Wearable Augmented Reality System for Wide Indoor Environments Using Invisible Visual Markers

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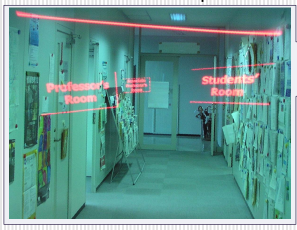
Wearable Augmented Reality (AR)

A new method for displaying location-based information.

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



Wearable AR Guide 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

recognizing "Visual Markers"

- ✓ Easy Infrastructures
- ✓ No power supply of infrastructures
- × Undesirable visual effects

Invisible Visual Markers

IrDA marker

[Hallaway, et al]

[Habara, et al]

Objective

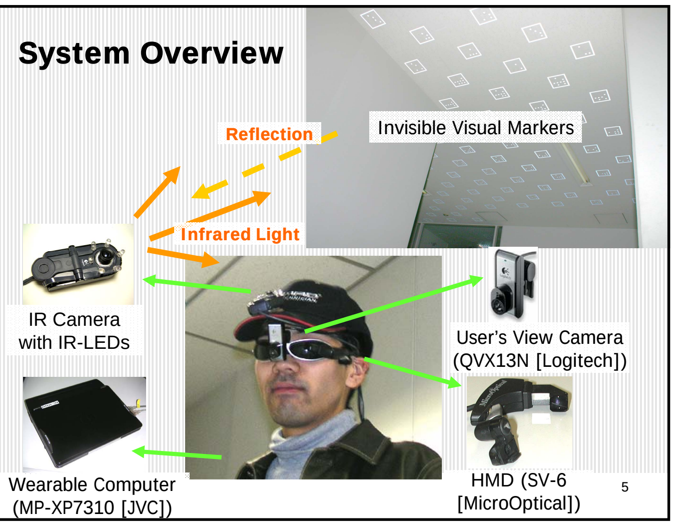
Wearable Augmented Reality System

- Easy infrastructures
- No impairing the scenery

Approach

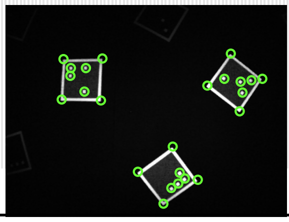
"Translucent Retro-reflective Markers" are used as invisible visual markers.
The system illuminates the markers by infrared lights and captured them.

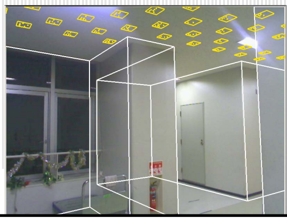
System Overview



Flow Diagram of Wearable AR System

1. Capturing an infrared image
2. Extracting the region of markers
3. Estimating of the camera position and orientation
   - Using a linear least-squares minimization method from 4 vertices and pattern's dots of a marker
4. Based on user's position and orientation, drawing virtual objects on an image captured by user's view camera



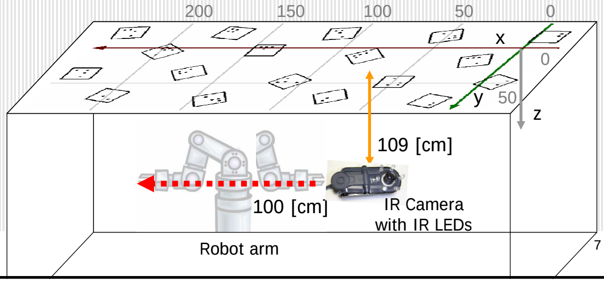


Evaluation of Localization

The camera looks toward the ceiling.

The camera moves from (65,36,109) to (65,136,109) in parallel to the ceiling.

Distance between the camera and the ceiling	: 109 cm
Size of captured images	: 640 x 480 pixels
View angle of the camera	: 92.6˚
Marker size	: 16 cm



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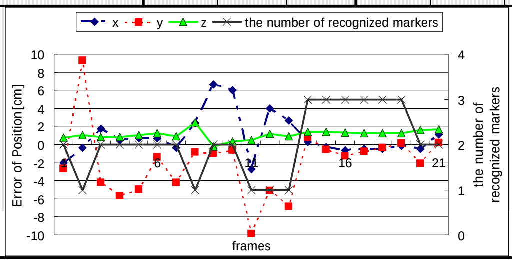
Result of Evaluation

Average absolute errors and standard deviations of localization (pitch, roll, yaw : rotation angles of x, y, z axes)

	x [cm]	y [cm]	z [cm]	pitch [deg]	roll [deg]	yaw [deg]
Average ABS Error	1.7	3.0	1.1	1.9	3.9	0.4
Standard Deviation	2.4	3.7	0.5	1.9	1.2	0.4



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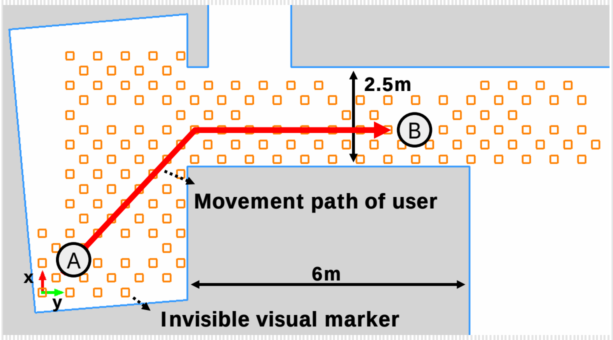
Experiment of Wearable AR

The user walks from A to B.



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Experimental Environment

The Invisible visual markers are set up on the ceilings.

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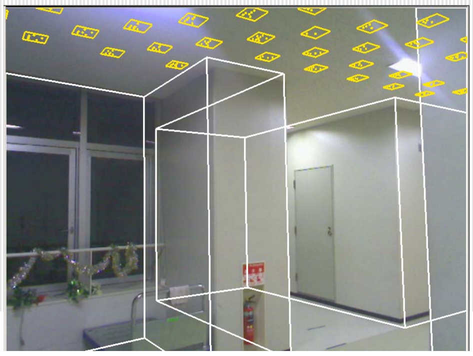
Augmented Images

A wireframe model of this building and invisible visual markers are overlaid with the real scene.

The frame rate is 11 fps (CPU : Pentium M 1GHz).



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Conclusion

Wearable AR system using invisible visual markers and IR-camera

- The system can be realized without impairing the scenery.
- The system can estimates position and orientation in the accuracy of 3.0 cm and 3.9 degrees.

Future works

- Improving and stabilizing the accuracy of localization
- Constructing applications using proposed localization method

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