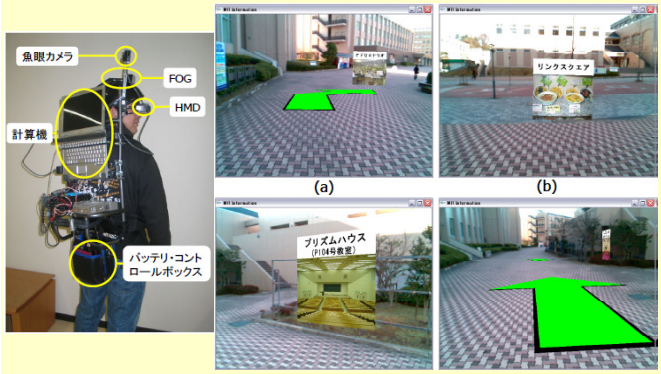
Annotation View Management for Wearable Augmented Reality Considering Movement of Target Objects

Koji Makita, Masayuki Kanbara and Naokazu Yokoya
Nara Institute of Science and Technology, Japan（NAIST）

Annotation overlay using wearable AR

Wearable AR shows virtual object as an annotation using 2D images or 3D models

[S.Feiner et al. 1997]



[Tenmoku et al. 2007]

The readability and the intelligibility of annotations are important

Our previous work

K. Makita, M. Kanbara, and N. Yokoya:
"Personal information annotation on wearable computer users with hybrid peer-to-peer communication", Proc. 16th Int. Conf. on Artificial Reality and Telexistence (ICAT 2006), pp. 217 - 227, 2006.

Motivation:
The readability and the intelligibility should be improved !

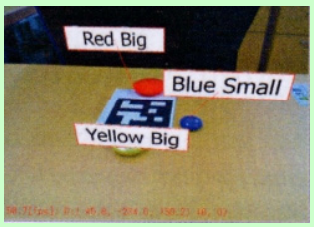
Related works

View management (VM) of annotations

- Avoiding annotation-overlaps
- Reducing the amount of hiding
- ⋮

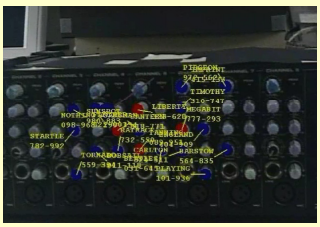
→ The readability and the intelligibility of annotations are improved

Without VM

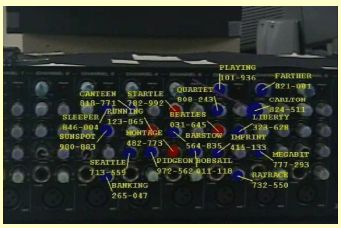


With VM

A view management method for mobile mixed reality systems
[F.Shibata et al. EGVE2008]



Without VM



With VM

Evaluating label placement for augmented reality view management
[R.Azuma et al. ISMAR2003]

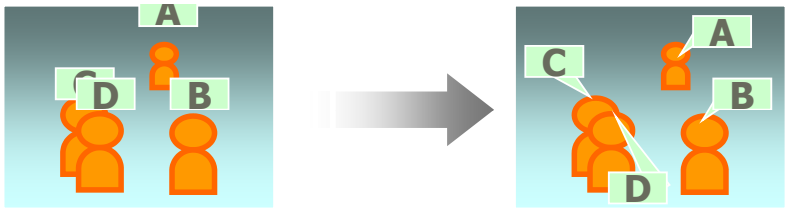
The positions, orientations, and shapes of annotated objects should be known for view management

Goal and approach

Goal

View Management

for improving the readability and intelligibility of annotations for moving target objects



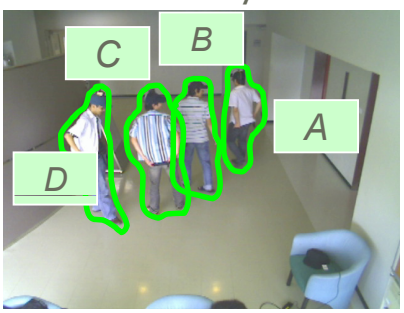
Without view management

With view management

Approach

Step 1:
Estimation of target object regions

Step 2:
Annotation overlay



Step1：Estimation of target object regions

～Objective～

Estimating target's region
(with the individual recognition)

～Assumption～

Each user has wearable PC
to estimate position

Approach

Obtaining the target's position data via wireless network

＋

Estimating target's region by using primitive models

Estimation of existing region of the targets

Obtaining the position data via wireless network(*)

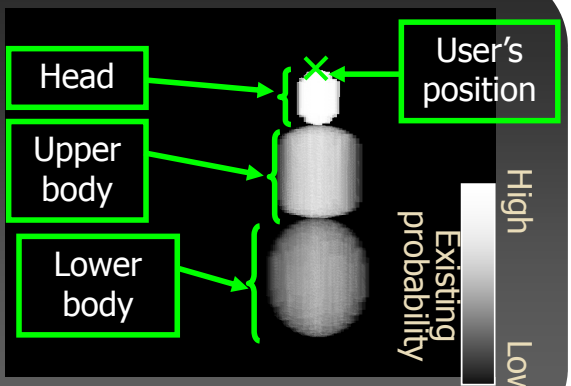
Obtaining the position data with identifier via hybrid P2P network

(*)Personal information annotation on wearable computer users with hybrid peer-to-peer communication (Makita et al, ICAT2006)

Estimating target's region by using primitive models

Generating a "probability map" by rendering primitive models

Each part has an existing probability as a parameter



Example of a probability map

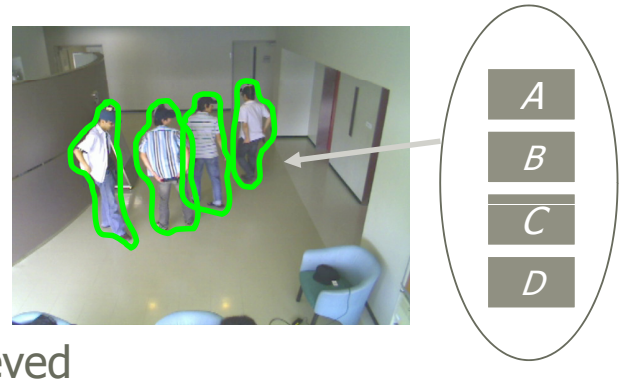
Step2: Annotation overlay

～Objective～

Decision of the arrangement of annotations

～Assumption～

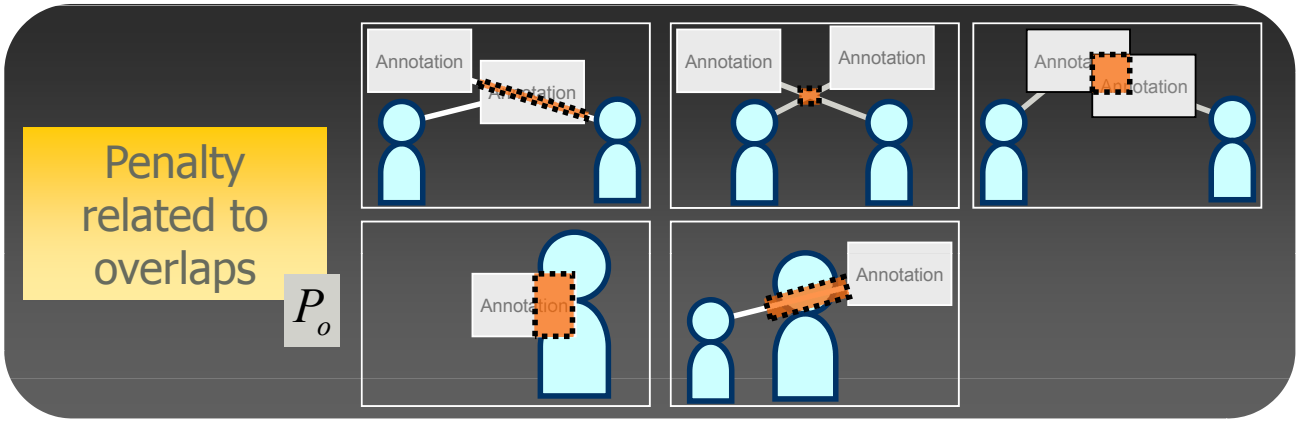
- Targets' regions are known
- Individual recognition is achieved

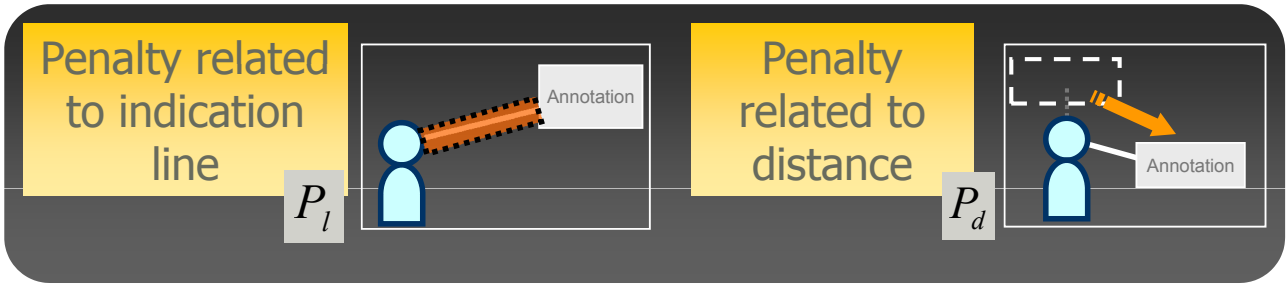


Approach

Making a list of factors related to the readability and intelligibility of annotations → Introducing penalty function for each factor → Overlaying annotations by minimizing the sum of penalties

Factors related to readability and intelligibility



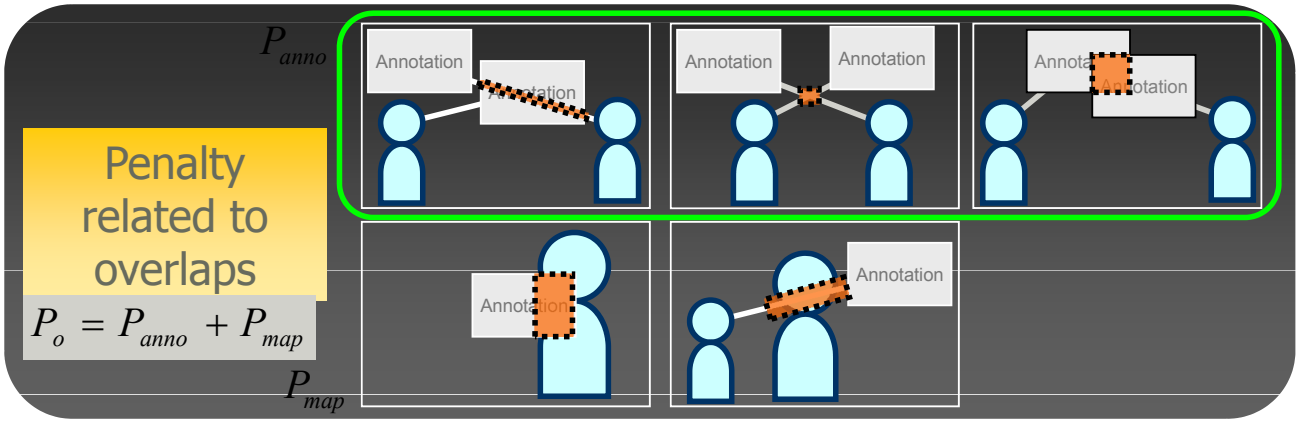


Penalty function (W: weighted parameters)

$$P = w_o P_o + w_l P_l + w_m P_m$$

Minimizing P

Calculation of penalty related to overlapping



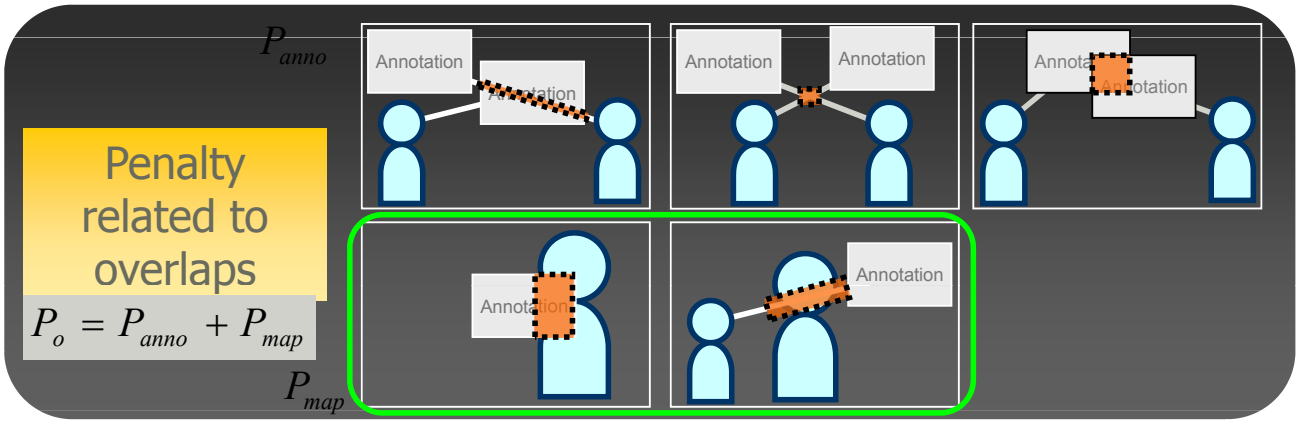
Penalty related to overlapping between annotations: P_{anno}

$$P_{anno}(x, y) = | A_{(x,y)} |$$

$A_{(x,y)}$: A set of points that are occluded when an annotation is placed at (x, y)

$| A_{(x,y)} |$: The number of points in a set $A_{(x,y)}$

Calculation of penalty related to overlapping



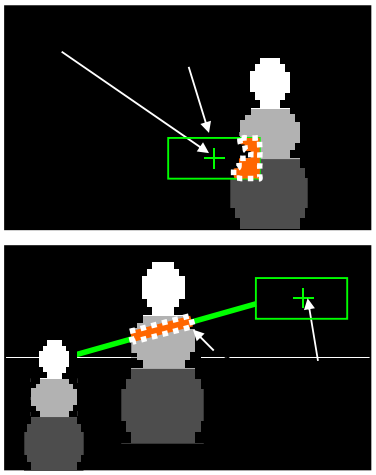
Penalty related to overlapping between the annotation and users: P_{map}

$$P_{map}(x,y) = \sum_{i \in A_{(x,y)}} C_i$$

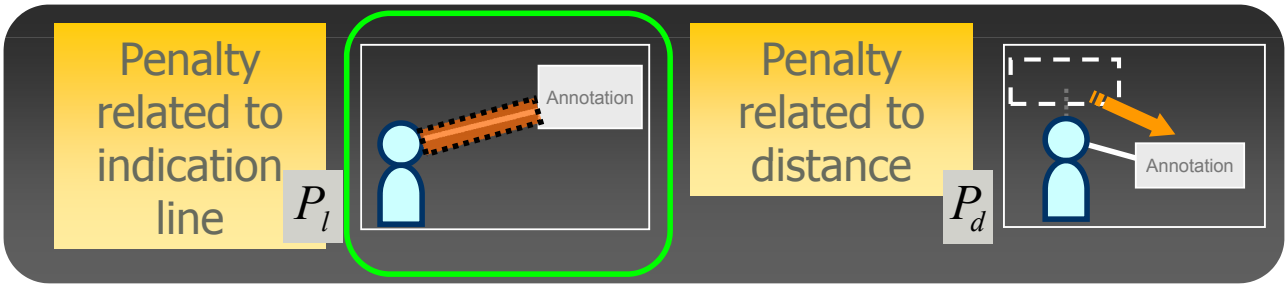
i : a point on the probability map

C_i : the brightness value of the point i

$A_{(x,y)}$: a set of points that are occluded if an annotation is placed at (x,y)



Calculation of penalty related to distance



Penalty related to the line between the annotation and the user: P_l

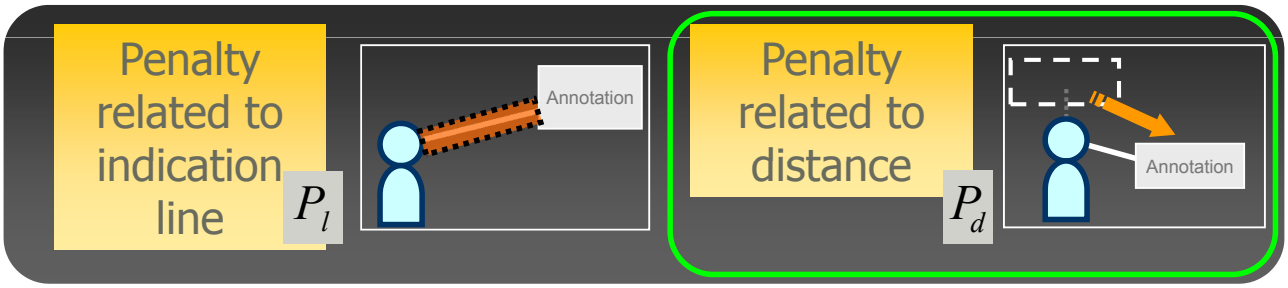
$$P_l \propto l$$

l : The length of the line between the annotation and the user

In this study, P_l is empirically defined as

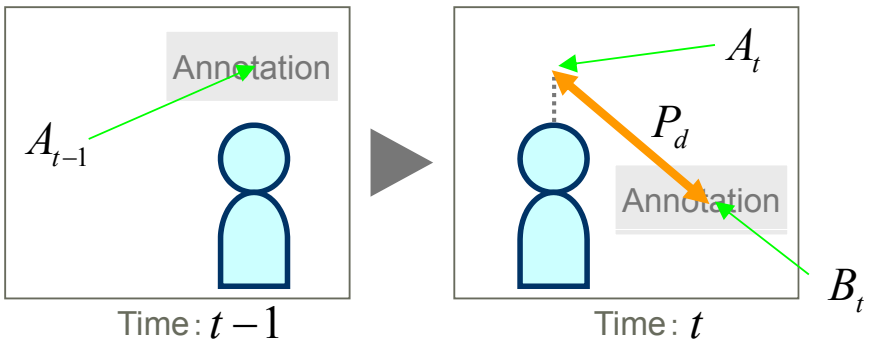
$$P_l = l^2$$

Calculation of penalty related to distance



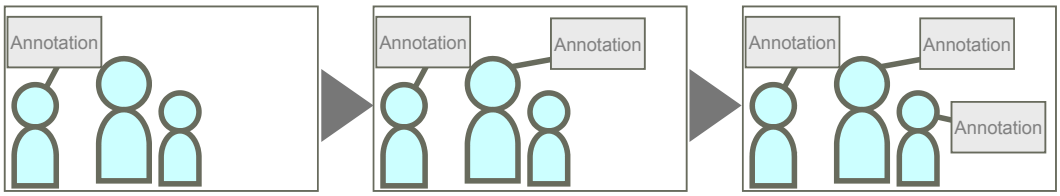
Penalty related to the distance between annotation positions on the view plane in sequential frames: P_d

$$P_d = |B_t - A_t|$$



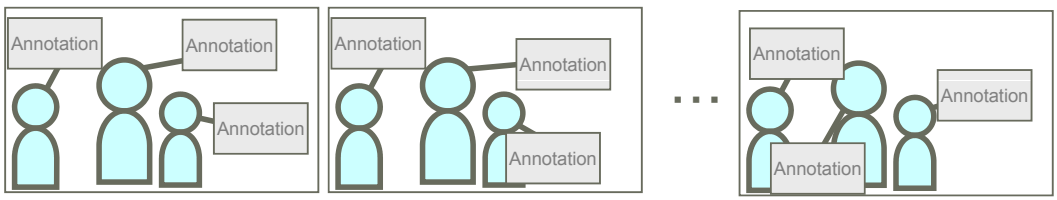
Decision of the arrangement of annotations

Sequential minimization



The position of each annotation is decided in order

Global minimization



All the patterns of arrangements of annotations are checked

Comparison

	Penalty	Amount of calculation
Sequential minimization	△ (Local minimum)	$O(n)$
Global minimization	○ (Global minimum)	$O(e^n)$

Experiment

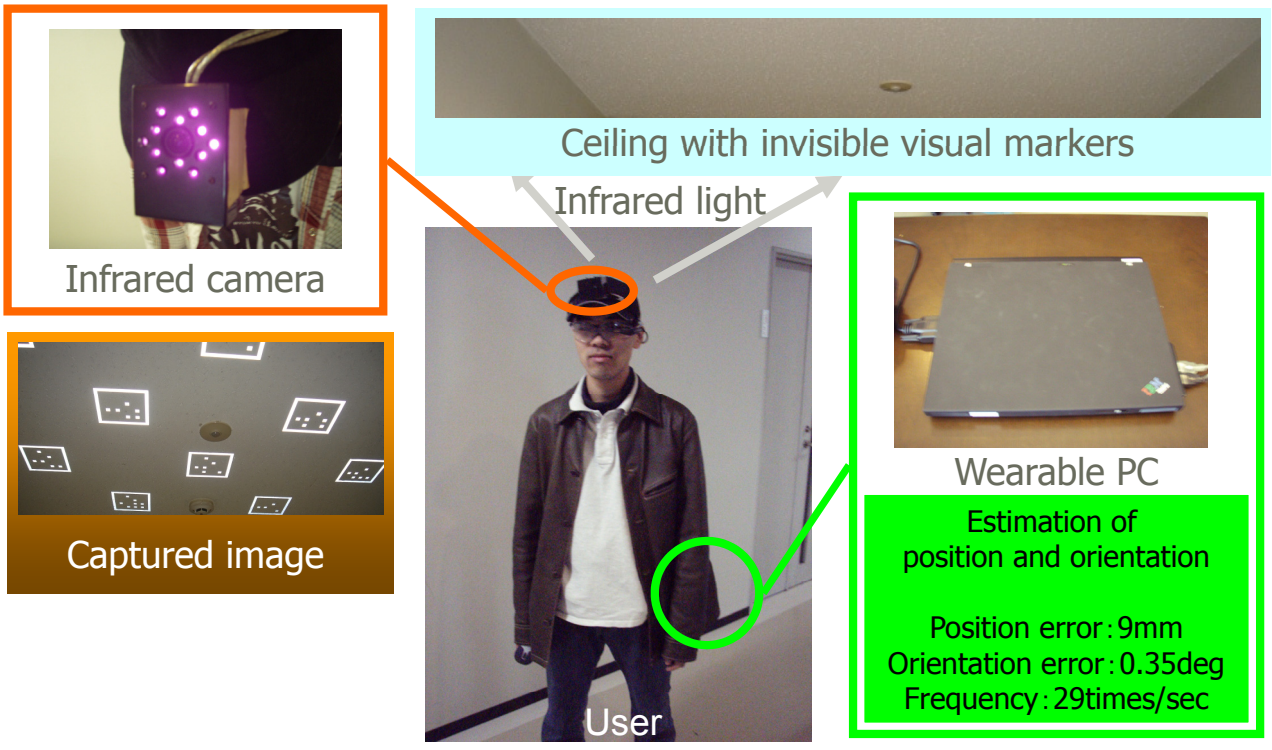
～Settings～

- Targets：Wearable computer users
- The number of targets：3
- Estimating position and orientation：
  A method using invisible visual markers (*)

～Experiment description～

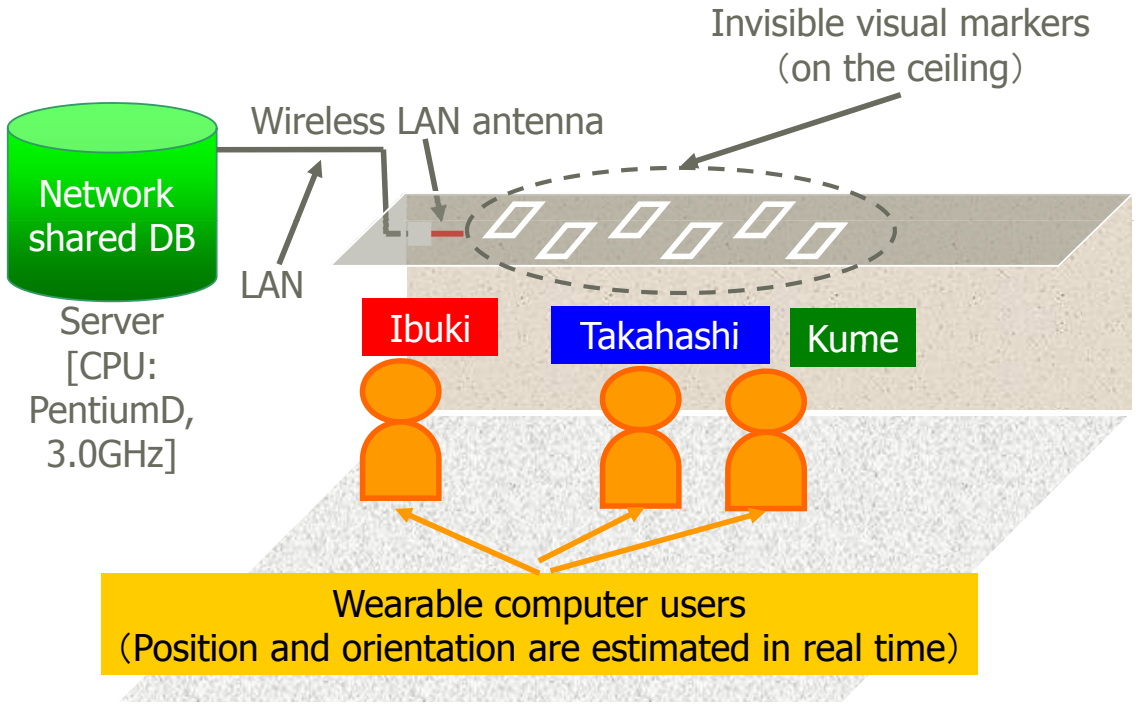
- Pilot study：Estimation of the region of the target
- Experiment：Annotation overlay

Estimating position and orientation(*)



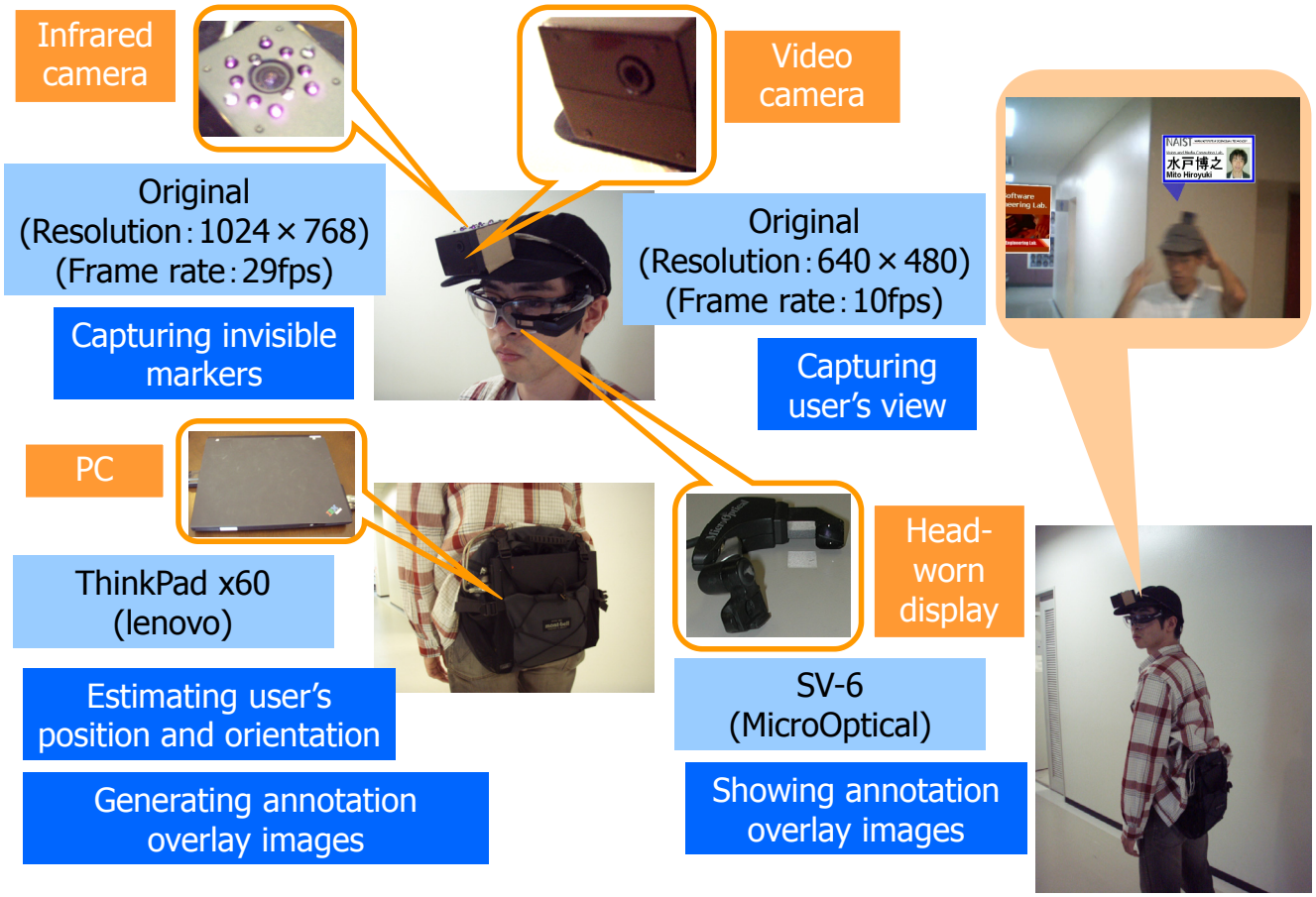
(*)Y. Nakazato, M. Kanbara and N. Yokoya:
"A localization system using invisible retro-reflective markers,"
Proc. IAPR Conf. on Machine Vision Applications (MVA2005), pp. 140–143, 2005.

Experimental environment



(In our laboratory. Distance to the ceiling is about 2.8m)

Configuration of wearable AR system

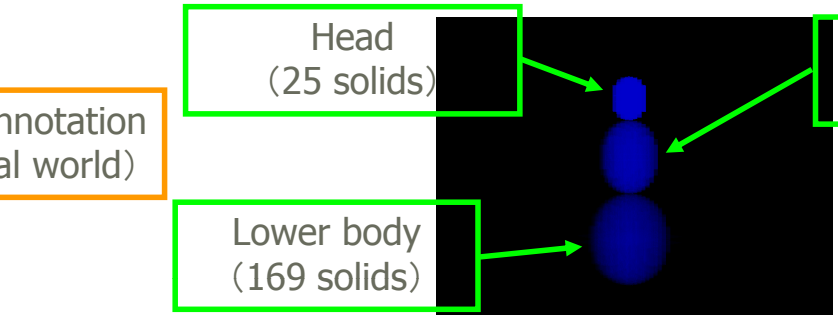


Pilot study：Estimation of the region of the target

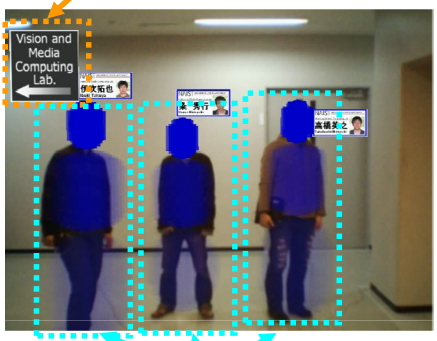
Head
（25 solids）

Upper body
（81 solids）

Lower body
（169 solids）



3D object annotation
（fixed in real world）



Wearable computer users

Experimental result
(Estimated regions are overlaid)

Annotation overlaying

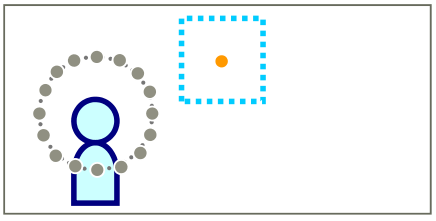
・Setting of penalty function

$$P = w_o P_o + w_l P_l + w_m P_m$$
$$(w_o = 0.1, w_l = 0.5, w_m = 0.2)$$

・Method for deciding the arrangement of annotations

Sequential optimization
(The order of annotations is fixed)

・Limited search range (for faster penalty calculation)

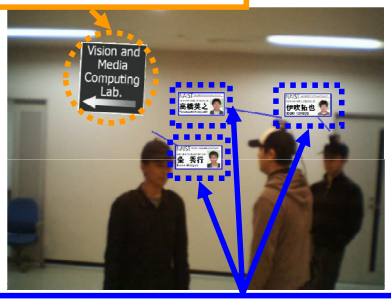


● ：Relative position of the annotation in the previous frame

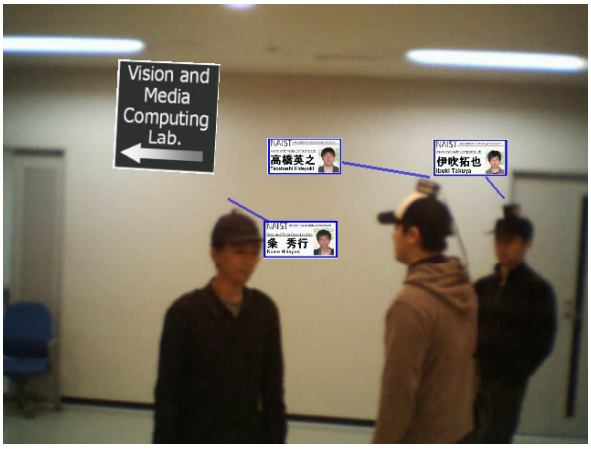
：Search range
（21×21 pixels）

● ：Search positions
（16 points around the user's position）

3D object annotation
（fixed in real world）

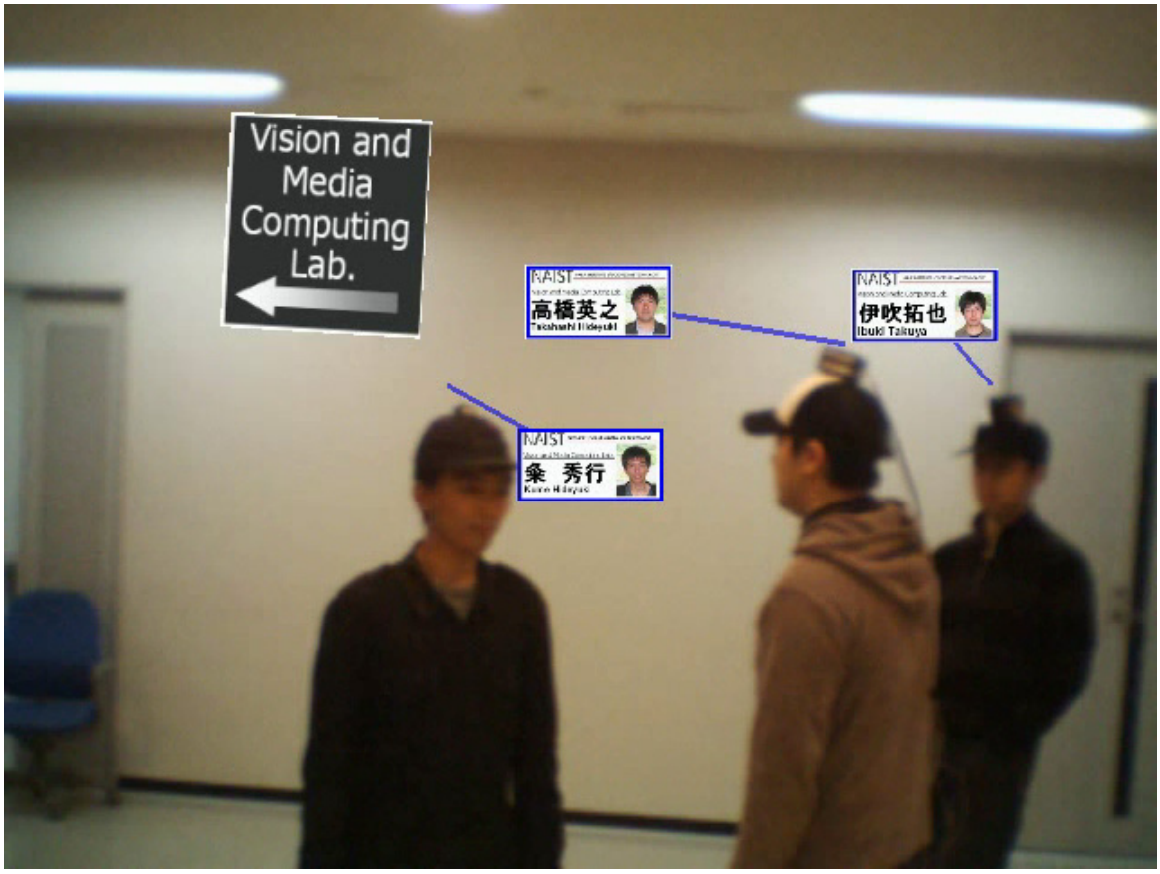


Annotations of users
（overlaid with view management）



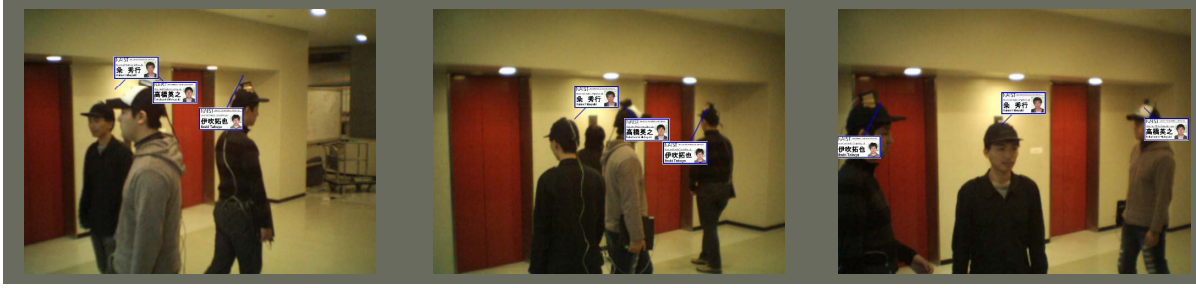
Frame rate：8～12 [fps]

Experimental result (video)



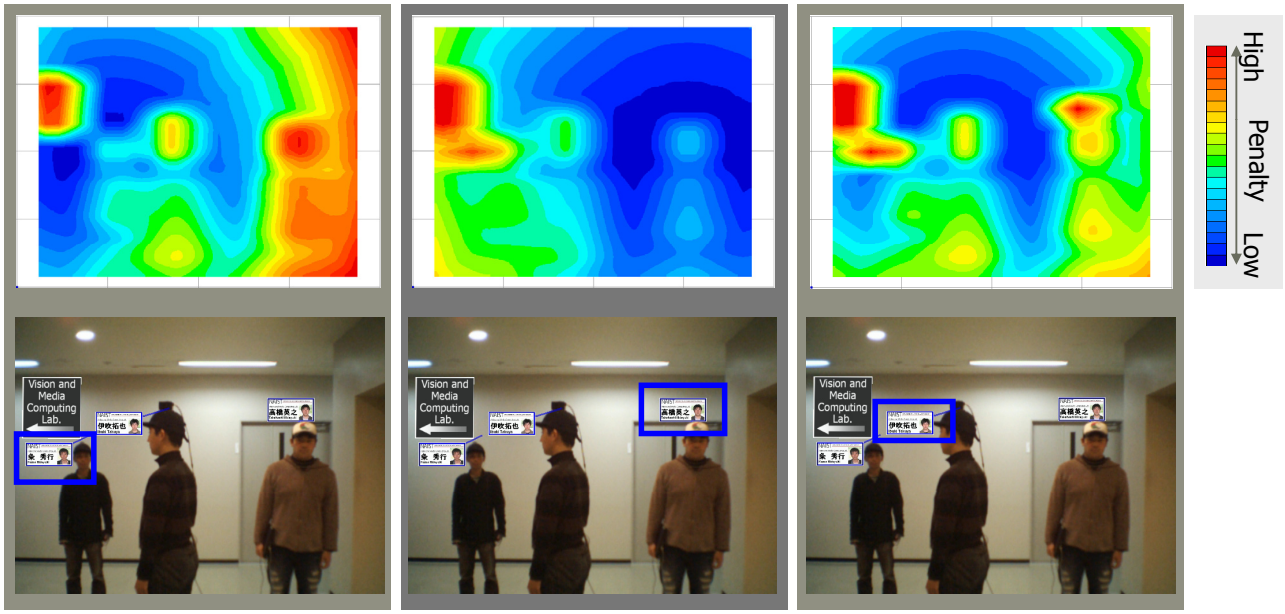
Comparative result

Without proposed view management
(Relative positions of annotations are fixed)



With proposed view management

Penalty distribution and annotation overlay image



: Target annotation to calculate the penalty

Conclusion

- We have proposed annotation view management method for wearable AR considering movement of target objects
  - Estimating existing regions of target objects by using position data and primitive models
  - Minimizing penalty to decide the arrangement of annotations
- Future work
  - Considering different settings of weighted parameters of penalty
  - Improving the order of deciding annotation positions
  - Filtering of annotations