AR Display Method of a Person's Identifier near the Head on a Camera Screen Based on the GPS Information and Face Detection Using Ad hoc and P2P Networking

Masahiro Gotou and Kazumasa Takami

Department of Information Systems Science, Faculty of Engineering, SOKA University, Hachioji-shi, Tokyo 192-8577, Japan

Abstract: The spread of social media has increased contacts of members of communities on the Internet. Members of these communities often use account names instead of real names. When they meet in the real world, they will find it useful to have a tool that enables them to associate the faces in front of them with the account names they know. This paper proposes a method that enables a person to identify the account name of the person ("target") in front of him/her using a smartphone. The attendees to a meeting exchange their identifiers (i.e., the account name) and GPS information using smartphones. When the user points his/her smartphone towards a target, the target's identifier is displayed near the target's head on the camera screen using AR (augmented reality). The position where the identifier is displayed is calculated from the differences in longitude and latitude between the user and the target and the azimuth direction of the target from the user. The target is identified based on this information, the face detection coordinates, and the distance between the two. The proposed method has been implemented using Android terminals, and identification accuracy has been examined through experiments.

Key words: Ad hoc networking, AR (augmented reality), face detection, GPS information, person's identifier, P2P communication, smartphone.

1. Introduction

The penetration of the Internet has given rise to a growth in social media, such as Twitter, Facebook, and LINE. The percentage of social media usage now exceeds 60% [1]. Community members increasingly get together in the real world. According to a survey conducted in fiscal 2010 [2], 45.9% of the respondents who belong to an SNS, and 62.2% of those who access an SNS daily had attended offline meetings. Such meetings have become part of their lives. However, since most people in an offline meeting meet for the first time, they find it difficult to identify other attendees before they introduce themselves. One solution proposed was NameTag [3], which requires each member to attach a face photo to his/her icon or profile in social media and uses these photos to identify attendees to an offline meeting using facial recognition technology. However, this method cannot be useful if many members hesitate to disclose their face photos to the public. Another idea is to require members to wear nametags that contain their business cards but this cannot be useful if the fonts on business cards are too small.

Since smartphones have become widespread and its computing power has risen, applications have been developed for personal identification using sensors, GPS and AR (augmented reality) [4-6]. Several services, such as "Sekai camera [7]," "Layar [8]," display information that is derived from GPS data, and tags either printed on books or attached on objects using AR. However, these services can display only large buildings, such as stores, commercial buildings or other landmarks, which can be easily identified from GPS information, or objects to which tags were

Corresponding author: Kazumasa Takami, doctor of engineering, professor, research fields: self-organized network, intelligent software system, ad hoc communications, P2P services.

attached in advance.

There is a study on an opportunistic network [9-14], which is an information communication network that uses terminals owned by people who pass by in daily lives as nodes. A software program that has a passer-by communication function is provided for Android terminals. It allows the user to send tweets, etc. to get in touch with the persons who passed by him/her on the street. However, if the user is to exchange, with confidence, information with a person whose face photo is not disclosed, some means should be available to identify the passers-by.

This paper proposes a method that enables the user to know the identity of people in close proximity using a smartphone. The smartphones of the people concerned exchange messages that contain the identifier (i.e., account name in a community on the Internet) and GPS location information. The identifier is displayed near the head of the target person on the camera screen using AR. This will enable users to easily identify those people whom they know by their account names on the Internet but have not met physically. This method involves two procedures. One is calculation of the identifier display coordinates from differences in longitude and latitude between the locations of the user and the target person and the azimuth direction of the target from the user. This was already proposed by the authors in Ref. [15]. This is supplemented by the second procedure, which uses the distance between the coordinates obtained above and the face detection coordinates. We implemented this method in Android smartphones and examined the accuracy of identifying target persons through experiments. Section 2 presents a conceptual model of the proposed method, and describes how the GPS coordinates and face detection coordinates of the target person is used to display the identifier of the target person. Section 3 describes the configuration of the experimental system we developed using Android terminals. Section 4 discusses experiment results. Section 5 gives conclusions and future issues.

2. Displaying the Identifier of the Target Person near His/Her Head Based on His/Her GPS Coordinates and Face Detection Coordinates

This section describes how the identifier of the target person can be displayed near his/her head on a camera screen using AR. A conceptual model is used to explain the functions of this method. Three technical issues are discussed. The first is how to improve the accuracy of a person's location information derived from GPS coordinates. The second is how to calculate the relative spatial positions from differences in longitude and latitude between the user and the target and the azimuth direction of the target from the user. The third is how to correct the identifier display position from the face detection coordinates.

2.1 Conceptual Model of the Proposed Method

A model for displaying a person's identifier on the camera screen is presented here. Three types of coordinates are considered: the *GPS coordinates* of a person, the coordinates of the position at which a person's face is detected through a camera (*face detection coordinates*), and the position at which the person's identifier should be displayed (*identifier display coordinates*).

Three patterns are considered with regard to the number of targets and the number of persons involved. Let the identifier of a target person s be s_id, the GPS coordinates of s be $s\_GPS\_coordinate$, and the identifier display coordinates of s be P_s. Let the face detection coordinates of an unknown person be F_{uk}. After the person is identified as s, F_{uk} changes to F_s. The persons involved exchange messages using P2P communication. Each message contains the s_id and $s\_GPS\_coordinate$ of the owner s of the sending terminal.

2.1.1 Pattern 1: Only One Target Person

Only Target B is near User A. A's camera screen displays the face of B. This pattern is shown in Fig. 1.

B's terminal sends a message to A. Since both F_{uk} and P_B exist within A's camera screen, it is determined that F_{uk} is B, and identifier (B_id) is displayed near the head of F_B.

2.1.2 Pattern 2: Only One Target Person but the Faces of Two Persons Are Detected

Target B and non-target C are near User A. B sends a message to A. A's terminal detects two faces. This pattern is shown in Fig. 2.

F_{uk1}, F_{uk2} and P_B are within A's camera screen. The distance between P_B and F_{uk1} and the distance between P_B and F_{uk2} are compared. Since F_{uk1} is closer to P_B than F_{uk2} is, it is determined that F_{uk1} is B, and identifier (B_id) is displayed near the head of F_B.

2.1.3 Pattern 3: Two Target Persons and the Faces of Two Persons are detected

Both Targets B and C are near User A. Both of them send a message to A. A's terminal detects two faces. This pattern is shown in Fig. 3. F_{uk1}, F_{uk2}, P_B and P_C are within A's camera screen. The distance between P_B and F_{uk1} and the distance between P_B and F_{uk2} are compared. P_B is closer to F_{uk1} than to F_{uk2}. Therefore, it is determined that F_{uk1} is B. Likewise, distance between P_C and F_{uk1} and the distance between P_C and F_{uk2} are compared. Since P_C is closer to F_{uk2} than to F_{uk1}, it is determined that F_{uk2} is C. Thus, identifiers of B_id and C_id are displayed near the heads of the respective persons.
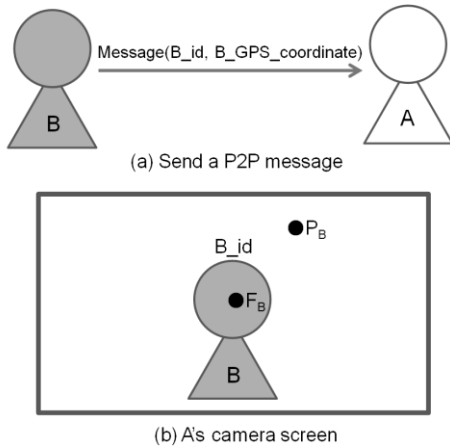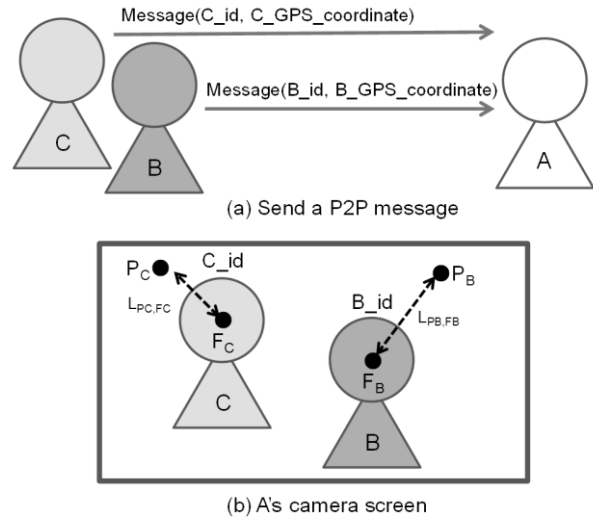

(a) Send a P2P message

(b) A's camera screen

(note) s_id: identifier of s, s_GPS_coordinate: location information of s,
P_s: identifier display coordinates calculated from s = GPS_coordinate,
F_s: face detection coordinates of s

Fig. 1   Only one target person.
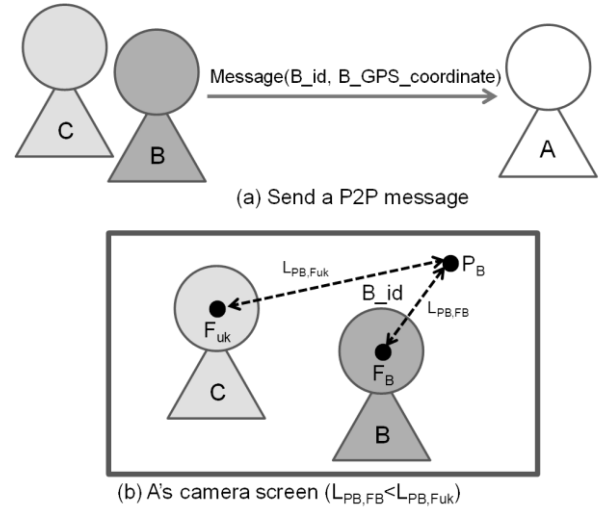
(a) Send a P2P message

(b) A's camera screen ($L_{PB,FB} < L_{PB,Fuk}$)

(note)) s_id: identifier of s, s_GPS_coordinate: location information of s,
P_s: identifier display coordinates calculated from s = GPS_coordinate,
F_s: face detection coordinates of s, L_{PsFs}: distance between P_s and F_s

Fig. 2   Only one target person but the faces of two persons are detected.

(a) Send a P2P message

(b) A's camera screen

(note)) s_id: identifier of s, s_GPS_coordinate: location information of s,
P_s: identifier display coordinates calculated from s = GPS_coordinate,
F_s: face detection coordinates of s, L_{PsFs}: distance between P_s and F_s

Fig. 3   Two target persons and the faces of two persons are detected.

2.2 *Use of a Center-Of-Gravity Model to Compensate for GPS Measurement Errors*

To identify the target persons on the camera screen correctly, it is important to ensure that GPS measurements are accurate. To compensate for GPS measurement errors, we use a center-of-gravity model, which the authors proposed in Ref. [15]. This model assumes that the user and the targets are close enough

to see each other, and that they share the same GPS measurement conditions, such as the weather and other environmental conditions and the number of accessible satellites.

Consider the center of gravity of a triangle made up of three GPS coordinates of the same person measured within a relatively short span. We regard that the person is located at the center of gravity. As shown in Fig. 4, an advantage of this model is that the error of the center of gravity is always equal to or smaller than the maximum error of any point even though it may be greater than the error of one or two points.

(note)
★ True position of the terminal
○ Results of 3 GPS measurements
● Center of gravity (assumed position)
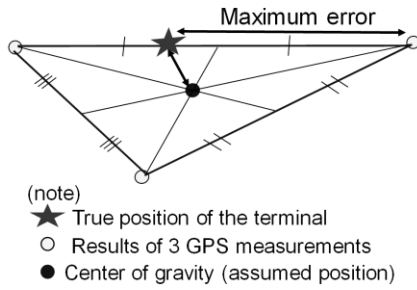
Fig. 4   Calculation of a target person's location using the center-of-gravity model.

2.3 Calculation of the Identifier Display Coordinates from Differences in Longitude and Latitude between the Two Persons and the Azimuth Direction (Relative Spatial Position)

The terminals of the persons involved exchange their GPS location information obtained in the manner described in Section 2.2. We calculate the relative spatial position of the two terminals, and calculate identifier display coordinates $P_s(x,y)$, the position at which identifier s_id is displayed. The algorithm that was proposed by the authors in Ref. [15] is used for this calculation. This algorithm is described below. Refer to the relative spatial position plane shown in Fig. 5.

Step 1: Calculate the differences in longitude and latitude between the GPS locations of the user and the target. Create a relative spatial position plane. Its vertical axis shows the difference in latitude, and the horizontal axis shows the difference in longitude. The user is at the origin. Let the coordinates of the target s

be $R_s(x,y)$. Calculate $R_s(x,y)$ and determine the quadrant in which the target is.

Step 2: Consider a point (H) on the horizontal axis at which it intersects with a line that goes through s and is parallel to the vertical axis. Create a triangle with vertices U, S and H. Calculate the angle δ(=arctan(y/x)) between the oblique line of this triangle and the horizontal axis.

Step 3: Calculate angle α between the direction of north (which is the reference direction) and the target based on the quadrant in which angle δ and the target exist.

3-1: If the target is in the second or third quadrant, $\alpha=90°+(-1)^{n-1}\times\delta$ (n is the quadrant number);

3-2: If the target is in the first or fourth quadrant, $\alpha=270°+(-1)^{n-1}\times\delta$ (n is the quadrant number).

Step 4: Using an electronic compass, measure angle β between the direction of north and the direction in which the user is facing. Calculate the difference in angle between the direction in which the user is facing and the direction of the target: $\Delta us(=\beta-\alpha)$.

Step 5: Calculate $P_s(x,y_{fix})$ from the fact that the direction of the target differs from the direction in which the user is facing by angle Δus. The x coordinate of $P_s(x,y_{fix})$ is calculated using Eq. (1). The y coordinate is fixed at y_{fix} to avoid the influences of shaking of the camera.

$$x=\Delta us\times K \qquad (1)$$

where K is a constant that depends on the camera screen size and the viewing angle.
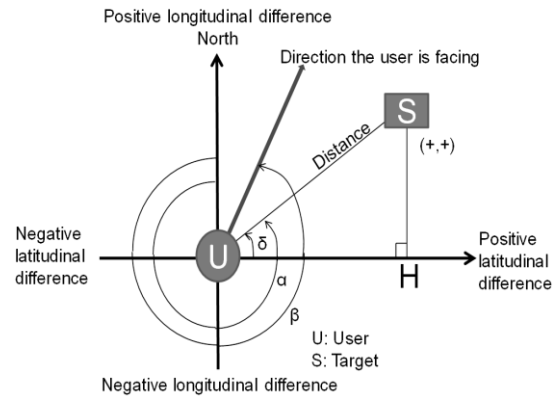
Fig. 5   Relative spatial position plane.

2.4 Correction of the Identifier Display Position Based on Face Detection Coordinates

This section describes the algorithm for determining the *s_id* display position from $P_s(x,y)$ calculated in Section 2.3 and $F_{uk}(x,y)$ of the unknown person.

Step 1: The user receives *m* messages and detects *k* faces.

Step 2: Calculate $mP_s(x,y)$, and calculate its set $\{P_{si}(x_i,y_i)|i=1\sim m\}$.

Step 3: Calculate set $\{F_{ukj}(x_j,y_j)|j=1\sim k\}$ of *k* face detection coordinates.

Step 4: Calculate the distances of all combinations of $P_{si}(x_i,y_i)$ and $F_{ukj}(x_j,y_j)$. Let the set of these distances be $\{L_{si,ukj}|$ i=1~m, j=1~k$\}$.

Step 5: Determine the correspondence between the targets and the faces detected. The candidate of Target s_i is stored in $C_{si}(F_{ukj},L_{si,ukj})$.

5-1: Set j=1, search column set $\{L_{si,uk1}|i=1\sim m, j=1\}$, and find s_w that has the minimum value. This s_w is considered the candidate, and is set in $C_{sw}(F_{uk1},L_{sw,uk1})$.

5-2: Set j=2 and perform the following for s_w, which already has a candidate value.

Case 1: If $L_{sw,uk2} \geq C_{sw}(L_{sw,uk1})$ then retain C_{sw}.

Search column set $\{L_{si,uk2}|i=1\sim m, i\neq w, j=2\}$ excluding s_w, and find s_z that has the minimum value. This s_z is considered the candidate, and is set in $C_{sz}(F_{uk2},L_{sz,uk2})$.

Case 2: If $L_{sw,uk2} < C_{sw}(L_{sw,uk1})$ then discard C_{sw}.

Search column set $\{L_{si,uk2}|i=1\sim m, j= 2\}$, and find s_z that has the minimum value. This s_z is considered the candidate, and is set in $C_{sz}(F_{uk2},L_{sz,uk2})$.

5-3: Repeat 5-2 for j = 3 to *k*.

5-4: Check whether candidates are found for all s_i.

Case 1: If yes, go to Step 6.

Case 2: No.

Case2-1: There is a competitor (target s_i). Go to Step 5-1.

Case2-2: There is no competitor, and only s_v remains. F_{ukq}, which has not been associated with any target, is selected as the candidate for s_v and is set in $C_{sv}(F_{ukq},L_{sv,ukq})$. Go to Step 6.

Step 6: The identifier s_{i_id} is to be displayed near the head of F_{ukj} of $C_{si}(F_{ukj})$. This is repeated for i=1 to *m*.

Two examples of the above algorithm are described below for cases where *m*=2 and *k*=2. The distance between the coordinates is different between the two examples.

(Example 1)

Steps 1 to 4: Generate set $\{L_{si,ukj}|$ i=1~2, j=1~2$\}$. The value of each element is shown below.

Face detected *uk* / Target *s*	*uk1*	*uk2*
s1	2	4
s2	3	1

Step 5-1: Search column *uk1* for the minimum value. Target *s1* has the minimum value. Generate $C_{s1}=$ (*uk1*,2). Nothing is done on *s2*.

Step 5-2 Case 1: Move to column *uk2*. Since *s1* has a candidate value, compare $L_{s1,uk2} = 4$ with C_{s1}(distance value)=2. Since C_{s1}(distance value) is smaller, candidate value $C_{s1}=$(*uk1*,2) is retained.

Step 5-4 Case2-2: *s2* has no candidate value, and the candidate for *s1* is already determined. Since there is no other competitor, it is determined that *s2* is *uk2*, i.e., $C_{s2}=$(*uk2*,1).

Step 6: It is determined that *s1* = *uk1* and *s2*=*uk2*.

(Example 2)

Steps 1 to 4: Generate set $\{L_{si,ukj}|$ i=1~2, j=1~2$\}$. The value of each element is shown below.

Face detected *uk* / Target *s*	*uk1*	*uk2*
s1	3	4
s2	2	1

Step 5-1: Search column *uk1* for the minimum value. Target *s2* has the minimum value. Generate $C_{s2}=$ (*uk1*,2).

Step 5-2 Case2: Move to column *uk2*. Since *s2* has a candidate value, compare $L_{s2,uk2}= 1$ with C_{s2}(distance value)=2. Since $L_{s2,uk2}$ is smaller, clear the candidate value for *s2*.

Step 5-2: Neither *s1* nor *s2* has a candidate value. They are competitors. Search column *uk2* for the minimum value. Target *s2* has the minimum value. Generate $C_{s2} = (uk2,1)$.

Step 5-4 Case2-1: Go back to *uk1*, and perform the determination of the candidate again. Since *s2* has a candidate value, compare $L_{s2,uk1} = 2$ with C_{s2}(distance value)=1. Since C_{s2}(distance value) is smaller, it is determined that *s2* is *uk2*.

Step 5-4 Case2-2: Since the candidate for *s2* is already determined, there is no other competitor. Therefore, it is determined that *s1* is *uk1*.

Step 6: It is determined that *s1 = uk2* and *s2=uk1*.

3. Development of an Experimental System for Evaluation

We used two smartphones from Panasonic: ELUGA V P-06D. Bluetooth was used for short-range wireless communication. The main specifications of ELUGA V P-06D related to this paper are shown in Table 1. Android Studio was used for the development environment. The application program for the algorithm proposed in Section 2 was implemented in Java. The application program was launched by Android OS. The smartphones synchronized with each other using Bluetooth communication. Location

information was obtained via a Wi-Fi AP (access point). Identifiers were displayed using AR and face detection functions. The experimental system has two user interfaces: the camera screen and the touch screen. GPS information and calculated display positions were also displayed on the camera screen using AR. The configuration of the experimental system software is shown in Fig. 6. GPS coordinates were exchanged via a wireless access point assuming that this method will be used in indoor events, such as offline meetings.
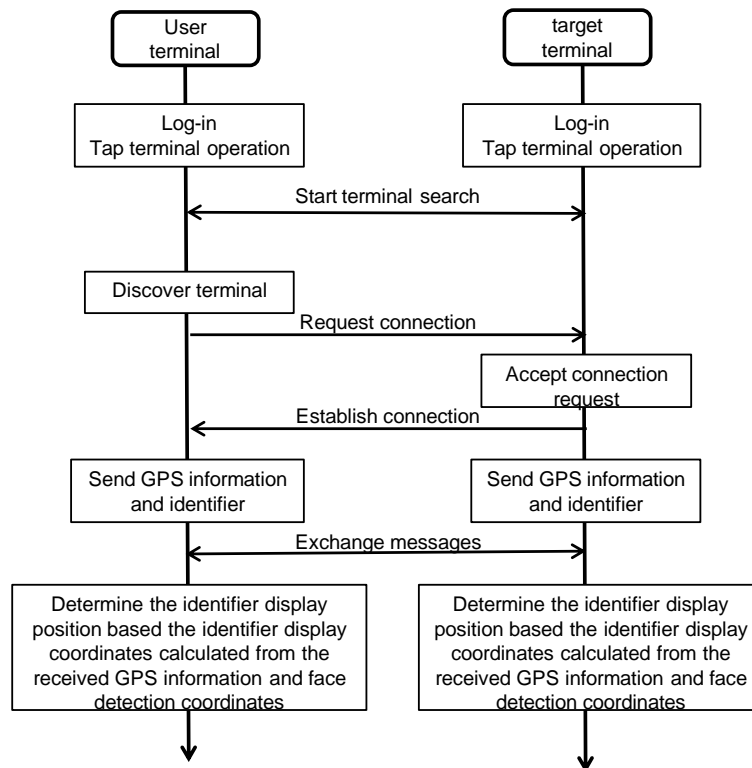
3.1 P2P Communication Sequence

Each person inputs his/her identifier, and logs in. When the terminal search is tapped, a screen for selecting terminals is displayed. When a target terminal is tapped, a connection is set up between this terminal and the target terminal. Each terminal acquires its GPS location information and sends it along with the identifier. Each terminal determines the target's identifier display position from the identifier display coordinates, which has been calculated from the received information, and the face detection coordinates, and displays the identifier using AR. This communication sequence is shown in Fig. 7.

Table 1   Main specifications and design conditions of the smartphone.

Item	Specification
Product name	ELUGA V P-06D (Panasonic)
OS	Android 4.0
Development environment	Android Studio, SDK4
Short-range communication	Bluetooth 3.0 (profile: OPP)
Face detection function	The FaceDetectionListener class was used.
Wireless LAN	IEEE802.11b/g/n
GPS acquisition function	NETWORK_PROVIDER of the LocationManager class via Wi-Fi was used.
Display (resolution)	4.6-inch HD(720 ×1280 pixels)
Setting of camera display coordinates	Origin (427 pixel, 287 pixel) x coordinate: The part above the origin is positive. The part below the origin is negative. y coordinate: The part above the origin is negative. The part below the origin is positive.
Constant for conversion from the relative spatial position to the identifier display coordinates	$K = 20$ $y_{fix} = 50$ pixel
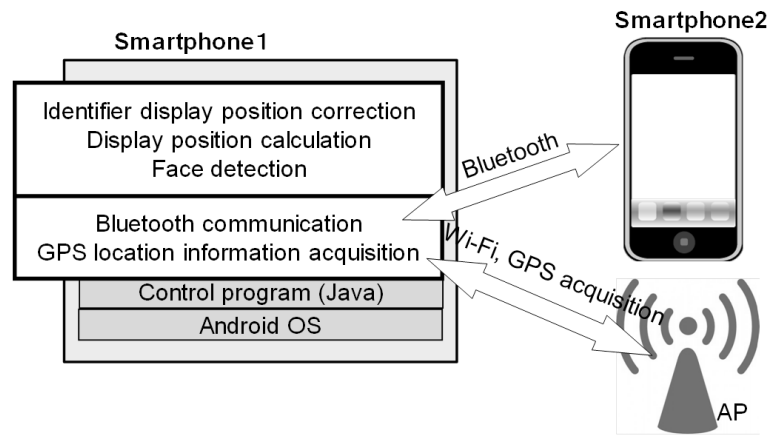
Fig. 6 Configuration of the experimental system software.

Fig. 7 P2P communication sequence.

3.2 Operation Example of the Experimental System

In order to establish Bluetooth communication, the user taps "Terminal search" from the list of icons shown in the upper right corner of Fig. 8. Then, a screen for selecting a terminal appears. The user taps a target terminal to establish the connection to the target. The user taps "Location acquisition" in the upper right corner of Fig. 8 to acquire its location information and

taps the "Send" button to send his/her identifier and location information to the target terminal.

The user taps "Camera" in the upper right corner to launch the camera. At the same time, the terminal calculates the angle to the target from the target's location information, and converts this information into a relative spatial position. An example of usage is shown in Fig. 9. In this case, the distance to the target was 1 m. The target's identifier was "test." This identifier

was displayed above the face detected using the camera, as shown in Fig. 9a. Fig. 9b shows the relation between P_{test} and F_{test} on an x-y plane. Although the position of P_{test} is outside the camera screen because of GPS errors, the algorithm described in Section 2.4 corrected the display position and the identifier was shown near the head of the target. Even when the target is so far away that his/her face cannot be detected, the use of zooming makes face detection possible. For example, even when the target was 5 m away as in Fig. 10a, the use of zooming allowed face detection, and the target's identifier was displayed.
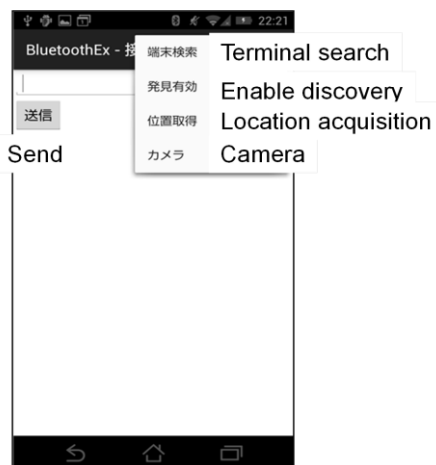
Fig. 8   Initial screen.
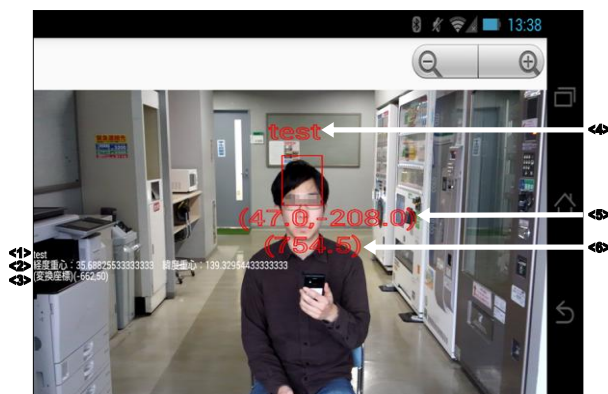
(Note) <1> Identifier of the target whose information has been received.
<2> Center of gravity in longitude and that in latitude of the target whose information has been received.
<3> Converted relative spatial position P_{test}.   <4> Identifier of the target displayed.
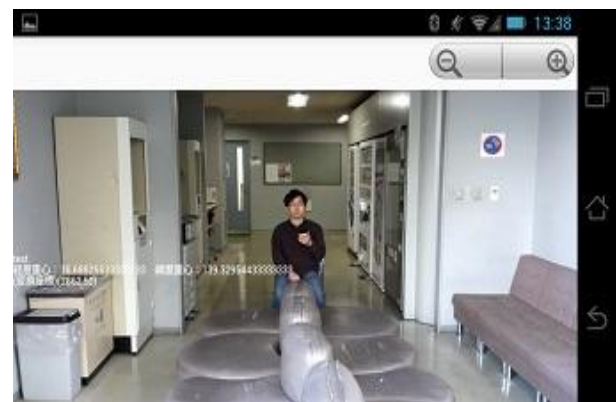<5> Face detection coordinates F_{test}.   <6> Distance between F_{test} and P_{test}.

(a)   Camera screen example

Fig. 9a   Identifier is displayed near the head using AR.
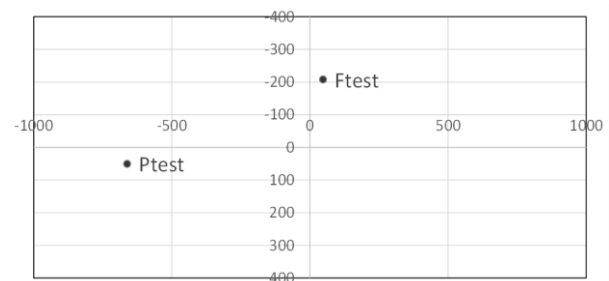
(b) Relation between P_{test} and F_{test}

Fig. 9b   Identifier is displayed near the head using AR.


(a) Without zooming

(b) With zooming

Fig. 10   Usage example when the target is 5 m away.

When two faces are detected, each identifier is displayed near the head that is found to be closer based on the coordinates into which the acquired location information has been converted and the face detection coordinates. In the case of Fig. 11, for example, the user has received a message only from Target A but two faces, A and B, have been detected. Target A's identifier "*test*" is displayed near A, who is closer to the coordinates into which A's location information has been converted.
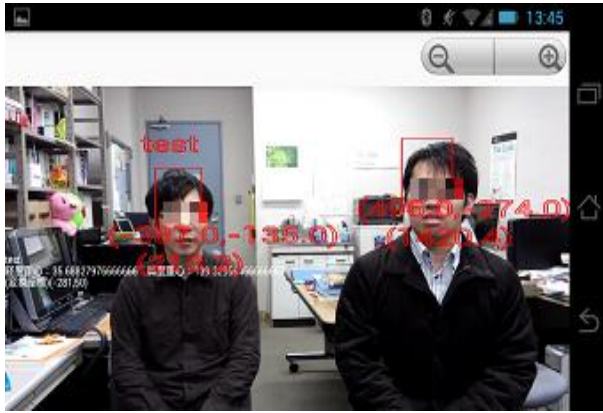
Fig. 11   Usage example when two faces are detected.

4. Evaluation with Experiments

Using the experimental system, we evaluated the proposed method for a number of location relations of two targets.

4.1 Evaluation Conditions

The experiment conditions are shown in Table 2. Because of the constraints of the experimental system, it was not possible to set up simultaneous connections to multiple target terminals. Therefore, one target terminal was shared by two target persons. After Target A followed the sequence shown in Fig. 7, he tapped the "Return" button. This brought the terminal back to the initial log-in window and disconnected (logged out) the Bluetooth connection. After Target A confirmed the disconnection, he handed the terminal to Target B. Target B followed the sequence shown in Fig. 7.

4.2 Results of the Experiments Regarding the Relative Locations of Two Targets

Experiments were conducted for four relative locations of two targets. In Pattern 1, Target A (*tarou*) and Target B (*jirou*) were side by side. In Pattern 2,

Target A was in front of the user while Target B was behind the user. In Pattern 3, both targets were in the same screen but Target A was 1 m behind Target B. In Pattern 4, Target A is in front of the user but Target B was to the right of the user. The results for the four patterns are shown in Table 3. In Patterns 2 and 3, the targets cannot fit into one screen. Therefore, the camera was pointed to each target separately.

In all patterns, there was a big difference between the coordinates into which the target's location information was converted and the face detection coordinates. However, the targets were identified and the identifiers (*tarou* and *jirou*) were displayed correctly.

4.3 Error Examples and Accuracy of Identifier Display

Table 4 shows cases where GPS location information was not accurate enough or the relative positions of the targets were unfavorable.
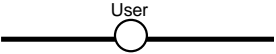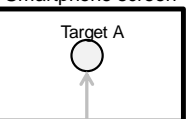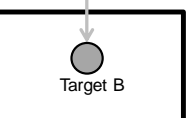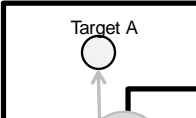
In the first example, there was another person in front of the target ("テスト" *test*). This person was identified as the target and the target's identifier was displayed near him. In the second example, the two targets (*tarou* and *jirou*) stood side by side. The identification of them was reversed, and thus a wrong identifier was attached to each target.

We examined the degree of accuracy of the proposed method. Ten experiments were carried out for a case where two targets were side by side. The experiment results are shown in Table 5. The identifiers were displayed correctly 6 times and incorrectly 4 times. The accuracy rate was 60%. The rate was not near 100% because the accuracy of identifier display coordinates highly depends on the accuracy of GPS location information, which was not accurate enough in some cases.
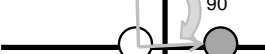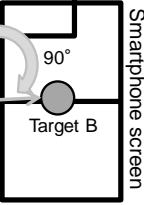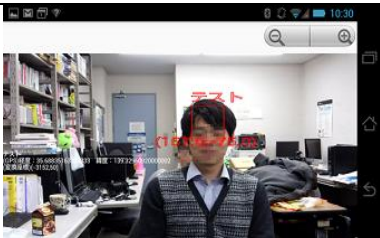
Table 2   Experiment conditions.

Item	Conditions and values
Experiment site	Indoor
Number of terminals	2 terminals (1 for user. The other was shared by 2 targets in the experiment.)
Number of subjects	1 or 2 targets. 1 non-target.
Distance from the user to the targets	1 to 5 m

AR Display Method of a Person's Identifier near the Head on a Camera Screen Based on the GPS Information and Face Detection Using Ad hoc and P2P Networking

205

Table 3   Results of the experiments regarding the relative locations of two targets.

Pattern	Relative locations	Camera screen
1	The two targets were side by side.	Targets A and B were correctly identified and their identifiers (*tarou* and *jirou*) were correctly displayed.
2	Target A is in front of the user while Target B was behind the user.	Target A (*tarou*) Target B (*jirou*)
3	The two targets were in the same screen but Target A was 1 m behind Target B.	
4	Target A is in front of the user but Target B is to the right of the user.	Target A (*tarou*) Target B (*jirou*)

Table 4   Error examples..

Error description	Screen image
There was another person in front of the target (" テスト"*test*). The identifier was displayed near this person.	
The identification of the two targets (*tarou*, *jirou*) was reversed.	

Table 5   Results of 10 experiments for examining display accuracy.

Number of experiments	Experiment data						Assessment
	FDC		*uk1*		*uk2*		
			x	y	x	y	
1	IDC		-347	-152	395	-274	Good
	tarou	x	-2683	2345	3095		
		y	50	*tarou*			
	jirou	x	1463	1821	1116		
		y	50		*jirou*		
	FDC		*uk1*		*uk2*		
			x	y	x	y	
2	IDC		-353	-119	491	-202	Bad
	tarou	x	1279	1641	827		
		y	50		*tarou*		
	jirou	x	-2362	2016	2864		
		y	50	*jirou*			
	FDC		*uk1*		*uk2*		
			x	y	x	y	
3	IDC		-428	13	423	-157	Good
	tarou	x	-1843	1415	2275		
		y	50	*tarou*			
	jirou	x	886	1315	507		
		y	50		*jirou*		
	FDC		*uk1*		*uk2*		
			x	y	x	y	
4	IDC		-365	-86	395	-208	Good
	tarou	x	-2428	2067	2835		
		y	50	*tarou*			
	jirou	x	-2791	2430	3196		
		y	50		*jirou*		
	FDC		*uk1*		*uk2*		
			x	y	x	y	
5	IDC		-315	-263	414	-430	Good
	tarou	x	-1720	1439	2187		
		y	50	*tarou*			
	jirou	x	2423	2756	2066		
		y	50		*jirou*		

Number of experiments	Experiment data						Assessment
	FDC		*uk1*		*uk2*		
			x	y	x	y	
6	IDC		-358	-19	408	-219	Good
	tarou	x	-2584	2227	3004		
		y	50	*tarou*			
	jirou	x	2832	3191	2439		
		y	50		*jirou*		
	FDC		*uk1*		*uk2*		
			x	y	x	y	
7	IDC		-325	-157	395	-374	Bad
	tarou	x	-2847	2530	3270		
		y	50		*tarou*		
	jirou	x	-983	690	1442		
		y	50	*jirou*			
	FDC		*uk1*		*uk2*		
			x	y	x	y	
8	IDC		-387	-102	390	-308	Bad
	tarou	x	-2808	2426	3218		
		y	50		*tarou*		
	jirou	x	-2737	2355	3147		
		y	50	*jirou*			
	FDC		*uk1*		*uk2*		
			x	y	x	y	
9	IDC		-415	-208	426	-308	Good
	tarou	x	-3002	2600	3447		
		y	50	*tarou*			
	jirou	x	2521	2947	2125		
		y	50		*jirou*		
	FDC		*uk1*		*uk2*		
			x	y	x	y	
10	IDC		-315	-174	466	-313	Bad
	tarou	x	-2305	2003	2795		
		y	50		*tarou*		
	jirou	x	-1016	736	1526		
		y	50	*jirou*			

(note1) FDC:Face detection coordinates, IDC:Identifier display coordinates

(Note2) The upper part in a cell: distance between P_s and F_{uk}. The lower part in a cell: identifier selected.

AR Display Method of a Person's Identifier near the Head on a Camera Screen Based on the
GPS Information and Face Detection Using Ad hoc and P2P Networking

207

5. Conclusions and Future Issues

This paper has proposed a method of displaying the identifier of each target person near his/her head on the camera screens of the smartphones. The smartphones exchange their location information and identifiers of their owners using short-range wireless communication. The paper has proposed to correct identifier display positions using face detection coordinates in order to make up for errors in GPS location measurements. The proposed method was implemented on Android terminals, and experiments were conducted indoors with two target persons. This method determines the identifier display position based the differences in longitude and latitude between the user and the target person and the azimuth direction between the two. This method is sensitive to errors in GPS measurements and the azimuth direction indicated by the electronic compass. It was confirmed that, if these measurements are stable, the correction that uses face detection coordinates yields good results. Identifiers were displayed near the correct target persons at an accuracy rate of 60%.

Looking forward, it will be necessary to improve display accuracy and evaluate the method with more than two target persons. When a third person was between the user and the target person, that person was erroneously recognized as the target person. It will be necessary to improve the method so that the calculation of the identifier display position will take the distance to the target into consideration.

Acknowledgements

References

[1] Investigation Report on the Use Time and the Information Behavior of the Information and Communication Media of 2014, Ministry of Internal Affairs and Communications of Japan, May 2015. Available online at http://www.soumu.go.jp/menu_news/s-news/01iicp01_02000028.html.

[2] Contractors Report of Research on Actual Use of Social Media, Ministry of Internal Affairs and Communications of Japan, March 2010. Available online at http://www.soumu.go.jp/johotsusintokei/linkdata/h22_05_houkoku.pdf.

[3] "NameTag." FacialNetwork.com. Available online at http://www.nametag.ws/.

[4] Avery, B., Thomas, B., and Piekarski, W. 2008. "User Evaluation of See-Through Vision for Mobile Outdoor Augmented Reality." In *7th Int'l Symposium on Mixed and Augmented Reality,* 69-72.

[5] Zendjebil, I. M., Ababsa, F., Didier, J.-Y., and Mallem, M. 2008. "Hybrid Localization System for Mobile Outdoor Augmented Reality Applications." First Workshops on Image Processing Theory, Tools and Applications, 1-6, 23-6.

[6] Myung, H., Lee, B., Kim, H., and Kang, S. 2009. "A Study on Effective Visual Communication Method with the 'Pictomation' Contents in Augmented Reality Environment Information Visualization." *13th International Conference Information Visualization,* 274-9.

[7] "Sekai Camera." Available online at http://techcrunch.com/2010/07/14/augmented-reality-app-sekai-camera-goes-multi-platform-adds-api-and-social-gaming/.

[8] "Layar." Available online at http://www.fastcompany.com/1441526/layar-augmented-reality-app-hits-200th-data-layer.

[9] Conti, M., Giordano, S., May, M., and Passarella, A. 2010. "From Opportunistic Networks to Opportunistic Computing." *IEEE Communications Magazine*: 126-39.

[10] Ochiai, H., Shimotada, K., and Esaki, H. 2010. "DTIPN: Delay Tolerant IP Networking for Opportunistic Network Applications." ACM/SIGMOBILE MobiOpp'10, Pisa, Italy.

[11] Pietilainen, A., and Diot, C. 2009. "Experimenting with Opportunistic Networking." ACM International Workshop on Mobility in the Evolving Internet Architecture (MobiArch'09), Krakow, Poland.

[12] Keranen, A., Ott, J., and Karkkainen, T. 2009. "The ONE Simulator for DTN Protocol Evaluation." Second International Conference on Simulation Tools and Techniques (SIMU Tools), Rome, Italy.

[13] Daly, E., and Haahr, M. 2007. "Social Network Analysis for Routing in Disconnected Delay-Tolerant MANETs." ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc'07), Montreal, Quebec, Canada.

[14] Burke, J., Estrin, D., Hansen, M., Parker, A., Ramanathan, N., Reddy, S., and Srivastava, M. B. 2006. "Participatory Sensing." Workshop on World-Sensor-Web (WSW'06): Mobile Device Centric Sensor Networks and Applications (WSW'06 at SenSys '06), Boulder, Colorado, USA.

[15] Kawabata, H., and Takami, K. 2012. "A Method of Simultaneously Displaying a Passing Person and His/Her Message on the Same Screen Space." IEEE International Workshop on the Impact of Human Mobility in Pervasive Systems and Applications 2012 (PerMoby 2012), Lugano, Switzerland.