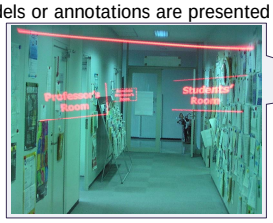
Localization Using Invisible Visual Markers and an IR Camera

Yusuke NAKAZATO

Vision and Media Computing Lab.

Wearable Augmented Reality (AR)

CG models or annotations are presented based on user's location.



Wearable AR System

Users' position and orientation are required.

- Outdoor : GPS + Gyro sensor
- Indoor : IrDA markers, ultrasound, Visual Markers, etc

Localization for Indoor Environments

- using the position IDs received from IrDA markers [Hallaway, et al].
  - ✓ High robustness
  - × Power supply of infrastructures
  - × Undesirable visual effects

[Hallaway, et al]

- recognizing "Visual Markers"
  - ✓ Easy Infrastructures
  - ✓ No power supply of infrastructures
  - × Undesirable visual effects

Invisible Visual Markers

[Habara, et al]

Objective

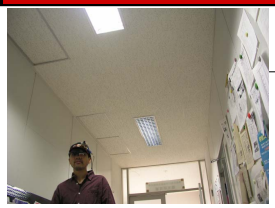
Localization
for wearable computer users in indoor

- Easy infrastructures
- No impairing the scenery

Approach

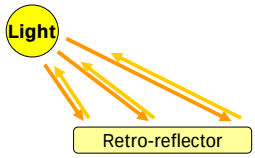
- "Translucent Retro-reflective Markers" are used as invisible visual markers.
- The system illuminates the markers by infrared lights and captured them.

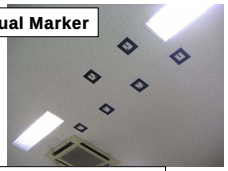
System Overview

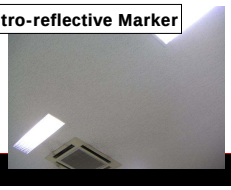


Translucent Retro-reflective Marker

The retro-reflector reflects a light toward a light source.

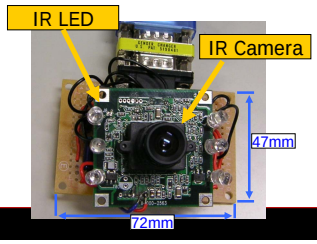






IR Camera Attached IR-LEDs

- IR-LEDs are controlled by PC through RS-232C communication.
- Images are captured synchronously with flashing IR-LEDs.
- View angle :92.6[deg]



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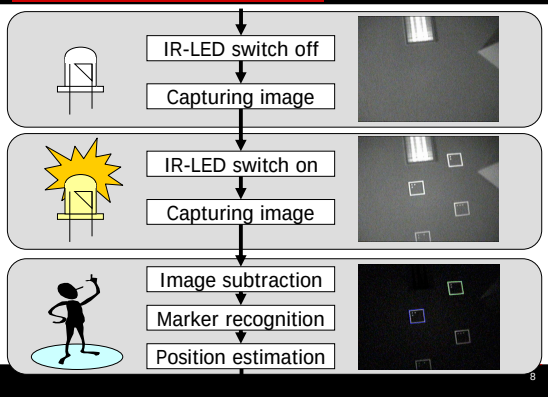
Flow Diagram of Position Estimation



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Estimation of Camera Position

1. Image Subtraction between when IR-LEDs switch on and off
2. Marker Recognition (Using ARToolKit[Kato])
   i. Extraction of the markers' region
   ii. Detection of IDs which associated markers
3. Position Estimation

   Estimation of camera's position and orientation using 4 vertices of a square markers (The markers' size and position are known.)

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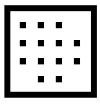
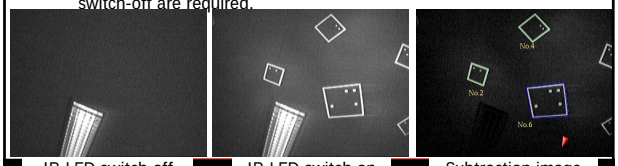
Experiment of Marker Recognition

- The size of captured images is 320 x 240 pixel.
- Retro-reflective marker
  - **Size: 16 cm x 16 cm, 28 cm x 28 cm**
  - **Number of pattern: 2^{12}=4096**
- Result

  Processing rate : 15 fps

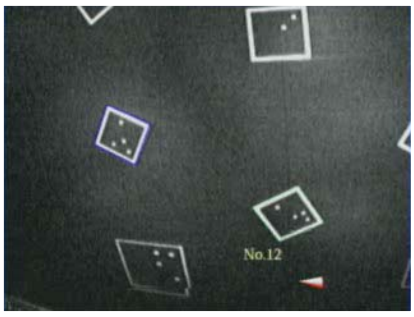
  Because two images when the infrared LEDs are switch-on and switch-off are required.





IR-LED switch off | IR-LED switch on | Subtraction image

Result of Marker Recognition



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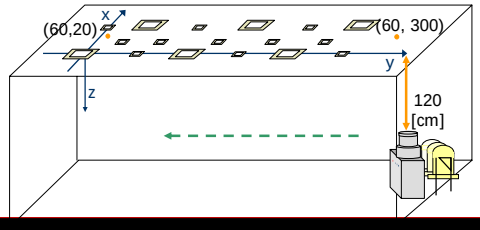
Experiment of Localization

- The camera looks toward the ceiling.
- The camera moves to (60,300,120) from (60,20,120) in parallel to the ceiling.
- Distance between the camera and the ceiling is 120 cm.
- Size of captured images is 320 x 240 pixels.



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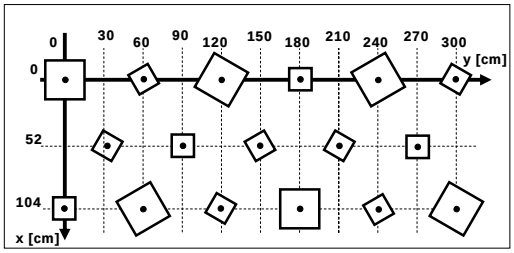
Layout of Markers on the Ceiling

- x-y plane represents the ceiling plane.
- z axis corresponds the vertical direction.



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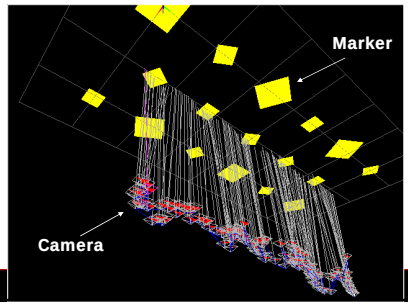
Result of Localization

- Accuracy
  - Average of estimated position error : 13.6 cm
  - Average of estimated orientation error : 7.7˚



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Conclusion

- Localization using invisible markers and IR-camera
  - Translucent Retro-reflective markers are used.
  - The system illuminates the markers by IR lights and captures them.
  - IR-LEDs are flashing in order to extract the invisible markers.
- Future works
  - Experiments at the extensive indoor environments
  - Stabilization of the localization

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