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Proposed system for augmented perception services using IoT technologies*

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Abstract

There is no doubt that the phrase "Internet of Things (IoT)" points out a vision of the machines (or things) of the future where "Things are learning to perceive", although there are a number of slightly varying definitions about the IoT.

Based on this concept of IoT, this paper proposes a system for augmented perception services to correspond to disasters where the main purpose of the system is to provide context information which is needed to respond to the scene of the disaster by collecting, creating, converting and sharing artificial sensory information at high speed for corresponding to disasters in the extreme or poor environment. For this, requirements and main functions for the services are identified, and the concept and architecture of the system are showed including a process flow on a method for the services. Finally, expected effects of using the proposed system are presented.

1. Introduction

Internet of Things (IoT) was coined some 10 years ago by the founders of the original MIT Auto-ID Center, with special mention to Kevin Ashton in 1999 [1]. The IoT is considered then as the mere extension of Radio Frequency Identification where "RFID is kind of the amoeba of the wireless computing world" (Kevin Ashton). But the phrase "Internet of Things" points out a vision of the machines (or things) of the future: in the nineteenth century, machines learned to do; in the twentieth century, they learned to think; and in the twenty-first century, they are learning to perceive – they actually sense and respond.

The IoT is variously defined according to the principal objective of research institutes as shown in Figure 1 [2]-[7] including similar technology concepts such as RFID, USN(Ubiquitous Sensor Network), M2M(Machine to Machine), CPS(Cyber Physical System), etc.

According to EU FP7, in the IoT, "smart things/objects" are expected to become active participants where they are enabled to interact and communicate among themselves and with the environment, while reacting autonomously to the "real/physical world" events and influencing it by

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running processes that trigger actions and create services with or without direct human intervention [8].

Using and extending this IoT concept, augmented perception services could be provided by the following IoT technologies:

- sensing technology for collecting various sensed data where it is hard for people to detect using IoT devices including all sorts of sensors;
- reliable information delivery technology for sharing information with other people (or things) under the environment with limited resources;
- information fusion technology for amalgamating various information and creating artificial sensory information; and,
- augmented perception service execution technology for converting artificial sensory information into sensory information such as sight, hearing, touch, etc. where it is easy for people to perceive and providing in form of augmented perception services with users.

This paper, in particular, introduces a system for augmented perception services to correspond to disasters. For this, requirements and main functions are identified for augmented perception services to correspond to disasters. Also, the concept and architecture of the system for the services are proposed based on IoT technologies, and a process flow on a method for the services is showed. Finally, expected effects of using the proposed system are presented.

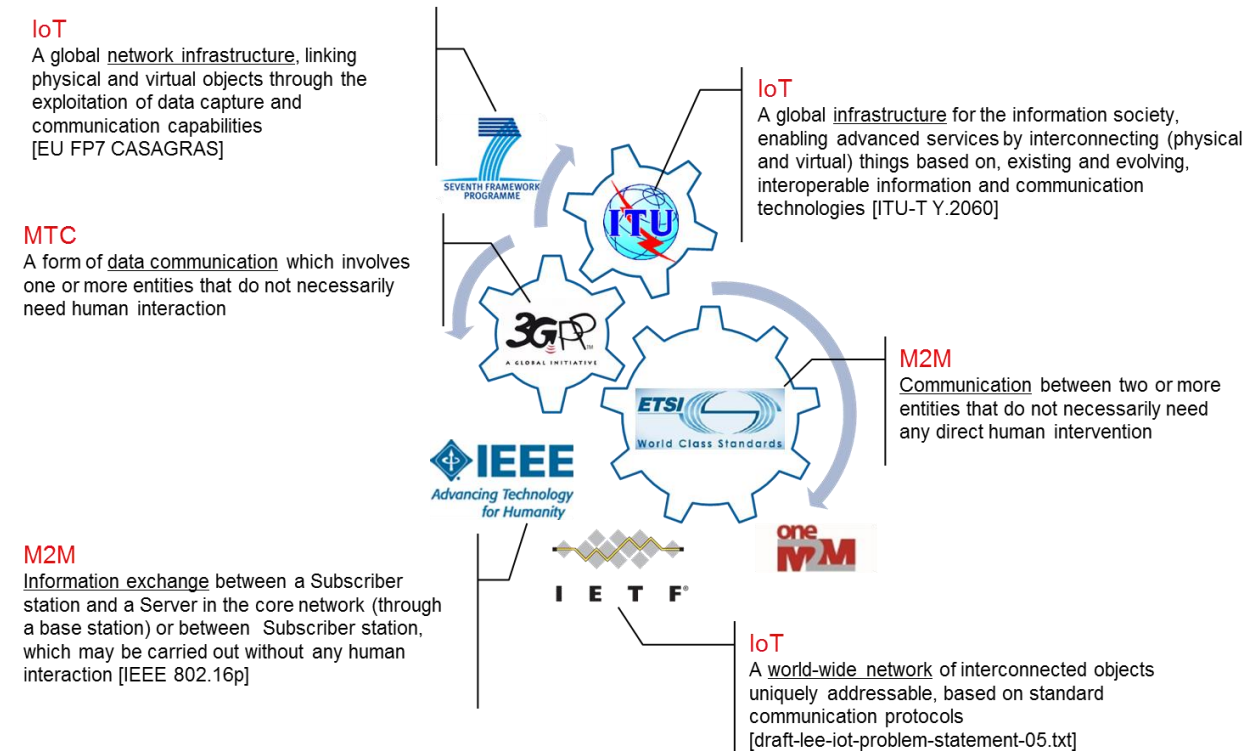


Figure 1. IoT related definitions

2. Requirements and main functions for augmented perception services to correspond to disasters

When workers (or fire fighters) are exposed to a poor environment such as the scene of a fire, more than 90% of sense of sight and 1/1000 of sense of hearing are dulled, and senses of touch and smell can no longer be used due to wearing firefighting gear. Moreover, because the bluntness of bodily sensations decreases sharply the recognition ability of workers, this put emotional pressure on workers and finally causes the loss of lives by reason of losing sense of direction or location.

These days there is a growing need for a disaster response system in national level for the people to lead a safe life in an uncertain situation such as disasters or accidents. According to the fire department officials, requirements at the scene of the firefighting include:

- recognition of dangers in the extreme or poor environment where communications infrastructure is destroyed by disasters such as a fire;
- securement of safe return routes; and,
- support of augmented perception services for workers to cope actively with an uncertain situation.

To settle above demands, it is needed a new system included indoor pedestrian dead reckoning (PDR) which is available in the poor environment where communications infrastructure is destroyed, and technology which improves rapidly workers' recognition ability based on artificial sensory information that is created in real time by interconnection of various sensors and devices via network [9-10].

When going into the scene, workers fit their body with several types of rescue (or firefighting) equipment which weight over 25 kilograms. They operate this equipment one by one, directly read information from one, perceive surroundings, and progress rescue operations at the same time. After all, it is difficult for them to cope promptly with the changing surroundings and to focus only on their main job.

Considering above requirements and pending problems, for augmented perception services to correspond to disasters, we suggest a system which has the following main functions:

- (Connection) all kinds of sensors with loadable size are implanted in an augmented perception device such as a helmet and other devices are connected with the augmented perception device using IoT communications;
- (Collection) the system collects surrounding environment information in real time using sensors implanted in the augmented perception device and other devices;
- (Creation & Fusion) the system analyzes and fuses collected information, makes context information such as danger information, return route, etc. into artificial sensory information; and,

- (Provision) the system projects collected information onto the display of the augmented perception device or provides augmented perception services with workers by converting artificial sensory information into sensory information such as sight, hearing, touch, etc.

Ultimately, workers can commit themselves to their duty by using useful information provided automatically via the system in decision making.

3. Concept and architecture of the system for augmented perception services

The main purpose of the system for augmented perception services is to provide context information such as danger recognition, return route, etc. which is needed to respond to the scene of the disaster by collecting, creating, converting and sharing artificial sensory information at high speed for corresponding to disasters in the extreme or poor environment.

The system for augmented perception services is made up of seven components as shown in Figure 2.

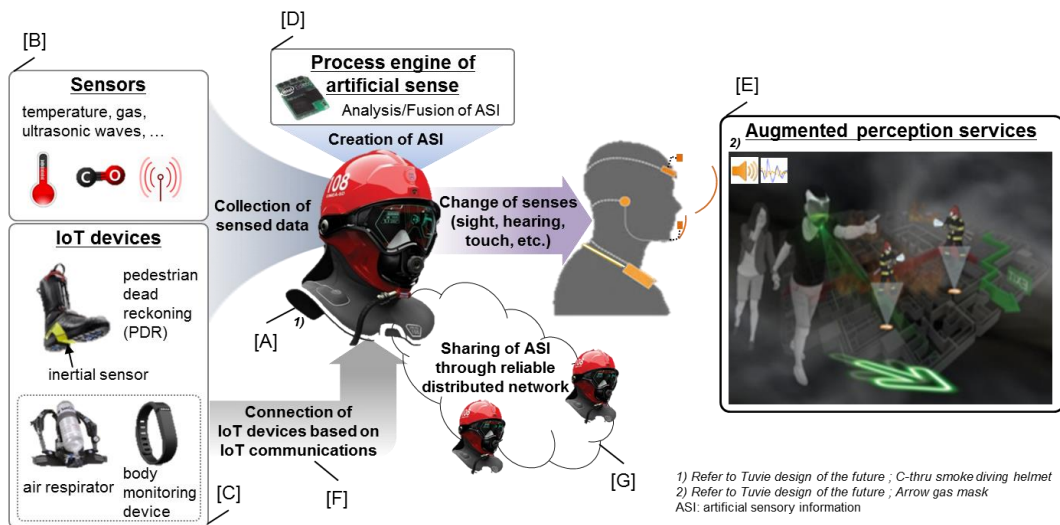


Figure 2. Conceptual system diagram for augmented perception services

All kinds of sensors [B] to collect surrounding environment information for improving workers' blunted senses are directly attached to the augmented perception device [A] such as a helmet in a patch or implant way. Firefighting boots installed inertial sensors for acquiring pedestrian dead reckoning (PDR) information, existing rescue equipment such as an air respirator, body monitoring device, signal detection device and so on, so called IoT devices [C] are connected with the augmented perception device using wireless IoT communications [F]. IoT devices have individual sensors for the purpose or role, and processing algorithms.

Through the connectivity of things (or devices), various sensed data (that is, surrounding environment information) are collected in real time using sensors implanted in the augmented perception device and other IoT devices. The process engine of artificial sense [D] in the

augmented perception device analyzes and amalgamates collected data, creates artificial sensory information, which it is hard for people to directly detect, such as explosion danger, body danger, return route, etc., and generates other artificial sensory information by fusing created information. The artificial sensory information created from the system are converted into sensory information such as sight, hearing, touch, etc. where it is easy for people to perceive and are provided in form of augmented perception services [E] such as return route navigation with users.

For communicating mutually in the environment where there is no communications infrastructure and workers move freely, the artificial sensory information is able to be exchanged and shared with other workers through reliable distributed network between augmented perception devices [G], which is to perform dynamically the change of network topology according to movements by grasping continuously other agents with which can be communicated and to improve the efficiency of information delivery according to distance with counterparts or signal reception environment. By fusing and handling more information which is not collected by himself, the system is able to do above affairs for providing augmented perception services in the poor communications environment.

Figure 3 shows the functional architecture of the system for augmented perception services.

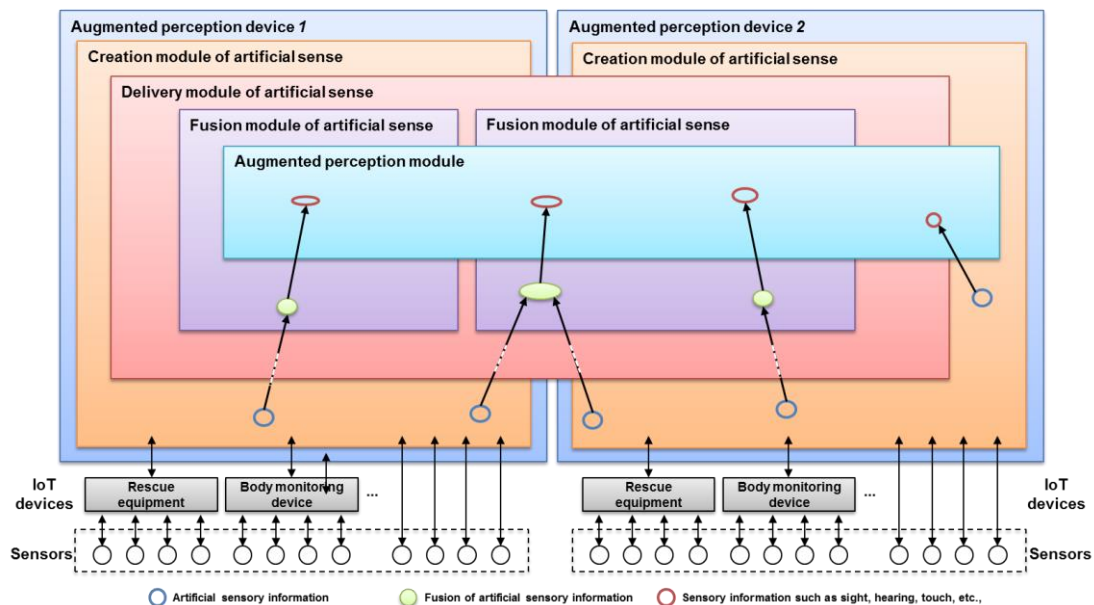


Figure 3. Functional architecture of the system for augmented perception services

The augmented perception device is physically and directly/indirectly connected with IoT devices and sensors, and collects sensed data from these devices and sensors. The augmented perception device includes the creation module of artificial sense, the delivery module of artificial sense, the fusion module of artificial sense and the augmented perception module.

The creation module of artificial sense creates artificial sensory information from collected data. This module can generate artificial sensory information for rescue operations by using several resources such as map or relative position which cannot be directly offered at the scene but can

be used in the environment where there is no communications infrastructure. The examples of artificial sensory information are dangerous situation, dangerous area, moving route, etc.

To share artificial sensory information with other augmented perception devices in the poor communications environment, the delivery module of artificial sense builds up reliable distributed network, exchanges and delivers artificial sensory information with/to other augmented perception devices.

The artificial sense is an individual sense and has disparate nature. For example, this is classified into artificial sense of five senses type such as sight, artificial sense such as danger or location, and so on. The fusion module of artificial sense performs a process to improve individual artificial sensory information by sharing, connecting and grouping (that is, fusing) disparate artificial sensory information.

In the augmented perception module, the artificial sensory information is finally provided in form of augmented perception services through the change of senses such as sight, hearing, touch, etc., according to the scene or situation with users.

4. Process flow on a method for augmented perception services

Figure 4 shows a process flow diagram on a method for augmented perception services.

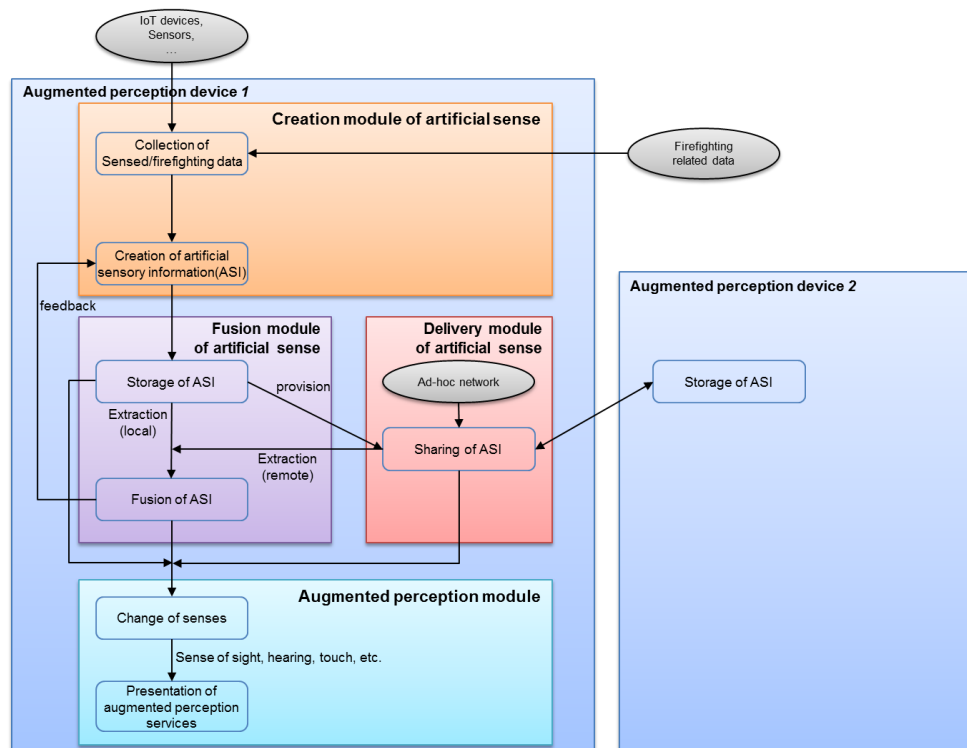


Figure 4. Process flow diagram on a method for augmented perception services

The augmented perception device collects sensed data from several IoT devices and sensors or firefighting related data which are available in the poor communications environment through

the creation module of artificial sense. The process to create artificial sensory information, which is composed of basic senses such as danger sense, location sense, route sense, etc., is performed from collected data.

To handle the artificial sensory information created from the creation module of artificial sense, the fusion module of artificial sense is to store them, to fuse stored information for the future scene situation or purpose, and to provide them to other augmented perception devices. Also, this extracts artificial sensory information in its local storage or extracts remote information created in other augmented perception devices. By fusing extracted information, new artificial sensory information is created.

To share artificial sensory information, the delivery module of artificial sense exchanges and delivers this information with/to the delivery module of other augmented perception devices. At this time, ad-hoc network is built up and made use of.

The augmented perception module converts artificial sensory information extracted from local/remote storage or the fusion of artificial sense into sensory information such as sight, hearing, touch, etc. and presents this information in form of augmented perception services based on UI/UX.

In the proposed system, the augmented perception device carries out the creation of artificial sensory information, interoperability of artificial sensory information, distributed cooperation processing, change of senses and augmented perception services. The stepwise procedure to create, share and fuse artificial sensory information is as follows:

- **Step 1:** artificial sensory information is created to recognize context information from all sorts of sensed data within the augmented perception device;
- **Step 2:** the primary fusion of artificial sense is performed through analyzing and amalgamating artificial sensory information;
- **Step 3:** artificial sensory information is mutually shared through interoperability such as description, interworking, etc., and change of senses between augmented perception device and IoT device, and between augmented perception devices;
- **Step 4:** distributed artificial sensory information are collaborated and new artificial sensory information (the secondary fusion of artificial sense) is created; and,
- **Step 5:** the use's optimal change of senses such as sight, hearing, touch, etc. and augmented perception services are fulfilled based on UI/UX.

5. Expected effects of using the system for augmented perception services

The creation and delivery module functions of artificial sense, out of main functions of the system for augmented perception services based on indoor pedestrian dead reckoning (PDR) which is available in the poor communications environment, are expected to be applied to the following areas:

- area for corresponding to disasters such as fire, explosion, collapse, etc.;
- area for worker's safety in various industrial environments such as construction, chemistry, plants, etc.;
- area for various indoor location based services for general users which form the fast-growing market; and so on.

Also, the process engine of artificial sense in the augmented perception device can be used for processing of newly-rising wearable devices.

Furthermore, the introduction of the proposed system leads to the enhancement of firefighters' safety and the reduction of damage for firefighters by allaying fear of an accident. As a result, this system can be of help to decrease the loss of lives and property damage by improving the efficiency of firefighting due to the enhancement of firefighters' safety. This can also contribute to reduce the damage of industrial accidents by using this system for life protection and safety planning of industrial workers.

In addition, this system is expected to have a great ripple effect. For instance, by grasping danger and location in the extreme environment, it is applied to the execution of duty in operating area of the military and the police, the development of industrial protective gear, and so on.

6. Conclusions

In this paper, the system for augmented perception services to correspond to disasters was proposed to provide context information which is needed to respond to the scene of the disaster by collecting, creating, converting and sharing artificial sensory information at high speed for corresponding to disasters in the extreme or poor environment. For this, requirements and main functions for the services, and the concept and architecture of the system were presented including a process flow on a method for the services and expected effects of using the proposed system.

The ETRI and joint research companies begin a research project focusing on development of the system for augmented perception services based on IoT technologies. A system prototype of the proposed architecture and augmented perception service prototypes are being developed. In the near future, it is expected that the proposed system and method will be fundamental to drive public or consumer centric creative IoT services.

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