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

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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:

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]

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

Approach

Obtaining the target’s position data via wireless network  
Estimating target’s region by using primitive models

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**Step 1: Estimation of target object regions**

~Objective~
Estimating target’s region  
(with the individual recognition)

~Assumption~
Each user has wearable PC to estimate position
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

Step 2: 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 related to overlaps

Penalty related to indication line

Penalty related to distance

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 overlaps

\[
P_o = P_{anno} + P_{map}
\]

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: $P_{\text{map}}$

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

- $i$: 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: $P_i$

$$P_i \propto l$$

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

In this study, $P_i$ is empirically defined as

$$P_i = l^2$$
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

<table>
<thead>
<tr>
<th>Penalty</th>
<th>Amount of calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta$ (Local minimum)</td>
<td>$O(n)$</td>
</tr>
<tr>
<td>$\bigcirc$ (Global minimum)</td>
<td>$O(e^n)$</td>
</tr>
</tbody>
</table>
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(*)

Experimental environment

Invisible visual markers
(on the ceiling)

Wireless LAN antenna

Network shared DB

Server
[CPU: PentiumD, 3.0GHz]

Ibuki
Takahashi
Kume

Wearable computer users
(Position and orientation are estimated in real time)

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

Configuration of wearable AR system

Infrared camera

Original
(Resolution: 1024 × 768)
(Frame rate: 29fps)

Capturing invisible markers

ThinkPad x60
(lenovo)

Estimating user's position and orientation

Generating annotation overlay images

Video camera

Original
(Resolution: 640 × 480)
(Frame rate: 10fps)

Capturing user's view

Head-worn display

ThinkPad x60
(lenovo)

SV-6
(MicroOptical)

Showing annotation overlay images

Capturing user's view
Pilot study: Estimation of the region of the target

3D object annotation (fixed in real world)

3D object annotation (fixed in real world)

Upper body (81 solids)

Head (25 solids)

Lower body (169 solids)

Wearable computer users

Experimental result
(Estimated regions are overlaid)

Annotation overlaying

- Setting of penalty function
  \[ P = w_o P_o + w_i P_i + w_m P_m \]
  \( w_o = 0.1, \ w_i = 0.5, \ w_m = 0.2 \)

- 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)

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

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