**Goal and approach**

Realizing offline augmented telepresence (AT) system in wide outdoor environment using aerial views

Registration problems between real and virtual worlds
- Geometric registration
- Photometric registration

Geometric registration: Aligning omnidirectional images

Photometric registration: Rendering augmented images

Capturing omnidirectional video

**Geometric registration**

1. Camera position and posture estimation using structure-from-motion (SfM) and GPS measurement [Yokochi, et al.]
   - Estimation process uses only video.
   - Accumulative errors appear.
   - Scale factor is unknown.

2. Alignment of the omnidirectional images
   1. Omnidirectional images are mapped on a sphere.
   2. The sphere is rotated by $R^{-1}_i$: Estimated posture of OMS $R_i$: Estimated posture of OMS

3. Posture refinement of OMS
   1. Optical-flows near the horizon of two consecutive frames on aligned video are calculated.
   2. 3DOF rotation of two consecutive frames $R_{xy}$ is estimated by minimizing an energy function defined as the sum of squares of lengths of the optical-flows mapped on the sphere.
   3. $R_{xy} = R_{xy}$ is multiplied with posture of OMS.
   4. The processes are applied to the whole sequence.

**Photometric registration**

1. Alignment of the aligned video are calculated.
2. Parameters in All Sky Model [Igawa, et al.] are estimated from the unified image.
3. Intensities in the missing area are copied from the estimated model.

**View-dependent perspective images**

Captured omnidirectional image

Captured augmented image

Augmented Reality (AR) beyond time

Telepresence beyond space

Augmented Reality (AT) beyond time and space

**Capturing omnidirectional video**

Unmanned airship
- Length: 12m
- Payload: 15kg
- Max. speed: 50km/h

The largest battery-powered unmanned airship in the world.

Equipped
- Omnidirectional Multi-camera System (OMS)
- Ladybug3 (Point Grey Research, Inc.)
- Differential GPS
- P4-GPS (Hitachi Zosen Corp.)
- Fiber-optic gyroscope

**Environmental maps for Image-based-lighting (IBL)**

1. An area similar to the missing area is searched from previous frames using SSD criterion.
2. Intensities of corresponding pixels are copied to the missing area.

**Other applications**

Map, Landscape simulation, etc.

