3D Modeling of Outdoor Scenes from Omnidirectional Range and Color Images

Toshihiro ASAI

Vision and Media Computing Lab.

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3D Models of Outdoor Scenes

Application fields

- Site simulation
- Mixed reality
- Virtual walk-through

These models are made manually with high cost

Virtual walk-through

Automatic 3D modeling for outdoor scenes has been widely investigated.

Method of 3D Modeling

- **Estimating 3D shape from multiple images**
  - ○ Easy to acquire data
  - × Difficult to apply for wide area with high accuracy
- **Measuring environments by a laser rangefinder**
  - ○ Accurate range data
  - × Necessary to register multiple range data

Using a rangefinder is suitable for accurate modeling of outdoor scenes.

Objective

3D modeling of wide area outdoor scenes

Approach

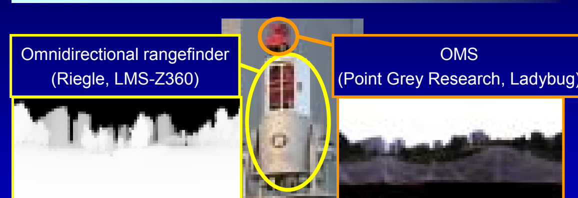
- **Omnidirectional sensors are used to acquire range and color images efficiently.**
- **RTK-GPS and gyro sensor are used to estimate position and orientation of the sensor system.**

Sensor system on a vehicle

Procedure of Modeling

1. Data Acquisition
   - Data are acquired at multiple points in outdoor scenes.
2. Registration of multiple range data
   - Acquired data by RTK-GPS and gyro sensor are used as initial value.
   - Position and orientation are optimized by using ICP algorithm.
3. Texture-mapping of color images
   - The highest-resolution suitable texture is selected.

Range and Color Image



omnidirectional range image

omnidirectional color image

Maximum measurable range
about 200m

Measurement accuracy
within 12mm

Six camera units in a camera block

More than 75% of full spherical view

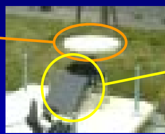
Data Acquisition

Position and Orientation

Position

RTK-GPS (Nikon-Trimble, LogPakII)

Accuracy : about 3cm



Orientation

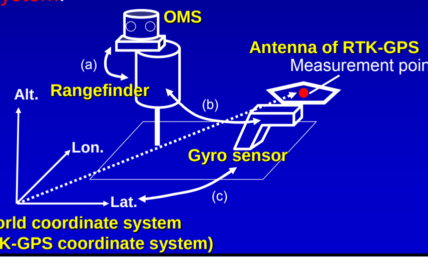
Gyro sensor (TOKIMEC, TISS-5-40)

Accuracy : about ±2 °

- RTK-GPS and gyro sensor are interlocking.
  - Two coordinate systems are aligned automatically.
  - Accumulative error of gyro sensor is corrected by measured value of RTK-GPS.
- Origin of the gyro sensor coordinate system and measurement point of the RTK-GPS are considered the same point.

Sensor system

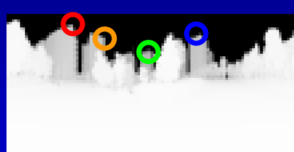
- Geometrical relationships among these sensor coordinate systems are fixed.
- These coordinate systems are aligned to world coordinate system.



(a) Transformation between rangefinder and OMS

estimating by giving corresponding points of color image and range data.

Color image

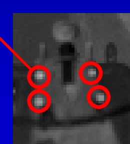


Range data

(b) Transformation between rangefinder and gyro sensor

- Gyro sensor placed at position which can be measured by the rangefinder.
- Marker which have high reflectance of laser are used.
  - The position of each marker in the gyro sensor coordinate system is known.

marker

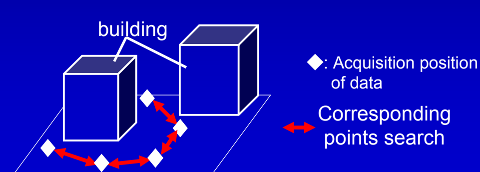


Layout of markers

Laser Intensity of markers

Registration of multiple range data

- Position and orientation acquired by sensors are used as initial values of range data.
- Whole data are optimized by using ICP algorithm.
  - Corresponding points are searched for between the range data whose acquisition positions are adjacent.



Optimization using ICP algorithm

1. Corresponding points are searched in paired range data respectively.
   - The sum of distance between corresponding points is defined as an error.
2. Each transformation is calculated by minimizing the error.

These processings are iterated until solution is converged.

Texture-mapping of color images

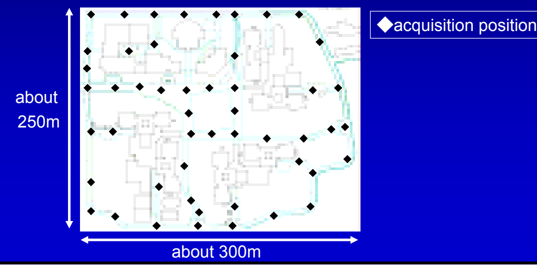
- Texture from the image which gives the highest resolution.
- Occlusions are detected from generated 3D shape.

Considering only resolution

Considering resolution and occlusion

Experiments

- Environment：our campus
- Data acquisition ：50 points (about 30m interval)
- Required time : about 3 hours



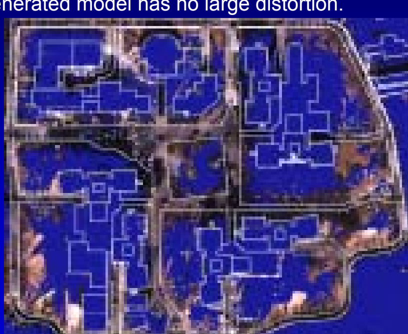
Result of 3D modeling


Generated model of our campus

The walker's view

2D CAD data overlaid on generated 3D model

Generated model has no large distortion.



Summary

3D modeling of outdoor scenes

- Range and color images are acquired efficiently by using two omnidirectional sensors.
- Position and orientation are acquired by using RTK-GPS and gyro sensor.
  - Using as initial value of position and orientation.

Future work

- Color Adjustment of neighboring polygons in which different images are selected.
- Reduction of holes (non-measuring portion) of the generated model.