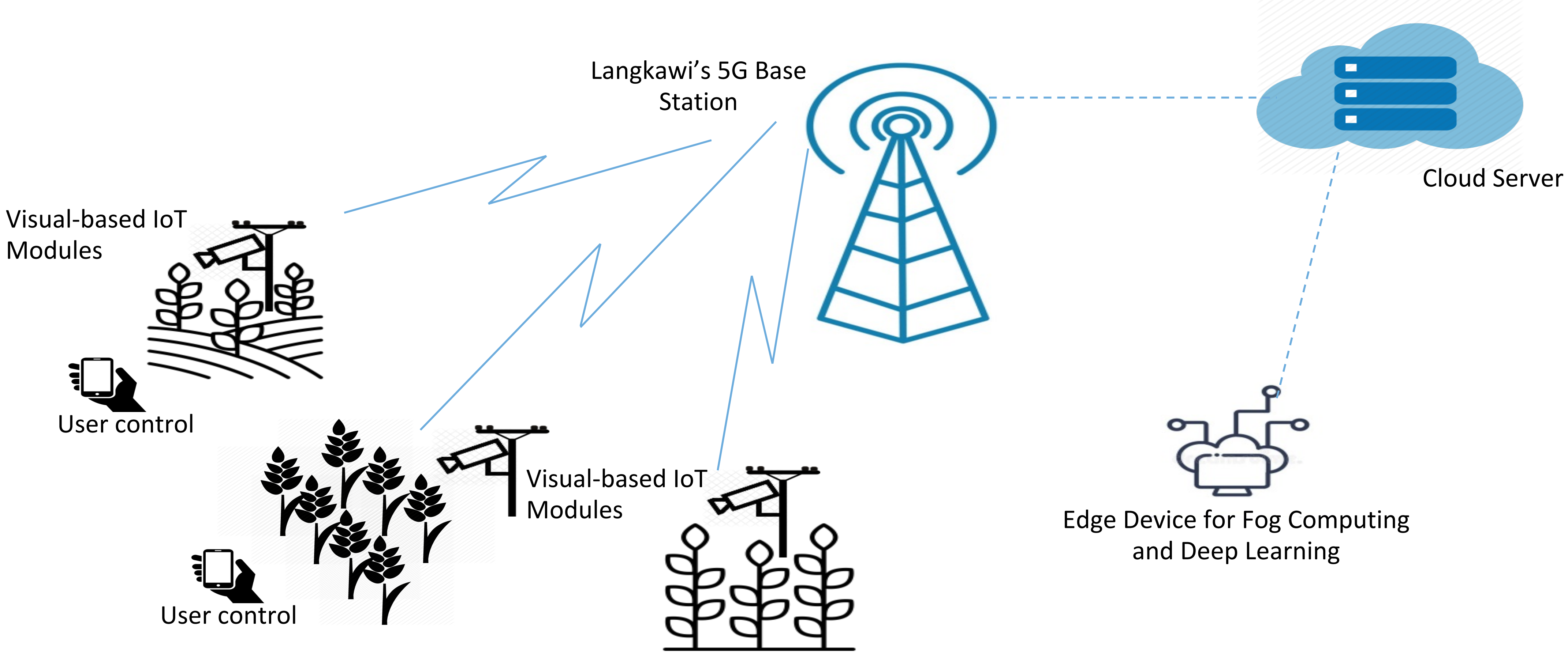


Figure 2: 5G Visual-IoT Framework that will be developed at MARDI's Agro Technology Park, Langkawi

AGROTECHNOLOGY PARK FEATURES

FRUIT ORCHARDS	- 15.19 HA
VEGETABLE PLOTS	- 1.20 HA
RECREATIONAL ZONES	- 1.50 HA
TROPICAL FOREST RESERVE	- 8.00 HA
HERB GARDEN	- 0.50 HA
OFFICE BUILDINGS	- 0.80 HA
RUBBER TREES	- 0.20 HA

JUMLAH	27.39 HA

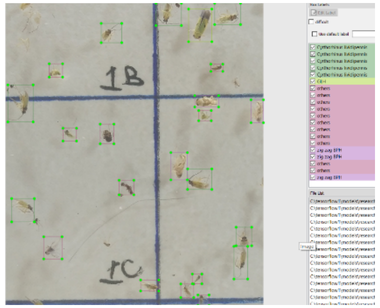

Agrotechnology Park
MARDI Langkawi
MARDI
INSTITUT PENYELIDIKAN DAN KEMAJUAN PERTANIAN
MALAYSIA


Teluk Datai
Pantai Pasir Tengkorak
Gua Cerita
Tanjung Rhu
Pulau Langgun
Teluk Ewa
Pantai Pasir Hitam
Padang Lalang
Gunung Mat Cincang
Air Terjun Temurun
Telaga Tujuh
Taman Buaya
Air Hangat
Durian Perangin
Kilim
Gua Kelawar
Galeria Perdana
Teluk Burau
Pantai Kok
Kuala Teriang
Beras Terbakar
Padang Matsirat
Ulu Melaka
Kg.Buku
Luhuk Semilang
Kisap
International Airport
Gunung Raya
Makam Mahsuri
Kg Tok Senik
Kuah
Pulau Rebak
Laman Padi
Kedawang
Taman Lagenda
Pantai Cenang
Temoyong
Dataran Lang
Jeti/ Terminal Feri
Underwater World
Pantai Tengah
Porto Malai
Star Cruise
Pulau Dayang Bunting
Pulau Tuba
Pulau Singa
Tasik Dayang Bunting
Layar Langkawi
http://langkawi.tourguide.net

#TATML

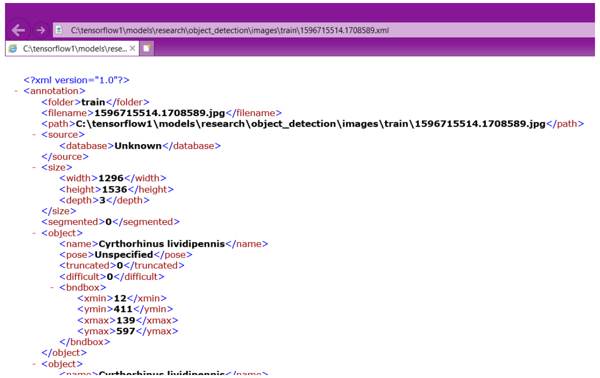
Insect Pest Recognition using Machine Learning

Image Labelling



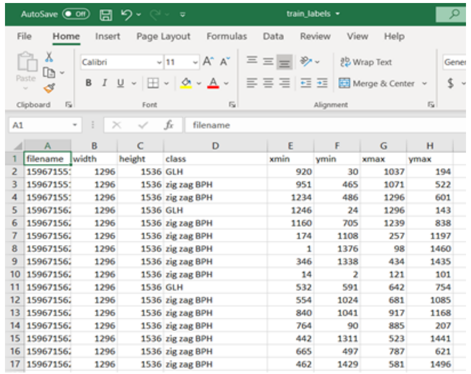
Insect were labeled into species with labelImg

.xml Files Generation



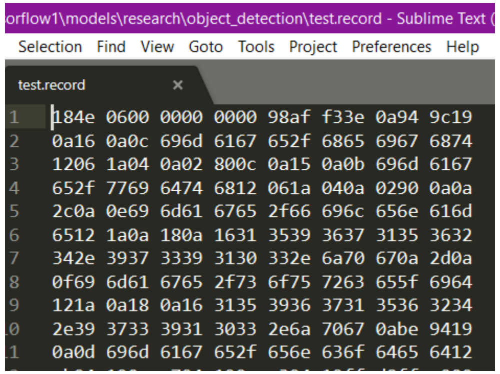
.xml files created when the insects were labeled. There were 1 .xml file per image

.xml to .csv Conversion



The .xml files were compiled and converted to .csv files.

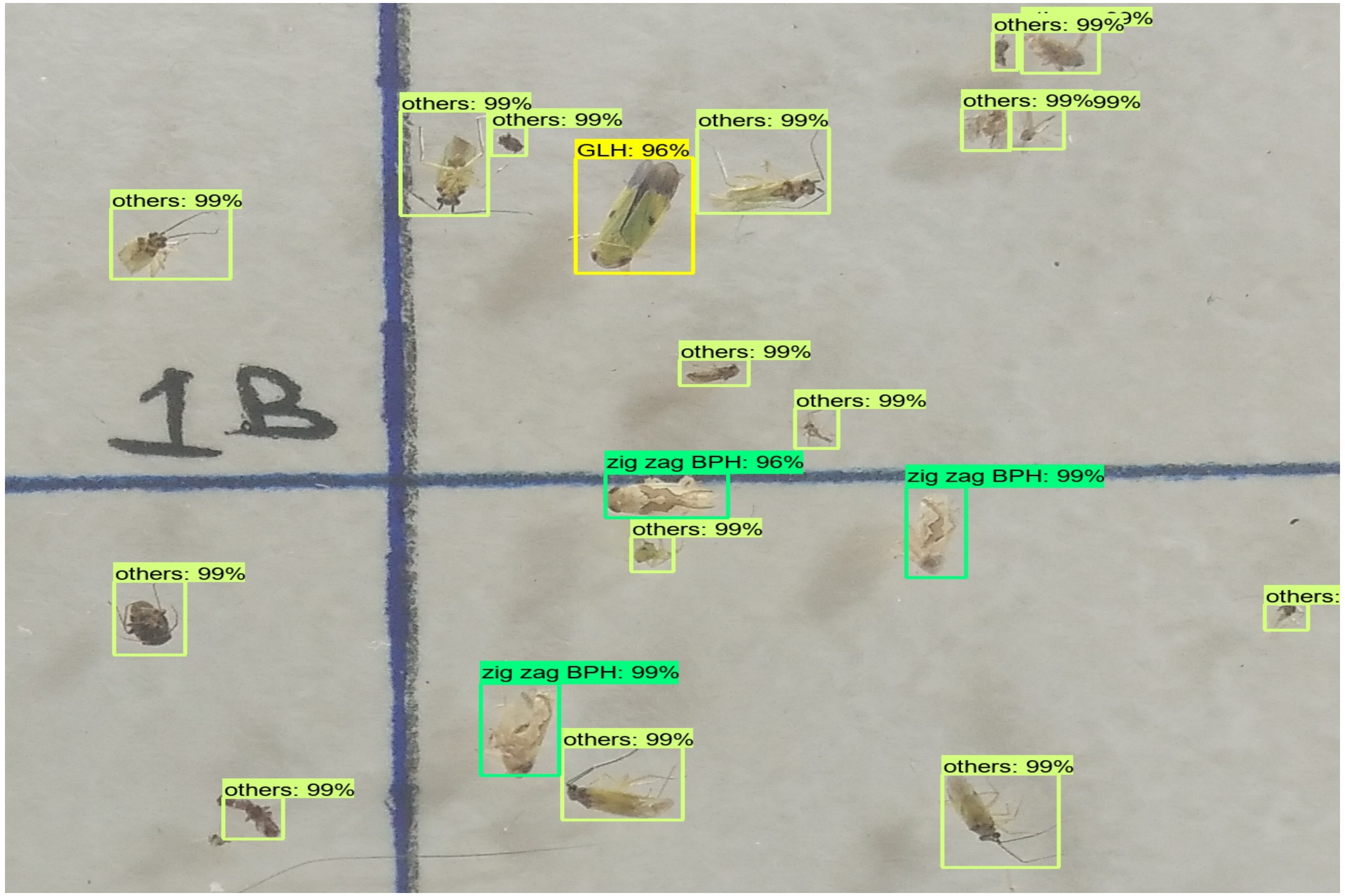
.csv to .record Conversion



The .csv files were converted to .record files

Insect Pest Recognition using Machine Learning

- Based on our pilot study, a Deep Learning model was developed using Faster R-CNN pretrained model
- The model had accuracy around 93% on identifying insect pests in the field



Insect pests were labeled, recognized and counted using deep learning analytics

Methods & Project Planning

Figure 4: This work will be extended to the full deployment of 5G V-IoT architecture at MARDI Agro Technology Park located near Kuah, Langkawi accessible to a TM 5G New Radio (NR) base station delivering 5G on 700MHz and C-Band simultaneously.

Gantt Chart and Project Milestones

Milestones	Project Activities	2021												2022					
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Development of visual-based 5G I-IoT framework	Stakeholder engagement	■	■																
	Visibility investigation on hardware components for the end nodes	■	■																
	Design and development of a 5G vision-based IoT module			■															
	Re-train the pre-trained the deep learning model				■	■													
	Design and conversion of deep learning model at edge device				■	■													
	Communication protocol implementation						■	■											
Experimental Setup of the System	Test bed set up at MARDI Agro Technology Park								■	■									
	Updating the pre-trained model with new data										■	■	■						
	Run measurement campaign for 5G communication capability analysis for images data										■	■	■						
System Verification	Run the full 5G V-IoT pest recognition system at the test site													■	■	■			
	Validation of the data analytics accuracy of the pest recognition																■		
	Efficiency assessment of full end-to-end application																	■	
	Results interpretation, discussion and documentation																		■

Benefits

- For community: Visual-IoT can be adapted for a wide range of applications
- For M&C Industry: help accelerate innovation and progress to be used once 5G technology is fully rolled out

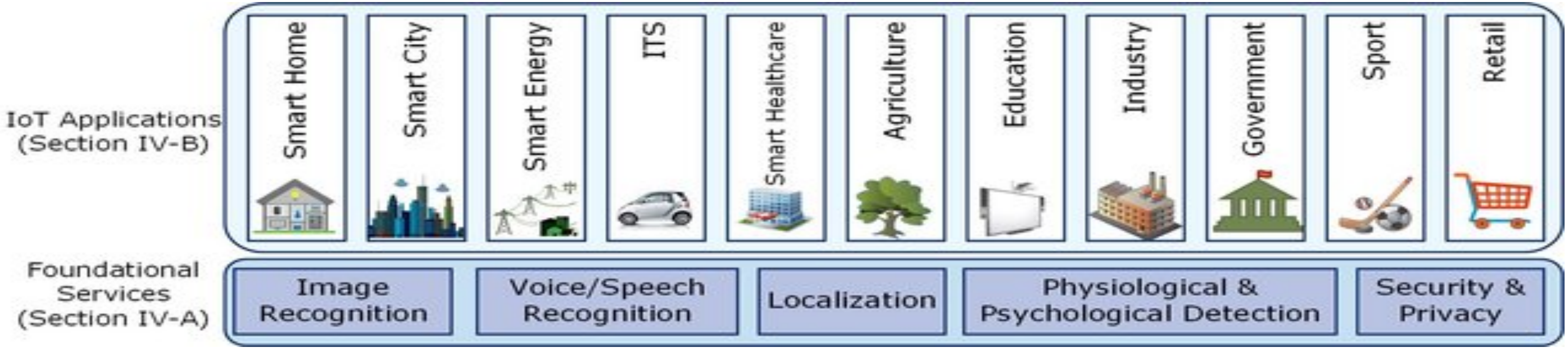
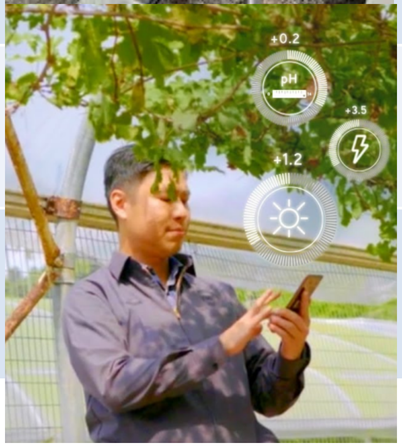


Figure 5: IoT verticals and the foundational services. *Source: IEEE Communications Surveys & Tutorials*

Standards Development

Table 1. Comparison of requirements for agricultural solutions based on IoT functional architecture

Requirements	Visual IoT- 5G	NB-IoT	LoRA
Computing	Complexity and computational capabilities		
Connectivity	Nodes– edge computing systems– cloud-based services (latency, data rates, effective utilization of channels)		
Security	Confidentiality, integrity and authentication		
Manageability	Device, network and functionality management		
Analytics	Analytical accuracy		



Challenges and Future Trends

- Challenges:
  - **Computation**: High noise visual data (overlapped and condensed insects on images; or complex image conditions: require high level computational algorithms)
  - Availability of **communication** network
- Future Trends:
  - Advanced data analytics algorithms to process large visual data at much faster rate are expected to boost the adoption of V-IoT applications in agriculture.
  - Wide and good coverage of communication network could improve adoption of the applications

References

- Dan Wang, Dong Chen, Bin Song, Nadra Guizani, Xiaoyan Yu and Xiaojiang Du. From IoT to 5G I-IoT: The Next generation IoT-Based Intelligent Algorithms and 5G Technologies. *IEEE Communications Magazine* vol. 56, no. 10, pp. 114-120, October 2018, doi: 10.1109/MCOM.2018.1701310
- Mehdi Mohammadi, Ala Al-Fiqaha, Sameh Sorour and Mohsen Guizani. Deep Learning for IoT Big Data and Streaming Analytics: A Survey. *IEEE Communications Surveys & Tutorials*, vol. 20 no. 4, 4th Quarter 2018, doi: 10.1109/COMST.2018.2844341
- Akram H. Jebril, Aduwati Sali, Alyani Ismail, Mohd Fadlee A. Rasid. Overcoming Limitations of LoRa Physical Layer in Image Transmission. *Sensors*, 18(10):3257, 2018, doi: 10.3390/s18103257
- Lai Zhi Yong. Paddy Insect Pest Identification using Artificial Intelligence and Machine Learning. Final Year Thesis, Bachelor of Agricultural and Biosystems Engineering with Honours (unpublished), 2020. University Putra Malaysia.