Remote Sensing for Environment of Angkor World Heritage Site
(1) Inscription: 1992 → World Cultural Heritage Site
   → World Heritage Site in Danger;

(2) Repair and restoration: 1993 – 2013

(3) Tourists: 20,000 → 2 millions

(4) Urbanization

(5) Threats
Remote Sensing on Environment of Angkor Site

Prof. Huodong Guo of HIST and RADI and Director BUN Narith of APSARA signed an MOU during the 37th session of the UNESCO World Heritage Committee in Phnom Penh, June 2013

Cambodian Deputy Prime Minister H. E. Dr. Sok An met with the HIST/RADI delegation, and expressed full support for the proposed collaborative project

Angkor Site and its environment

- Forest ecosystem (deforestation/fire)
- Water system (flood/soil erosion)
- Ground subsidence (loosen/displacement)

Spatial database of Angkor Site
3D simulation and GIS
Policy recommendations for heritage protection and sustainable development
Training of heritage management personnel

- Climate system (wind/temperature/precipitation)
- Soils
- Rock Types
- Human Activity (tourism/urbanization)

Multi-platform remote sensing data
Basic geodata
Auxiliary data

Optical image
Radar data
LiDAR data

Satellite platform
Ground collection

www.radi.cas.cn
Research Progress:
(1) Land Cover Change

Data source (1985-2014)
- Landsat MSS
- Landsat TM
- HJ-1A
- Landsat LOI

Classification Map (2009/01/05)

- Urban area: gradually increasing
- Forest area: unstable growth
- Water area: seasonal fluctuations
Forest changes during three periods (1989-2000-2014)

- Deforested area is 575 km² from 1989 to 2014, which occupied almost 35% of the total area.
- Reproduction area is 62 km² from 1989 to 2014, which is about 5% of the total area.
- 22% deforested area during the period of 2000-2014, while only 13% during the period of 1989-2000.
- As time goes, deforestation spread from south to the north of Kulen mountain随着时间推移，森林砍伐由南往北蔓延。
RS Data: ZY3 image (2 m), Jan. 5, 2014

Image Classifier: Object-oriented Classifier

Features used: Ndvi, Area, Home, Color, Smoothness, Compactness, Shape index, Rectangular fit

Study Area: Kulen Mountain area from 40-120 m above seal level.

- Forest areas of Kunlen Mountain mainly located above 40 m a.s.l.
- Frequent human activities are the main reason which led to forest changes during the past 30 years.
Research Progress: Economic Forest Extraction

Classified objects

- Total Number: 345
- Min. Area: 0.000534 Km²
- Max. Area: 0.342613 Km²
- Sum Area: 5.837428 Km²
- Area < 0.03 km²: 298 (86.3%)
Road 67 buffer: 4 Km
Count: 208 (60.29%)
Area: 2.99 Km² (50%)
The first inversion of surface deformation using 42 scenes of TerraSAR-X images (3m) in the observation period of 2011-2013. Although it is significant, the motion of relics and its surroundings is hampered by other movements triggered by urbanization, farming as well as surface erosion after wild-fires.
Through the discussion with staff from APSARA and field investigations, causes of temple collapse have been confirmed, including erosion, tree growth and motion heterogeneity.
An improved PSInSAR model for the motion anomalies detection.

Local ground sinking intersperse among the site (with values ranging from -15 to -2 mm/a) due to urbanization and groundwater pumping, marked by “1, 2 and 3”.
Research Progress: Ground Subsidence Monitoring

Temple-level monitoring, e.g. Bakong Temple

www.unesco-hist.org
Findings and comments

Water pumping either by public or private does not cause a problematic regional surface subsidence threatening the sustainability of surrounding monuments, although local ground sinking intersperse among the site (with values ranging from -15 to -2 mm/a) due to urbanization and groundwater pumping.

Local government and APSARA made an optimal site selection for public wells located along the National Route No.6 on the south of West Baray, reserving a safe distance from the site core area and assuring the groundwater table replenishment from West Baray and moats of Angkor Wat and Angkor Thom.
Research Progress:

(3) 3D Simulation and Spatial Information System

3D Modeling Technology
- 3D modeling based on different multi-source data, such as pictures, videos, CAD data, photogrammetric data and LiDAR data.

Realistic and physical Simulation of Spatial elements
- To simulate natural phenomena (rain, snow, cloud, fog, shadow, water reflection, etc.) combining hydrodynamics, physical particle model and optical transmission model.

Visualization of Typical Natural Elements
- To simulate the typical natural elements in Angkor Site, such as forests, buildings, roads, rivers and lakes.
- To simulate the dynamic changes of natural elements, such as land subsidence, land use changes.
A. 3D Modeling & Models Collecting

- **3D Modeling by multi-source data**
  - Rebuild 3D models based on different multi-source data, such as pictures, videos, CAD data, photogrammetric data.

- **Models Collecting**
  - Collect some shared elements and models from the Internet to provide material for the 3D simulation system.
B. Design and Implementation of Spatial Database

- Designed and implemented the spatial data tables of remote sensing images, vectors and 3d models of Angkor Site.
- Stored the current multi-source data.
- Developed some database functions, such as information querying.
Exchange of Visit

12. 2013

03. 2014

06. 2014

05. 2014

07. 2014
Exchange of Visit
Thank you for your attention!