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Images Based Classification for Warm Cloud Rainmaking using Convolutional Neural Networks

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Outline

1. Background
2. Objectives
3. Experiments
4. Results
5. Conclusion & Implementation

The Daily Rainmaking Operation

Analyze data and define target area.

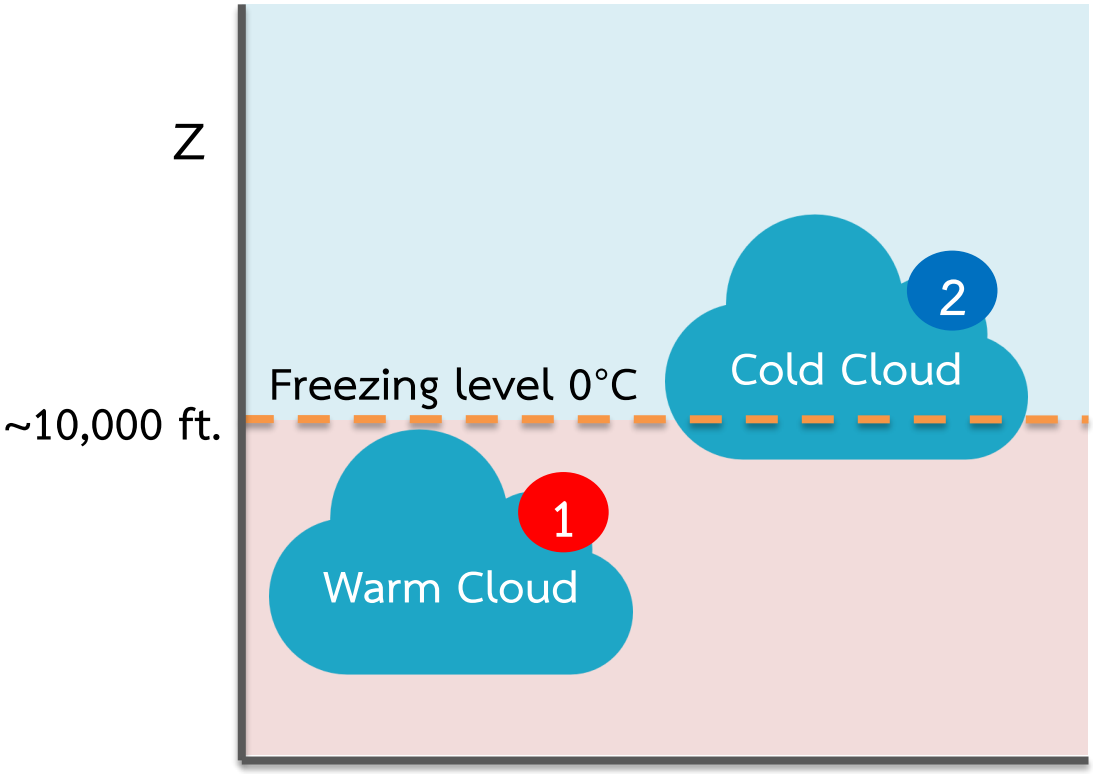
Preparing materials for operation.

Cloud selection process by human observation.

Seed the selected cloud.

Report.

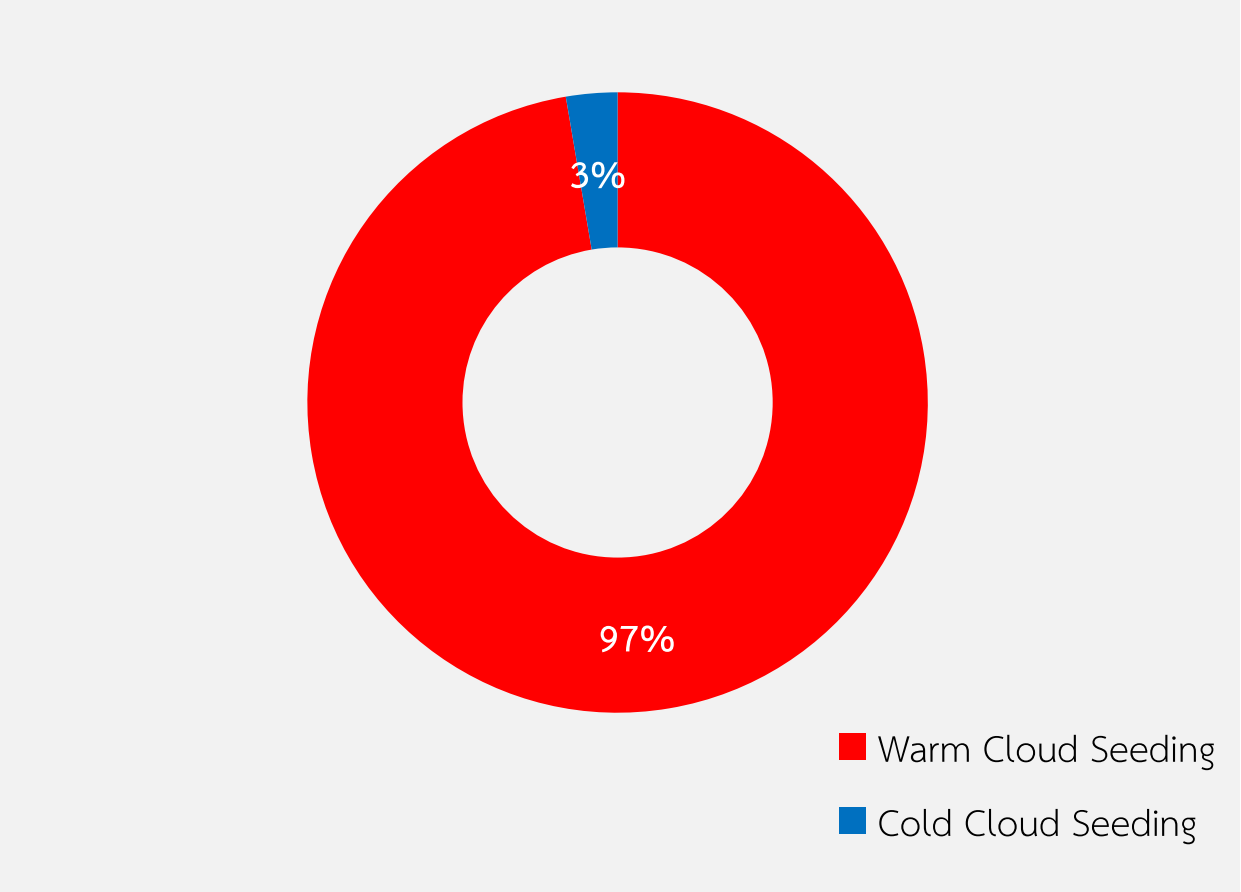
The Rainmaking Technology



The weather modification methods to make rain from

"Warm Cloud" and "Cold Cloud"

Rainmaking operation in Thailand 2017



The Warm Cloud Seeding

1. Triggering

Clear sky or Few cloud.

2. Fattening

Towering stage.

3. Attacking

Late towering stage.

4. Enhancing

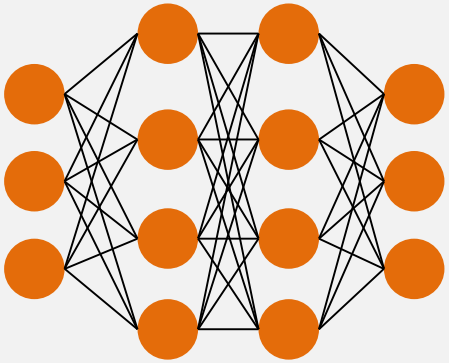
Rainfall some area.

Objectives

1

Deep Learning

Input

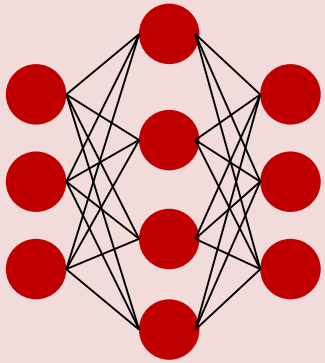


Output

Feature Extraction + Classification

2

Traditional Method

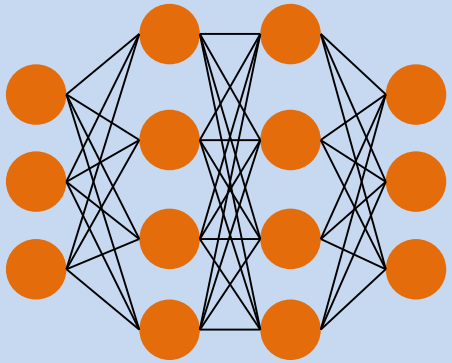


Feature Extraction

Classification

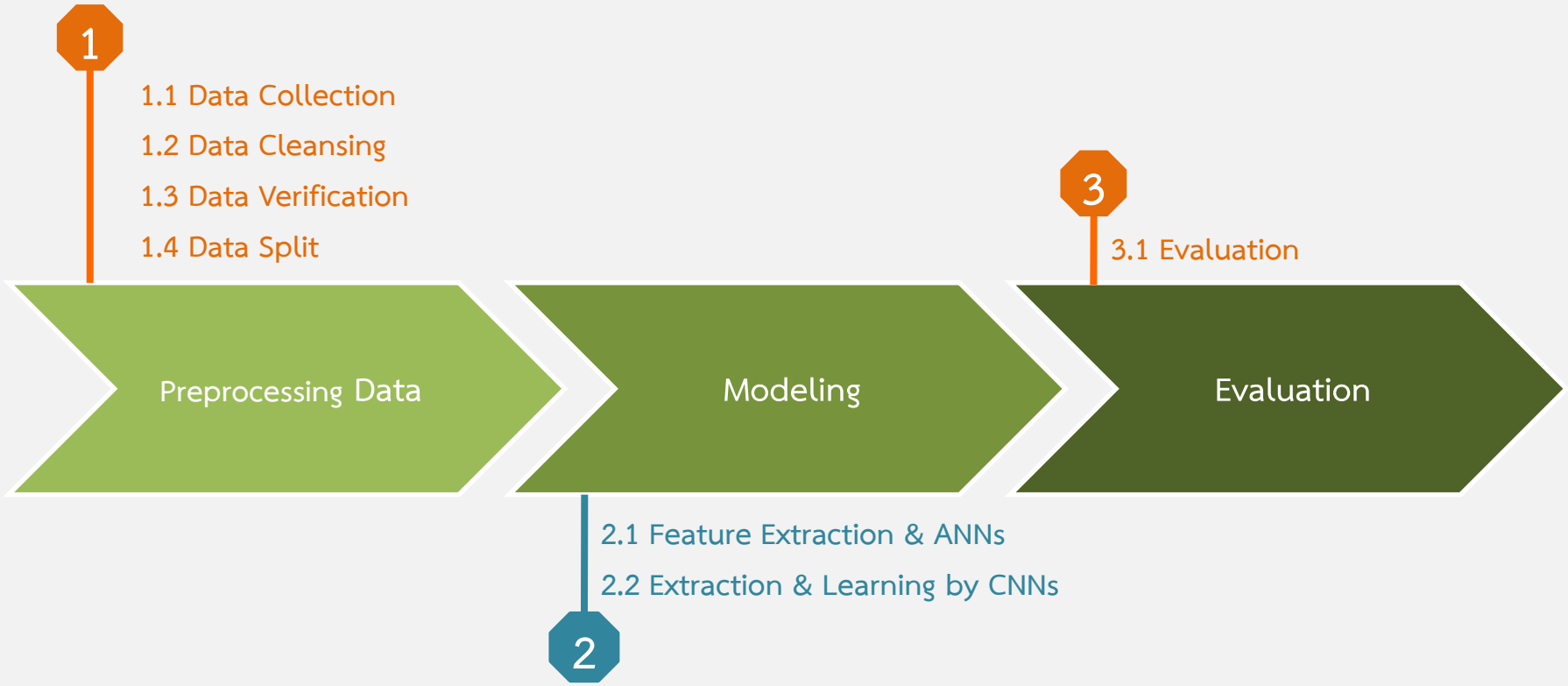
VS

Deep Learning

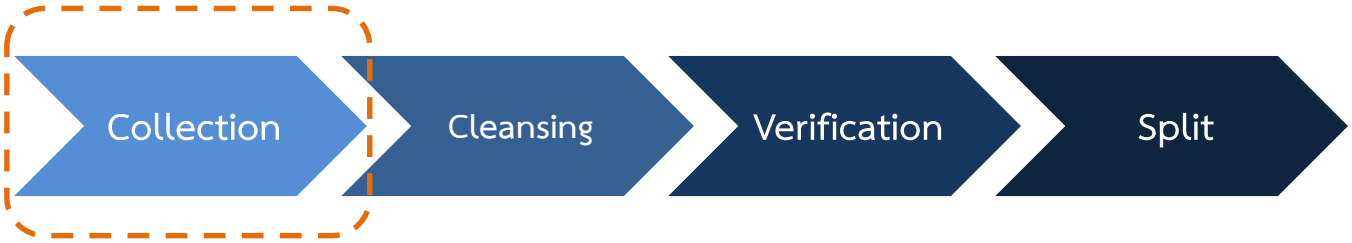


Feature Extraction + Classification

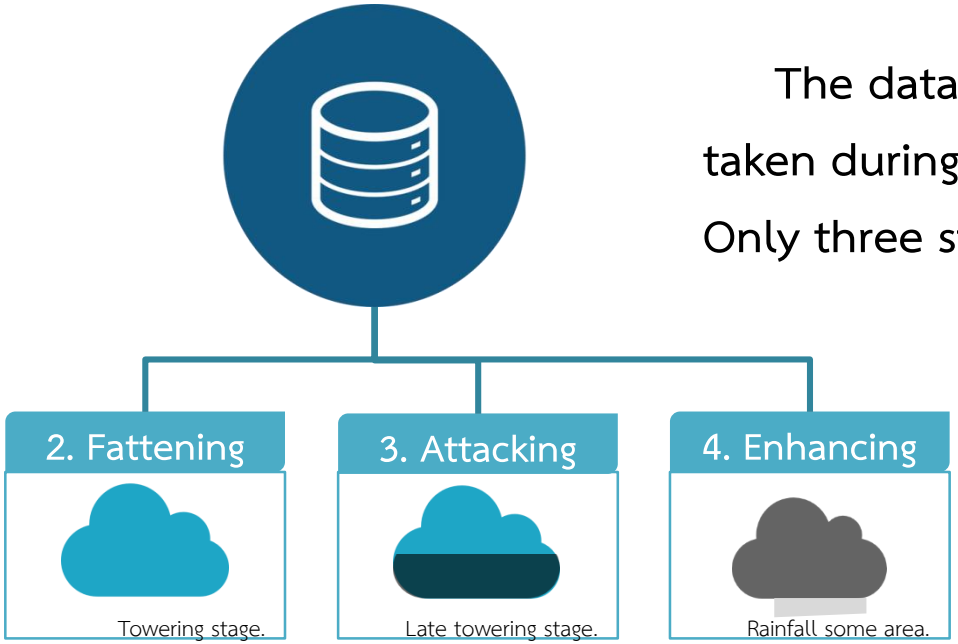
Experiment Overview



Preprocessing Data

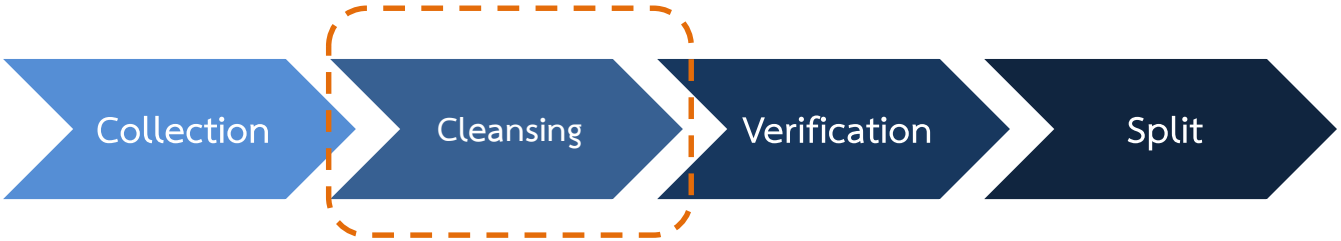


2.1 Data Collection



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

Preprocessing Data



2.2 Data Cleansing

Discard unclear and noisy images.

Aircraft's Windows

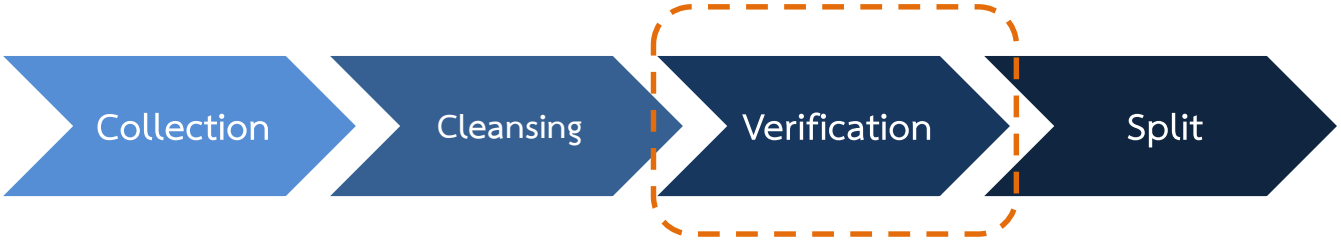
Aircraft's Wing

Weird Color

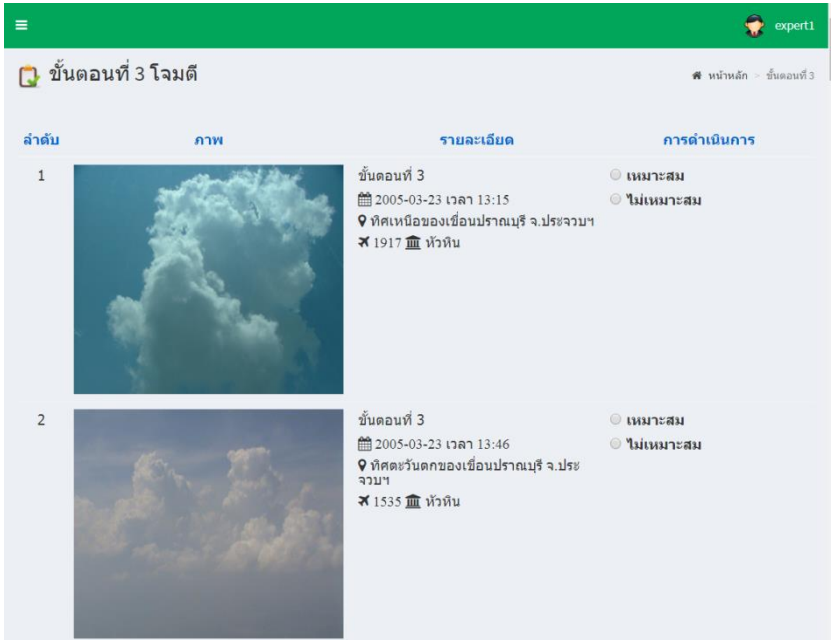
Blur

Water Vapor

Preprocessing Data



2.3 Data Verification



Verify the suitability of images that matches the seeding method by three specialists.

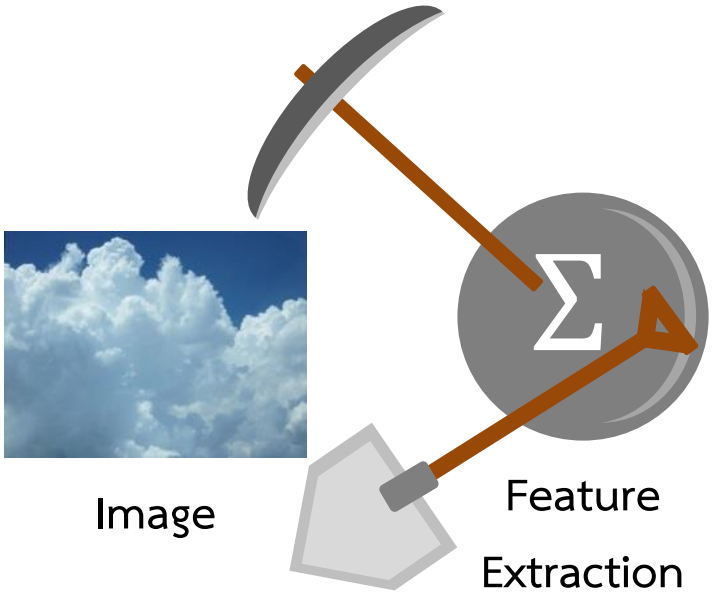
Preprocessing Data

2.4 Data Split

	Fattening	Attacking	Enhancing	Total
Sample Images				3 Class
Training Data (70%)	420	350	168	938
Validation Data (20%)	120	100	48	268
Evaluation Data (10%)	60	50	24	134
Total	600	500	240	1,340

Modeling

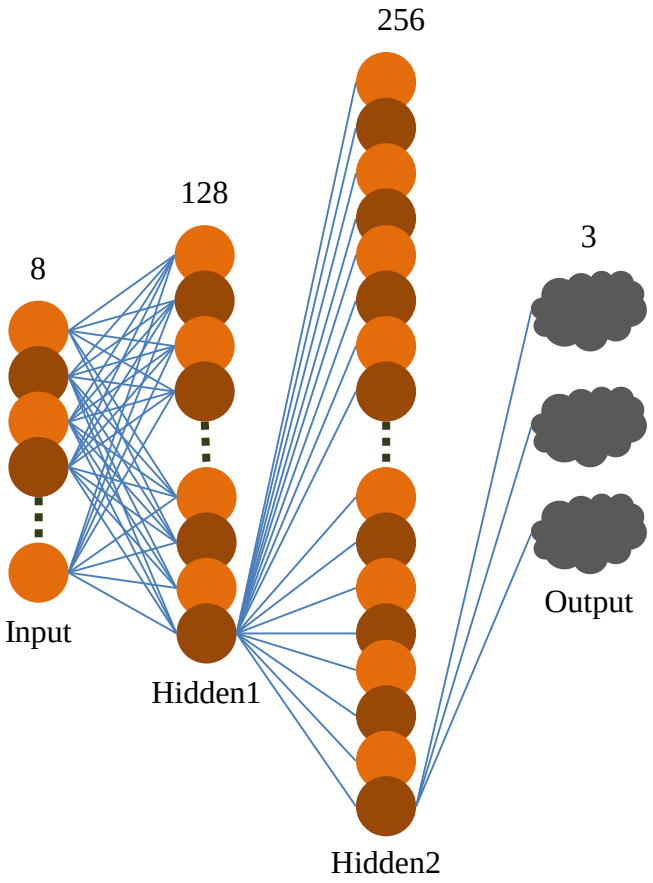
3.1 Feature Extraction & ANNs



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

Modeling

3.1 Feature Extraction & ANNs



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

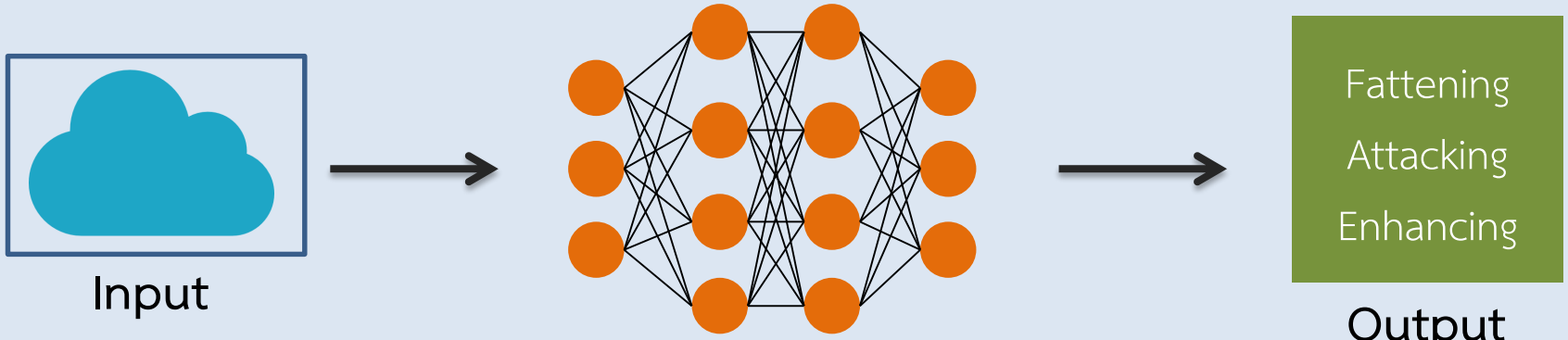
epochs=100

batch_size=64

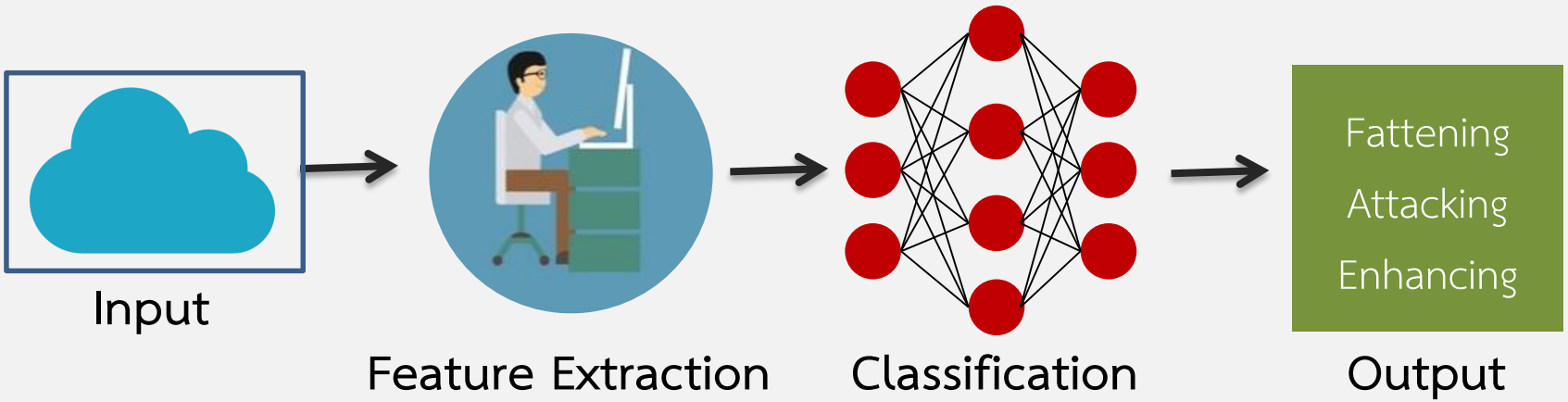
Modeling

3.2 Extraction & Learning by CNNs

Deep Learning

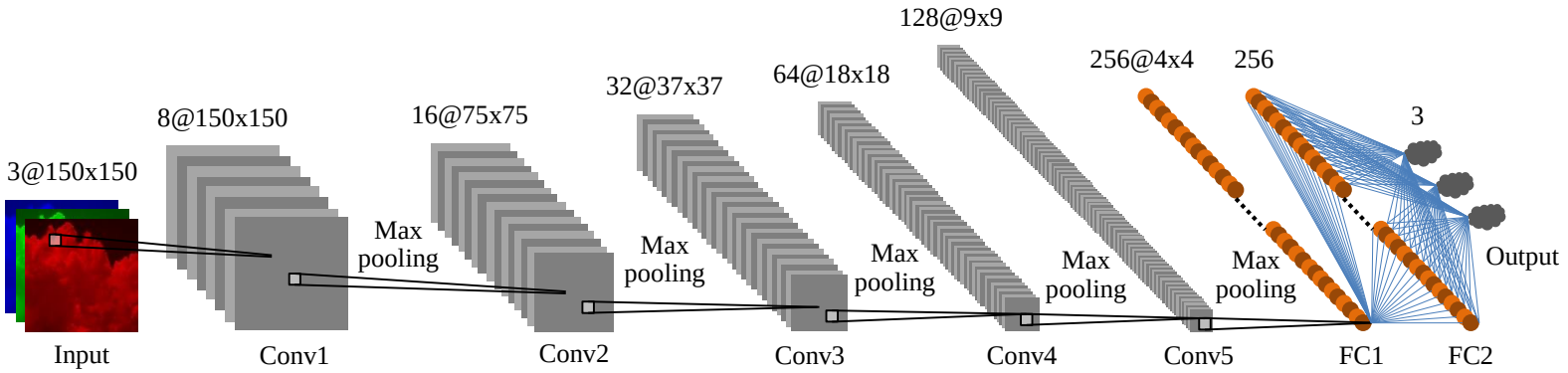


Traditional Method



Modeling

3.2 Extraction & Learning by CNNs



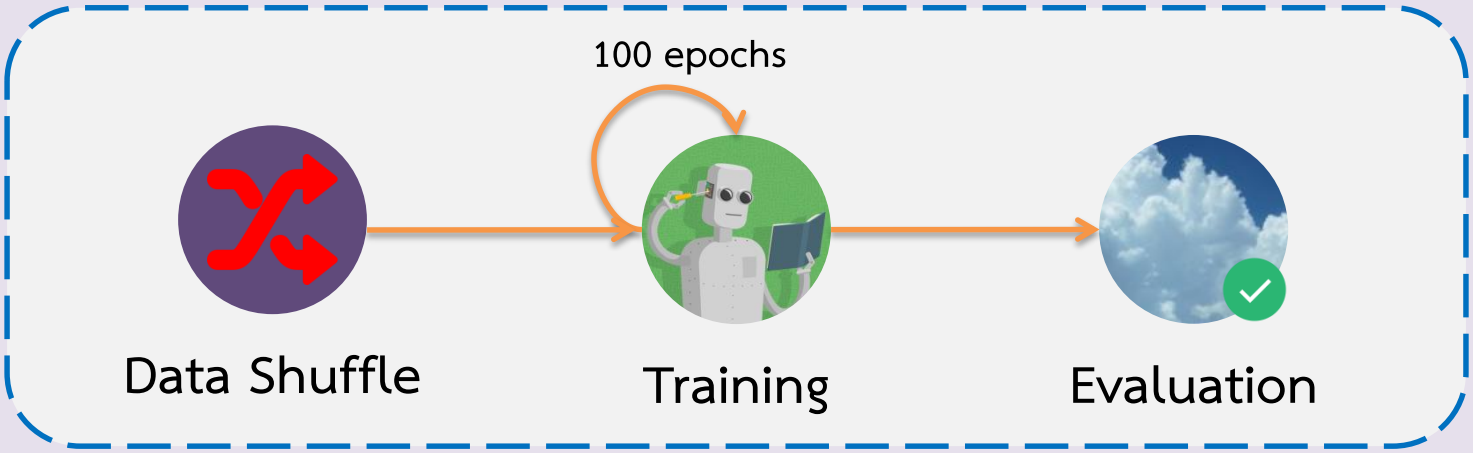
CNNs Architecture

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)

Evaluation



10 Round

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

Results

Method	Accuracy					Mean
	1	2	3	4	5	
ANNS	76.81	**77.61**	75.37	76.12	74.36	**76.12**
CNNS	**84.33**	82.14	83.58	82.12	81.34	**82.70**
Difference	+7.52	+4.53	+8.21	+6.00	+6.98	**+6.65**

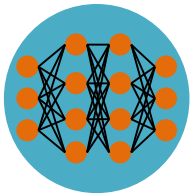
Method	Precision	Recall	F-measure
ANNS	78.29	77.61	77.08
CNNS	84.58	84.33	84.36
Difference	+6.29	+6.72	+7.28

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

around 6%

Conclusion

The input is a color image and same size at 150x150.
We use 1,340 cloud images that passed preprocessing.



In tradition modeling, We use 8 manual features for classify with ANNs. Compare with CNNs that can extract & learning directly from image data.

Deep learning achieved more accuracy than traditional method around 6% and all metrics (Precision, Recall, F-measure)

Future Work

Plan to set the standard at data collection process
and try the whole-sky images for classification.

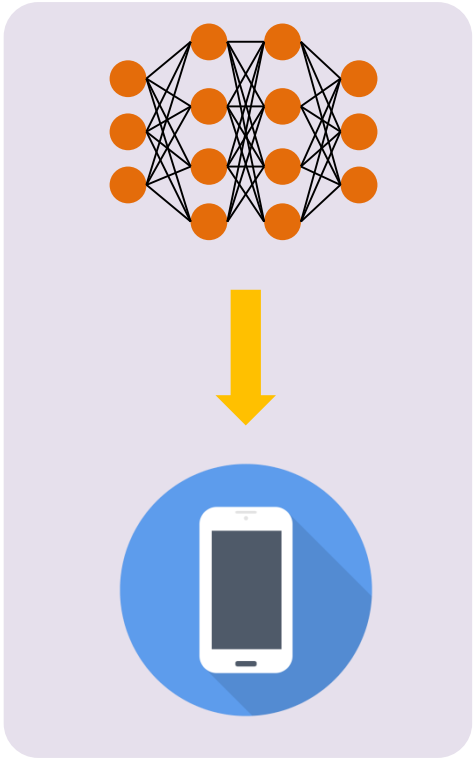
Add sub-categories like Hard, Medium and Soft
for support decision-making in cloud selection process.

Take the CNNs methods on images classification
for cold cloud seeding.

Implementation

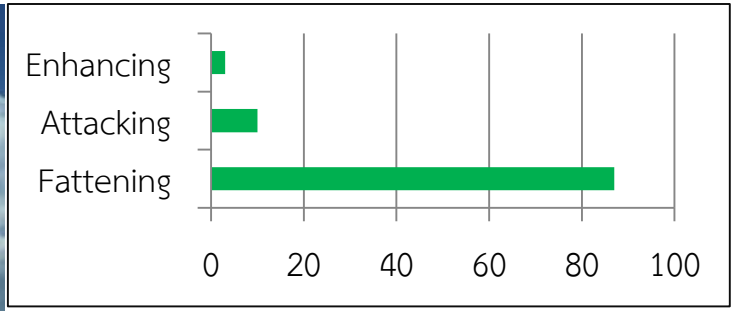
Deploy a Pre-trained CNNs Model

To Smartphone



Take a Photo

Get a Result to Support Decision-Making



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