



## 3D Display based on Motion Parallax Using non-contact 3D Measurement of Head Position

Tsuyoshi Suenaga  
Robotics Lab.  
Nara Institute of Science and Technology, Japan

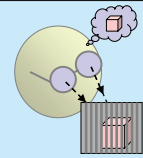
## Introduction

### Binocular parallax :

Stereovision the user utilizes both eyes

A system utilizing binocular parallax needs

- special eyewear or
- special monitors

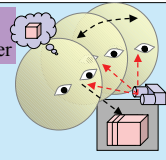


### Motion parallax :

Stereovision by moving the head of the user

A system utilizing motion parallax needs to

- estimate the head position of the user
- generate the image which corresponds to the measured viewpoint.



2006/08/24

T. Suenaga: 3D display, COE 2006.8.

2

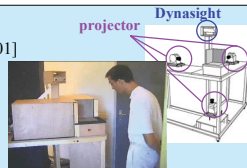
## Related works on 3D display based on Motion Parallax

### Cubby (3D display in 3 planes)

[Djajadiningrat et al. 2001]

Dynasight : Head tracking device

- utilize infrared rays
- marker attached to the head



### Eye controllable 3D display

[Pastoor et al. 1999]

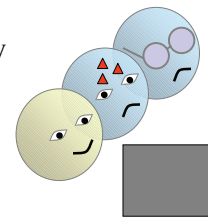
Head tracking using one color camera

- depth estimation
  - compute the distance between two eyes
  - But **inaccurate**



## Motivation

- can be utilized intuitively
- without eyewear
- non-contact, marker-less



**3D display based on motion parallax**

2006/08/24

T. Suenaga: 3D display, COE 2006.8.

4

## Approach

3D display based on Motion Parallax utilizing  
face tracking system to measure head position.

### Face Tracking System

[Matsumoto et al. 2004]

- Measures 6DOF of head and 3D gaze vector
- Non-contact, and Passive
- Speed: 30Hz
- Measurement error:
  - Trans: 2mm / Rot: 2deg
  - Gaze vector: 5deg



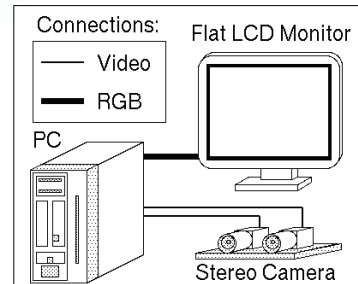
2006/08/24

T. Suenaga: 3D display, COE 2006.8.

5

## System configuration

- Hardware -



2006/08/24

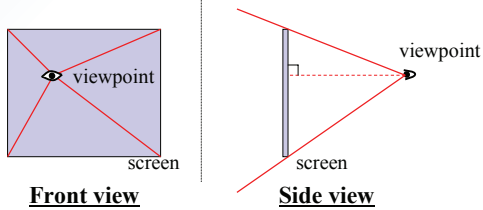
T. Suenaga: 3D display, COE 2006.8.

6

## System configuration

### - Image generation -

- The CG image is generated with OpenGL
  - Perspective transformation of asymmetric quadrangular pyramid



2006/08/24

T. Suenaga: 3D display, COE 2006.8.

7

## System configuration

### - Image generation -



2006/08/24

T. Suenaga: 3D display, COE 2006.8.

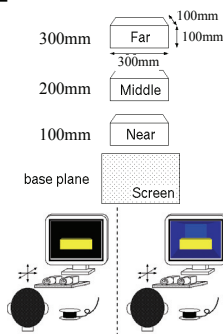
8

## Evaluation experiment

### - Method -

- Reporting depth
  - the perceived depths from the surface of the LCD monitor
- the depth was changed randomly
- five times for each given depth

	Single eye	Both eyes
Cuboid only	Case1	Case2
Cuboid with a surrounding space	Case3	Case4



2006/08/24

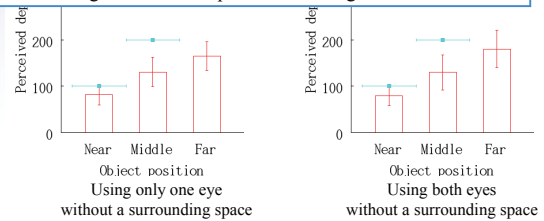
T. Suenaga: 3D display, COE 2006.8.

9

## Results of evaluation experiment

### - Depth perception -

- There was little difference in the perceived depth between only one eye and both eyes for the other subjects.
- The perceived depth was underestimated.
- Error has grown as the depth becomes larger.



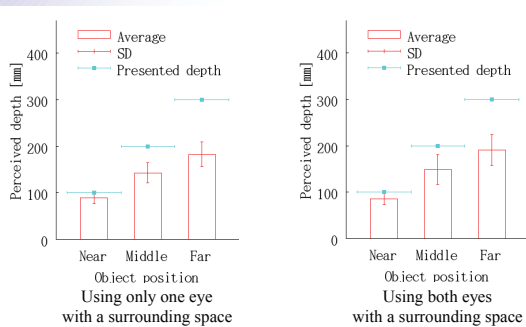
2006/08/24

T. Suenaga: 3D display, COE 2006.8.

10

## Results of evaluation experiment

### - Effect of the surrounding space -



2006/08/24

T. Suenaga: 3D display, COE 2006.8.

11

## Results of evaluation experiment

### - Individual results -

The normalized errors when both eyes were utilized [%]

		Subject A	Subject B	Subject C	Subject D	Subject E	Subject F	Subject G
Near	without walls	0.05	-0.10	-0.11	-0.53	-	-0.22	-0.33
	with walls	-0.10	-0.05	-0.01	-0.33	-0.30	-0.16	-0.20
Middle	without walls	-0.10	-0.38	-0.19	-0.55	-	-0.41	-0.48
	with walls	-0.06	-0.31	-0.05	-0.43	-0.38	-0.30	-0.40
Far	without walls	-0.24	-0.48	-0.27	-0.57	-	-0.45	-0.39
	with walls	-0.26	-0.43	-0.20	-0.50	-0.44	-0.38	-0.40

2006/08/24

T. Suenaga: 3D display, COE 2006.8.

12

## Results of evaluation experiment - Summary -

- There was little difference of the perceived depth between only one eye and both eyes.
- The perceived depth was underestimated and the error has grown as depth becomes larger.
- The existence of a surrounding space enhanced depth perception.

2006/08/24

T. Suenaga: 3D display, COE 2006.8.

13

## Summary & Future works

- We proposed and implemented a non-contact and marker-less 3D display based on motion parallax.
- Through the preliminary experiment, the feasibility of the system was shown.
- Future works
  - Interaction using gaze direction



2006/08/24

T. Suenaga: 3D display, COE 2006.8.

14



*Fin*

2006/08/24

T. Suenaga: 3D display, COE 2006.8.

15