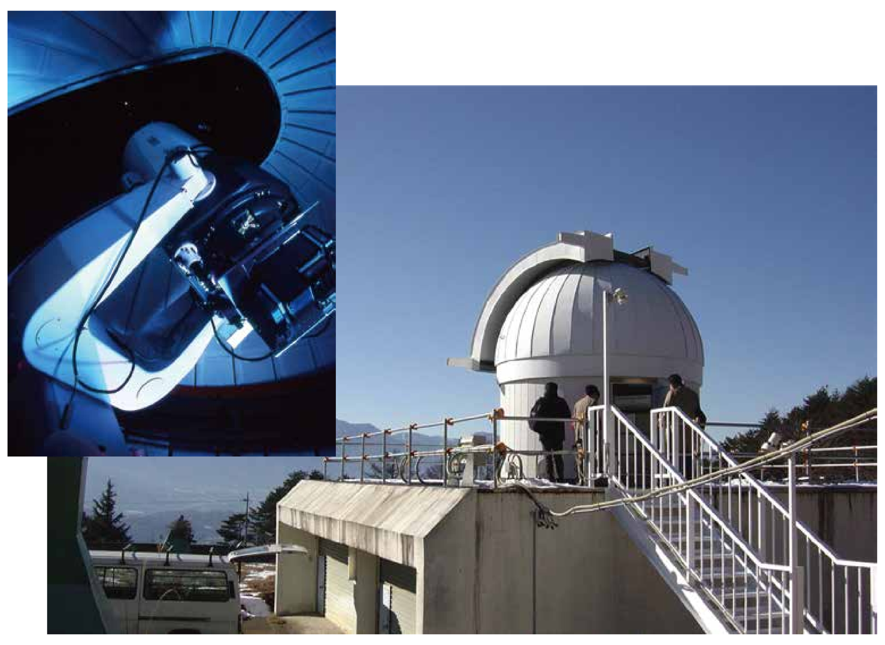
Real Time Weather Recognition based on Deep Learning

Collaborative work with Y. Yatsu, T. Yoshii, N. Kawai, J. Sakuma, N. Inoue, K. Shinoda (Tokyo Institute of Technology)
Astrophysics | Pattern recognition

Overview

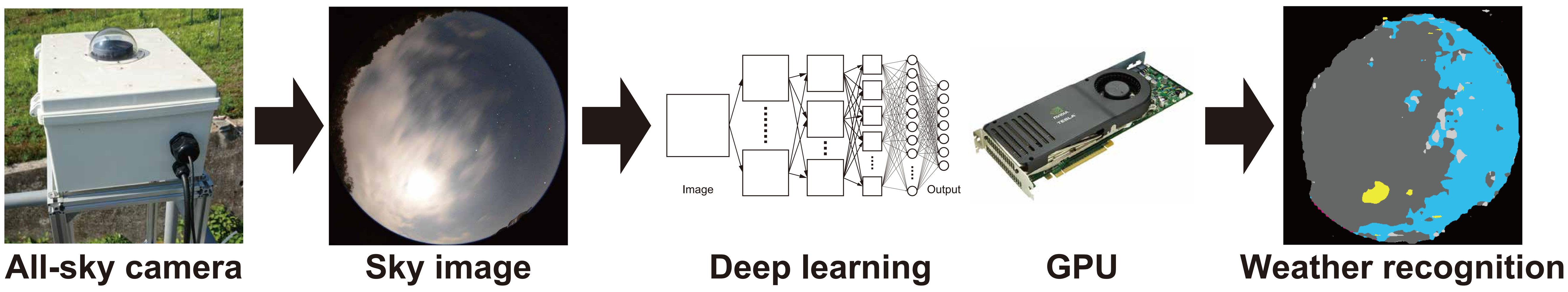
In astronomy, the study of time-critical phenomena such as gravitational wave events, supernovae and gamma-ray bursts is becoming more important. In order to perform optical follow-up observations of these events with ground-based telescope immediately after the events occur, these observation systems need to be highly automated. However, observatories especially in Japan often suffer from clouds. Visibility and sensitivity toward the particular field in the sky must be considered when the follow-up observations are arranged. To improve observation efficiency, we are developing a weather recognition system that is capable of automatically recognizing the open sky, clouds and the moon in all-sky images by utilizing the deep learning technology. We employ the images obtained by the all-sky camera located at MITSuME Akeno observatory in Yamanashi, Japan for this development.



MITSuME Akeno 50cm telescope

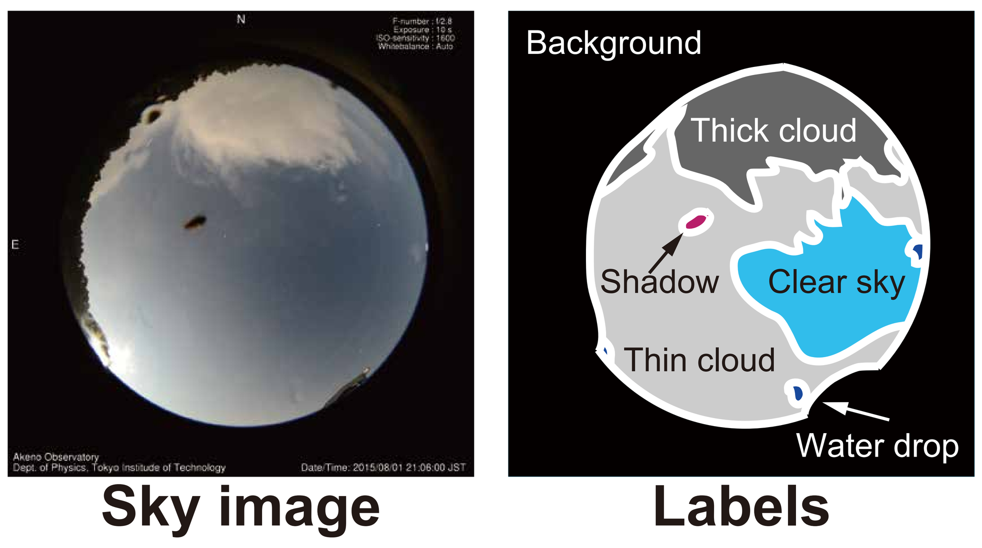
Weather Recognition System

Weather recognition system for small observatories
- Ultra-low cost
- Recognition in real time
- High portability
- Using the deep learning
- Using commercially available devices



Algorithm & Training

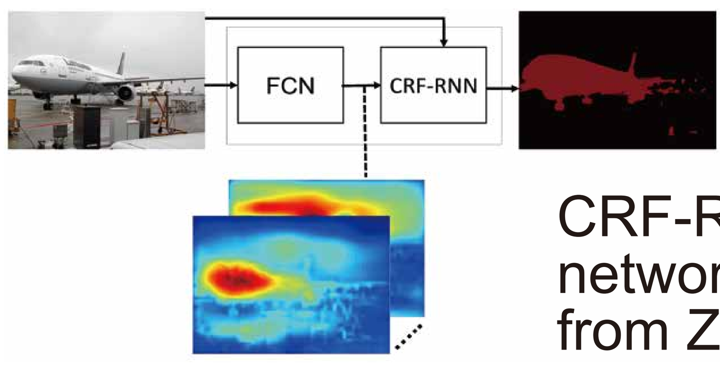
Preparing Training Data



- Sampling 1,000 images
- Defining 7 classes
  Clear sky, Moon, Thin cloud, Thick cloud, Shadow, Water drop, Background
- Labeling these classes to the all sampling images by eyes.

Algorithm

The algorithm proposed in "Condition Random Fields as Recurrent Neural Networks (CRF-RNN)" is used. It consists of two stages: Fully convolutional network (FCN) and CRF-RNN. A FCN predicts pixel-level labels without considering structure. A CRF-RNN stage performs CRF-based probabilistic graphical modeling for structured prediction.



CRF-RNN trainable network. Figure adapted from Zheng et al.

Reference: S. Zheng, S. Jayasumana, B. Romera-Paredes, V. Vineet, Z. Su, D. Du,C. Huang and P. Torr **"Conditional Random Fields as Recurrent Neural Networks,"** *The IEEE International Conference on Computer Vision (ICCV)*, 2015, pp. 1529-1537

Training

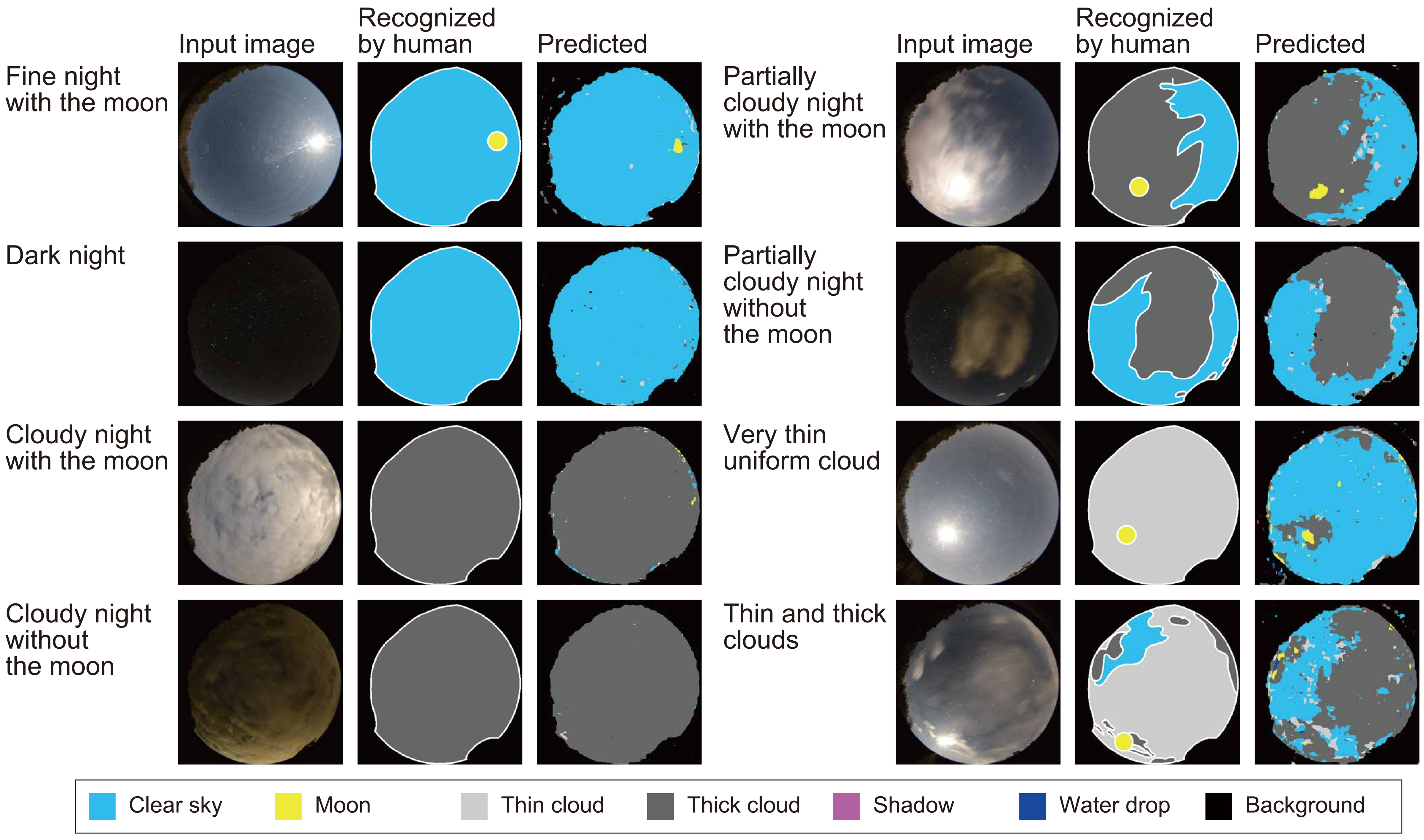
- Using a pre-trained model with MS COCO and Pascal VOC
- Fine tuning with the sky camera images
  - Resized from 2762x2762 pixels to 500x500 pixels to reduce the memory usage of a GPU
  - Randomly sampled 900 images for training and other 100 images for testing.
- Training the network for 130 epochs
- Using the customized Caffe for CRF-RNN with cuDNN running on NVIDIA GeForce GTX TITAN X

Number of training images and test images that include the classes.

	Sky	Moon	Thin cloud	Thick cloud	Shadow	Water drop	BG
Training	562	220	165	622	10	39	900
Test	61	33	20	72	0	3	100
Total	623	253	185	694	10	42	1000

Results & Evaluation

Result Images

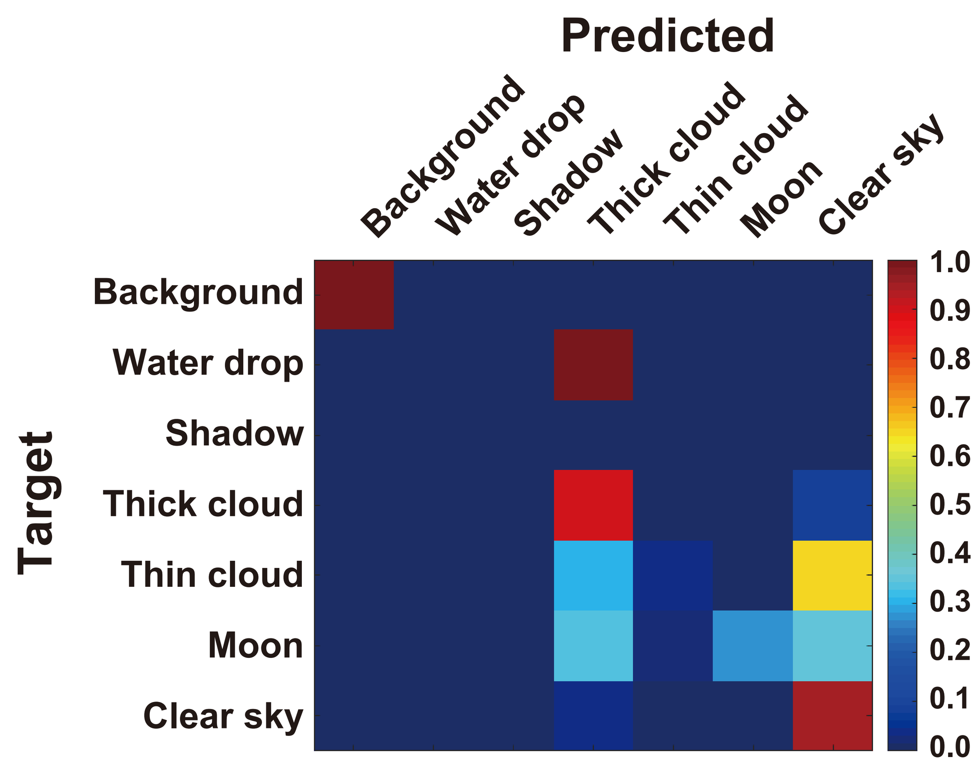


Evaluation

Intersection over Union (IoU) is used for this evaluation. It is the standard metric used in the Pascal VOC challenge.

$$IoU = \frac{TP}{TP + FP + FN}$$

		True condition	
		It was "A"	It was not "A"
Prediction	It may be "A"	*True positive*	*False positive*
	It may not be "A"	*False negative*	*True negative*



Visualization of the learnt label compatibility matrix.