Patch-based CNN for Drone-based Bamboo Forest Image Classification

Chinsu Lin[1], Wenzhi Liao[2], Satoshi Tatsuhara[3] , Sian-En Ma[1] , Chien-Ju Huang[1]

1: Department of Forestry and Natural Forestry, National Chiayi University, TAIWAN. E-mail: chinsu@mail.ncyu.edu.tw

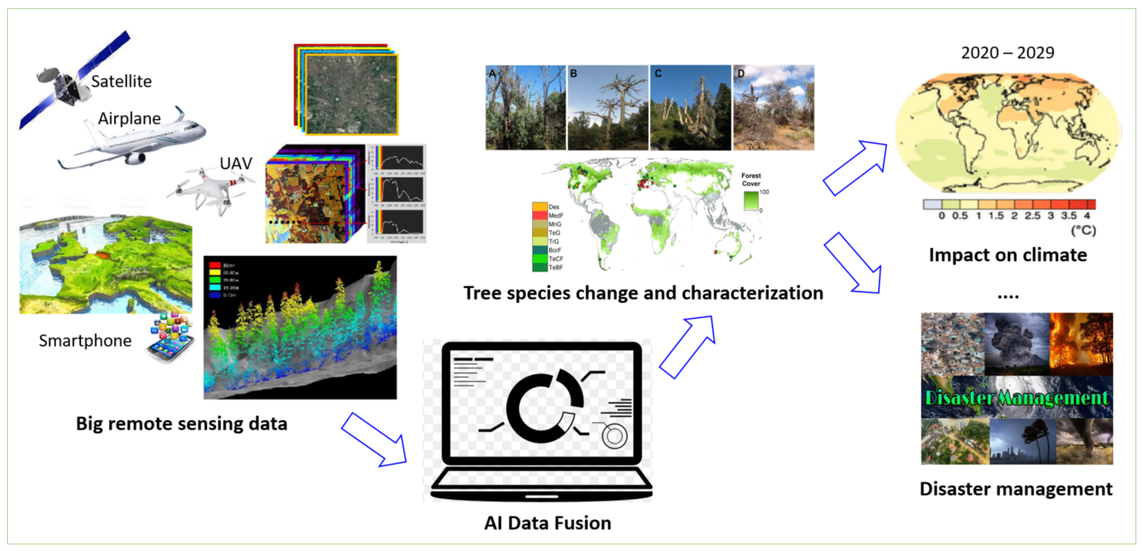
2: Flanders Make and Ghent University, BELGIUM. E-mail: wenzhi.liao@ugent.be

3: Department of Forest Science, Graduate School of Agriculture and Life Science, The University of Tokyo, JAPAN. E-mail: tatsu@fr.a.u-Tokyo.ac.jp

Abstract

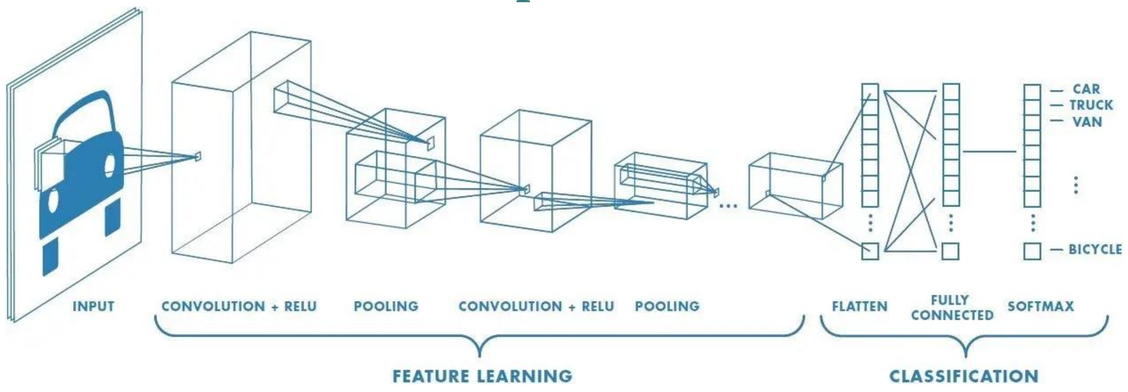
Bamboo growth is closely related to temperature (better grown in high-temperature and humid environments in Asia, including Taiwan) and has great potential for increasing carbon sequestration as it is well managed. However, the fast expansion of unmanaged bamboo plantations can invade forests, inducing forest fragmentation and biodiversity loss. Therefore, classifying the bamboo forest images and tracking their changes have impacts on environmental monitoring. This paper proposes a patch-based convolutional neural network (CNN) for very high-resolution bamboo forest remote sensing image classification. Experimental results from drone remote sensing images show that the proposed patch-based CNN can improve classification accuracy by more than 20% over classical object-based classification.

1. Study Framework

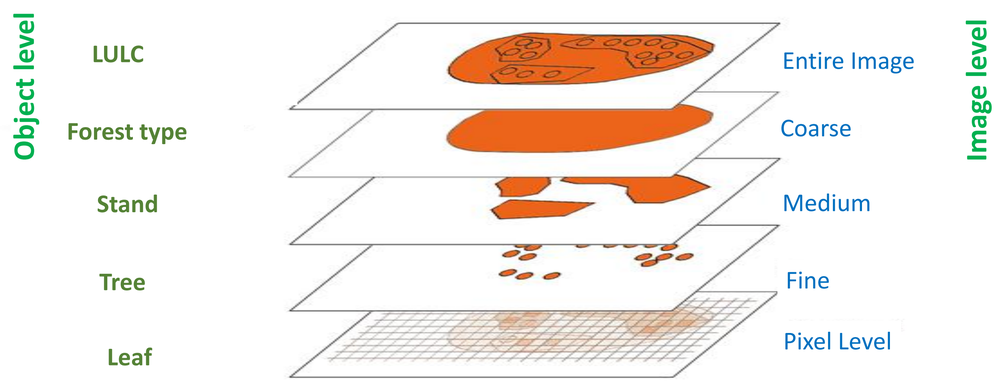


Objective: *build models to predict and analyze which environmental factors (e.g., temperature, elevation, soil properties) help to drive tree species distributions, offering some guidance on species sensitivity to environmental changes*

2. Conceptual Model

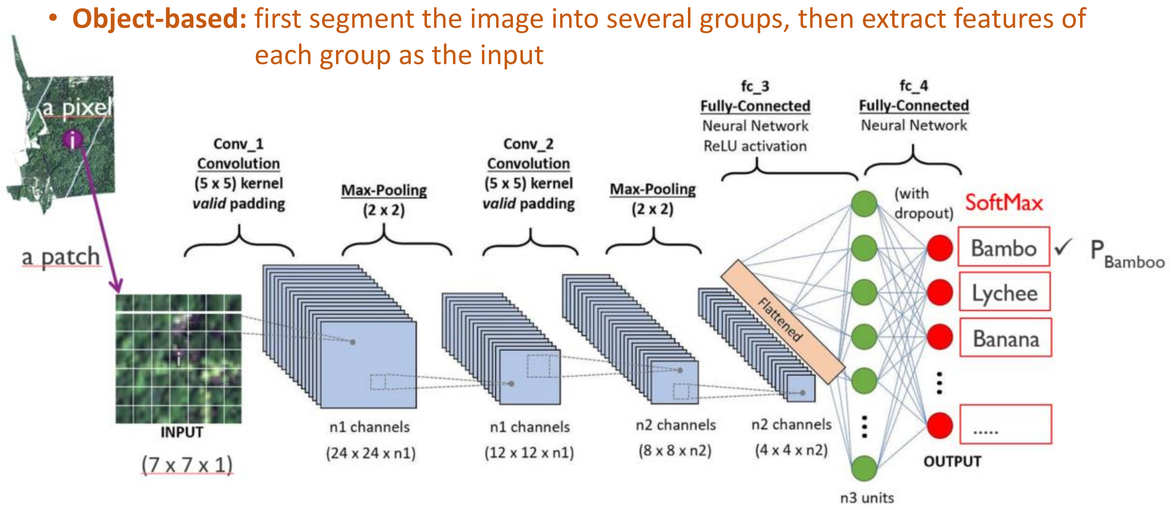


A: CNN uses kernels to learn and extract relevant features from image and classify this image to a specific class.



B: Meaningful hierarchical image object levels in high-resolution remotely sensed data

- **Pixel-based:** treat features of each pixel as the input
- **Object-based:** first segment the image into several groups, then extract features of each group as the input



C: Patch-based CNN model

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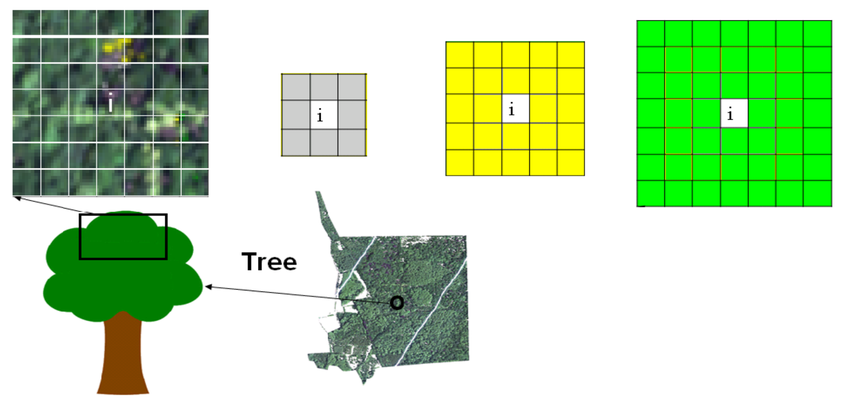
3. From Pixel- to Batch-based Features for CNN

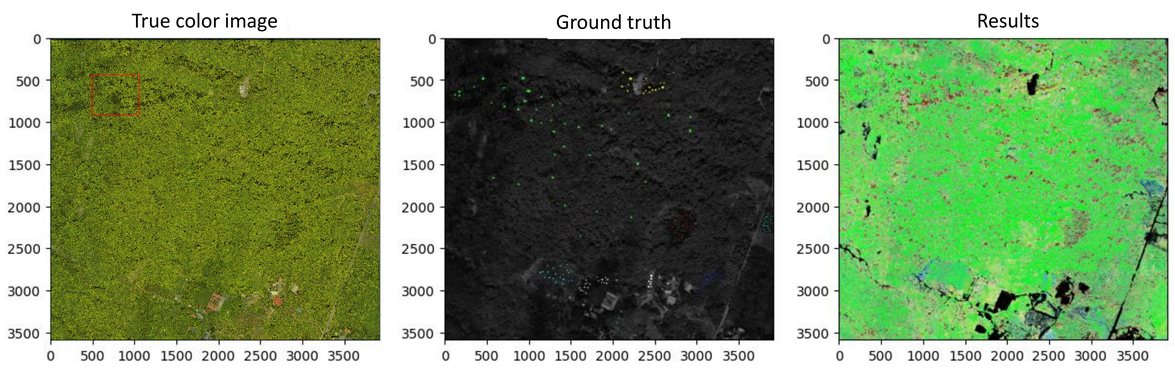


- **Patch:** take a pixel and its NxN neighboring pixels within a sliding window (by reflection padding to increase the edge pixels)
- A remote sensing image with a size of 100x100 pixels will have 10000 patches
- Treat a patch as an input image for CNN
- Classify 100x100 pixels equals to classify 10000 patches

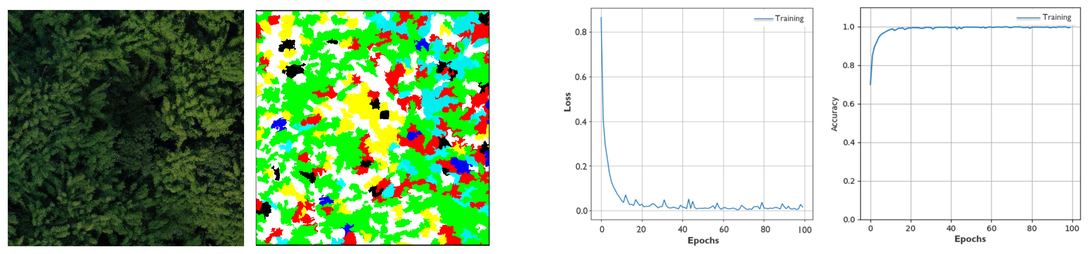
4. Experimental Design & Results

- Our goal is to classify each pixel to a specific class and comparing the proposed approach's performance with random forest classifier.
- A unmanaged bamboo forest near rural-agricultural area is used.

Study site*: A outlook of study site from UAV as well as close-look bamboo forest from the air and the ground.*



Left: *SLIC segmented areas,* ***Center:*** *Ground truth for evaluation;* ***Right:*** *Pixel-based RF map*



Left: *Patch-based RF map;* ***Right:*** *Loss and accuracy curves for Patch-based CNN approach*

Species	Per-pixel classification (RF)	Object-based classification (SLIC-RF)	Patch-based CNN with a patch size of 15x15 (2D-CNN)
Bamboo	0.59	0.75	0.97
Honduran Mahogany	0.16	0.44	0.99
Lychee	0.19	0.64	0.99
Banana	0.26	0.70	0.99
Mango	0.19	0.62	0.95
Grass	0.52	0.83	0.99
Broadleaf	0.31	0.70	1.00
Coconut Palm	0.30	0.75	0.99
Others	0.98	0.98	1.00
Macro avg	**0.39**	**0.71**	**0.99**

Table: Accuracy metric