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Images Based Classification for Warm Cloud Rainmaking using Convolutional Neural Networks

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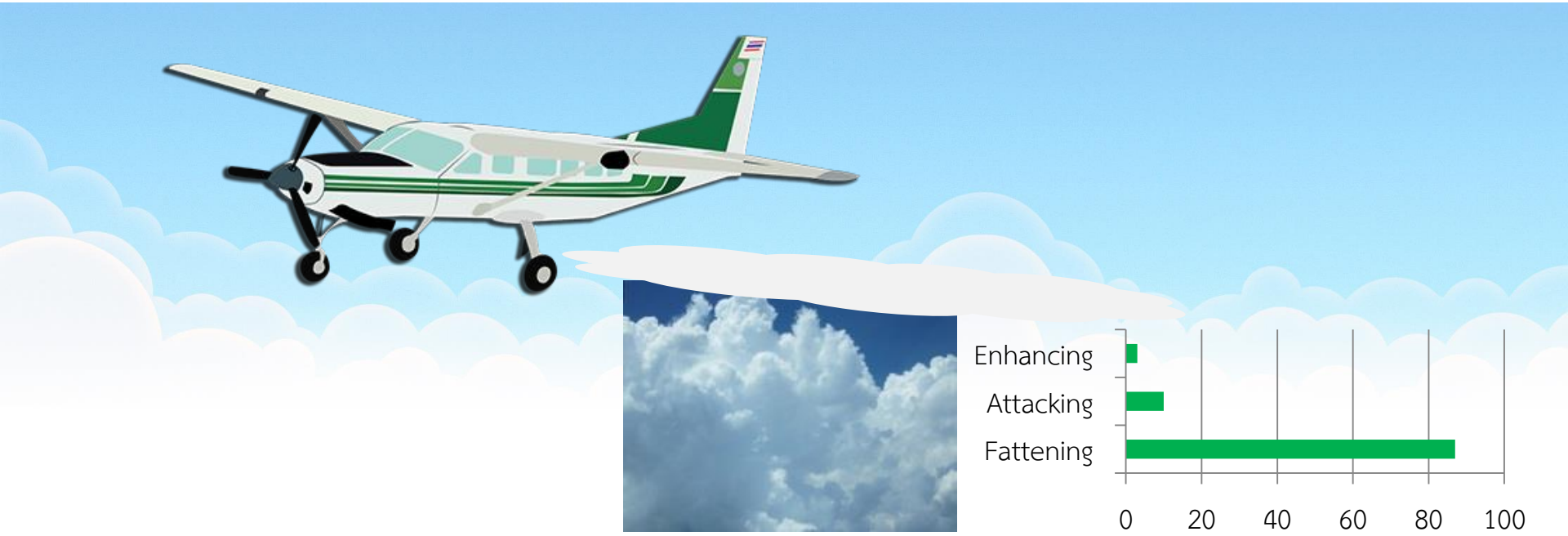
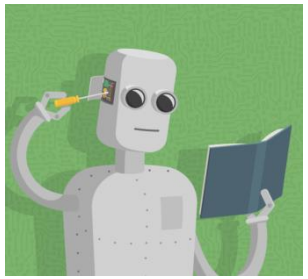


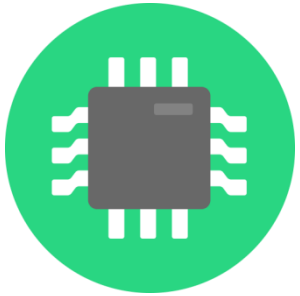
This paper published on IEEE

What is AI & What makes an AI intelligent?



ML Algorithm

Data



Hardware

What can AI do?

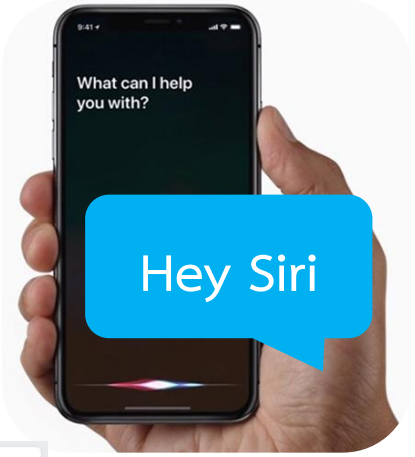
Computer Vision

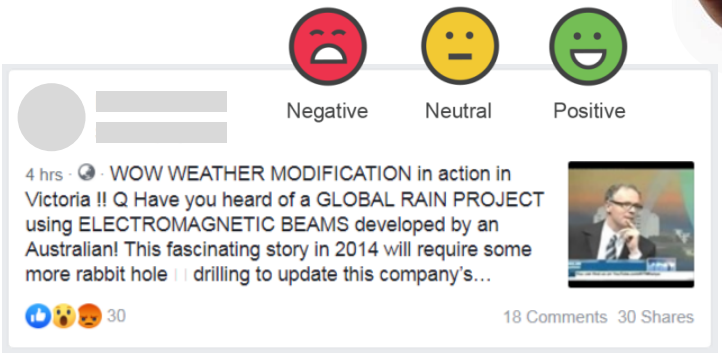
Natural Language Processing

[1] Steve Jobs

[2] Human

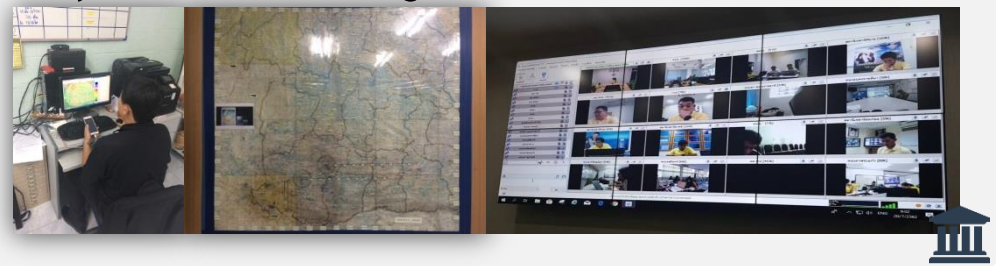
[3] Man, Phone





The Daily Rainmaking Operation

Analyze data, define target area and discuss in conference.



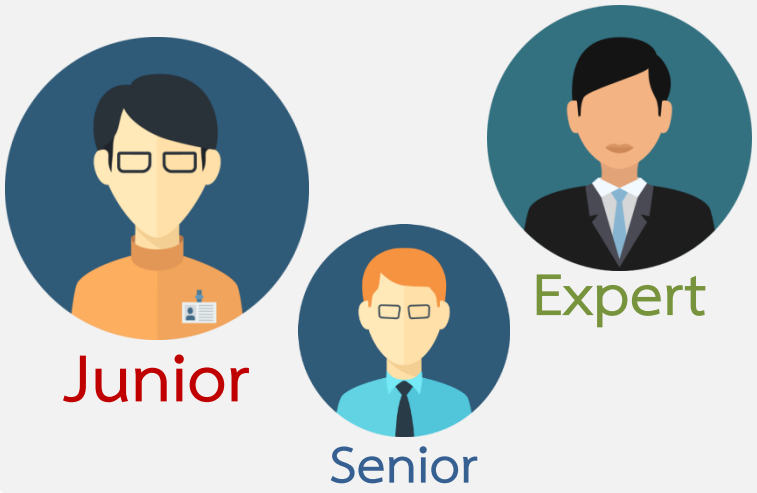
Preparing materials for operation.

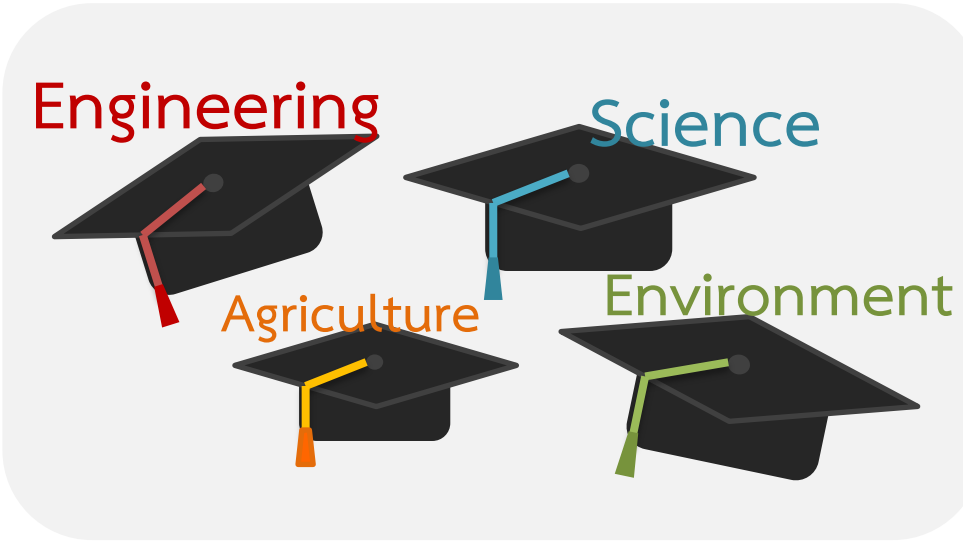
Cloud selection process by human observation.

Seed the selected cloud.

Report.

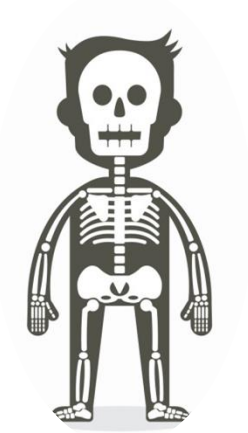
What is a problem in cloud selection?





"Work Experience" and "Personal Skills"

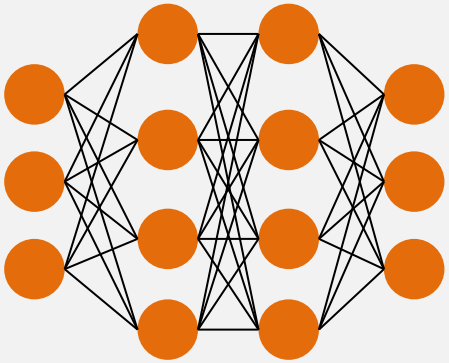
are affecting to cloud selection.



How to solve this problem?

Computer Vision

Cloud Image



Deep Learning

Fattening 88.44
Attacking 11.56
Enhancing 0.00

Output

We build an “Image Classification Model”
for predict suitability from cloud images.

Objective 1 : Reduce Human Bias

Warm cloud seeding method

1. Triggering

Clear sky or Few cloud.

2. Fattening

Towering stage.

3. Attacking

Late towering stage.

4. Enhancing

Rain in some area.

Objective 1 : Reduce Human Bias

Warm cloud seeding method

1. Triggering

Clear sky or Few cloud.

2. Fattening

Towering stage.

3. Attacking

Late towering stage.

4. Enhancing

Rain in some area.

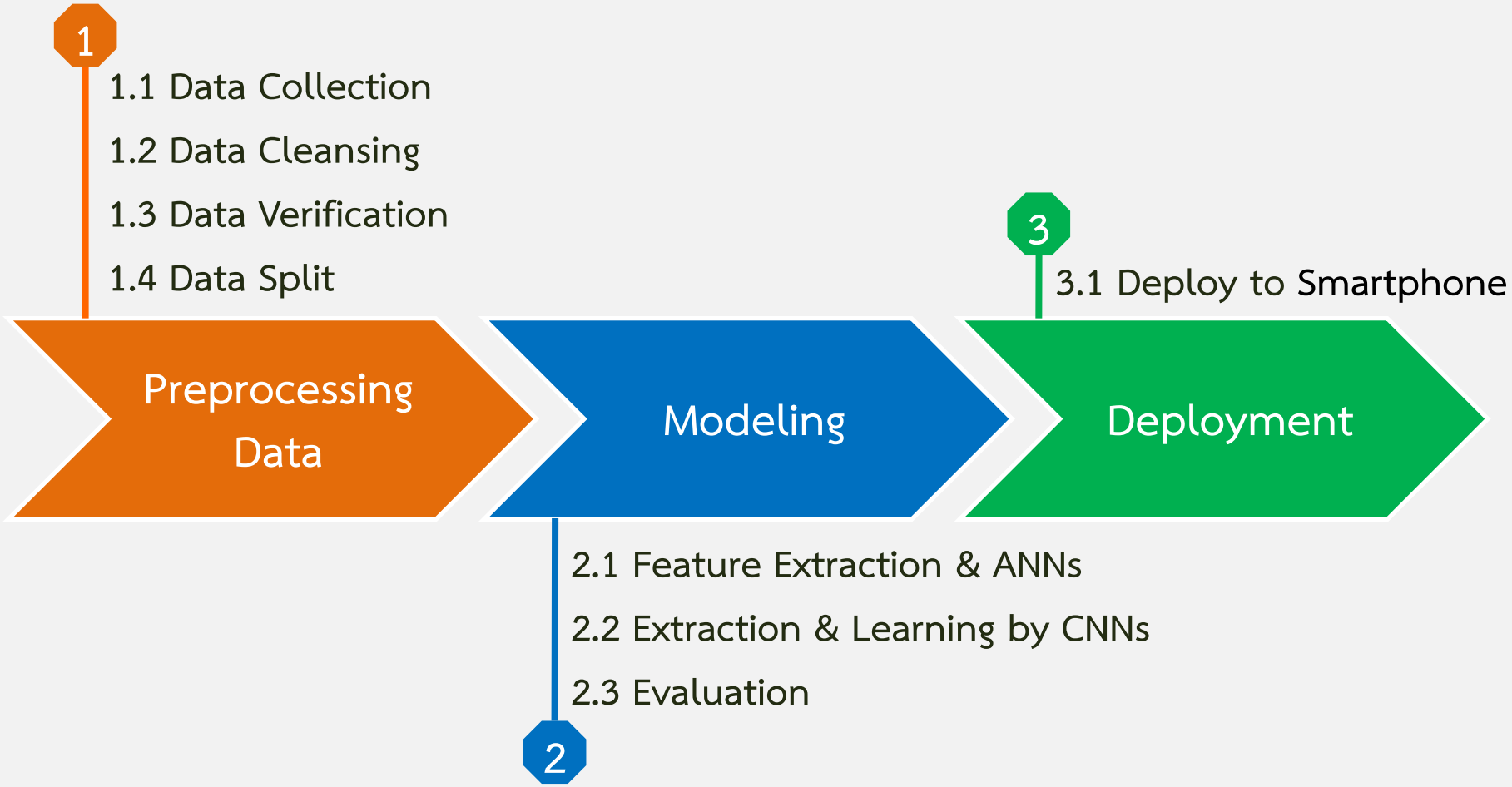
Objective 2 : Mobility

Must be able to use on aircraft.

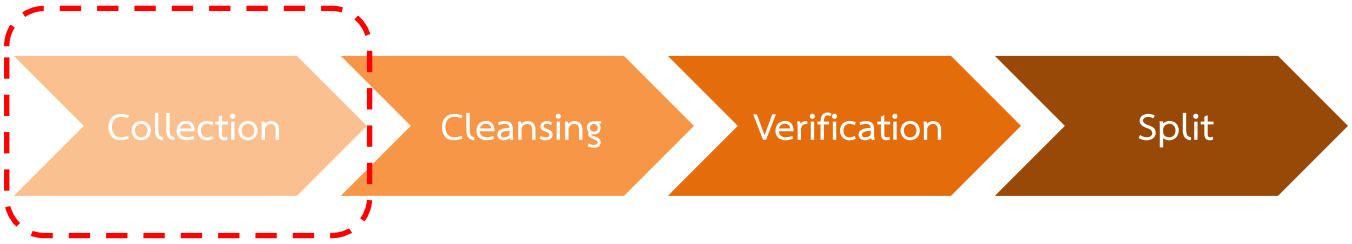
Don’t need internet.

Don't need any additional equipment.

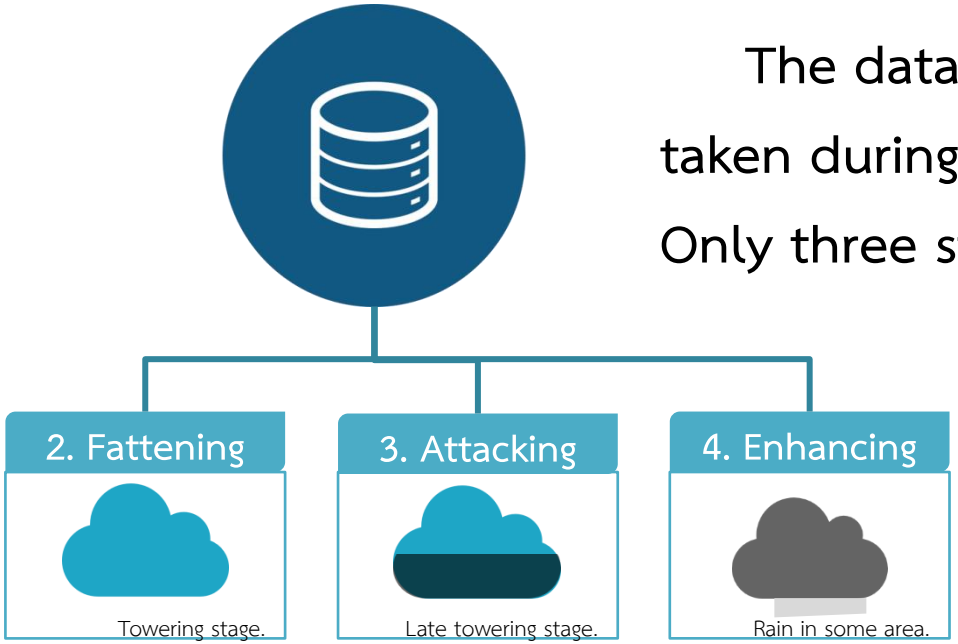
Workflow


1
1.1 Data Collection
1.2 Data Cleansing
1.3 Data Verification
1.4 Data Split
Preprocessing Data
Modeling
3
3.1 Deploy to Smartphone
Deployment
2.1 Feature Extraction & ANNs
2.2 Extraction & Learning by CNNs
2.3 Evaluation
2

Preprocessing Data

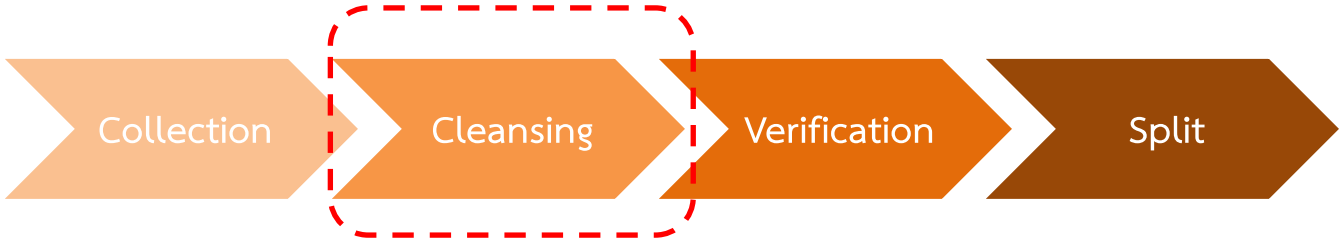


1.1 Data Collection



The dataset are derived from images taken during July 2004 to October 2017. Only three steps of warm cloud seeding.

Preprocessing Data



1.2 Data Cleansing

Discard unclear and noisy images.

Aircraft's Windows

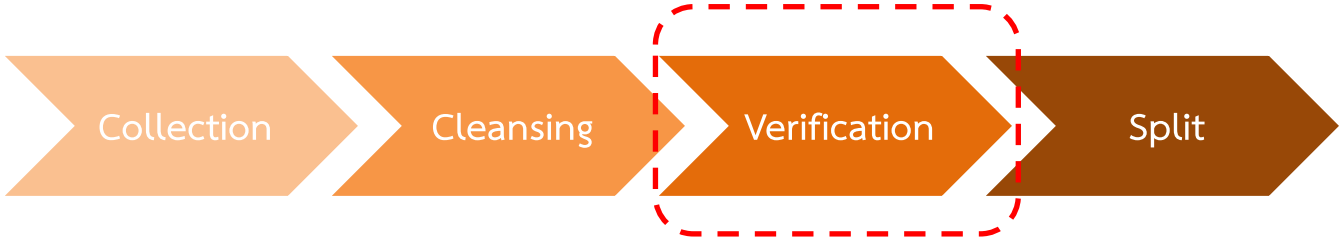
Aircraft's Wing

Weird Color

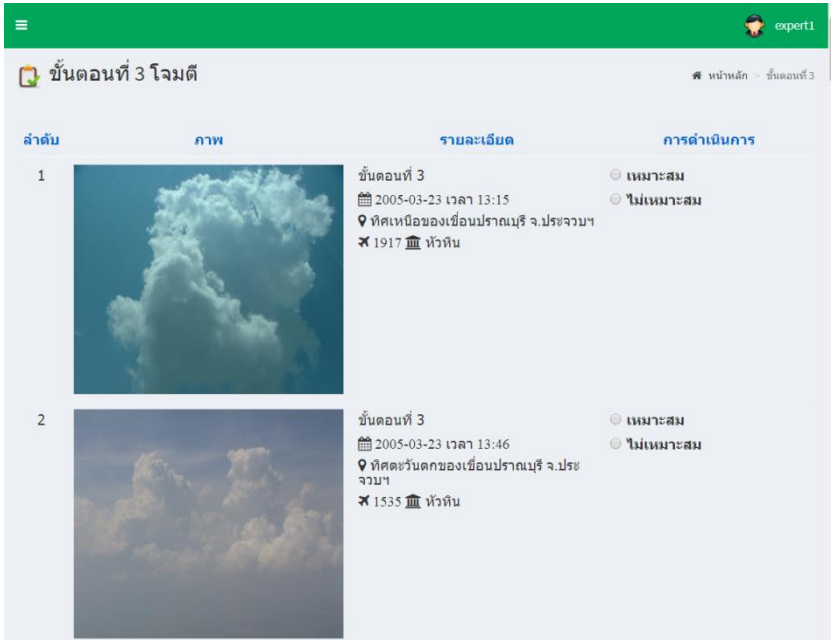
Blur

Water Vapor

Preprocessing Data

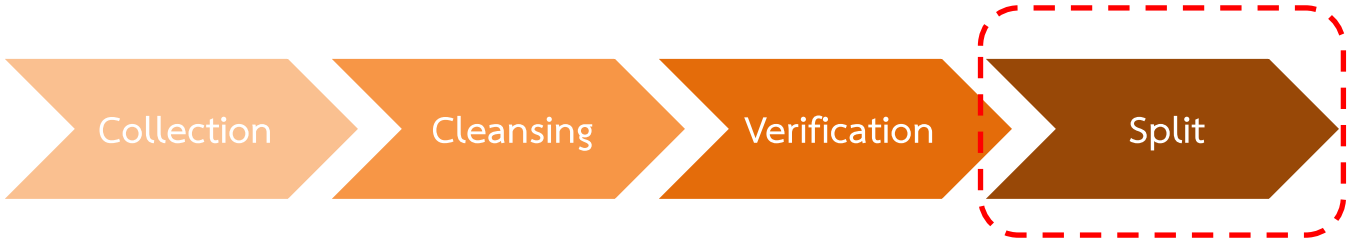


1.3 Data Verification

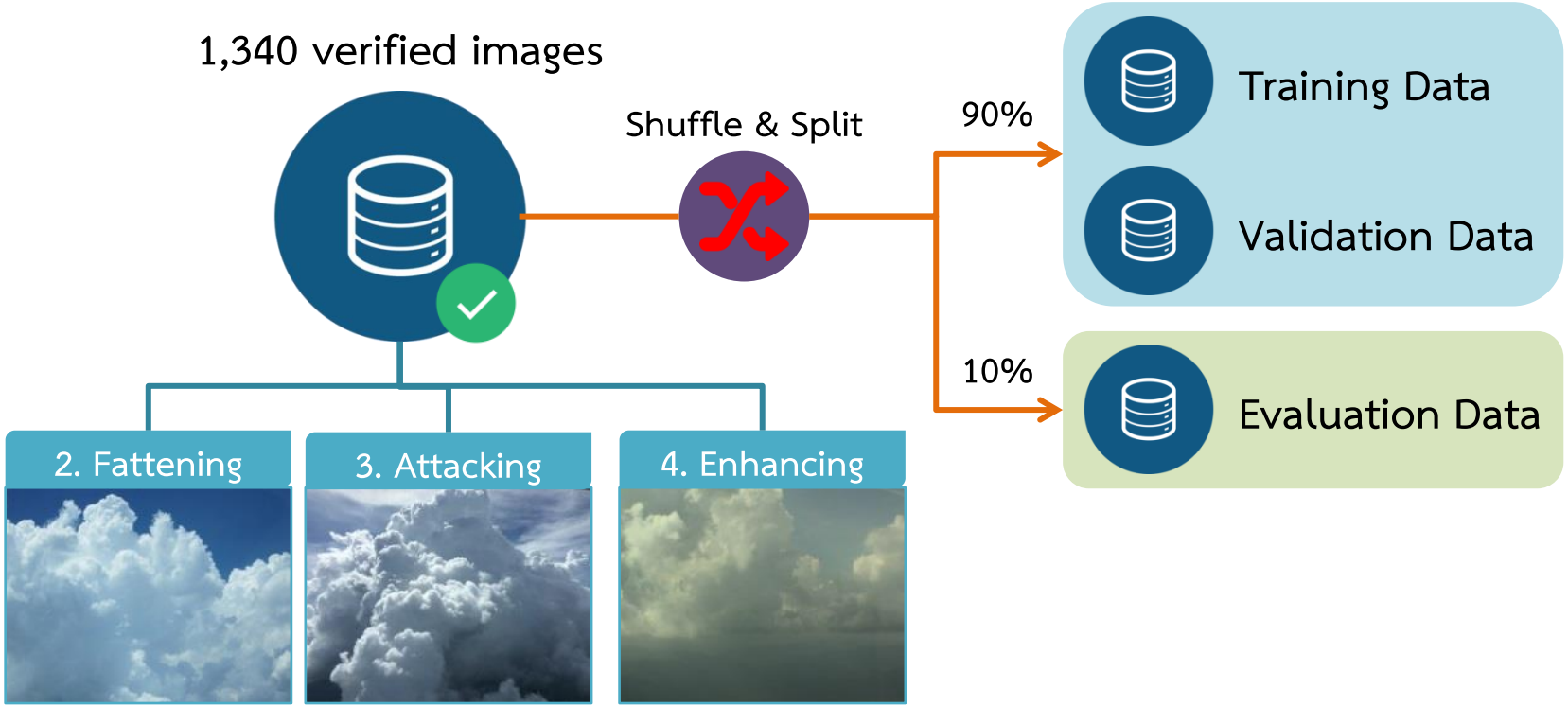


Verify suitable images that matches the seeding method by three specialists.

Preprocessing Data



1.4 Data Split

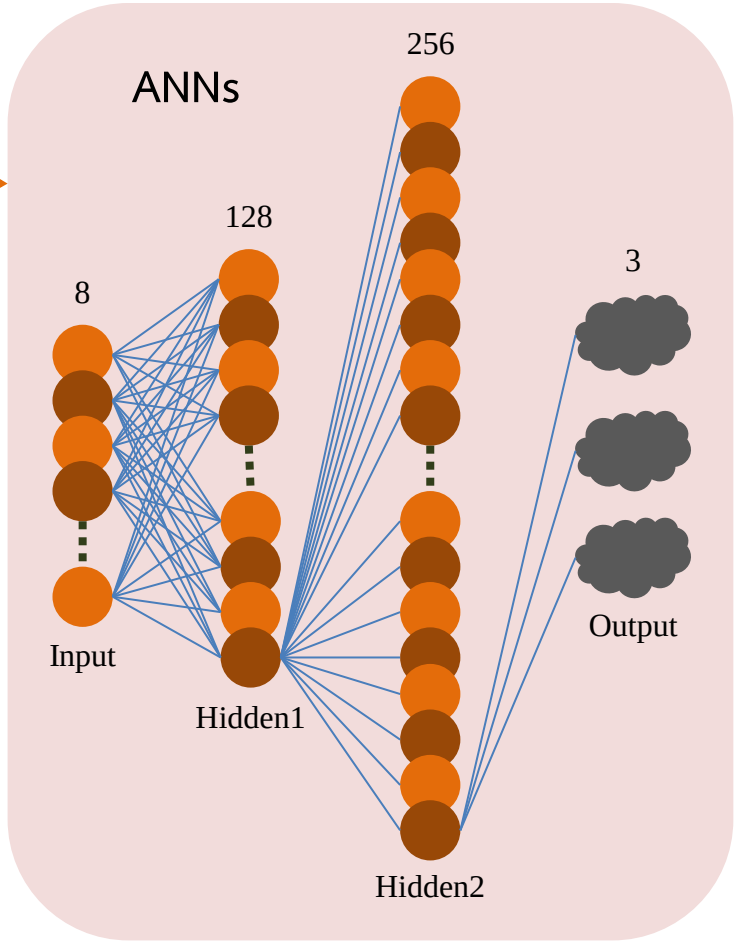


Modeling

2.1 Feature Extraction & ANNs

Images

Feature Extraction

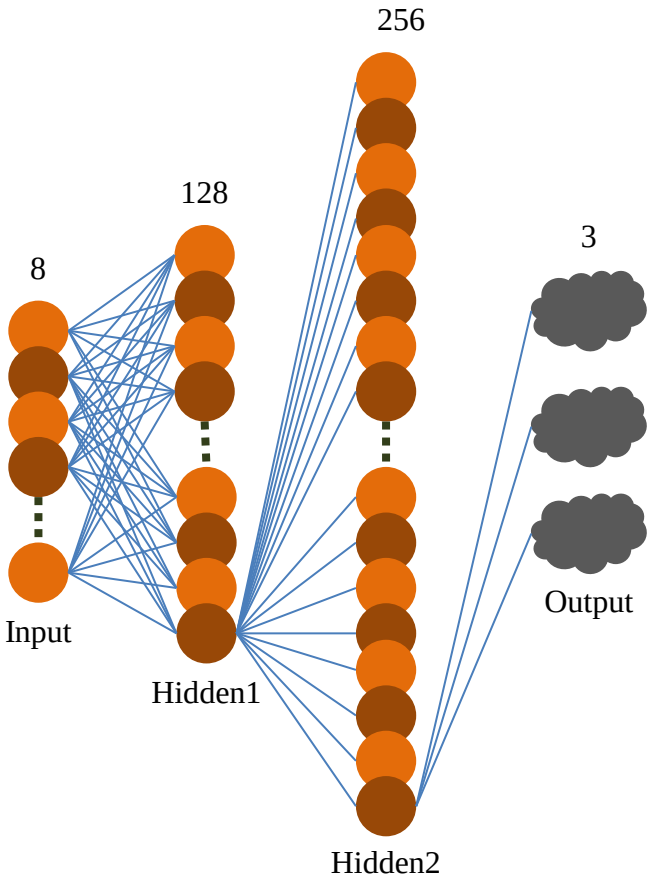


Color Features	
M_B	Mean of the channel B
M_R	Mean of the channel R
S_B	Standard Deviation of the channel B
Sk_B	Skewness of the channel B
Texture Features	
E_B	Energy of the channel B
C_B	Contrast of the channel B
H_B	Homogeneity of the channel B
Ent_B	Entropy of the channel B

Zhu Tingting et al., 2016

Modeling

2.1 Feature Extraction & ANNs (Cont.)



ANNs Architecture

1) Input Layer(dim=8)

2) Hidden Layer(dim=128, activation=ReLU)

3) Hidden Layer(dim=256, activation=ReLU)

4) Output Layer(dim=3, activation=Softmax)

Training Configuration

optimizer=adam

loss=categorical_crossentropy

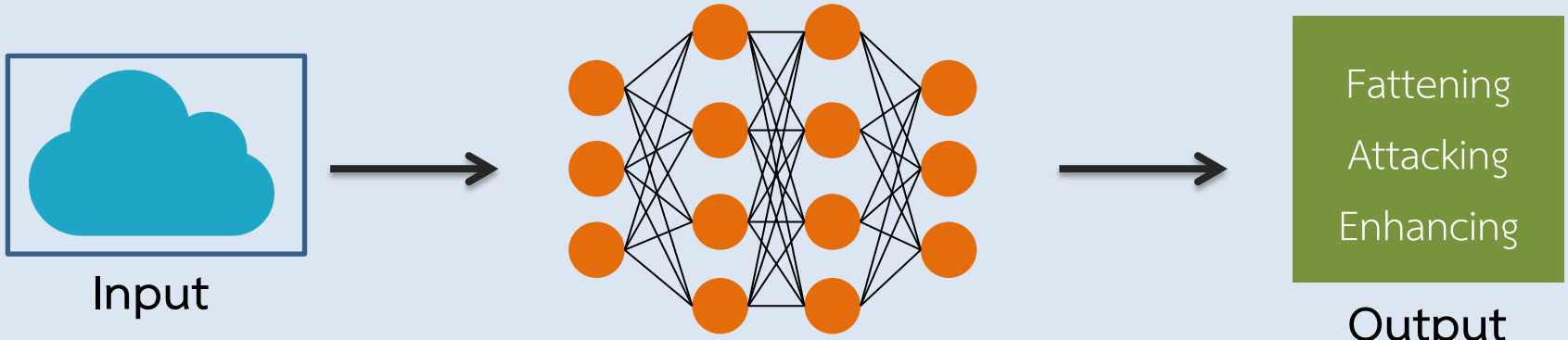
epochs=100

batch_size=64

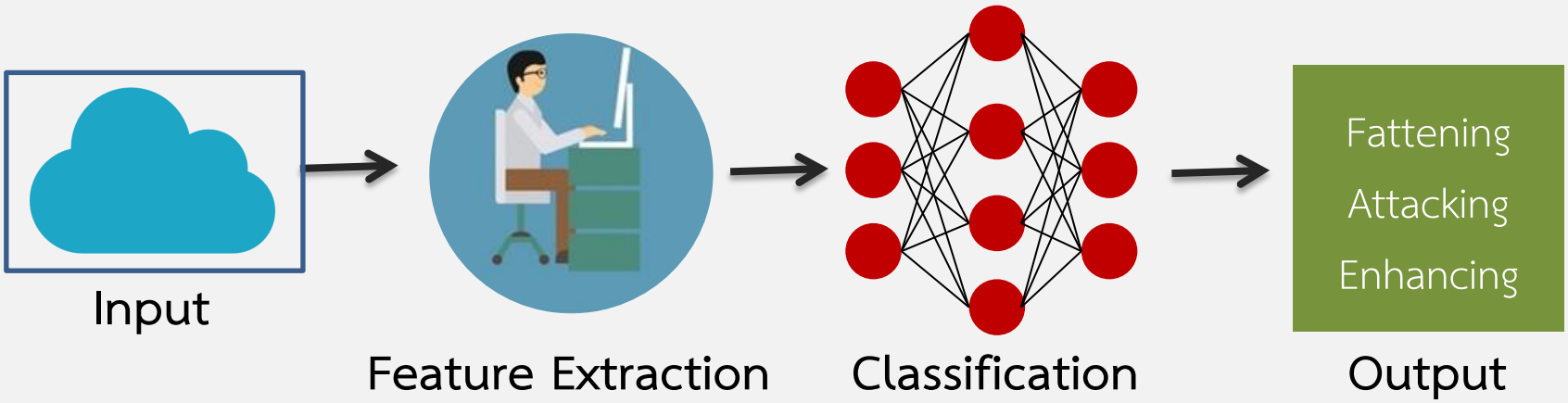
Modeling

2.2 Extraction & Learning by CNNs

Deep Learning

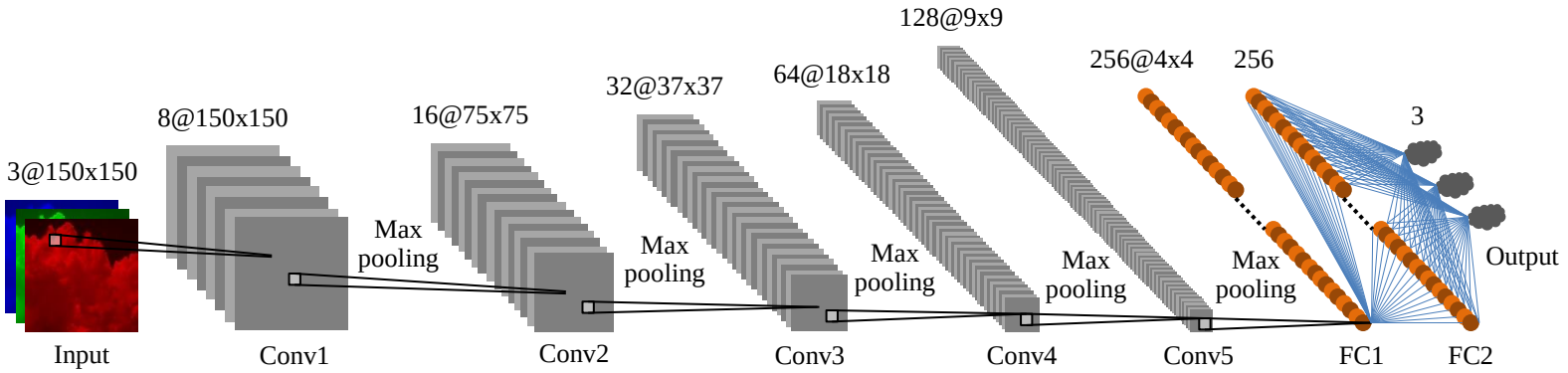


Traditional Method



Modeling

2.2 Extraction & Learning by CNNs (Cont.)



CNNs Architecture

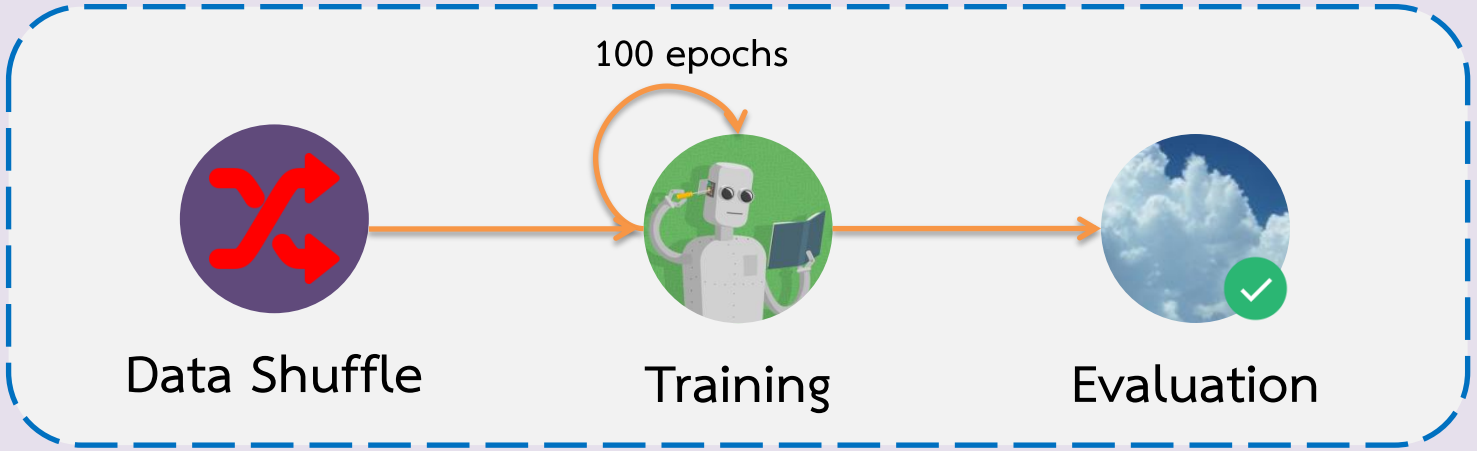
1) Input Layer(shape=(150, 150, 3))
2) Conv1 Layer(filters=8, size=(3, 3), strides(1, 1), activation=ReLU)
   Max-pooling Layer(size=(2, 2), strides(2, 2))
3) Conv2 Layer(filters=16, size=(3, 3), strides(1, 1), activation=ReLU)
   Max-pooling Layer(size=(2, 2), strides(2, 2))

...

6) Conv5 Layer(filters=128, size=(3, 3), strides(1, 1), activation=ReLU)
   Max-pooling Layer(size=(2, 2), strides(2, 2))
7) FC1 Layer(dim=256, activation=ReLU)
   Dropout(0.5)
8) FC2 Layer(dim=256, activation=ReLU)
   Dropout(0.5)
9) Output Layer(dim=3, activation=Softmax)

Modeling

2.3 Evaluation



10 Round

- Top-5 Accuracy
- Top-1 Precision, Recall, F-measure

Results

Method	Top-5 Accuracy					Mean
	1	2	3	4	5	
ANNS	**80.60**	79.10	78.36	78.36	78.36	**78.96**
CNNS	**86.57**	85.80	85.80	85.08	83.61	**85.37**

Method	Top-1			
	Accuracy	Precision	Recall	F-measure
ANNS	80.60	80.89	80.60	80.12
CNNS	86.57	87.52	86.57	86.58
Difference	+5.97	+6.63	+5.97	+6.46

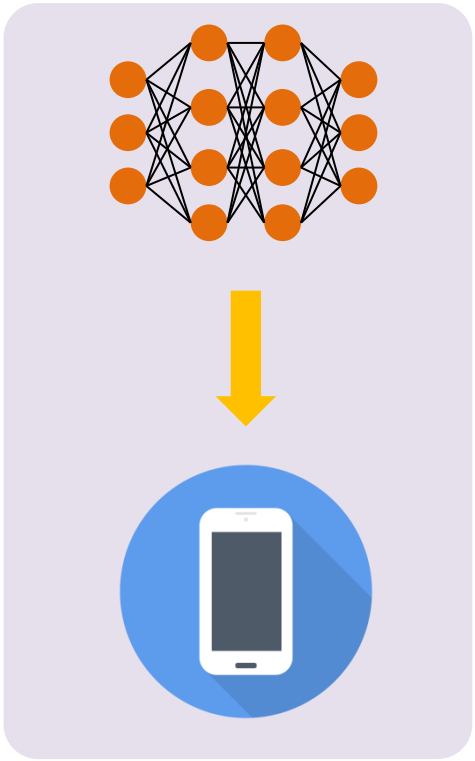
CNNs has a Accuracy, Precision, Recall, F-measure > ANNs

around 6%

Deployment Plan

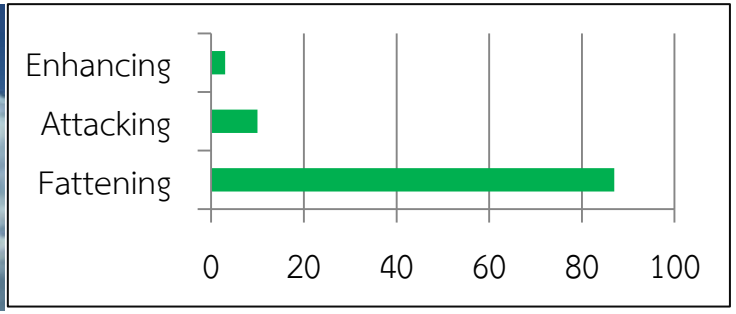
Deploy a Trained CNNs Model

To Smartphone



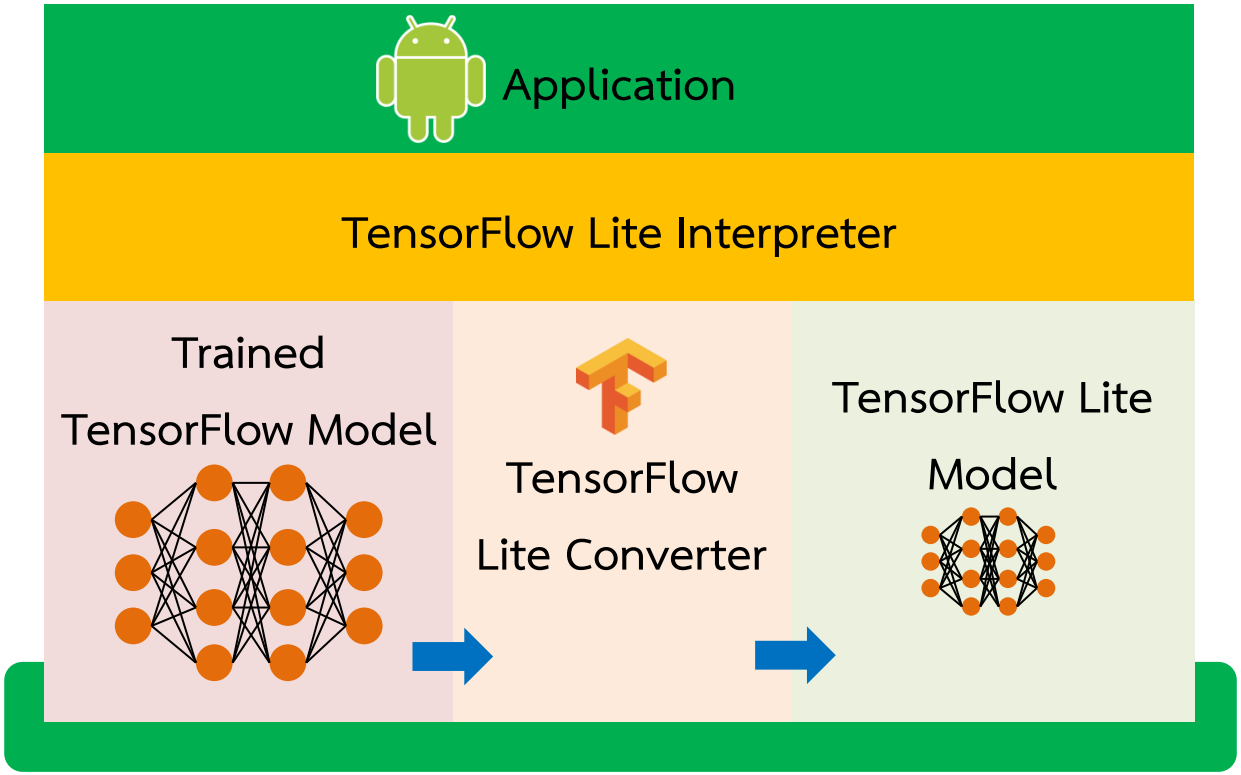
Take a Photo

Get a Result to Support Decision-Making



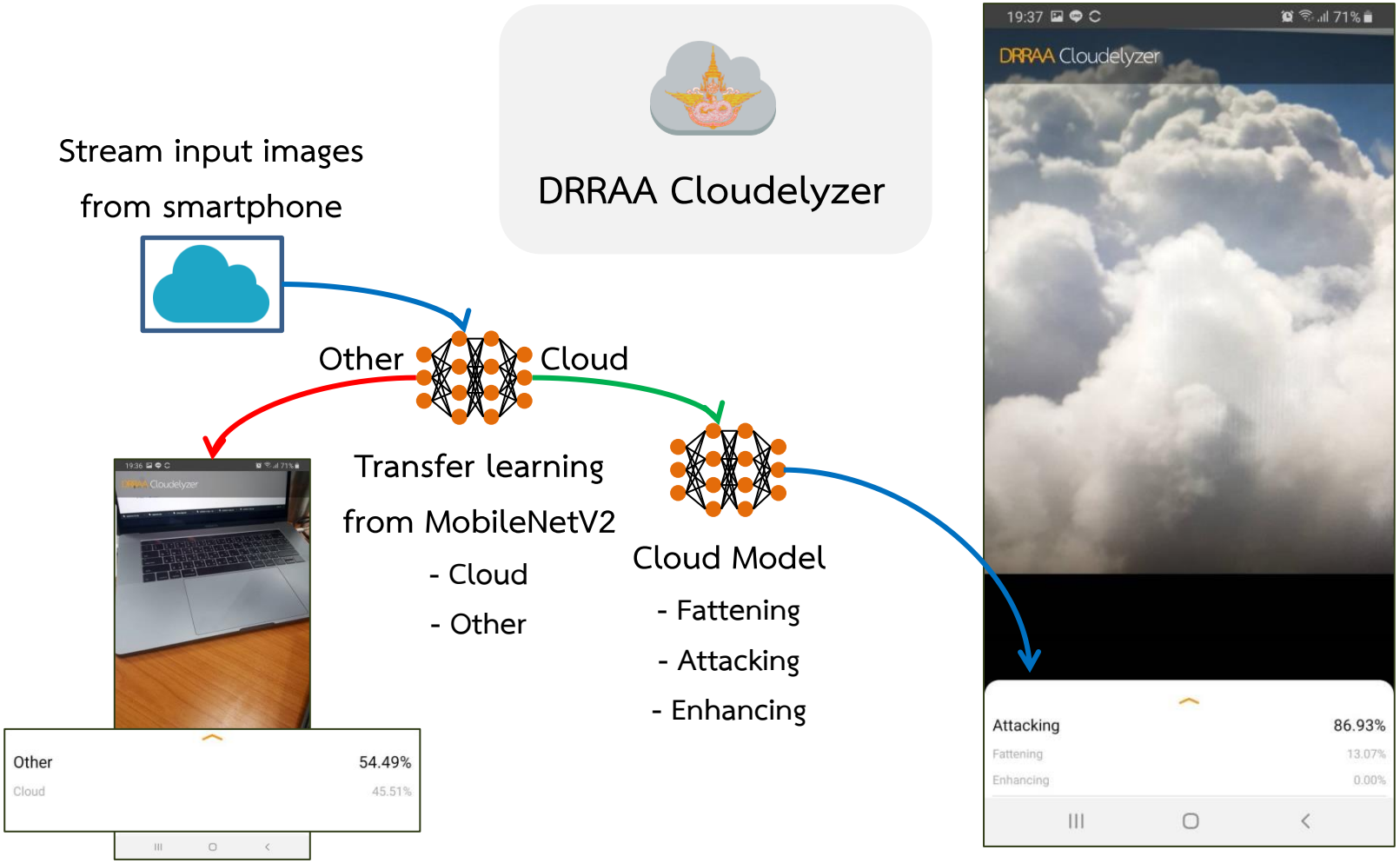
Deployment

3.1 Deploy to Smartphone

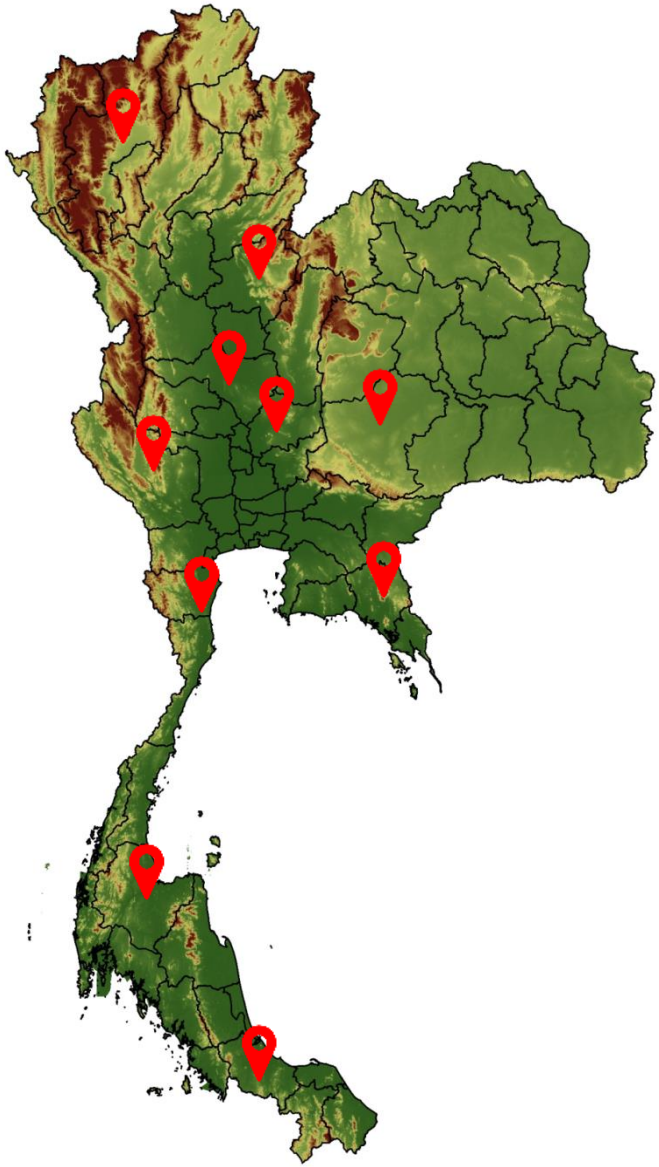


Deployment

3.1 Deploy to Smartphone (Cont.)



Current Status & Future Focus



1. Testing accuracy on daily operation.
2. Collect user feedback and suggestions.
3. Retrain model with new training data.

- Change model
- Transfer learning
- Learning with noisy

- IoT camera
- Ground-based camera
- Cloud observation sensors

- Hard, Medium, Soft
- Cloud types

- Cold cloud seeding

Thank you for your attention.