Monitoring landscape changes in catchment areas using remote sensing technique

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OUTLINE

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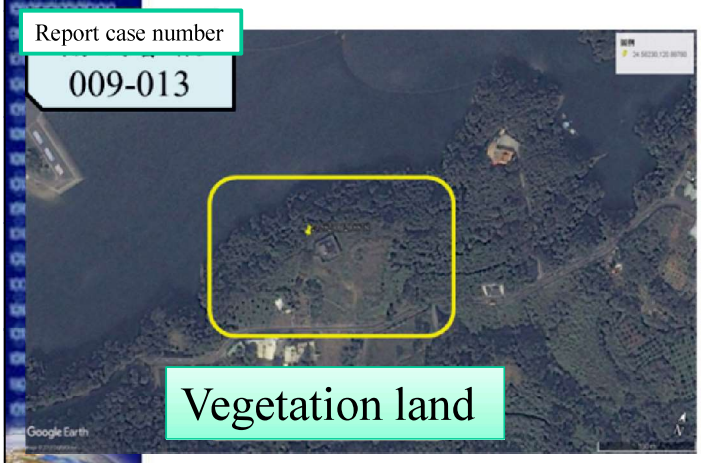
1. INTRODUCTION



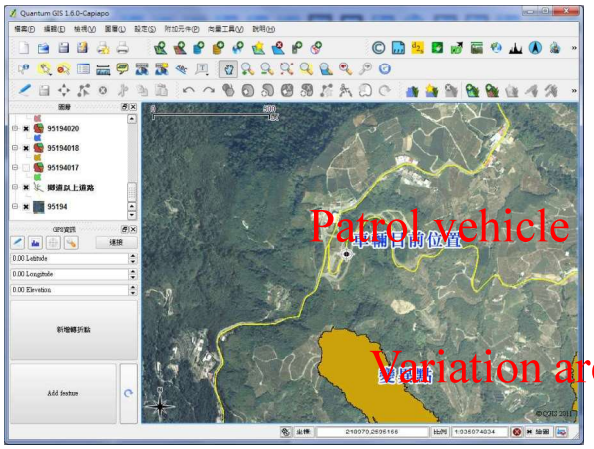
Satellite imagery shows that the vegetation land has become a building and bare soil due to illegal development.

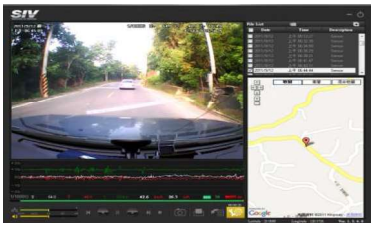
1. INTRODUCTION

Patrol vehicle survey and inspection

- Patrol vehicle configuration includes tablet computer (installation of GIS software), GPS, digital camera, high-quality DV.
- When patrolling vehicles are traveling according to route planning, they can use tablet computers to connect with GPS to track the position of vehicles in real time, and overlap them in the relevant layers to understand the current traveling position.
- When the vehicle passes through the variation area, the inspectors get off the vehicle and conduct on-site investigation of the variation point.

Catchment area survey and inspection



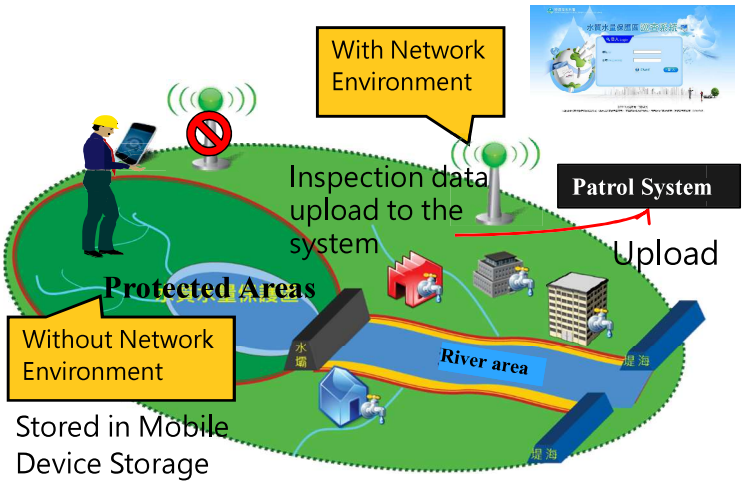


Recording high-quality video

1. INTRODUCTION

Patrol System of Water Source and Water Quality Protected Areas

- User: Executing patrol operators in protected areas.
- Inspectors can start the inspection record when the inspection is carried out, and automatically record the inspection time, route, place and inspectors, and can also upload the survey overview.



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1. INTRODUCTION

The route of inspectors can be recorded by GPS and uploaded to the inspection system after the inspection.

When a suspected violation of the regulations is found during the inspection, a new violation is added for notification.

Provide users to download and manage all information, inspection records and case of illegal use.

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1. INTRODUCTION

Over development and illegal use

- Due to frequent incidents of over development and illegal use of catchment areas, land use management must be strengthened by regularly checking for illegal use.

Checks serve to maintain ecological conservation

- Such checks serve to maintain ecological conservation within a catchment area and prevent overutilization and illegal development.

Patrol personnel conduct routine inspections

- Conventionally, patrol personnel conduct routine inspections onsite by using digital cameras, GPS device, and paper records.

Manual inspection - time consuming and labor intensive

- However, such manual inspection methods are time consuming and labor intensive, resulting in low inspection frequency and varying inspection standards due to personnel differences.

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1. INTRODUCTION

Remote sensing images can help :

Monitor large areas and find suspicious locations

- Remote sensing images can help monitor large areas and be analyzed algorithmically to find suspicious locations.

Instant, low-cost, and long-term observation and monitoring

- Remote sensing techniques can provide instant, low-cost, and long-term observation and monitoring of a catchment area.

Water resources management in catchment areas

- These advantages are especially useful for monitoring overall landscape change trends in catchments encompassing water sources and thus help in the management of these sources.

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1. INTRODUCTION

FORMOSAT-2 satellite

- This study evaluated the normalized difference vegetation index (NDVI) using hyperspectral remote sensing data for Taiwan from the FORMOSAT-2 satellite with 8-m spatial resolution.
- FORMOSAT-2 can provide red spectral band (0.630–0.690 μm) and near-infrared band (0.760–0.900 μm) images that can be used to estimate the NDVI.

Chlorophyll in leaves has strong absorption

- Chlorophyll in leaves has strong absorption at 0.45 and 0.67 μm and high reflectivity at near infrared (0.7–1.1 μm).
- In short-wave infrared spectroscopy, vegetation exhibits three absorption characteristics, which can be directly related to the water contained in the absorbed leaves.

1. INTRODUCTION

Spectral reflectance data can be used to calculate various nutritional indices

- Because of chlorophyll absorption, plants usually have low reflectivity in the blue and red parts of the spectrum,
- Plants have slightly higher reflectivity in the green part, which is why plants look green to human eyes.
- Near-infrared radiation energy is strongly reflected from plant surfaces. The amount of reflection depends on the characteristics of the leaf tissue.
- Contrast between vegetation and soil is largest in the red and near-infrared regions.
- Therefore, spectral reflectance data can be used to calculate various nutritional indices, which are closely related to agronomic and biophysical plant parameters related to photosynthetic activity and plant productivity

1. INTRODUCTION

Relationship between vegetation cover and satellite spectral images

- Satellite imagery has been widely used for monitoring and researching large-scale water conservation in catchment areas.
- Using various analytical methods, the relationship between spectral data and land use can be established to distinguish abnormal land use in catchment areas.
- In the present study, the relationship between vegetation cover and satellite spectral images was established.
- The location of vegetation cover was selected by calculating the NDVI, and then the empirical coefficient of the output threshold was calculated through statistical regression.
- The NDVI was employed to interpret the actual application of landform change in the catchment area.

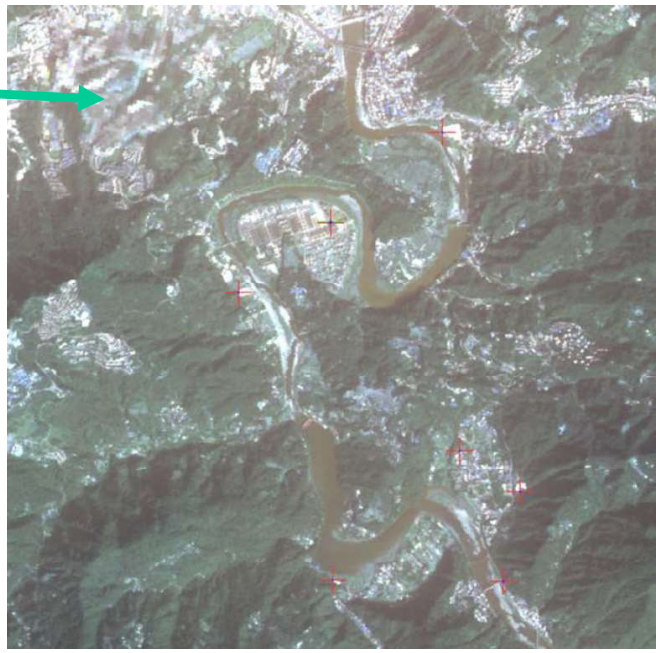
The NDVI is given as follows:

$$NDVI = (NIR - RED) / (NIR + RED)$$

where NIR is reflectance in the near-infrared band and RED is reflectance in the visible red band.

2. METHODOLOGY

Study area : upper reaches of the Xindian River catchment area



Schematical illustration of satellite image geometry correction

1. INTRODUCTION

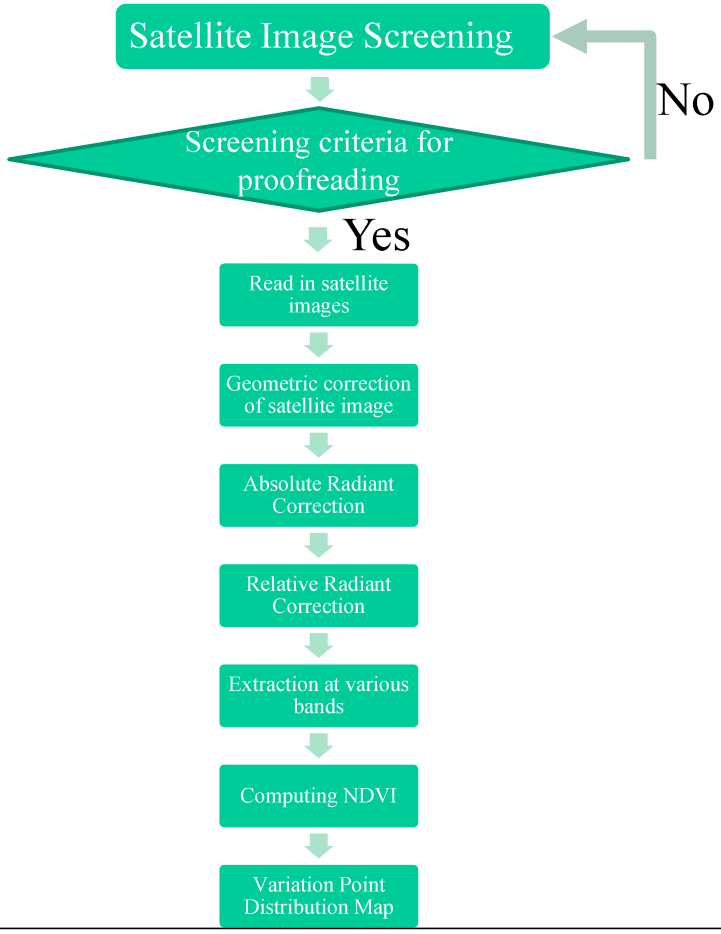
The upper reaches of the Xindian River catchment area

- Location for analysis was selected as the upper reaches of the Xindian River catchment area.
- Using pre- and postimages, NDVI interpretation was employed to identify the landform variation points (i.e., the threshold of green and non-green covered).
- By comparing the early images with later images, the variation points could be determined. The NDVI was used to interpret the geomorphological variation.

Satellite spectral values can be converted into the information of land use

- According to the transformation relationship, satellite spectral values can be converted into the information of land use.
- Distribution of the overall use can be obtained so that the correct management strategies can be adopted.

2. METHODOLOGY



2. METHODOLOGY

A. Satellite image data collection

- Selected satellite images were based on the frequency of satellite passing through the target area and the requirements of the patrol service.
- Satellite images are affected by cloud occlusion; therefore, reasonable frequency and period were determined according to requirements.

B. Satellite image geometry correction

- Satellite image data could not be used to determine the spatial geometric distribution of images in different periods.
- To ensure that the spatial geometric distribution between multitemporal images corresponded correctly, geometric correction of multitemporal satellite images was conducted.

C. Satellite image correction

- The purpose of this step was to correct images under different radiometric conditions at different times.
- Analysis and comparison of images taken in different seasons and from different positions requires consideration of varying angles of solar irradiation and different intensities of reflection. Therefore, the follow-up analysis could be conducted for images taken at different times.

D. Establishment of the regression model

- According to calculation of the NDVI, the location of plants can be screened, but the threshold of each regional index differs.
- Therefore, a regression equation was generated by referring to the literature and empirical coefficients of statistical regression output thresholds.

E. Model verification and amendment

- If new satellite imagery is used, the old regression relationship can be validated and corrected, and a new threshold can be established.
- Completed validation results becomes a new regression model for long-term monitoring.

F. Conversion of spectral values to land variation points and establishing a theme map

- By changing the spectral values of other satellite images into the regression formula, a land variation map was obtained.

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2. METHODOLOGY

Schematical illustration of satellite image geometry correction

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3. CASE ANALYSIS OF SATELLITE IMAGE

A. Study location

- The upper reaches of the Xindian River catchment area were used as the study site.

Landscape variations in catchment areas in upper reaches of the Xindian River was conducted

NDVI was used to identify landscape changes in the pre- and post-images .

•Site map of the case study in the upper reaches of the Xindian River catchment area. (Red square area is selected as study area)

3. CASE ANALYSIS OF SATELLITE IMAGE

B. Satellite telemetry image data

- The satellite telemetry images used were multispectral images from FORMOSAT-2, providing blue, green, and red visible light bands and near-infrared light bands.
- The image-to-ground resolution was 8 m. The preimage data were from November 13, 2015, and the postimage data were from April 19, 2016.

C. Interpretation of images using the NDVI

- According to the selected pre- and postimage data, and after image correction, each band of image data was converted to the NDVI (Fig. 2), where every pixel from dark to light represented its NDVI from small to large (ranging from −1 to 1).
- If the NDVI is greater than 0, it means that the land is covered with green. If the NDVI is less than 0, it means that the land is not covered with green.

Fig.2 NDVI in the upper reaches of the Xindian River catchment area.

3. CASE ANALYSIS OF SATELLITE IMAGE

D. Converting images into green and non-green coverage

- Threshold of the NDVI for green and non-green covered land was determined as 0.05.
- The image was transformed into an image with a NDVI greater or less than the threshold (Fig. 3). The green parts indicate green coverage, and the dark gray parts indicate non-green coverage.

E. Pre- and postimage interpretation and comparison

- After image transformation, the pre- and postimages were compared using the algorithm to locate variation points in the landscape from original green coverage to non-green coverage, thereby establishing the variation areas (Figs. 4–7).

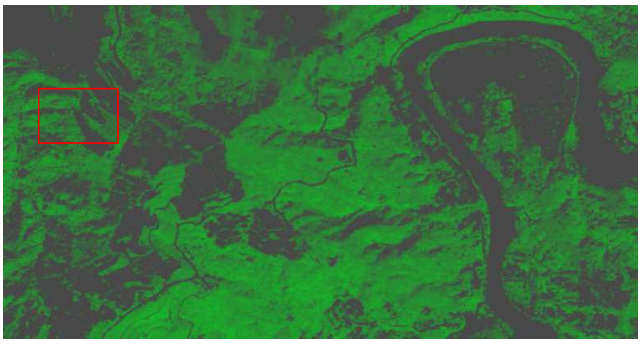

Fig.3 Image conversion using the threshold.

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4. RESULT AND DISCUSSION

Covered in green

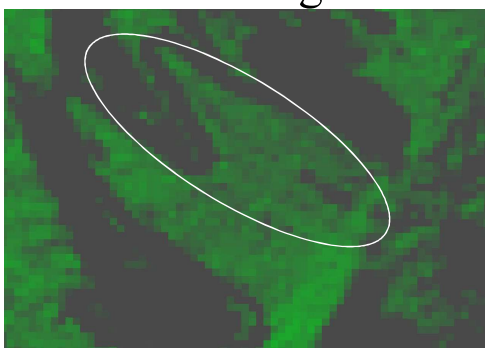

Fig.4 Preimage green coverage in variation area.

Green cover was reduced or even eliminated

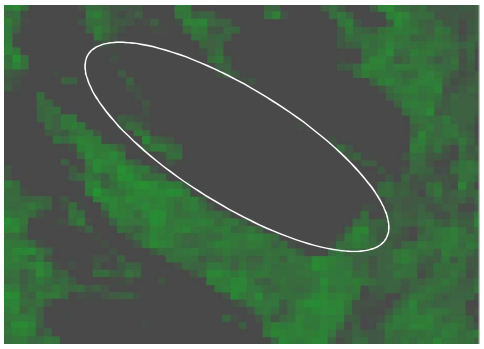

Fig5 Postimage non-green coverage in variation area.

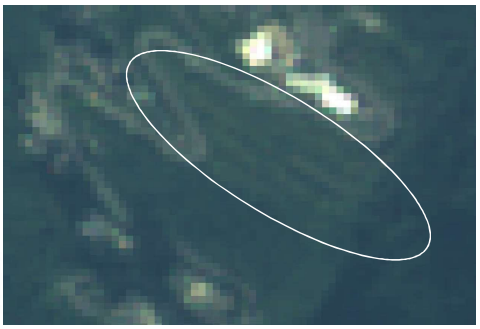

Fig.6 Satellite preimage in variation area

Green cover is clearly visible

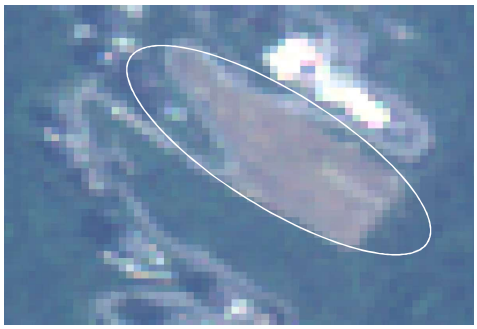

Fig.7 Satellite postimage in the variation area

Surface soil

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4. RESULT AND DISCUSSION

NDVI can be effectively applied to interpretation of landform variation

- According to the preliminary case analysis results, the NDVI can be effectively applied to interpretation of landform variation in a target catchment area.

Unmanned aerial vehicles(UAVs) will be used in a follow-up experiment to take detailed photographs

- Unmanned aerial vehicles(UAVs) will be used in a follow-up experiment to take detailed photographs of the selected variation points for automatic interpretation.

Monitoring and tracking the degree of restoration in the region

- Multispectral images can be used to calculate a more detailed NDVI for the site, which could enhance the reliability of the data and help in monitoring and tracking the degree of restoration in the region.

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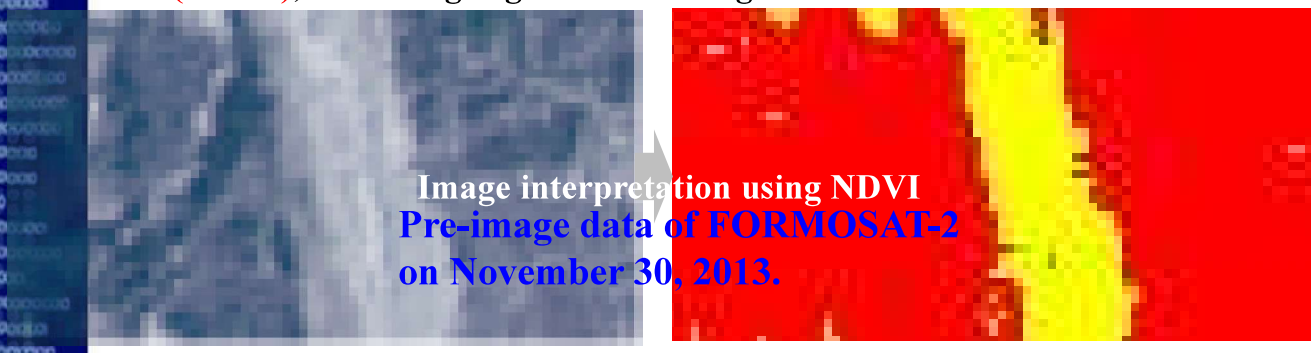
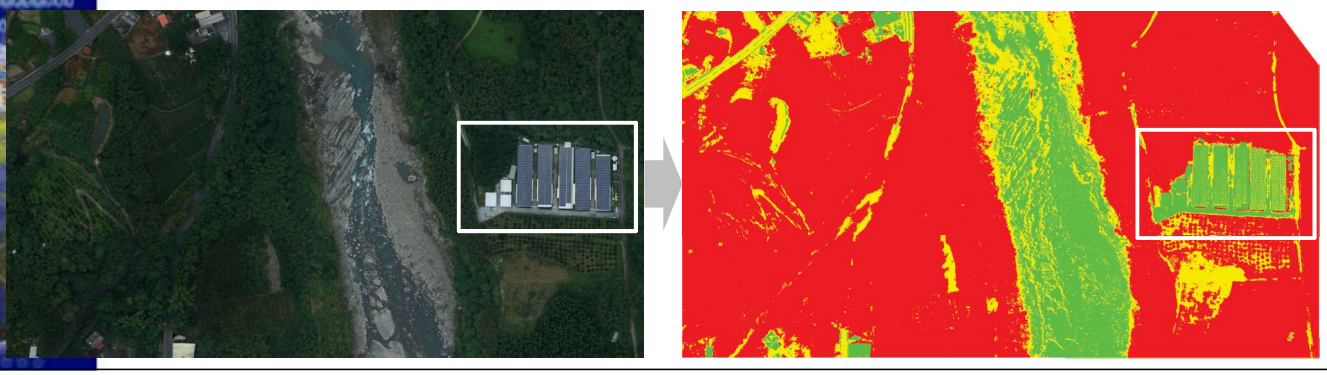
4. RESULT AND DISCUSSION

Green (-1~-0.2) means the ground cover is cloud, water, snow, etc.
Yellow (-0.2 ~ 0.2) is highly reflective to visible light; indicates that there is rock or bare soil, etc.
Red (0.2 ~ 1), indicating vegetation coverage



UAV was in a follow-up experiment to take detailed photographs on 10/8, 2018.



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4. RESULT AND DISCUSSION

Manual intervention help confirm interpretation results

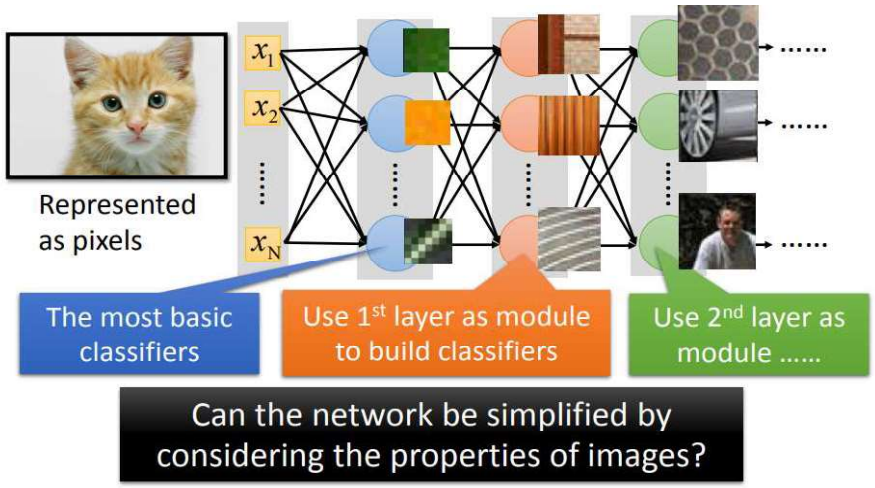
- Previously, automatic interpretation technology often required manual intervention to help confirm interpretation results.
- Manpower confirm landform variation is impractical.

Artificial intelligence assist in land use interpretation

- Artificial intelligence assist in land use interpretation and enhance the ability to search for variation points.
- Recent developments in computing power have led to the expansion of deep learning technology and application of neural networks
- Especially in terms of image recognition based on convolutional neural networks.

4. RESULT AND DISCUSSION

- Input the image pictures to the neural network
- Identify images through several layers of features and classifications
- Handle complex images efficiently,
- With the learning ability and results of the image data can be predicted.
- Consisting of one or more sets of a Convolution layer and a Pooling layer,
- Prediction result is obtained by inputting a flattened layer to a fully connected feedforward network.

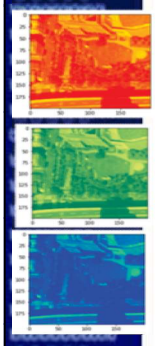


Schematic diagram of convolutional neural network

4. RESULT AND DISCUSSION

Convolution layer and Pooling layer

Fully connected feedforward network



R

G

B

1. 32 filter 3x3
2. 32 filter 3x3
3. Maxpool 2x2

1. 64 filter 3x3
3. Maxpool 2x2

flat layer

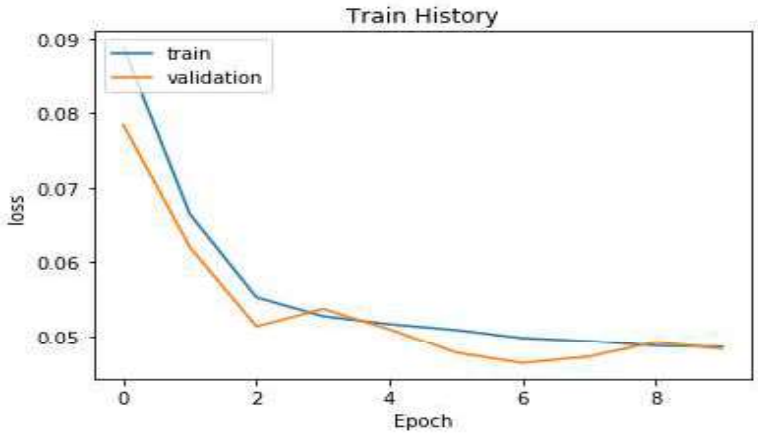
2000 Neurons

1000 Neurons

5000 Neurons

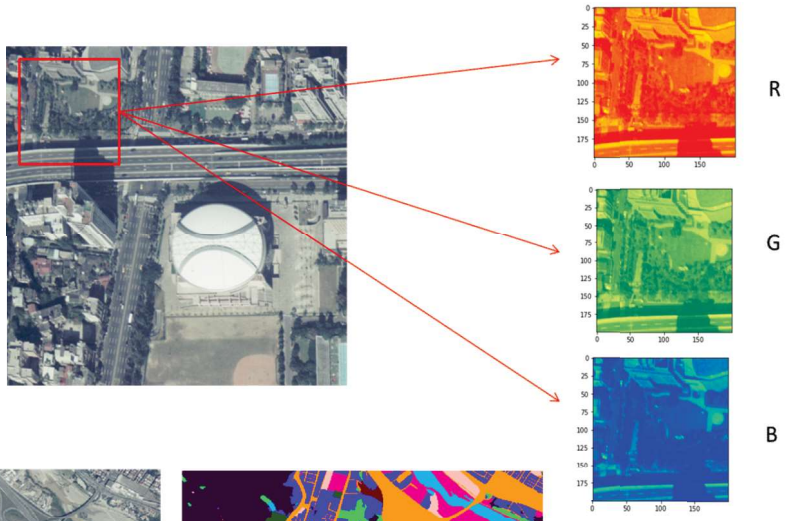
200 Neurons

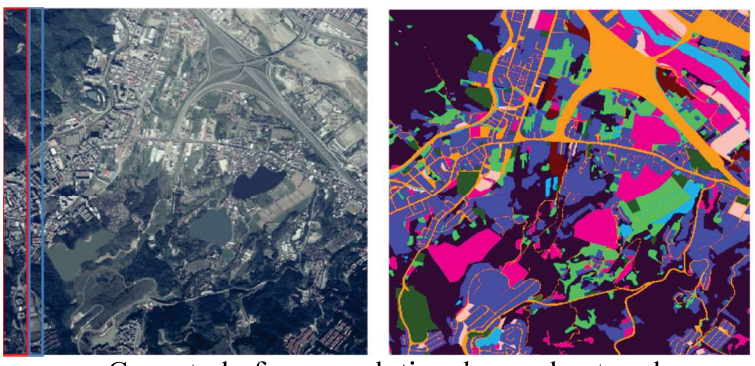
Output



Comparison for model training and verification results

4. RESULT AND DISCUSSION





Case study for convolutional neural network

4. CONCLUSION AND SUGGESTION

Monitor and manage water resources using satellite remote sensing

- Application of satellite imagery to large-scale water conservation in catchment areas has become increasingly common, and it is now feasible to monitor and manage water resources using satellite remote sensing.

Relationship between spectral data and land use can evaluate abnormal land use

- By applying various analytical methods, the relationship between spectral data and land use can be established to evaluate abnormal land use in water resource conservation areas.

Threshold (0.05) of NDVI was used to automatically generate images for green and non-green coverage

- Threshold of NDVI for green and non-green coverage was 0.05. Green parts of the image were vegetation areas and the dark gray parts were places where the landscape changed.

Landscape variation points can be selected through image transformation

- Through image transformation, the landscape variation points based on the change from the original green to non-green space can be found.

4. CONCLUSION AND SUGGESTION

NDVI can be used to judge the scale of landscape change

- The algorithm employed in this paper demonstrates that the NDVI can be used to judge the scale of landscape change.

Hyperspectral remote sensing data to judge illegal development zones

- Patrol personnel may be unable to judge illegal use of catchment areas, and therefore, the use of hyperspectral remote sensing data to judge illegal development zones can further protection and management of water resources.

Image data acquisition and interpretation can help water resources protection and land use management

- Intelligent image interpretation technology combined with image data acquisition and interpretation can help water resources protection and land use management in catchment areas by revealing illegal exploitation.

Thanks for Your Attention