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Descriptive Title of Invention:

Non-invasive multi-sensor system for identification and tracking of objects with high level monitoring purposes.

Name of Project:

Sentient Spaces

Product Name or Number:

Not applicable

Was a description of the invention published, or are you planning to publish? If so, the date(s) and publication(s):

No

Was a product including the invention announced, offered for sale, sold, or is such activity proposed? If so, the date(s) and location(s):

No

Was the invention disclosed to anyone outside of HP, or will such disclosure occur? If so, the date(s) and name(s):

No

If any of the above situations will occur within 3 months, call your IP attorney or the Legal Department now at 1-857-2542 or 415-857-2542

Was the invention described in a lab book or other record? If so, please identify (lab book #, etc.) No

Was the invention built or tested? If so, the date: No

Was this invention made under a government contract? If so, the agency and contract number: No

Description of Invention: Please preserve all records of the invention and attach additional pages for the following. Each additional page should be signed and dated by the inventor(s) and witness(es).

A. Prior solutions and their disadvantages (if available, attach copies of product literature, technical articles, patents, etc.).

Many automatic monitoring systems based on tracking or on identification technologies have been studied. Wide-scope real-time tracking systems based on non invasive sensors (like cameras) hardly obtain reliable level of accuracy. Vice versa, identification systems can reach high accuracy, but are spatially limited and/or location unaware (like RFIDs).

B. Problems solved by the invention.

The invention merges together the two aforementioned approaches, tracking and identification, obtaining a system that has:

1. wide scope (floors, buildings, parking lots, ...),
2. location awareness (through the tracking sensors),
3. very reduced invasiveness of the sensors on the environment,
4. possibility to store information on the events and their actors, for off-line analysis and queries;

C. Advantages of the invention over what has been done before.

Monitoring systems that merges the advantages of tracking and identification systems are still to be widely explored. The advantages of this invention on tracking or on identification systems are:

1. level of accuracy that is high enough to rely on for automatic monitoring systems (thanks to the accuracy of the identification layer),
2. rich description of the events and their actors (thanks to the tracking sensors);

D. Description of the construction and operation of the invention (include appropriate schematic, block, & timing diagrams; drawings; samples; graphs; flowcharts; computer listings; test results; etc.)

A monitoring system is a tool that allows its users to be aware of *what is happening* in the target environment (event awareness) and *who are the actors* involved (actors means persons and/or objects of any kind, like vehicles, boxes, pallets, ...).

The monitoring system is always characterized by a variable grade of human interaction, that depends also on the accuracy and the reliability of the automatic part. The present invention allows a variable level of human interaction, depending on the customer needs.

Events awareness and actors characterization are subject to an abstraction introduced by:

- the sensors (implicit abstraction). A camera gives a visual abstraction of the target. A microphone gives a sound abstraction;
- grade of detail of the description desired by the users of the monitoring system (explicit abstraction). It is up to the users to

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decide if a person should be described, for example, by a unique meaningless code, or the passport number, the height, the shape of the iris, or part or all of them.

The invention doesn't set any specific constraint on explicit or implicit abstractions, that are decided given the users' needs.

The present invention is a monitoring system that merges tracking and identification systems.

A tracking system (figure 1) is a system able to:

1. determine the presence of actors in the monitored environment;
2. maintain, in space and time, the identity of each actor; the identity could be obtained as an external input or generated internally, as a simple unique identification code. The present invention provides the identities to the tracking system from an external input, specifically from the identification system.

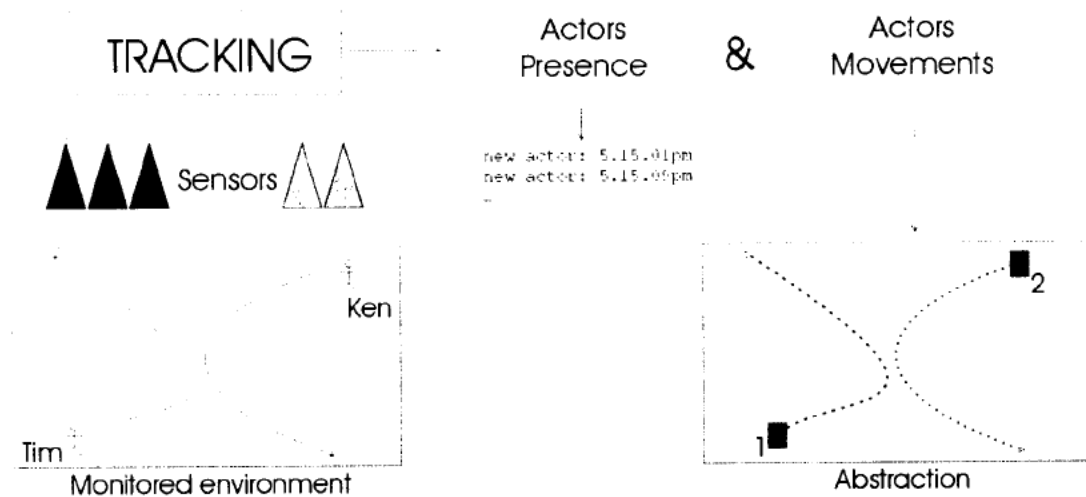


Figure 1: tracking system

The accuracy of the tracking system widely depends on the type and quality of sensors used. We do not specify which type of sensors should be used. Surely cameras (traditional RGB cameras, or IR or range cameras) are typical sensors used for this kind of systems. Cameras are considered as non-invasive sensors, in the meaning that the actors don't need to be equipped with anything specific to be tracked. Today invasive sensors, such as indoor GPS using Locus HP, could become suitable for tracking purposes in the future, in case the invasive requirements on the actors will be lightened.

Regardless of the chosen type, generally the sensors suitable for tracking systems give a detailed level of description of the tracked actors; this information could be very useful to be stored for future monitoring analysis (for example visual data, from traditional cameras); moreover these sensors have wide scope and allow to obtain location awareness: these three aspects (rich descriptions, wide scope, location awareness) are essential for modern monitoring purposes.

As drawback the real-time non-invasive automatic systems introduce tracking errors (figure 2) in case of odd situations (such as crowded scenes that create identities confusions): the present invention recovers this weak point using the information provided by the identification system.

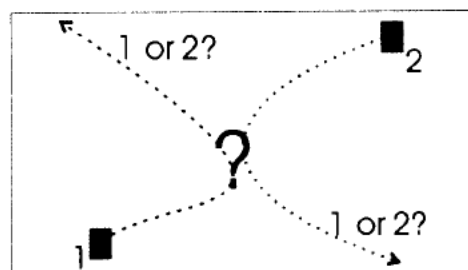


Figure 2: typical tracking confusion

The identification system recovers, with high grade of accuracy, the identification property from the actors, targets of the system. The identification systems that we consider in this invention are:

1. local/punctual systems, in the meaning that the identification system is not required to have wide range of operability (for example the identification takes place only at less than 1 meter from the sensor) and do not need to recover more than 1 identity at a time;
2. automatic or human-assisted systems; a typical human-assisted identification system is given by a police officer that checks the passport number from the people passing through a security point; RFID technology is used for automatic identification systems, that allow to recover wirelessly the numeric code on an ID-tag, using an RFID reader. Another automatic approach is based on pattern recognition, using for example vision sensors (face recognition or object classification are traditional approaches).
3. (optionally) descriptive systems: in case is needed, the system retrieves the identity and gathers also more data about the actors (such as weight, shape, size, ...)

The typology of the identification system and of its sensors determines the type/quality/level of identification and description obtained on the actors. For example, on people identification, face recognition using vision sensors provides a very descriptive identity but also lower reliability, compared to the RFID technology: but both systems do not provide the information on the citizenship of the actor that could be obtained with a passport check.

For this reason the identification systems considered in the invention can be a combination of multi-sensor, multi-technology and also human-assisted systems of identification: in this way it is possible to reach the level of accuracy and description required by the user of the monitoring system.

The invention consists of the deployment of tracking and identification systems, mutually interconnected, monitoring a given environment; more specifically, this environment is physically/logically divided in areas connected one to the other by gateways (also called checkpoints), through which there is the passage of actors. For example, the environment could be the story of a building (like an airport or a warehouse), the areas are different rooms/spaces in it and the gateways are the doors/hallways between them. Each area is covered by a tracking system. These tracking systems can be independent and do not need to be *directly* communicating on with the other; this fact allows to implement different technologies for different tracking systems in different areas: for example it could be possible to implement infra-red cameras in some areas (where the face detection is essential) and traditional video cameras in others, where moving karts should be tracked too.

The tracking systems are interconnected, one to the other, through the identification systems, that are placed in the gateways. (Figure 3).



Figure 3: Monitoring System schema

As aforementioned, the tracking systems of the invention get the identifier of the tracked actor from an external input, that is provided by the identification systems at the gateways. More in details, at the first gateway, a unique code is associated at each actor; in an ideal system, the given code is tracked without errors, across the monitored environment. See Figure 4.



Figure 4: tracking/identification systems handoff

During its existence, the actor's data pool is enriched of information provided by:

1. the gateways that the actor pass through. In fact, in case the identification system has also descriptive skills, new information is added to the data pool each time the actor passes through a gateway (for example: weight, appearance, shape, volume, ...)
2. the tracking systems, that can provide approximated trajectories of the actors. Moreover, comparing together the trajectories, it is possible to find out interactions between actors (defined for example by spatial proximity).

At each gateway, 2 fundamental operations, beyond the simple identification, are computed:

- **comparison:** comparison between the data pool associated to the identity suggested by the tracking system and the data obtained at the identification system of the gateway. If there is wrong matching it could be the case to generate a warning message. See figure 5;
- **recovery:** as aforementioned, the tracking system can be wrong. The alternation of tracking and identification systems allows an automatic recovery of tracking errors and confusions. In fact, the gateway can either provide the correct identity back to an actor whose identity was lost by the past tracking system or reduce the uncertainty in case of confusion; see figure 6.

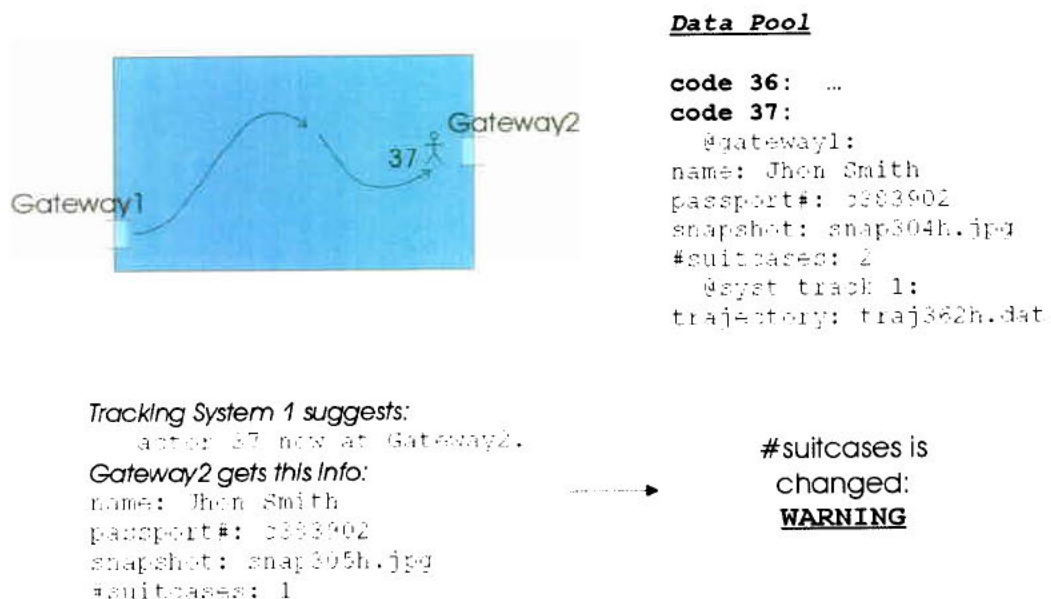
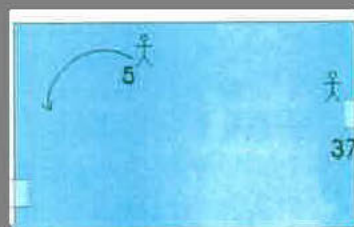
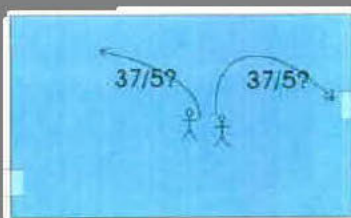
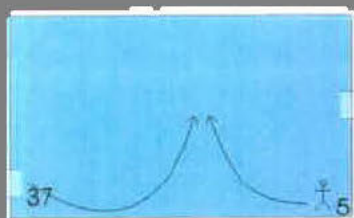
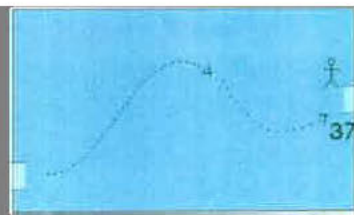


Figure 5: comparison example

Recovery on lost tracking



GIDI KIMMEL GIDDI

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H INVENTION

DISCLOSURE

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Signature of Witness(es):
The invention was first explained to me by:

I have tried to obtain the signature of the person(s) to whom invention was first explained to, and understood by, me (us) on this date: []

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Page ____ OF ____

Date of Signature

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