Cultural Heritage Tourism with Augmented Reality

Takafumi Taketomi, Koji Makita,
Tomokazu Sato, and Naokazu Yokoya
Nara Institute of Science and Technology, Japan

Cultural Heritages in Nara

Todai-ji

Yakushi-ji

Kawaradera

Heijyo-kyo

There are several now-defunct cultural heritages.

Cultural Heritage Reconstruction Methods

- Physical reconstruction at the original place
  - Tourists can intuitively imagine the atmosphere of the time.
  - Huge money need to reconstruct buildings.

- Reconstruction by CG in virtual space
  - Buildings are reconstructed with low financial cost.
  - Tourists cannot intuitively imagine the atmosphere of the time.

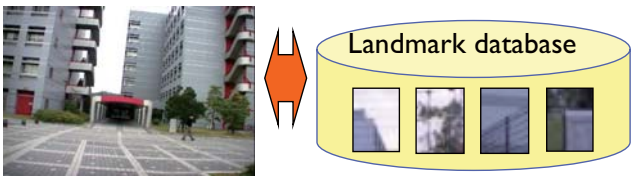
- Reconstruction by augmented reality (AR) at the original place
  - Tourists can intuitively imagine the atmosphere of the time.
  - Buildings are reconstructed with low financial cost.

Requirement for reconstruction by AR:
Geometric registration of real and virtual worlds in an outdoor environment

Geometric Registration Methods in Augmented Reality

Vision-based approach

- The method can achieve pixel-level geometric registration.
- Robust geometric registration is difficult in a wide area.



[Taketomi et al. 2008]

Sensor-based approach

- It is difficult to achieve pixel-level geometric registration.
- Robust geometric registration is achieved in a wide area.

[Azuma et al. 1999]

Our Goal

Virtual cultural heritage reconstruction on the real site in an outdoor environment

Approach

We have developed and tested two types of AR system for realization of virtual cultural heritage tourism.

- Vision-based System

  High quality AR images are generated to watch key buildings in a limited area.

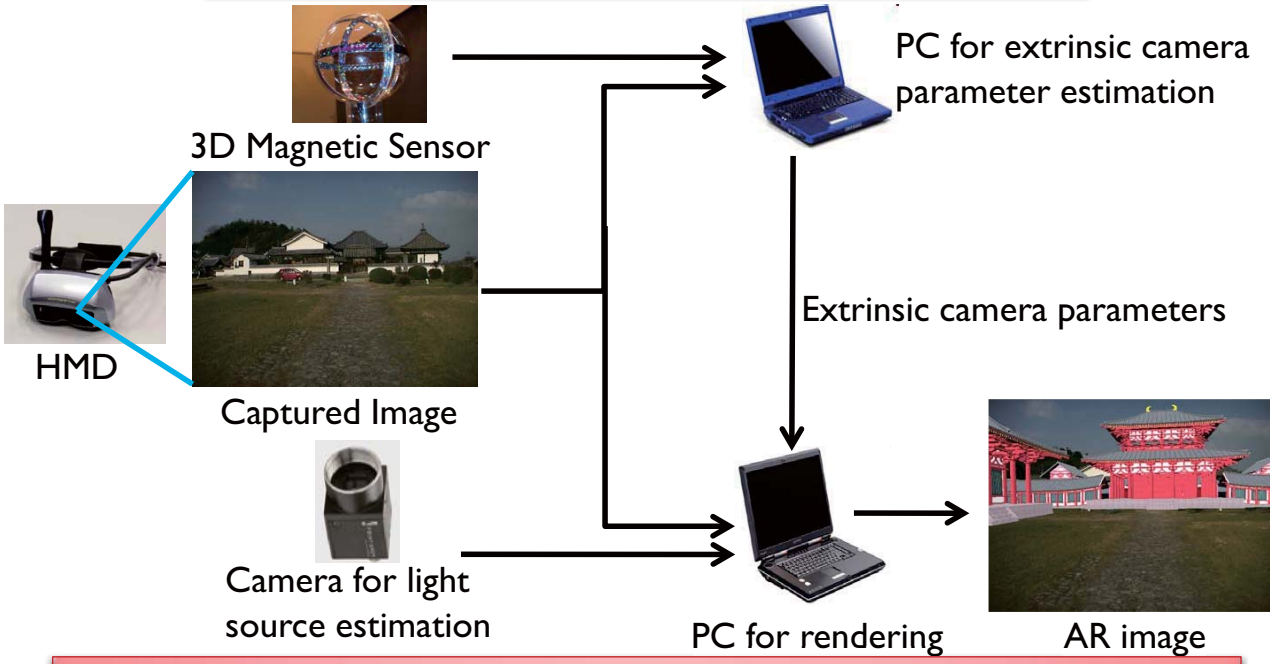
- Sensor-based System

  Roughly registered AR images are generated to watch the appearance of the buildings in a wide area.

Vision-based System

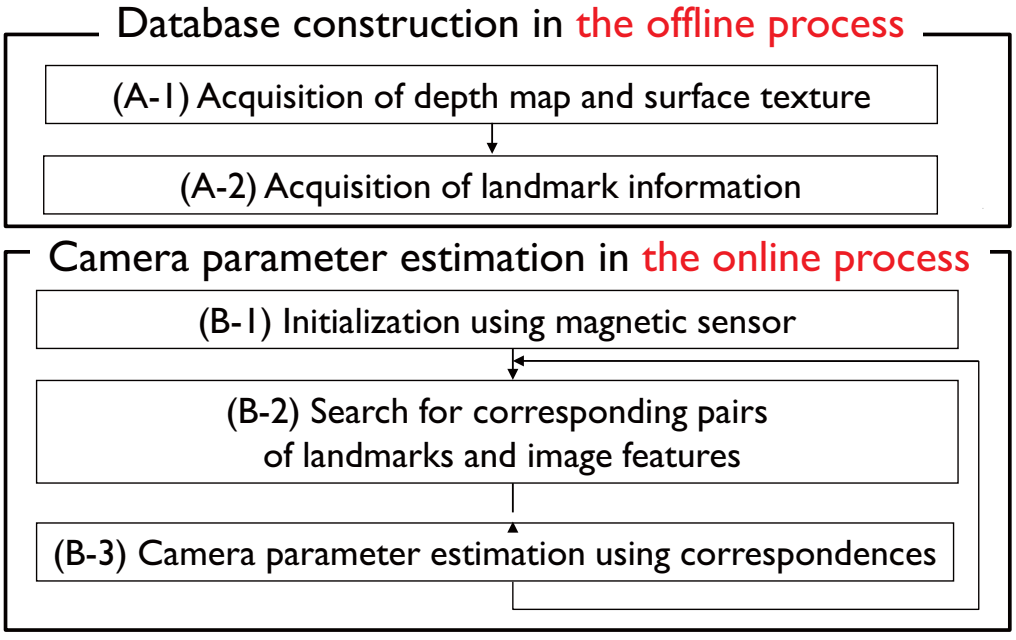
Hardware Configuration

Geometric registration is achieved by extrinsic camera parameter estimation.



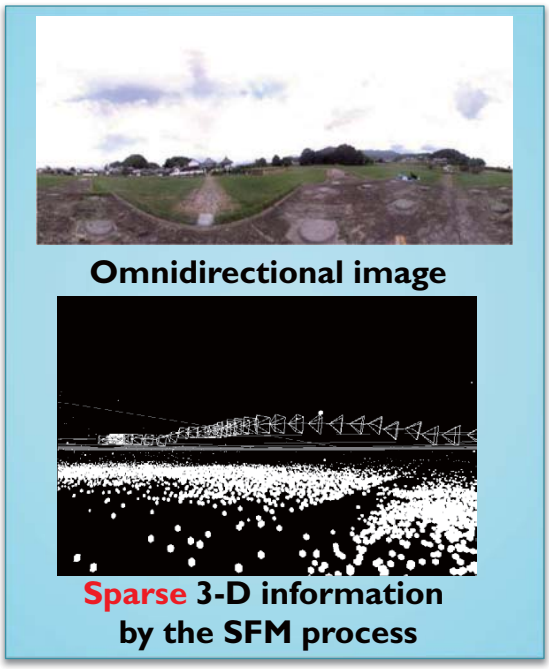
CG models are rendered by using estimated light source [Kakuta et al. 2007].

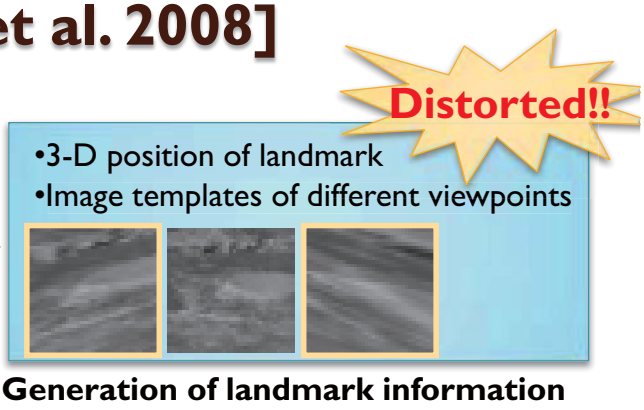
Flow of Vision-based Geometric Registration

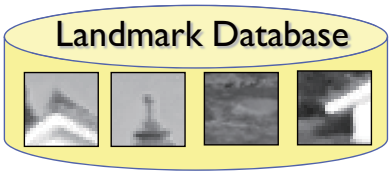


We have firstly tested previously developed the landmark-based geometric registration method [Taketomi et al. 2008] for AR sightseeing.

Original Database Construction Method [Taketomi et al. 2008]



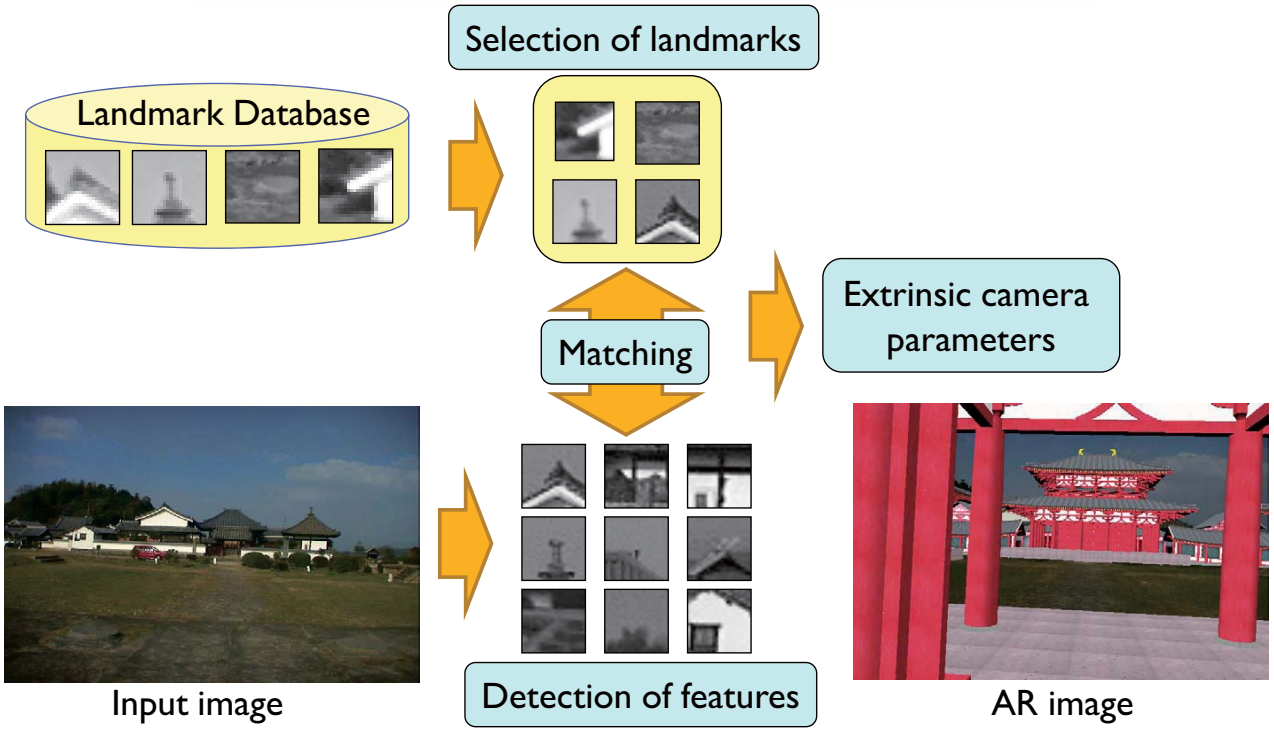




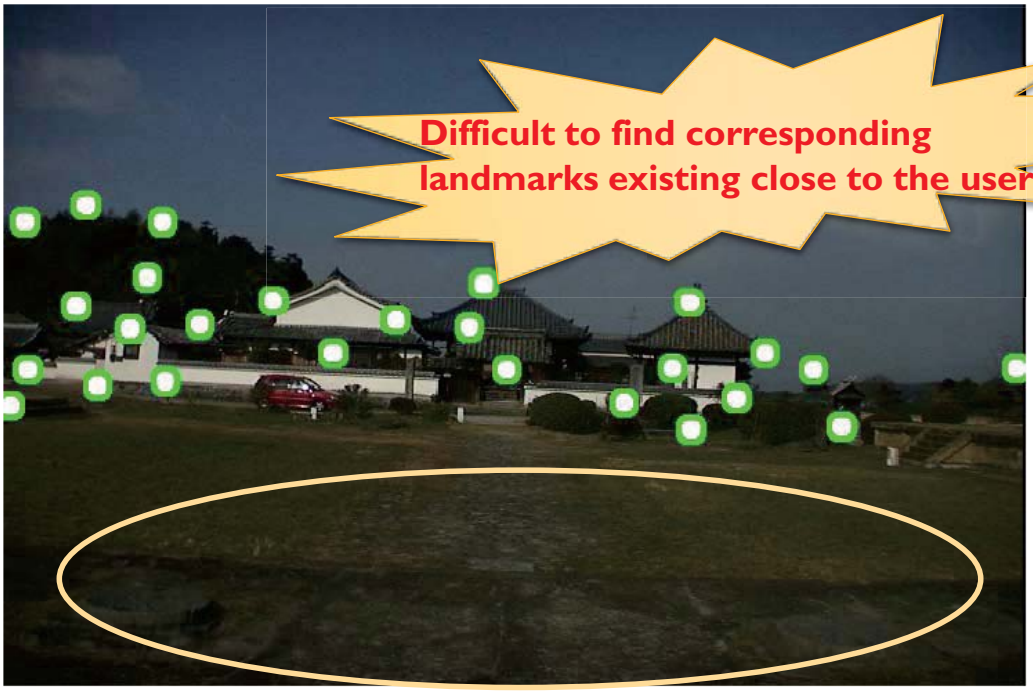
Problem: Appropriate compensation for image templates only from sparse 3-D information is difficult.

Extrinsic Camera Parameter Estimation

Extrinsic camera parameters are estimated using corresponded landmarks.



Corresponded Landmark Using an Original Landmark Database



Circles show positions of the corresponded landmarks in the input image.

Database Construction Using Omnidirectional Laser Range Sensor

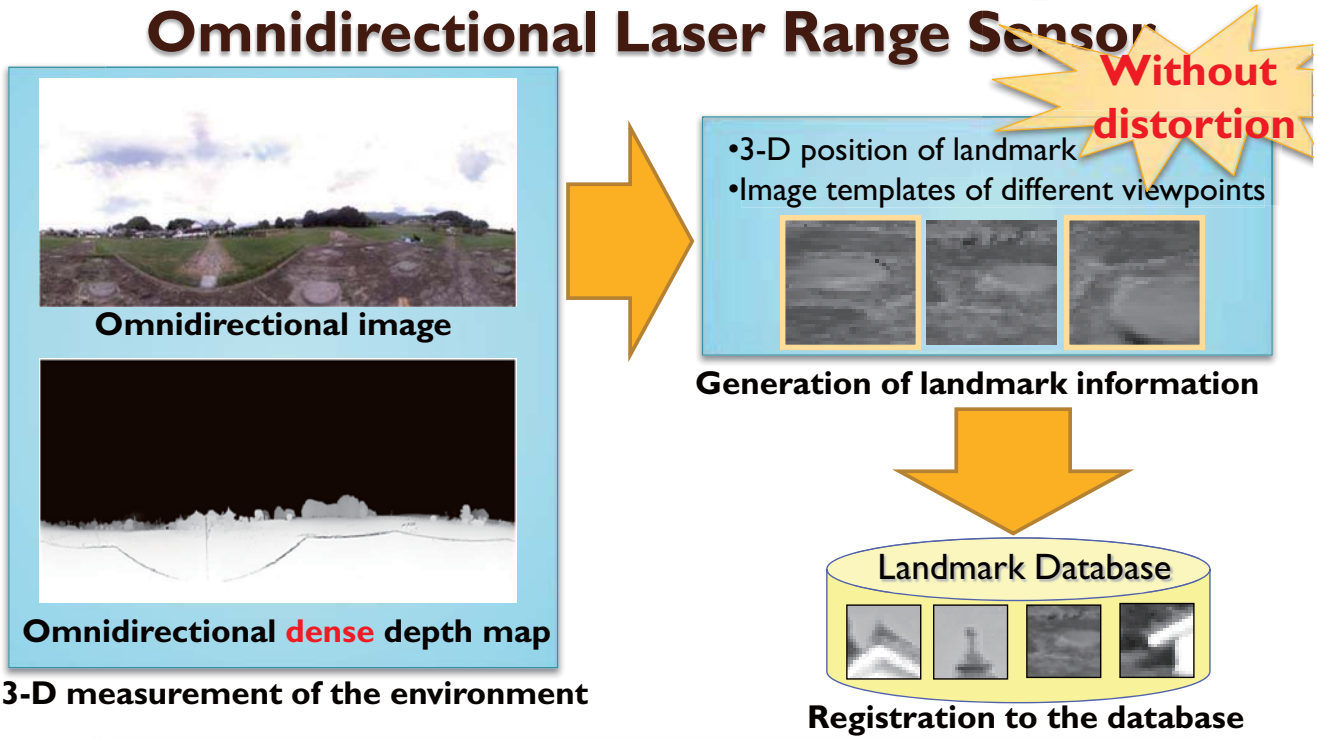
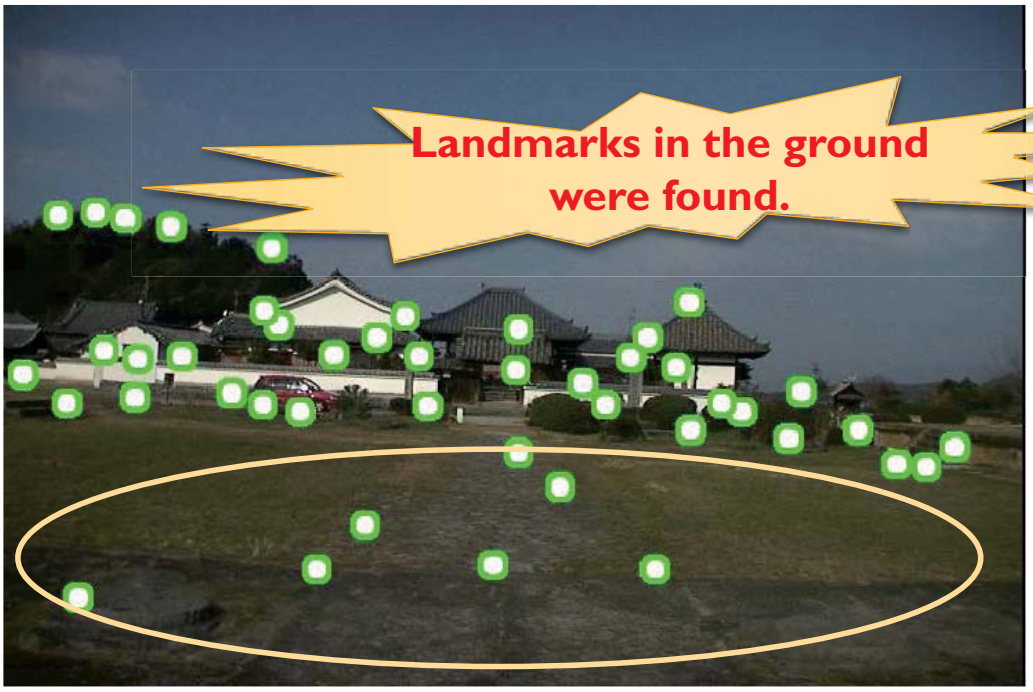


Image templates are appropriately compensated for different viewpoints using a dense depth map.

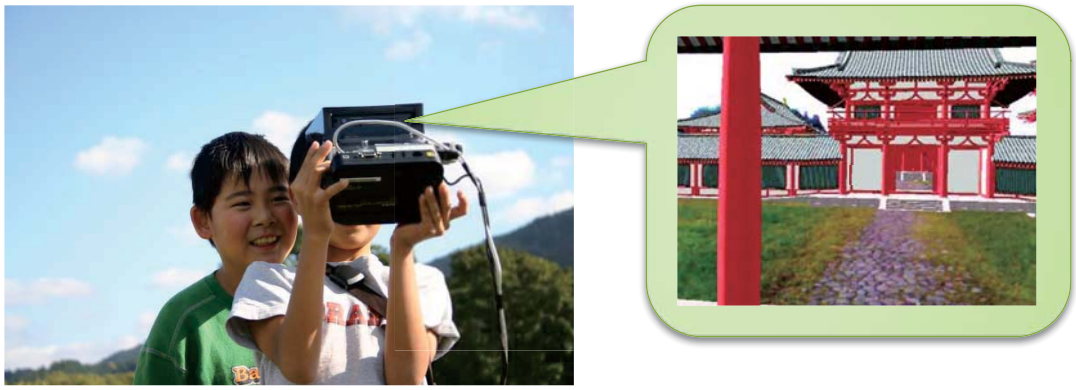
Corresponded Landmarks Using a New Landmark Database



Circles show positions of the corresponded landmarks in the input image.

Preliminary Test for Vision-based Geometric Registration in The Target Environment

Sensor-based System



Hardware Configuration

AR images are displayed on the ultra-mobile PC's display.

Appearance of the user

VAIO type U

- CPU: 1.2GHz,
- Camera is at the back side of the device.
- Weight: 500g

InertialCube2

- Angular accuracy: 1°
- Angular resolution: 0.01°
- Weight: 25g

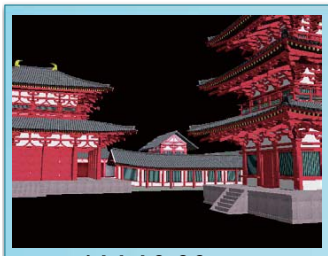
P4-GPS

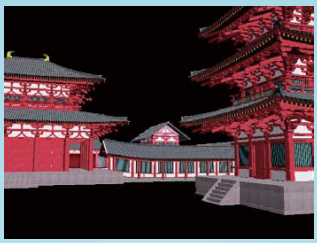
- Positioning accuracy: 40cm
- Sampling rate: 4Hz
- Weight: 500g

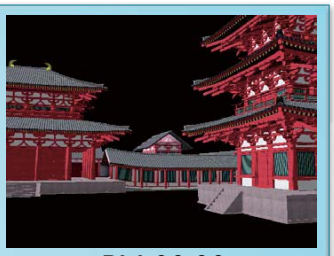
Position and posture of the system are acquired by GPS and inertial sensor respectively.

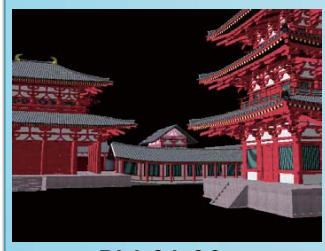
Reflection of lighting condition for the CG Model

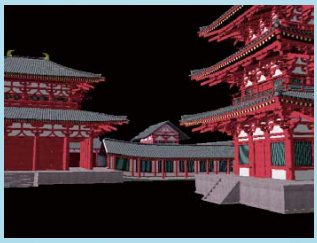
7 patterns of lighting condition are prepared and used to produce appropriate shadows on the CG model.

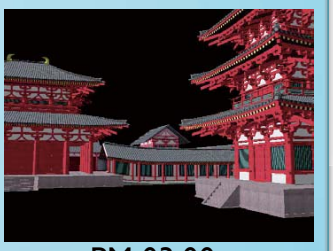

AM 10:00


AM 11:00


PM 00:00


PM 01:00


PM 02:00


PM 03:00

Fine day


Cloudy day

Lighting condition is manually switched depending on time and weather.

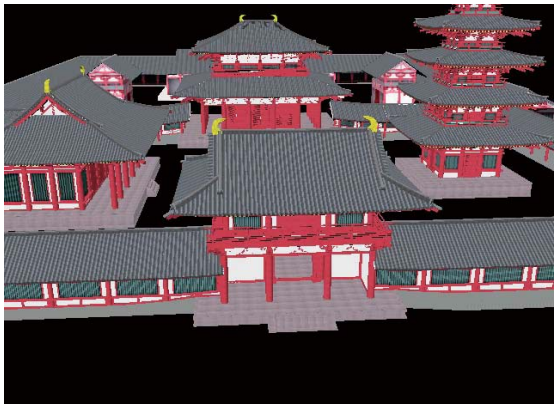
Preliminary Test for Sensor-based Geometric Registration in The Target Environment

Public Experiment in Asuka Village

To demonstrate the effectiveness of our developed system, we had carried out a public experiment at the Kawaradera.

- Date: November 21 ~ 23, 2009
- Time: 10:00 ~ 15:00 for each day

Kawaradera temple ruins



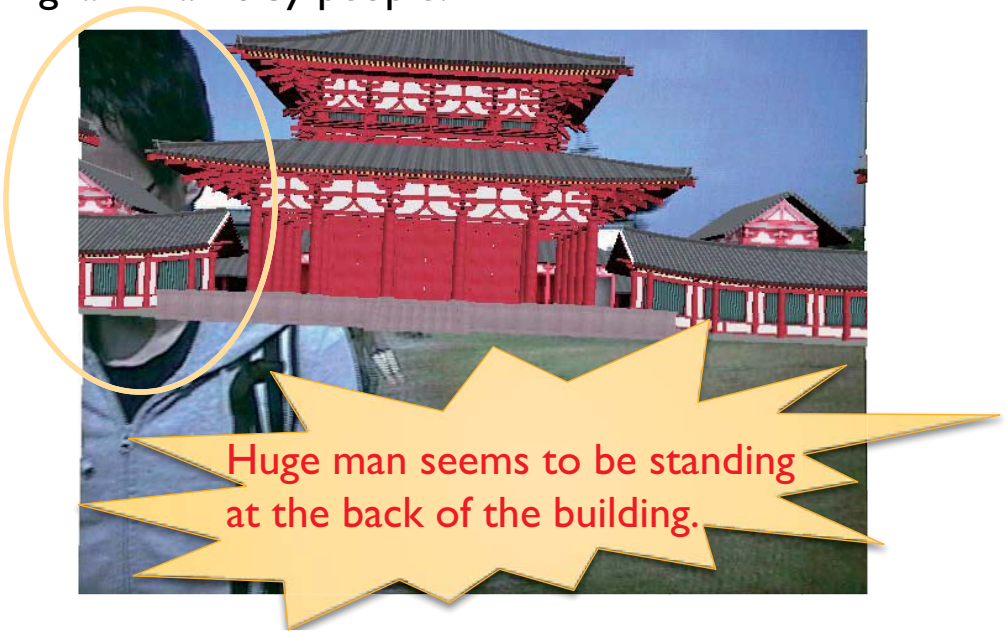
CG models of Kawaradera

* CG models were provided by Ikeuchi Laboratory, The University of Tokyo.

Appearance of the Public Experiment

Problems

- Generated AR images were sometimes felt unnatural due to incorrectly occluded people by virtual object.
- Vision-based system could not work well due to fast head motion and hiding landmarks by people.



Conclusion

We have reconstructed the defunct temple with augmented reality by using two types of system.

- **Vision-based System**
  High quality AR images are generated in a limited area.
- **Sensor-based System**
  Roughly registered AR images are generated in a wide area.

Future work

- Occlusion problem between virtual object and tourist must be solved to achieve realistic AR sightseeing.
- Fusion of vision and sensor based registration is necessary to achieve robust and accurate geometric registration.

Acknowledgements
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