World Academy of Science, Engineering and Technology
International Journal of Computer and Information Engineering
Vol:8, No:8, 2014

Human Tracking across Heterogeneous Systems Based On Mobile Agent Technologies

Tappei Yotsumoto, Atsushi Nomura, Kozo Tanigawa, Kenichi Takahashi, Takao Kawamura, Kazunori Sugahara

***Abstract*—**In a human tracking system, expanding a monitoring range of one system is complicating the management of devices and increasing its cost. Therefore, we propose a method to realize a wide-range human tracking by connecting small systems. In this paper, we examined an agent deploy method and information contents across the heterogeneous human tracking systems. By implementing the proposed method, we can construct a human tracking system across heterogeneous systems, and the system can track a target continuously between systems.

***Keywords*—**Human tracking system, mobile agent, monitoring.

I. Introduction

MONITORING systems, such as video surveillance systems are widely used in various situation in our daily life. In such video surveillance systems, a monitoring person should fix his eyes on monitors of multiple cameras to find suspicious person. However, a long time tracking gives not only heavy workload to the monitoring person but also incensement of possibility not to find suspicious person. In addition, the system cannot track other suspicious persons while tracking one person. Suspicious person should be tracked is called "target" in the following.

In order to solve above problems, we developed an automatic human tracking system using the Mobile Agent technology through multiple video cameras to track multiple targets [1]. In our system, the program called “Mobile Agent” tracks targets in place of the monitoring person. The mobile agents track targets according to their features obtained from image data of video cameras. Introducing of the mobile agents into video surveillance systems enables easy construction of multi-target tracking systems. In our system, no personal data of target persons are needed and data processing task for targets tracking is able to be distributed to computers in the system.

The related researches of the human tracking system using the agent technology are about the following cases: The system which tracks one target by plural agents [2], the system which can track a target through multiple cameras in the actual environment where there are many obstacles [3], the system which unifies image data from multiple video cameras by Karman filter and tracks a target efficiently [4]. On the other hand, a multi-camera system for tracking persons using PC controlled cameras connected with network was proposed [5].

T. Yotsumoto and K. Tanigawa are with the Melco Power Systems Co., Ltd, Kobe, Hyogo 652-8555 Japan (e-mail: Yotsumoto.Tappei@zb.MitsubishiElectric.co.jp, Tanigawa.Kozo@zx.MitsubishiElectric.co.jp).

K. Takahashi, T. Kawamura and K. Sugahara are associate professor and professors of Graduate School of Engineering, Tottori University, Tottori 680-8552 Japan (e-mail: takahashi/kawamura/sugahara@ike.tottori-u.ac).

In these human tracking systems, it was possible to continue tracking a target only within the monitoring range of the systems. For example, if you want to track a target even when it goes out of the monitoring range, the simple solution is to expand the monitoring range of the system by adding video cameras. However, enlarging the monitoring range of the system requires large increase of system management cost and data processing cost for target tracking.

Therefore, we propose a method that realizes a wide-range human tracking by connecting small systems. By implementing the proposed method, we realize a human tracking system across heterogeneous systems, and the system can track a target continuously.

This paper constitutes as follows. Chapter II mentions the human tracking system using the mobile agents. Chapter III mentions the human tracking across heterogeneous systems. Chapter IV mentions determination of a neighbor system to which the system sends a tracking request, and we describe the conclusion in Chapter V.

II. Abstract of the Human tracking system

The human tracking system constructed according to mobile agent technologies is illustrated in Fig. 1.

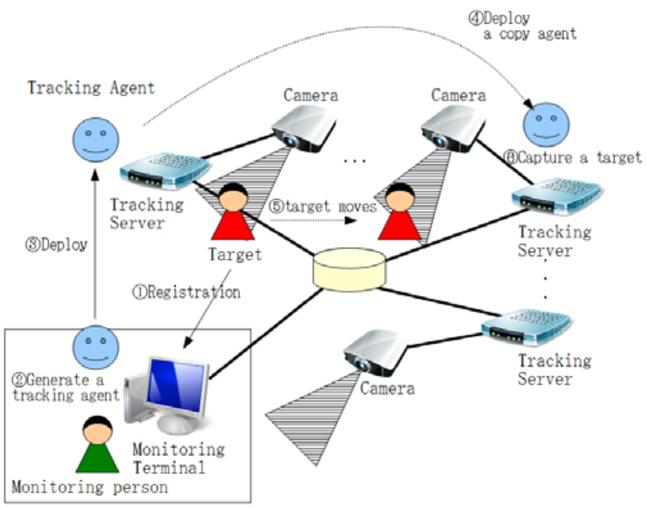

Fig. 1 System configuration of the human tracking system

The system is composed of four kinds of elements, i.e. tracking agents, tracking servers, video cameras and a monitoring terminal. The tracking agent is a mobile agent program that can migrate between tracking servers autonomously. In this system, the tracking agent moves between multiple tracking servers to track a target. Tracking servers connected to video cameras analyze image data, and extract futures from them to identify the target, such as the physique and the color of the clothes. The mobile agent uses the feature data of the tracking servers will be used to recognize the target. The monitoring terminal is used when a monitoring person registers a target. At the monitoring terminal, a mobile agent with the feature data is produced by registering a target.

Human tracking behaves as follows. It starts when a monitoring person registers a target at a monitoring terminal. Then a tracking agent with the target person's features data is activated at the monitoring terminal. The activated agent is sent to the tracking server that has captured a target. When the target moves, the tracking agent needs to move to a destination tracking server that is expected to capture the target next. The tracking agent generates itself-copies and sends them to the destination tracking server. When the copy agent detects the target on the tracking server, the copy agent notifies the detection information to the original agent. The original-agent deletes copy agents which do not detect the target. And finally, the original agent deletes itself. The copy-agent that has detected the target becomes the original-agent, and distributes itself-copies to a new destination tracking server.

Human tracking system tracks a target by repeating these processes.

III. Human Tracking across Heterogeneous Systems

In a human tracking system, a monitoring range which is available for tracking is limited to a certain extent. The monitoring range is decided by the number and the location of cameras, and also limited within one building.

As described in Chapter 1, we propose a method that realizes a wide-range human tracking by connecting small systems. By implementing this proposed method, we realize a human tracking system across heterogeneous systems in order to track a target continuously. In this study, we assume the following conditions to simplify a problem.

1) We adapt mobile agent to the system because the agent removes the differences of the systems and tracks targets continuously across the systems.
2) Only video cameras are used to get futures of targets.

Under these assumptions, two problems are remained to be examined in this study. One is what information contents should be sent to the neighbor systems and the other is how to deploy the agents to the neighbor systems. We describe the solution for these problems in the next sections.

A. Information Contents Sent to the Neighbor Systems

In one human tracking system, feature data obtained from cameras are used for detecting a target. In our heterogeneous system, the feature data are also used to keep tracking a target.

However, we must think about the case that determination of feature data may fail if the video cameras are different in other systems to which the data will be sent. So, we added supplemented information data to an agent as well as feature data. The agent sends both information data to the neighboring systems.

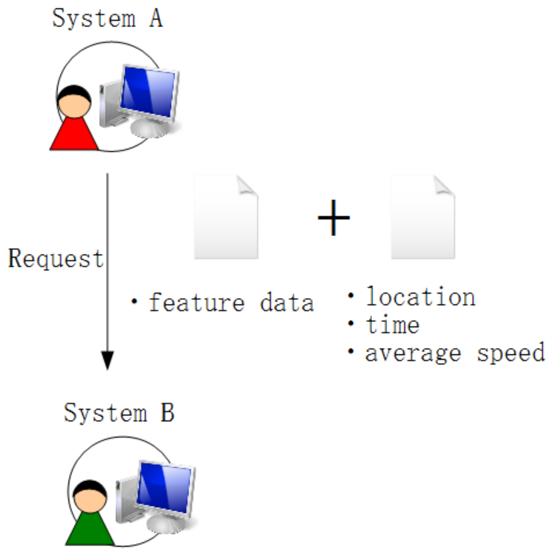

Fig. 2 Information contents which send to neighbor system

B. Deploy Method of the Agent to the Neighbor Systems

The human tracking systems need to know IP address of each gateway to keep tracking a target across heterogeneous systems. A monitoring terminal has a function of a gateway of a system and is called a gateway server. The gateway server has the configuration file which listed the IP address of the gateway server of other systems to transmit a tracking request to other systems. This is called a gateway list. The gateway list is located on the gateway server of each human tracking system. The gateway server can access directly only a gateway server listed in a gateway list. In this paper, the system does not needed to know IP addresses of all gateway servers of the area. It just needs a neighbor gateway servers' address.

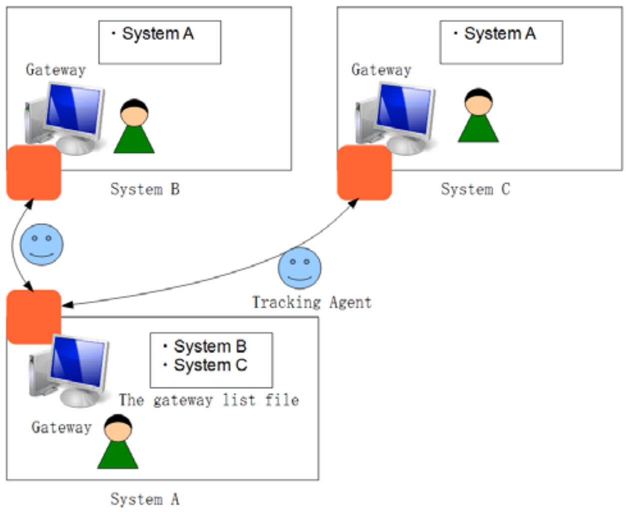

Fig. 3 Relations between systems through the gateway

For example, in Fig. 3, there are System A, B and C.A connects with both B and C, B and C connect only with A, and don't connect with each other. Therefore, System A knows IP addresses of System B and C. Due to the limitation of the network, System C cannot communicate with System B each other. System B and System C know IP address of System A only.

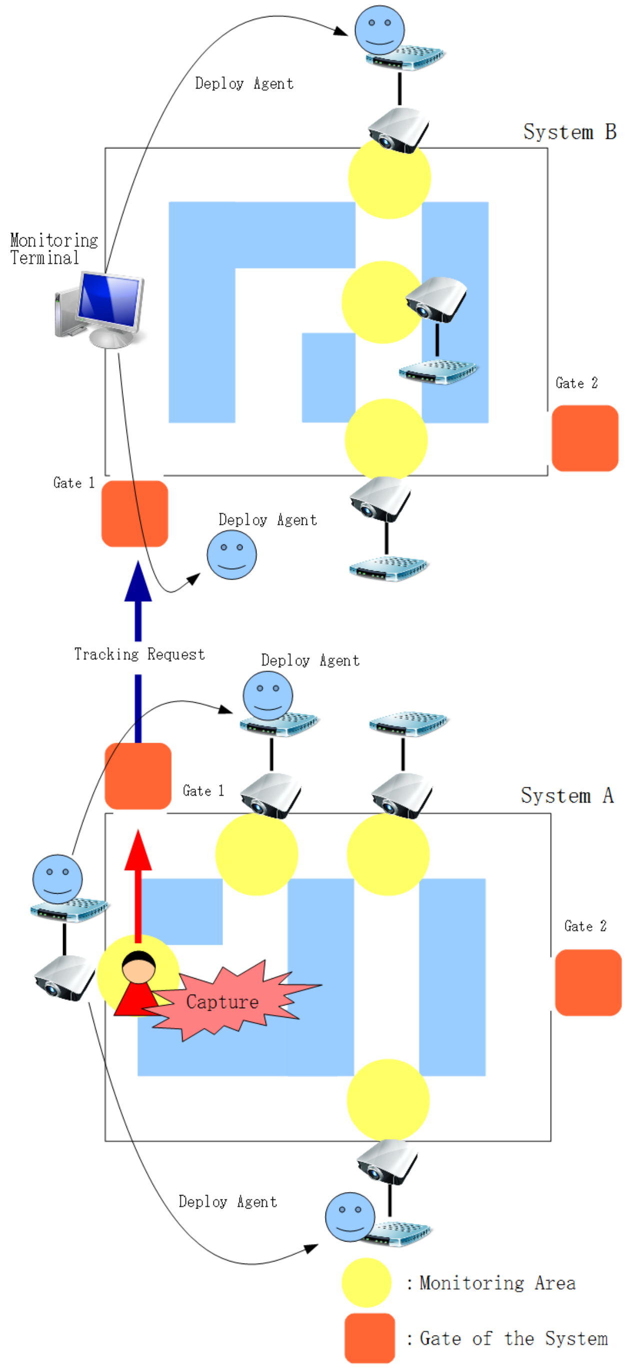

Fig. 4 Human tracking when a target goes out of a system

There are System A and B in Fig. 4. System A has four cameras and tracking servers, and has two gateways. System B has similar structures. When a target moves to other systems, the target passes a gateway by all means. For example, when the target moves to System B from System A, the target goes out of System A via a gateway of System A, and the target goes into System B via gateway of System B. The IP address of System B is listed on a gateway list of System A, and System A can send to System B the tracking request of the target from System A. For example, there is an agent program which tracks a target in System A, and the agent is tracking a target. If the gateway of the system B is a transfer candidate of deploying agents, an agent in the gateway of System A sends a tracking continuation request to the gateway of System B to which a target may move next. The gateway of System B which received the request deploys a tracking agent to a tracking server which may detect the target in System B. In this way, the tracking of the target is able to continue across the heterogeneous systems.

IV. Determination of Neighbor Systems

Fig. 5 shows the interrelation of systems A, B, C, D and E, where system D and E were added into Fig. 3. System D and System E only know IP address of System B. System D is nearer to System A than other systems. In this figure, we assume that a target moves from System A to other systems. When a target leaves System A for other systems, the agent in the gateway of System A sends a tracking request to neighbor systems listed in the gateway list. Above all System D may be more likely to track a target than System B and System C because System D is nearer to System A than other systems. The size of circles in a figure shows the size of the tracking range of the human tracking system. For example, the tracking range of System E is wider than a tracking range of System D.

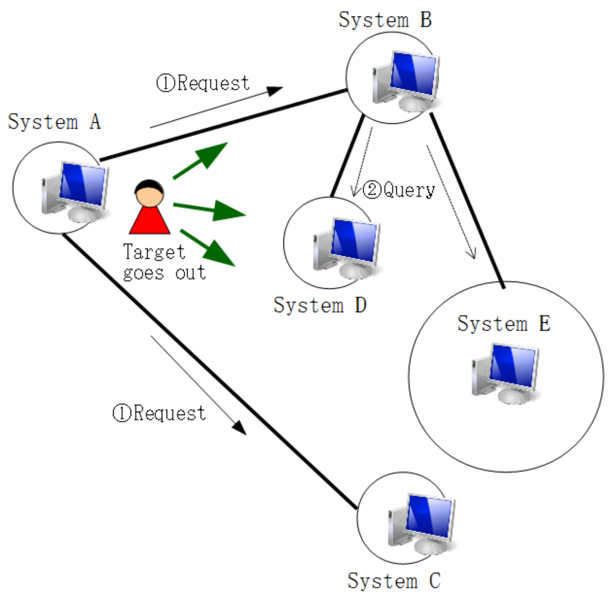

Fig. 5 Finding the system which is more likely to detect a target

The system which received the request to track the target must determine its neighbor system from its gateway lists. Then the requested system asks its neighbor system whether it is possible to track the target or not. If it is possible to track the target, the requested system sends the tracking request of the target to the System which replied. For example, the target which went out of System A may move to System B, C, D or System E. System A can send a tracking request to System B and C. However, System A cannot send a tracking request to System D and E. In addition, it is expected that the system that a target is more likely to arrive is System D nearest System A. System D and E can track the target which went out of System A by asking tracking possibility to System D and E, and sending a tracking request.

In this way, System D which is the nearest to System A becomes able to track a target which went out of System A. And continuous tracking can be realized.

In this case, we propose two methods to determine of trackable neighbor systems. One is to determine the trackable neighbor system by distance. The other is to determine by the size of tracking range of the system.

Those two determination methods are the followings.

1) There are three systems shown in Fig. 6. When a target leaves from System A to other systems, there are two candidate systems. System B asks tracking possibility to System D which is nearer to System A than System B because the target is more likely to be detected in a nearer system.

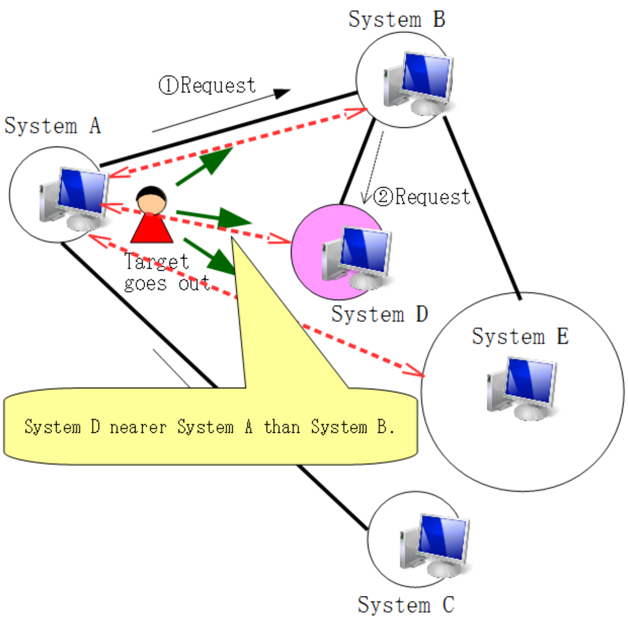

Fig. 6 The tracking request is sent to a nearer system

2) There are three systems shown in Fig. 6. When a target leaves from System A to other systems, there are two candidate systems. System B asks tracking possibility to System E which has wider tracking range than System B because the target is more likely to be detected in a system having a wider monitoring range.

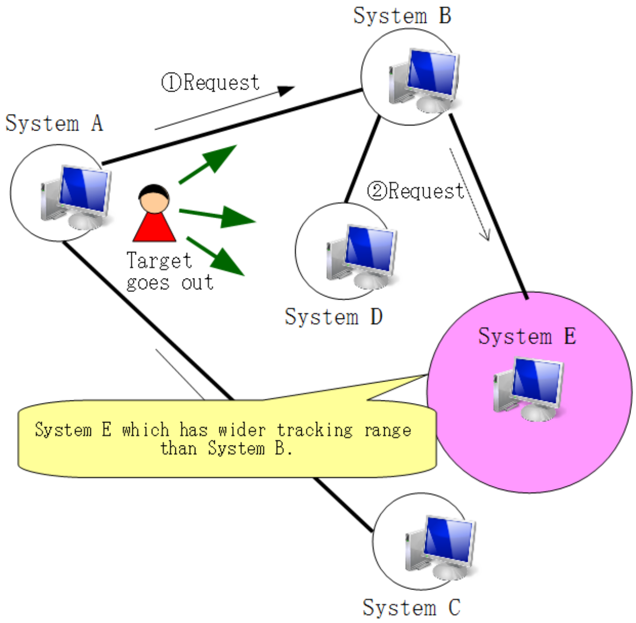

Fig. 7 The tracking request is sent to a system having a wider monitoring range

V. Conclusion

In this paper, we propose the method of human tracking across heterogeneous systems to perform a human tracking widely, and we examined a delivery method and contents of the information across the heterogeneous systems. If heterogeneous human tracking systems cooperate, the management cost of servers and cameras in one system will be able to reduce. Even if a server and a camera of one system break down, the system will be stable, because of independent operation of constituent unit of the system.

We will implement the proposed method into our system, and confirm availability of the system. We will improve our human tracking system by solving the problems found in the experiment.

References

[1] HirotoKakiuchi, Kozo Tanigawa, Takao Kawa-mura, and Kazunori Sugahara. A Construction Method for Automatic Human Tracking System with Mobile Agent Technology. Recent Developments in Video Surveillance, pp. 21-38, 4 2012.

[2] Atsushi Nakazawa, ShinsakuHiura, Hirokazu Kato, Seiji Inokuchi. Tracking Multiple Persons Using Distributed Vision Systems. The IPSJ Transactions, Vol. 42, No. 11, pp.2699-2710, 2001.

[3] Yutaka Nishigori, Youichi Taguchi, Masashi Eshima, Naohisa Komatsu. On a Structure of Human Tracking System using Distributed Cooperative Processing. IEICE Technical Report, IN, information network, Vol. 101, No. 558, pp. 7-12, 2002.

[4] Hiroki Mori, Akira Utsumi, Jun Ohya, Masahiko Yachida, Ryohei Nakatsu. Human Motion Tracking Using Non-synchronous Multiple Observations. The IEICE Transactions, D-II, information, system, II-pattern processing, Vol. 84, No. 1, pp.102-110, 2001.

[5] Sayaka Okamoto, Hiroshi Hanaizumi, Rica Hagiwara. An Object Tracking System using PC controlled Cameras Connected with Network. ITE Technical Report 32(54), 53-58, 2008-11-28.

T. Yotsumoyo was born in 1975. He graduated KagoshimaNational College of Technology, Kagoshima, Japan, in 1996, and has joined Melco Power Systems Co, Ltd, Kobe, Japan from 1996. He is now researching the mobile agent technologies and automatic human tracking system as a member of Tottori University.

A. Nomura received the B.E. degree from Tottori University, Japan in 2012. He is now researching the mobile agent technologies and automatic human tracking system as a member of Tottori University.

K. Tanigawa was born in 1972. He graduated Hyogo technical High school, Kobe, Japan, in 1991, and has joined Melco Power Systems Co., Ltd, Kobe, Japan from 1991. He was a team leader in Engineering Section 3 of the company in 2001. He is now researching the mobile agent technologies and automatic human tracking system as a member of Tottori University.

K. Takahashi received the B.E., M.E. and D.E. degree in Computer Science and Electrical Engineering, Kyushu University in 1999, 2001 and 2004, respectively. From 2004 to 2010, he worked at Institute of Systems & Information Technologies/KYUSHU as a researcher. Now he is an associate professor of Department of Information and Electronics at Tottori University. His research interests include security, ubiquitous computing and multi-agent system. He is a member of IEICE, IPSJ and IEEJ.

T. Kawamura was born in 1965. He obtained his B.Eng., M.Eng. and Ph.D. degrees in Computer Engineering from Kobe University, Japan in 1988, 1990 and 2002, respectively. Since 1994 he had been in Tottori University as a research associate and has been in the same University as an associate professor in the Faculty of Engineering since 2003. His current research interests include mobile-agent systems and distributed systems. Dr. Kawamura is a member of IPSJ and IEICE.

K. Sugahara received the B.Eng. degree from Yamanashi University in Japan in 1979 and M.Eng. degrees from Tokyo Institute of Technology, Japan, in 1981. In 1989, he received the D.Eng. degree from Kobe University, Japan. From 1981 to 1994, he was staff of the Department of Electronic Engineering, Kobe City College of Technology. In 1994, he joined Tottori University as an associate professor of the Department of Electrical and Electronic Engineering and he is a professor of the Department of Information and Knowledge Engineering. His current interest lies in the fields of mobile-agent system applications, computer architectures and hardware realizations of 1D and multidimensional signal processing algorithms. Prof. Sugahara is a member of IEICE and IPSJ.