Development of Monitoring and Simulation System of Human Tracking System Based On Mobile Agent Technologies

Kozo Tanigawa, Toshihiko Sasama, Kenichi Takahashi, Takao Kawamura, and Kazunori Sugahara

Abstract**—**In recent years, the number of the cases of information leaks is increasing. Companies and Research Institutions make various actions against information thefts and security accidents. One of the actions is adoption of the crime prevention system, including the monitoring system by surveillance cameras. In order to solve difficulties of multiple cameras monitoring, we develop the automatic human tracking system using mobile agents through multiple surveillance cameras to track target persons. In this paper, we develop the monitor which confirms mobile agents tracing target persons, and the simulator of video picture analysis to construct the tracking algorithm.

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

I. Introduction

SINCE the Personal Information Protection Law was established, the society has come to think that personal information must be treated carefully. The number of the cases of information leaks is increasing. Companies and Research Institutions make various actions against information thefts and security accidents.

One of the actions is adoption of the crime prevention system, including the monitoring system by surveillance cameras, personal identification and checking the entering and leaving the rooms by swiping IC cards through the card readers. However, it is hard for a system user to watch every monitor of the surveillance cameras and to find in which monitor a target person of watch list is. When the target person goes out of the monitor, the observer has to predict and grasp which monitor the person goes to. Also when the numbers of the target persons and surveillance cameras increase, it is far too difficult to watch every monitor. When the user misses the target person, he has to obtain the person's track record through the past monitoring information.

In order to solve above difficulties, we develop the automatic human tracking system using mobile agents through multiple surveillance cameras to track target persons [1], [2]. We aim to track easily every specified person as a target parson and to enable to identify the person and check his past track record if need arises. First, we need to confirm where a tracking agent detects and to confirm which the target person. Through this task, we expect to confirm easily the actions of the tracking algorithm. In this paper, we develop the monitor which confirms mobile agents tracing target persons, and the simulator of video picture analysis to construct the tracking algorithm.

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II. Abstract of the Human Tracking System

A. Abstract of the System

The proposed system is illustrated in the Fig. 1.

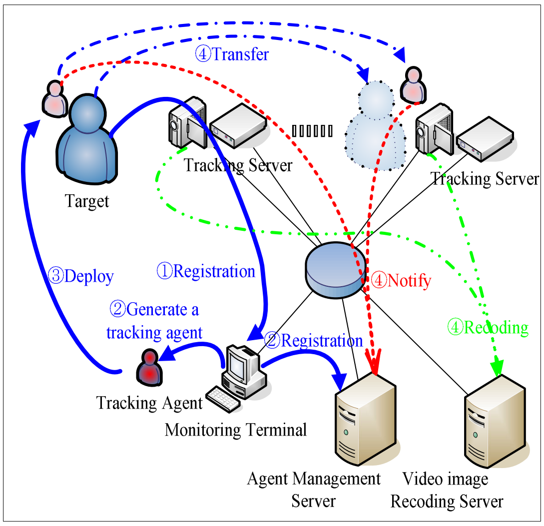

Fig. 1 System configuration of the proposed human tracking system

The system is composed of five elements, tracking agents, tracking servers, agent management servers, video image recording servers and a monitoring terminal. Each tracking agent corresponds one-to-one to its target person, and it identifies its target person and detects him according to the output of the tracking server's analyzed results of the video images. It also sends sequentially its current location and behavior to the agent management server.

Tracking servers connect themselves to surveillance cameras, analyze video pictures, extract personal information and provide it to tracking agents. Also the tracking servers transfer video images of surveillance cameras to the video recording servers. A mobile agent framework of OSGi [3] is mounted on the tracking servers.

Agent management servers record information sent from each tracking agent, and manage the information of the tracking agents using a unique ID assigned to each individual person. Video recording servers record every image sent from each tracking server, and provide the recorded images to the agent monitoring terminal by request. By agent monitoring terminals, the target persons are registered, the current locations of the target persons using persons' ID, pictures of the surveillance cameras and tracking records are browsed.

Human tracking is behaved as follows. Through the agent monitoring terminal, a target person is registered by input. Then a tracking agent is activated, and simultaneously, characteristic features of the target person are extracted from the video images and a unique ID is assigned to the person. The tracking agent which detects the target person compares the stored data of his characteristic features with the character features of the multiple persons extracted from the video images of the tracking server. Therefore, the layout of cameras is important for our system [4], [5]. When it captures the target person, it notifies the agent management server of the information of the location of the target person and that of the reproduction of the camera. By the agent monitoring terminal, we can specify a personal ID and watch the video images of the surveillance cameras capturing the target person.

B. Advantages of Using Mobile Agents to the System

Since typical surveillance system is wholly controlled by a central server, the system function will be disabled when the central server is out of commission. On the other hand, in our system, mobile agents move and detect persons. When one of the tracking servers is down, they can continue tracking by taking a roundabout route, therefore, our human tracking system will avoid breakdown of the function.

Secondly, we can easily add or delete the tracking servers, because mobile agents act independently from the number of the tracking servers of the whole system. Thirdly, the load of the central server will be balanced on each tracking server. Because mobile agents obtain the data of character features, etc. in the destination tracking servers, the central server lessens burden of the procession.

C. Destination of the Tracking Agent

The proposed system supposed to be used inside the building illustrated in Fig. 2. So, when the target person goes out of the area of one surveillance camera, the number of the areas to which the person is possible to move is limited. Each tracking server must hold the information of other tracking servers to which the person possibly moves from its own surveillance area. We call these tracking servers neighbor nodes. Each tracking agent moves through the neighbor nodes to follow the target person.

Fig. 3 shows each tracking server's neighbor nodes where each camera's surveillance area is supposed to be 8 meters in the building in Fig. 2. In Fig. 3, neighbor nodes are illustrated by lines connecting to each tracking server. For example, a neighbor node of node 1 is node 2, while node2's neighbor nodes are node3, node 5, and node 4.

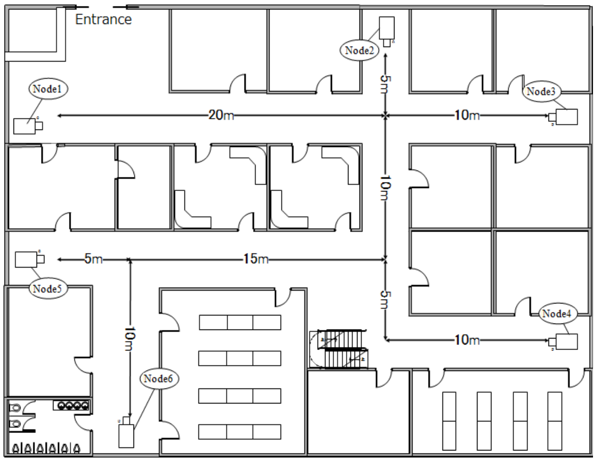

Fig. 2 Building map

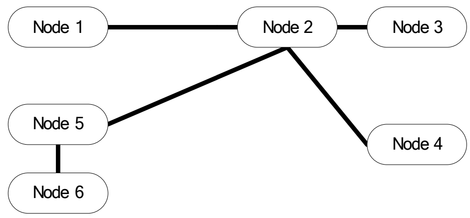

Fig. 3 Connections between neighbor nodes in Fig. 2

D.Human Tracking by Mobile Agents

A tracking agent is activated when a system user registers a person in watch list as a target on the agent monitoring terminal, and receives the data of the person's characteristic features and his personal ID. First, the activated agent moves to the tracking server which sends the target person's video image at the time of registration, and then track the person autonomously.

Since the tracking agent doesn't know when and to which neighbor nodes the target person moves, it sends its self-copies to the neighbor nodes notified by the tracking server, specifies the destination of the target person and detects him. Also, it is necessary to delete the copies of the agents, because providing endless copies causes unnecessary waste or false detection by miss-analysis of the images. Our system has four methods of human tracking by combinations of two kinds of tracking methods and two kinds of deleting methods.

We propose two kinds of tracking methods, to track in advance and to track concurrently. Each method is illustrated in Fig. 4.

Track in advance method acts as follows. When a tracking agent detects the target in the tracking server 1, it distributes its self-copies to its neighbor nodes, tracking server 2 and tracking server 3. If the target moves to the tracking server 3, the copy agent in the tracking server 3 will detect him. In this way, the agent distributes its copies to its neighbor tracking servers in advance and makes them wait for the target.

Track concurrently method acts as follows. When the target person goes out of the area of the track server 1 and the tracking agent fails to track the person, the tracking agent distributes its self-copies to its neighbor nodes. If the target goes to the tracking server 3, the tracking agent on the track server 3 will detect the target. In this way, when the tracking agent loses sight of the target, it distributes its self-copies to its neighbor nodes.

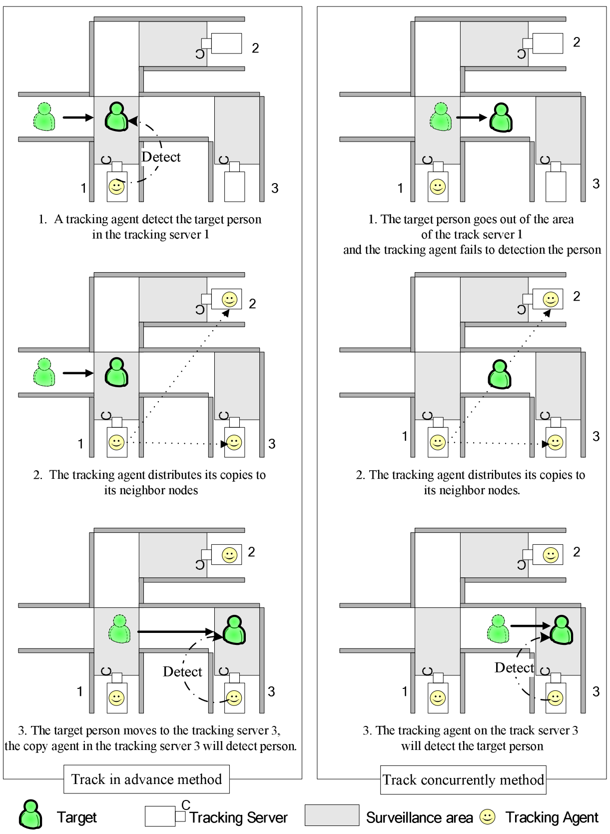

Fig. 4 Tracking methods of agents

We propose two methods for deleting unnecessary agent copies, i.e. deleting copies at detecting time and deleting overlapping copies. Each method is illustrated in Fig. 5.

The method to delete copies at detecting time acts as follows. When the target goes into the area of the tracking server 2 and is detected by the tracking agent, all the other copies in the neighbor nodes will be deleted. The method to delete overlapping copies acts as follows. When the tracking agent fails to detect the target, it distributes its self-copies to its neighbor nodes. If a self-copy already exists in the neighbor node, it will be deleted.

III. Monitor and Simulator

Our developed human tracking system uses the mobile agent framework based on OSGi framework. Since this system is designed to have image analyzers as bundle units, it can replace them easily. In this paper, we develop the agent monitor that means map viewer and tracer monitor, and the image analyze simulator as a bundle of OSGi.

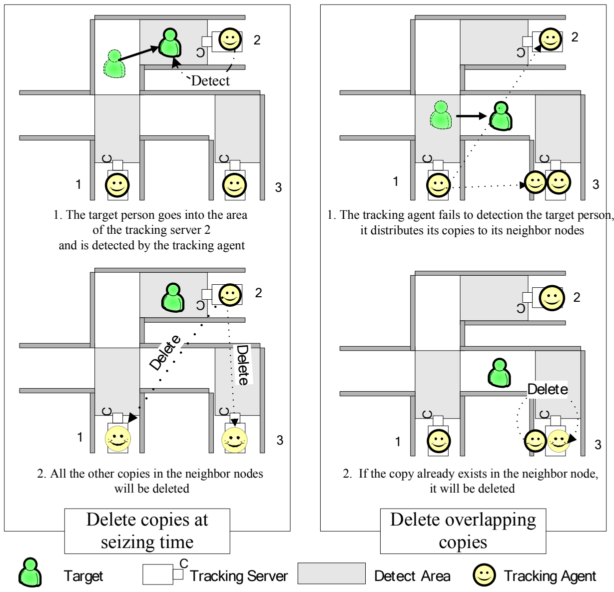

Fig. 5 Deleting methods of agents

This human tracking system creates the network connected by multiple nodes. Each node is a small computer mounted on a camera, and it works as a camera image sender, as a camera image analyzer, and as an agent server. The agents that have the information of the target come to the node, and check the camera image, then detect the target or move to other nodes.

A system user (watcher) always checks both camera images and a map of detected agents. This mark-up map supports a watcher to follow the target.

A. Agent Monitor (Tracer Monitor)

Each tracking agent has information of its own target person. Target information is expressed by some feature values that are calculated by image analyzers. An agent moves between nodes by repeating the following process. First it sends its self-copies to neighbor nodes, then it delete the copies. Fig. 6 shows how an agent changes its state. It is necessary for system users and developers to be able to see these states of agents on the display. So we develop the monitor on which the system users and developers to check the states of agents.

Fig. 7 shows the monitor window of agents and Fig. 8 shows the zoom-up image. On the map, routes and cameras are shown, and overlapped nodes and neighbor connections of nodes. A node is the system component that is a small computer connected on the camera and it communicates to the network. That is, a node is a camera view area, a camera image analyzer and one of agent servers.

Each node has agents list and these lists are shown under a corresponding node. From Fig. 8, we can see node 05 has one agent whose target ID is 1233226235773, and this agent state is 'wait'. Node 06 has an agent for 1233226235773 whose state is 'active'. 'Active' means that target exist in the camera image. The neighbor nodes of the active nodes are 'wait'ing for target moving. Left pane of the Fig. 7 is a log viewer and an agent

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viewer, and these viewers are switched on the same pane. The right pane is agent controller buttons area. To create a new agent, and to set the target character information on this agent, and to make this agent start tracing the target, these actions are done from this right pane.

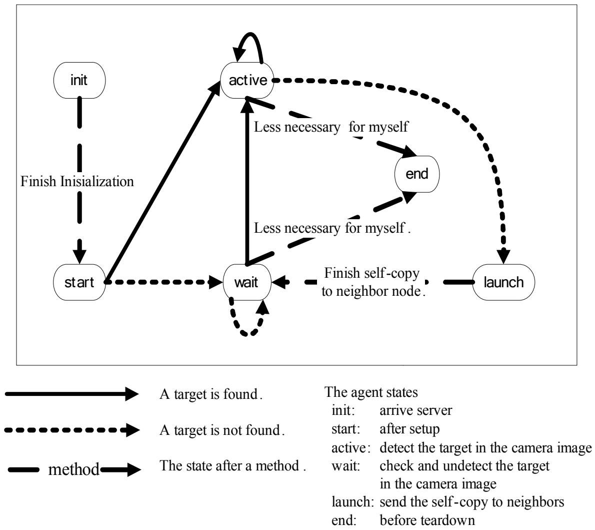

Fig. 6 State change diagram of the agent

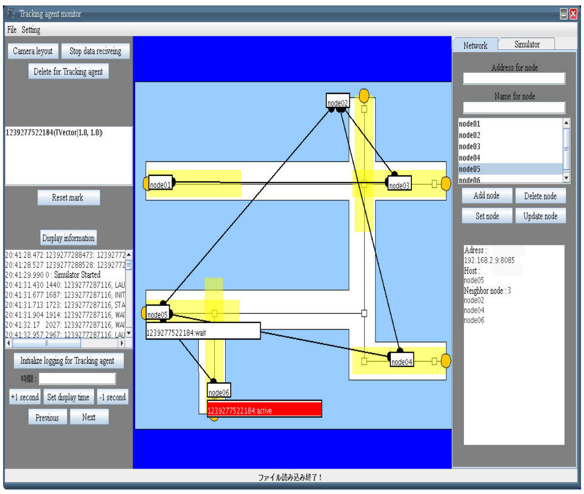

Fig. 7 Screenshot of the agent monitor

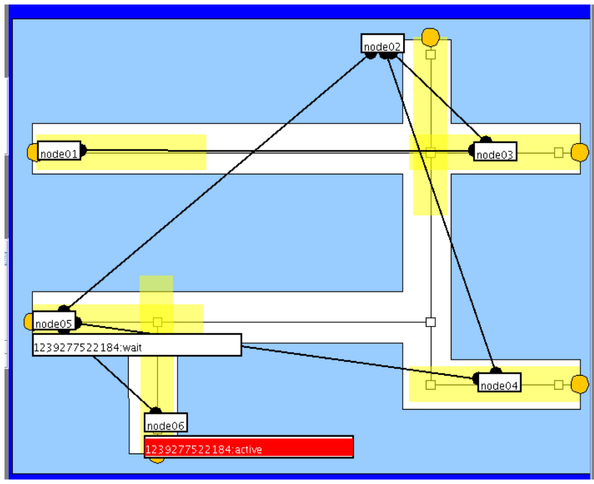

Fig. 8 Map part of the agent monitor

Fig. 9 shows the edit window of camera layouts and that zoom-up image is Fig. 10. On the map, routes and cameras are shown. Circles mean cameras, and colored blocks are each camera's view areas. Lines and there connectors mean route parts. These layouts are edited by drags and drops of mouse actions on this window. From these route connections and camera layouts, the system defines each camera's neighbors.

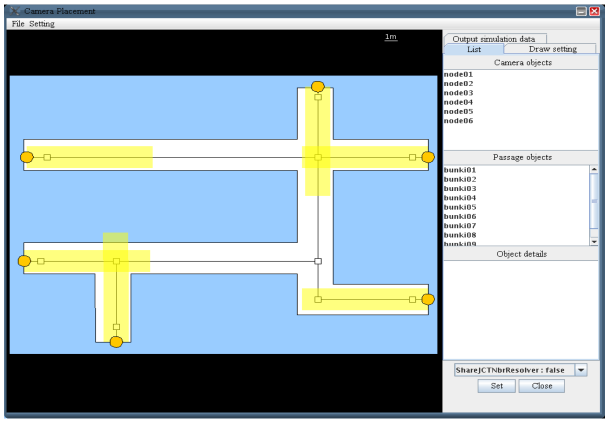

Fig. 9 Create window for the layout of cameras

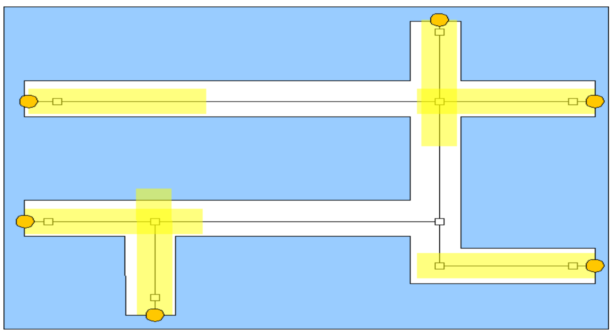

Fig. 10 Map part of the create window

B. Image Analyze Simulator

Fig. 11 shows the outline of the process that an agent detects a target. A tracer agent receives information of characteristic features of the people captured in video images of a node. Then it compares the information with its own stored information of the target. If there is a person who has the same characteristic information, a tracer agent detects him as a target.

A node is constructed by OSGi framework, so the block of image analyzers can be replaced easily to other types. Now we developed a color average analyzer, SIFT [6] analyzer, and so on. The right figure of Fig. 11 shows the outline of the same process that replaces an image analyzer to an image analyze simulator.

Fig. 12 shows the outline that output of image analyzers and image analyzes simulators. When a target person is in the center of a camera image, the feature value of the target is large. If he removes from camera, the feature value becomes smaller. By using this change of the values, we can trace the movement of the target.

Fig. 13 shows the edit of the target walking route using mouse's drag and drop action. Dragged mouse positions and speeds correspond to target footmarks. Fig. 14 shows the edit window of image analyze simulator. The user edits graph forms that vertical axis is the feature value and horizontal axis is time.

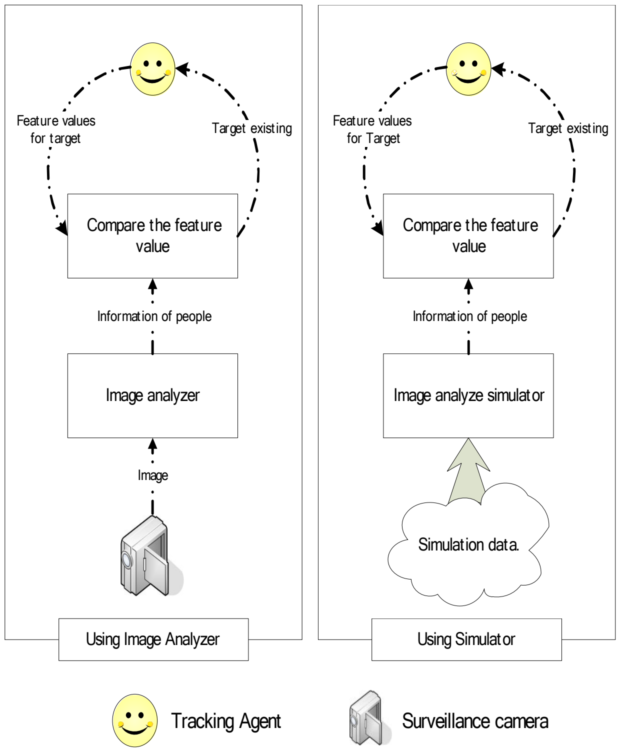

Fig. 11 Detect algorithm of the agent from camera images and simulation information

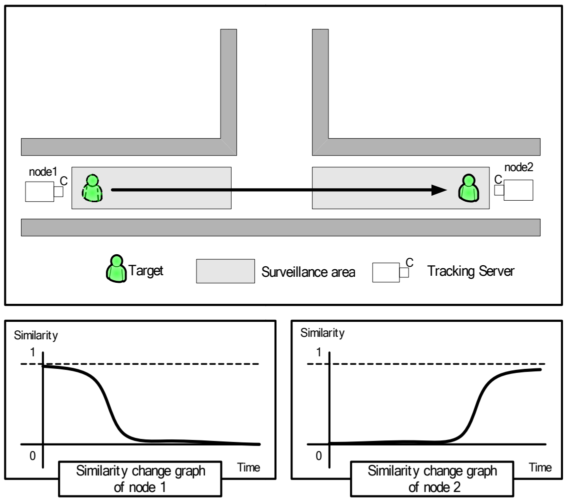

Fig. 12 Degrees of similarity while the target walking

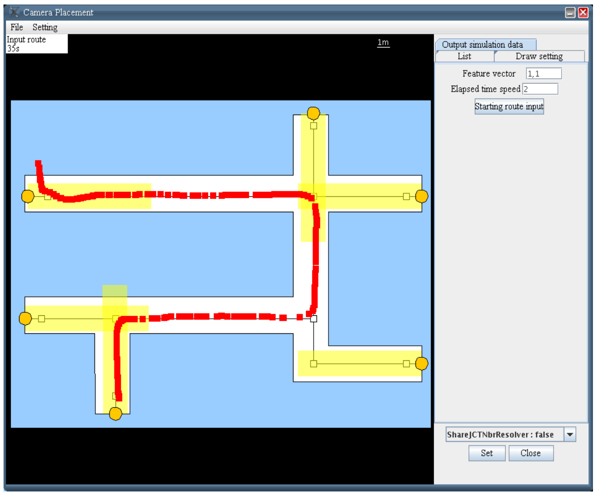

Fig. 13 Route configuration on the crate window

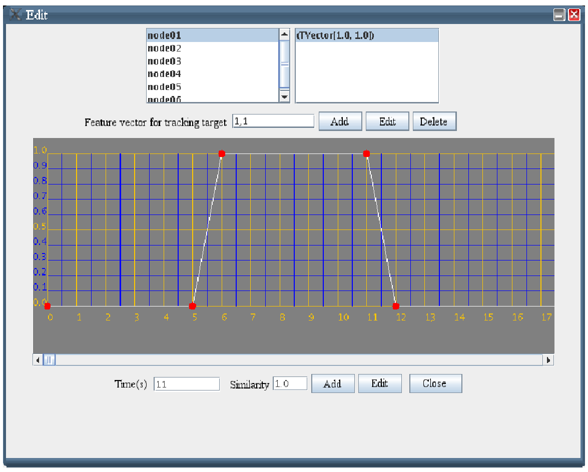

Fig. 14 Input window of the image analyzed simulator

IV. Experiments

In this section, we examined whether the system does the same actions on the real situation and on the simulation. Fig. 15 shows the layout of cameras of this experiment, and the target route of this experiment. We used 2 types of image analyzer. One is the image analyzed simulator that output feature values are 2 values. The other is the simple image analyzer that is color average detector, and the analyzed output feature values are 3 values (RGB). In this experiment, target person wore distinctive clothes in color. We used 4 types of target trace algorithms, shown in section 2. As the result of the experiments, our human tracking system worked well in any combinations of the analyzer and the trace algorithm.

V. Conclusion

In this paper, we develop the monitor of tracer agents and the simulator to analyze images. These are support parts of automatic human tracking system based on mobile agents. The human tracking system is composed by the video monitor including video analyzer, video server, agent monitor, and agent server, and this paper works on the substitutes of video units and debugger of agent units in the development. For the future assignments, we are developing trace algorithms for the human tracking system using these monitor and simulator.

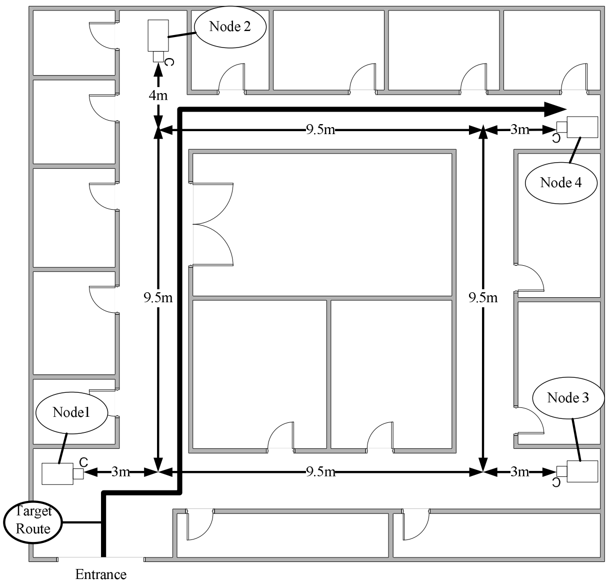

Fig. 15 Layout of the building and the target route

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