Project Title: **A framework for intelligent computations at IoT network edge computing for agriculture**

Background :

- Internet of Things (IoT) is the essential ICT infrastructure for smart agriculture.
- The huge number of connected devices in IoT systems requires efficient traffic engineering, big data processing and security.
- A security framework is essential for IoT systems which should able to different layers of network security for IoT environments.

Targets:

1) Proposal of Artificial Intelligence(AI) based traffic engineering techniques for IoT systems.
2) Proposal of a security framework for IoT systems including AI-based solutions for secure IoT infrastructure, secure data acquisition and transfer system.
3) Developing an application for prediction of disease status of trees in agriculture is developed and implemented.

Speaker: Dr. Trong-Minh Hoang
Post and Telecommunications Institute of Technolgy, Vietnam

Project Title: **A framework for intelligent computations at IoT network edge computing for agriculture**

Project Members :

Vietnam:

Trong-Minh Hoang, Dang-Hai Hoang, Huu-Tien Vu (PTIT)

Xiem-Hoang, Nam-Hoang Nguyen, Linh-Trung Nguyen, Thuy-Quynh Tran Thi (VNU);

Japan

Takeshi Takahashi (NICT)

Malaysia

Norliza Mohd Noor, Dr Hazilah Mad Kaidi, Dr Norulhusna Abdullah (UTM)

Thailand

Chalee Vorakulpipat (NECTEC)

Project Duration : 2021-2023

Project Budget: 75.000 USD

Project Activities

In the project, three major research activities will be carried out:

1) Proposing AI based algorithms to enhance quality of video streaming in IoT systems;

2) Developing a comprehensive security framework for IoT systems applied in smart agriculture;

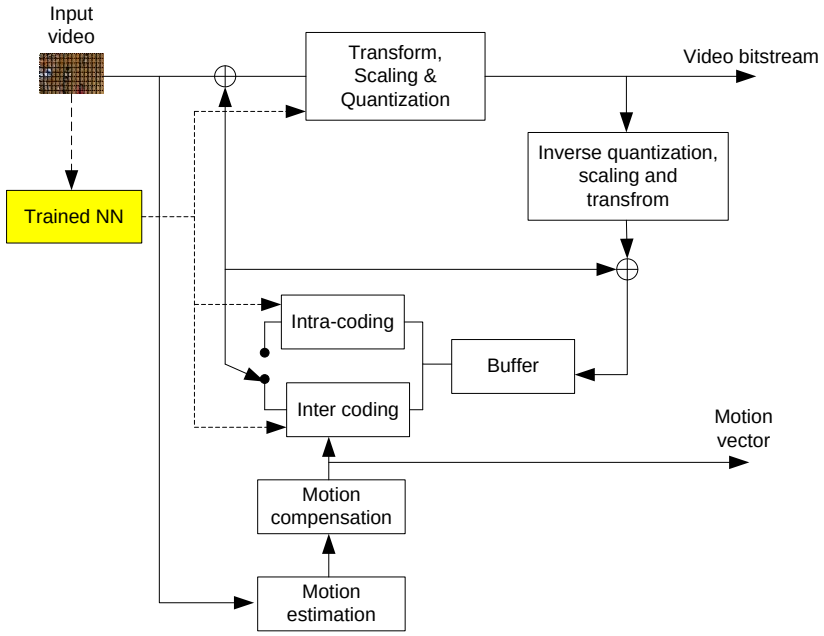
3) Developing an application for disease prediction on designed IoT for smart agriculture.

Motivations:

- In visual sensor networks, the task of video codec is to transmitting and receiving video streaming from nodes to central server. Therefore, the performance of video codec play an important role in enhancing the performance of IoT systems.
- Currently, the video codec H.265/HEVC has some more advantages such as higher compression rate, supporting higher resolution. However, HEVC still has some limitations such as the bitrate is rather high and optimization in coding mode decision is complicated and time consuming.
- Using AI algorithms to improve performance of HEVC codec up to 20% in terms of encoding time, encoding complexity, bitrate and quality of video.

Description:

- Improving HEVC codec performance by using trained NN to help the encoder to decide how to split the coding unit into coding blocks and the optimal coding modes for the coding blocks.
- In addition, NN will help encoder to select the optimal the quantization parameter to adjust the bitrate at the output of encoder according to the content of video.



Experiments plan:

- Establish a visual sensor network include:
  - 50 IP cameras at 4 sites.
  - 02 central server receiving video streaming.
- Performance assessment:
  - PSNR (dB) measurement
  - Subjective image quality assessment
  - Bitrate measurement

Budget plan

1st YEAR	Frequency/unit	Cost for 3 members (USD)	TOTAL (USD)
Knowledge sharing activities inclusive Attending Workshop and Conferences (travel and accommodation) • Japan • Vietnam • Thailand • Malaysia	 1 1 1 1	 5000 1500 1500 500	8,500
• Propose algorithm to enhance the performance of video codec • Field test and data collection		-	8,000
2nd YEAR			
Knowledge sharing activities inclusive Attending Workshop and Conferences (travel and accommodation) • Vietnam • Thailand • Malaysia	 1 1 1	 1500 1500 500	3,500
Data Collection & Analysis		-	5,000
TOTAL			**25,000**

Motivations:

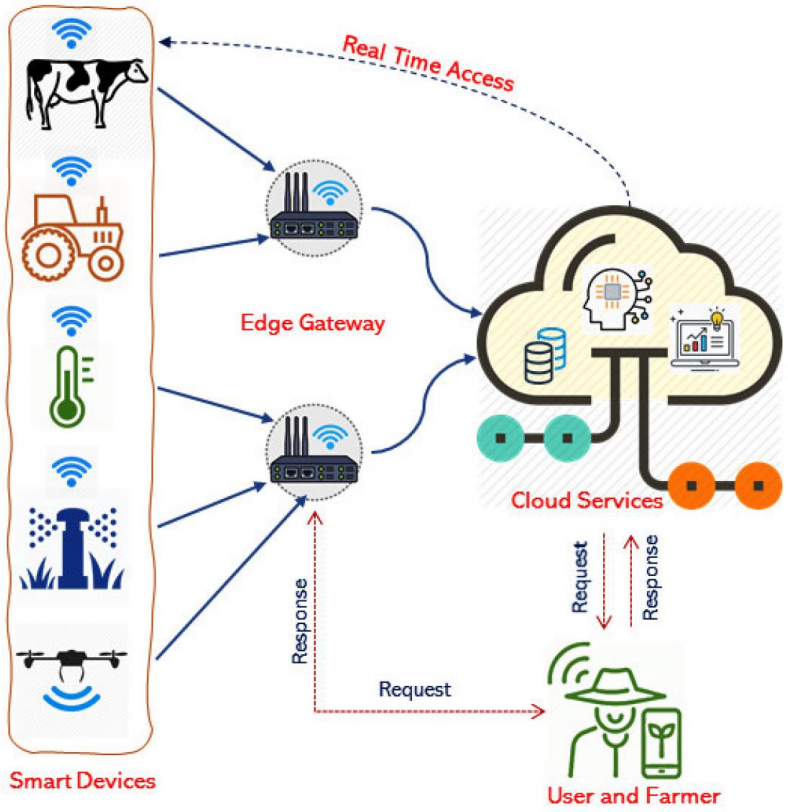
With the help of sensors (light, humidity, temperature, soil moisture, etc.), the IoT-based smart agriculture is a revolution. In which, the farmers can monitor the field conditions from anywhere in terms of more efficient water usage, or optimization of inputs and treatments.

Beside conventional, large farming operations, the smart agriculture also has new trends, such as organic farming, family farming (complex or small spaces, particular cattle and/or cultures, preservation of particular or high-quality varieties, etc.), and enhance highly transparent farming.

Developing a comprehensive security framework for the systems is extremely important.

Description:

- The security framework focuses on 3 levels: Data Acquisition, Data Transfer, and Data Processing and Storage.
- The proposed solutions based on advanced algorithms and technologies such as Machine Learning, Lightweighted Transfer, AI, and Blockchain.



A model of end-to-end interaction between various stakeholders in smart farming [1].

[1] Maanak Gupta; Mahmoud Abdelsalam; Sajad Khorsandroo; Sudip Mittal **Security and Privacy in Smart Farming: Challenges and Opportunities,** IEEE Access (Volume: 8), p.p 34564 – 34584, February 2020

Experiments plan:

- Implement a testbed includes:
  - 3 sensor networks with 1 IoT gateways and 8 smart devices per network.
  - 3 workstations for AI, ML, Blockchain,… research.
- Performance assessment:
  - System operation
  - Test ability of combating cyber attacks.

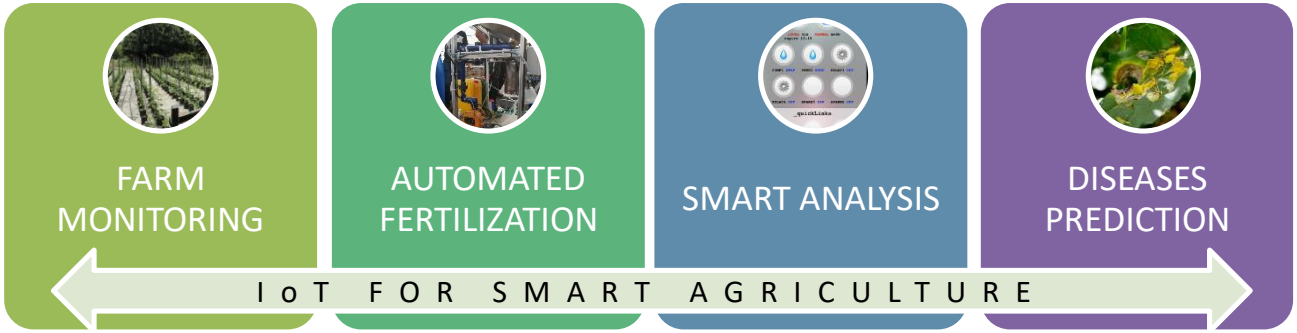
Budget plan

1st YEAR	Frequency/unit	Cost for 3 members (USD)	TOTAL (USD)
Knowledge sharing activities inclusive Attending Workshop and Conferences (travel and accommodation) • Vietnam • Thailand	 1 1	 1500 1500	 3,000
• Build a testbed		15,000	15,000
2nd YEAR			
Knowledge sharing activities inclusive Attending Workshop and Conferences (travel and accommodation) • Vietnam • Thailand	 1 1	 1500 1500	 3,000
Data Collection, Analysis & Testing		4,000	4,000
TOTAL			**25,000**

Activity 3: Application For Disease Prediction On Designed IoT For Smart Agriculture

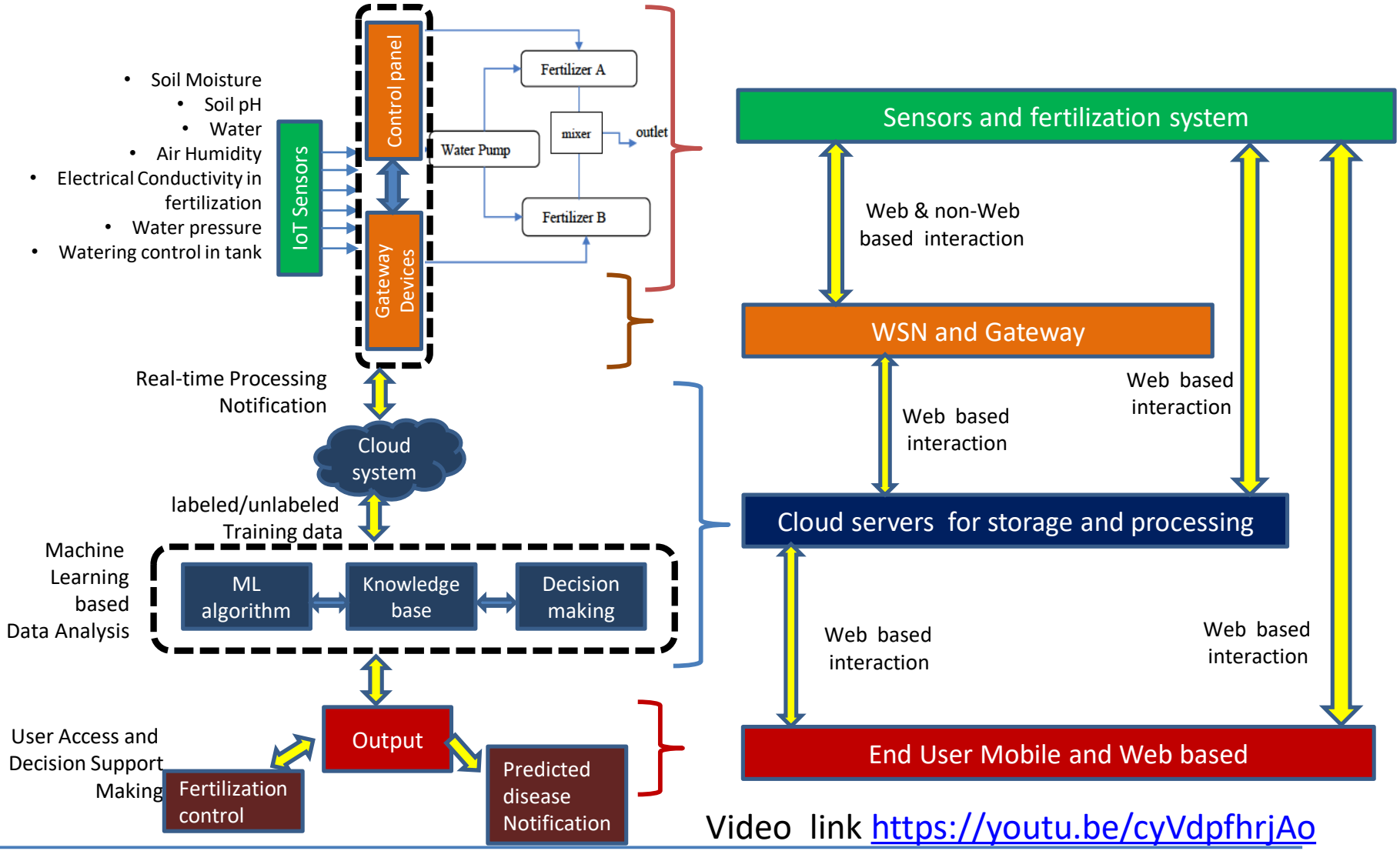
Introduction

- Continuous control, energy harvesting, automatic irrigation and disease prediction are the key challenges for smart agriculture. Some 80% of plants are killed by various diseases due to factors such as bacteria, viruses, temperature, etc, despite the farmer's hard work all year round [1].
- In addition, efficient crop protection steps include precocious detection and diagnosis of biotic stressors (weeds and pathogens) as well as abiotic stressors (nutrients, water deficiency)[2].
- Therefore, it is important to develop a complete IoT system design for agriculture that can control the fertilization and predict the disease of the plant using machine learning algorithm.



[1] V. Udutalapally, et. al. "sCrop: A Internet-of-Agro-Things (IoAT) Enabled Solar Powered Smart Device for Automatic Plant Disease Prediction", ArVix, May 2020.
[2] R.Sharma, et.al, " A systematic literature review on machine learning applications for sustainable agriculture supply chain performance", Computer and Operation Research, Vol.199, 2020

Technological Development



Video link https://youtu.be/cyVdpfhrjAo

Experiment Field Test

- **Field testbed**
  - 4 Plots (4 greenhouse)
  - 1 Plot consist of 10 beds
  - 1 bed = 8 plants
- Issue- Environment temperature
- Water quantity
- Fertilizer quantity
- Plot size
- 1 tank water = 600 gallon
- 1 tank fertilizer = 600 gallon
- 2” solenoid valve

Fertilization Schedule

PLOT	Fertilization 1		Watering 1		Watering 2		Watering 3	
	Start	End	Start	End	Start	End	Start	End
A	8.00 am	8.01 am	11.00 am	11.01 am	2.00 pm	2.01 pm	6.00 pm	6.01 pm
B	8.02 am	8.03 am	11.02 am	11.03 am	2.02 pm	2.03 pm	6.02 pm	6.03 pm
C	8.04 am	8.05 am	11.04 am	11.05 am	2.04 pm	2.05 pm	6.04 pm	6.05 pm
D	8.06 am	8.07 am	11.06 am	11.07 am	2.06 pm	2.07 pm	6.06 pm	6.07 pm

Current IoT Fertilization System Model

Activity 3: Application For Disease Prediction On Designed IoT For Smart Agriculture

Budget plan

1st YEAR	Frequency/unit	Cost for 3 members (USD)	TOTAL (USD)
Knowledge sharing activities inclusive Attending Workshop and Conferences (travel and accommodation) • Japan • Vietnam • Thailand • Malaysia	 1 1 1 1	 5000 1500 1500 500	8,500
• Field test and enhance prototype development for 2 plot greenhouse (sensors and installation) • Data collection • Cloud Computing services and rental	160	-	8,000
2nd YEAR			
Knowledge sharing activities inclusive Attending Workshop and Conferences (travel and accommodation) • Vietnam • Thailand • Malaysia	 1 1 1	 1500 1500 500	3,500
Data Collection & Yield Measurement Analysis Cloud Computing services and rental		-	5,000
TOTAL			**25,000**

R&D results - Expected outcomes

Activity 1

- Enhancing the quality of video streaming at server side in term of subjective and objective measurement.
- Reducing the bitrate of video streaming around 20% compared to H.265/HEVC standard.
- Establish a visual sensor network including 50 IP camera at 4 sites and 02 servers to receive and process video streaming.

Activity 2

- Establish a testbed includes 3 sensor networks connected to the blockchain network.
- Evaluate ability of combating cyber attacks of the proposed system.

Activity 3

- FARM MONITORING: Continuous Farm monitoring system, Online and offline Control system.
- AUTOMATED FERTILIZATION: Integrated Fertilization and irrigation system, flexible control of water and fertilizer amount.
- SMART ANALYSIS: Cloud based Data Analysis, Collected Sensor Data analysis.
- DISEASES PREDICTION: Machine Learning techniques (Regression), Deep Learning technique- Image analysis based on leaf and plant size.

The performance outcome of the crop harvesting will be compared with the conventional farming method

Scientific Contribution:

IoT/security/AI related International conference papers

Presentations at International Conferences:

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
1	Lung disease classification using different deep learning architectures and principal component analysis	Ming JTC, Noor NM, Rijal Om, Kassim RM, Yunus A	Universiti Teknologi Malaysia	Proc 2nd International Conference on BioSignal Analysis, Processing and Systems, ICBAPS2018	24 -26th July 2018	Kuching, Sarawak, Malaysia
2	Lung disease classification using reticular pattern scoring and five class features with greedy stepwise based on GLCM	Than JCM, Noor NM, Rijal OM, Kassim RM, Yunus A	Universiti Teknologi Malaysia	Proc. Of the 2017 IEEE Region 10 Conference (TENCON2017)	5-8th Nov 2017	Penang, Malaysia
3	Flood Disaster Prediction Model Based On Artificial Neural Network : A Case Study Of Kuala Kangsar Perak.	Nurul Syarafina Shahrir, Norulhusna Ahmad, Robiah Ahmad, Rudzidatul Akmam Dziyauddin[1]	Universiti Teknologi Malaysia	Conference on Flood Catastrophes in a Changing Environment 2016 (CFCCE'16)	15-16 November 2016	Kuala Lumpur, Malaysia

Scientific Contribution:

IoT/security/AI related Journal papers.

The Published Journal Papers:

No:	Paper title:	Author names	Affiliation	Journal name:	The publisher of the Journal	The volume number and Pages
1	Calcification detection using convolutional neural network architectures in intravascular ultrasound images	Sofian H, Ming JTC, Muhammad S, Noor NM	Universiti Teknologi Malaysia	Indonesia Journal of Electrical Engineering and Computer Science	Institute of Advanced Engineering and Science (IAES)	17(3):1313-1321. 2019 **DOI:** 10.11591/ijeecs.v17.i3.pp1313-1321
2	Lung disease classification using GLCM and deep features from different deep learning architectures with principal component analysis	Ming JTC, Noor NM, Rijal OM, Kassim RM, Yunus A	Universiti Teknologi Malaysia	International Journal of Integrated Engineering	Universiti Tun Hussein Onn Malaysia (UTHM)	10(7):76-89 2018

Societal Impact:

The social impact of this project will be greatly affected the farming community in producing quality food with high yield. This is inline with the UNDP sustainable development goals (SDGs) #2 Zero Hunger where the high yield of harvest will translate into cheaper quality food that is enough for everyone.

This project will also indirectly achieved the UNDP SDG #1 No Poverty and #3 Good Health and Well-Being. It is common knowledge that in Asia that poverty is prevalence among the farmers compared to other profession. This is due to the conventional farming method which is labour intensive and uncontrollable used of pesticide. In this project, the implementation of advanced farming method involving IoT will greatly help the farmers to produce high yield of quality food with minimal used of pesticide which will greatly reduce the poverty and increase the betterment of good health and well-being among the farmers.

The dataset and knowledge are collected by the projects that share equally to all sides. Practically, attack data and/or security framework will be stored in common place to analyze by ML