# OKI's sensing technologies for realizing Smart Society

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One of OKI's core technologies for the smart society is "smart sensing", an advanced sensing technology that not only handles simple sensing information such as temperatures and power measurements, but also recognizes contexts and movements of people or objects from video or acceleration information.

This article will first describe the role sensing technologies play in the achievement of the smart society. Then OKI's developments in sensing technologies are described including face recognition and human tracking/counting technologies that detect people from camera images to determine contexts and activities, and human activity recognition technology that uses acceleration sensors worn by people or radio-type sensors placed in rooms.

## Sensing Technologies in a Smart Society

The basic concept behind OKI's pursuit for "safe, secure and comfortable smart society that is kind to both environment and people" is recognizing contexts/activities at a location or of an individual from an aggregated sensor data then either present appropriate information or carry out autonomous control.

For instance, at a shopping mall, if information such as the shopper's current location and history of recent activity can be combined with weather and congestion information to predict the shopper's desire (for example, I have been walking around in the heat and want something cold to drink), appropriate product/shop recommendations can be delivered to the shopper at the right moment. This will enable a so-called "smart mall" which will provide shoppers with personalized user-friendly information rather than the generic ones of the past and boost sales for retailers.

For such a scenario, the capability to recognize surrounding situations and contexts/activities of people or objects in real-time using a variety of sensing means then further integrate the information for a more advanced understanding of situations to decide what services should be provided will become important. The latter capability is "smart awareness", another of OKI's core technologies for the smart society. Its technical development is being carried out while undergoing testing as part of a hospital information system in the GEMITS project[1].

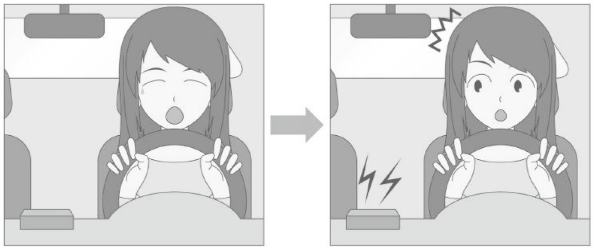
"Smart sensing" is the core technology used in former capability. Series of technical developments, described later in the article, is underway with special focus on advanced recognition of context and activity of "people".

## Face Recognition Technology

It is possible to recognize a variety of human conditions through the analysis of facial images. OKI's face recognition middleware "FSE®" *1) has basic functions to detect facial area from an image, extract feature point coordinates of eyes, mouth and other facial features, and make personal identification. These functions can be used to sense human attributes and conditions. For example, comparing alignment of feature points extracted using FSE with the average face created for each gender/age group, a person's gender and age can be estimated. Technology to sense human attributes has been built into an advertisement response support system "RESCAT®" *1) to be used in the analysis of digital signage visibility and store's customer base[2].

An example of using FSE to sense a person's context can be found in the driver monitoring system (DMS) that aids safe driving of automobiles. DMS monitors the context of the driver using a camera mounted on the steering column and alerts the driver when it detects that he/she is inattentive or dozing off (**Figure 1**). The speed and compact structure of the FSE enables integration into a variety of in-vehicle terminals according to usage environment.

*1) FSE and RESCAT are registered trademarks of Oki Electric Industry Co., Ltd.



Detects inattentiveness or dozing and alerts driver

**Figure 1. DMS Overview**

**(1) Determining Inattentiveness**

Direction of the face is measured by performing pattern matching against a template of average image features for each facial orientation. “Inattentiveness” is determined when a non-forward facing condition continues for a certain period of time.

**(2) Determining Yawning**

The degree of mouth opening is measured using the feature point coordinates of the central upper lip and central lower lip extracted with FSE. “Yawning” is determined when the mouth remains open for a certain period of time.

**(3) Determining Dozing**

Similar to the detection of mouth opening, degree of eye opening is measured using the coordinates of the upper and lower eyelids extracted with FSE. However, the driver’s seat is a very bright environment, and if the driver is wearing glasses, external light will reflect off the glasses (**Figure 2**). This will degrade the FSE’s extraction accuracy of the upper and lower eyelid coordinates making it difficult to determine the openness of the eye only using feature point coordinates. To address the issue, DMS performs pattern matching with image features of “opened” and “closed” eyes for stable determination of the eye condition even when there is reflection off the glasses. “Dozing” is determined when the eyes remain closed for a certain period of time.

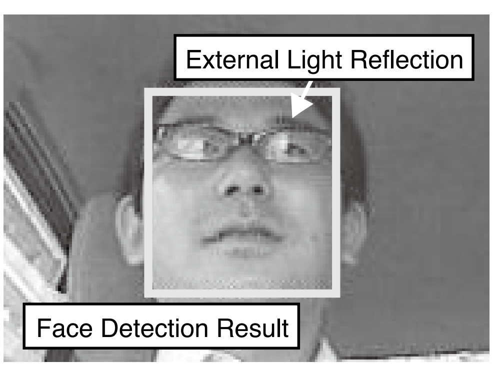



**Figure 2. Example of External Light Reflection**

## Human Tracking/Counting Technology using Videos

Recently, in order to collect marketing information and grasp the congestion situation, there has been an increasing need to measure the flow of people automatically with an image recognition system. Automating the people counting task, which was previously done manually, will enable a long-range view of changes in passers-by, so a firm understanding in the number of facility users and store customers can be obtained on a monthly or seasonal basis. People counting technology built into the previously introduced “RESCAT” will be described.

In order to minimize the measurement error during people count, it is necessary to perform an accurate detection and tracking of people. If detection of people fails due to low detection accuracy, the system’s count result will end up less than the actual number. If the tracking accuracy is insufficient, the same person may be counted several times leading to a result higher than the actual count. In addition to face detection/tracking using FSE, RESCAT performs human detection/tracking and integrates their results to achieve a more accurate count.

Human detection is performed primarily by pattern matching the body’s outline. Since several characteristic patterns of body sections are used in the detection process, human detection is possible even if a portion of the body is hidden in a crowd. Human tracking uses a combination of search around the last detection location and predictive search along the movement trajectory. This way, if a tracked person passes by another person and becomes completely hidden then reappears, tracking can be resumed. Additionally, the determination if person is the same or not is made from positional relationship based on the face and human detection/tracking results (**Figure 3**).

Result of the people count will be the sum of the following values.

1. Number of people found by both face and human detections
2. Number of people found by face detection only
3. Number of people found by human detection only

Since RESCAT is able to measure people’s direction of movement from the trajectory of the tracking results, it is for instance possible to separately count the number of customers entering and leaving a store.

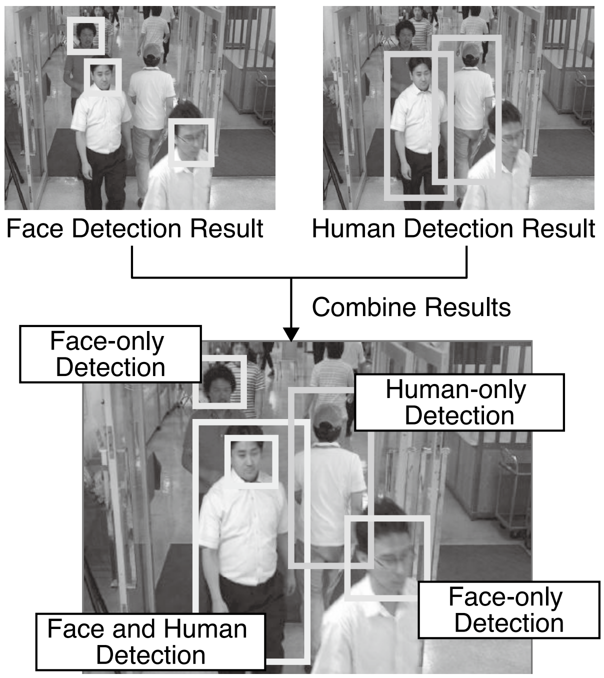



**Figure 3. Combining Face and Human Detection Results**

## Activity Recognition Technology using Wearable Acceleration Sensor[*2)]

It is possible to recognize the activity and context of a person by analyzing the temporal change in the data obtained from acceleration/gyro sensor a person wears directly. Activity recognition technology using such a wearable sensor was tested for validation in a trial conducted at a fitness club in Tokyo in 2010[3)].

The aim of the trial service was to automatically collect/visualize the variety of exercise habits in the club using the sensor and activity recognition technology, and from that show the beneficial results of exercising. Trial participants only needed to wear a single band containing the sensor on the upper arm to automatically obtain their detailed exercise history in the club. To implement the service, the fitness club, data center and the Internet were connected to build the system shown in **Figure 4**. Exercise history was created/provided using a setup with activity recognition technology at the core. More specifically, acceleration/gyro data obtained from the sensor is immediately converted into type of exercise (18 types including intervals) and exercise pace (speed/repetitions) using the activity recognition technology. Afterwards, the amount of exercise by type, exercise balance and calorie consumption are tallied. Then the tallied exercise history is visualized (**Figure 5**) on the SNS[*3)].

Trial was carried out for approximately four months with regular members of the fitness club. During the trial period, the service was used 830 times, and 15,560 hours' worth of data was recognized in real-time. In a survey of frequent users, 75% of the response indicated the service was effective in showing exercise benefits and 87% indicated willingness to continue the trial. Service was generally well received, and we were able to confirm the technology has certain effectiveness in health support.

This technology is not limited to the aforementioned fitness services. It can be applied to the analysis of productivity and purchasing activity based on human actions, and to natural user interface. For example, in the case of productivity analysis at a factory, recognition of worker activities will enable understanding of work rhythms and visualize changes in work contents. Furthermore, data collected over a long period can be used to make comparison in work proficiency and predict conditions of fatigue. From the progress seen in the implementation of acceleration sensors such as in mobile phones, the technology is expected to have a very broad deployment base.

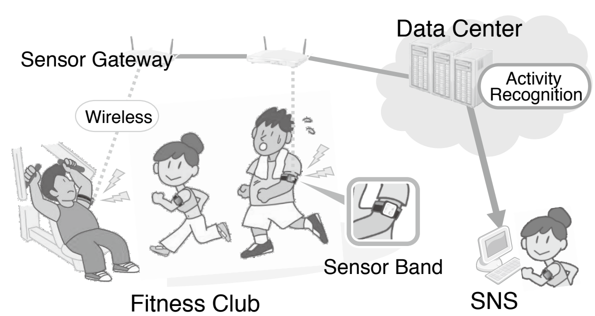



**Figure 4. Configuration of Trial System**

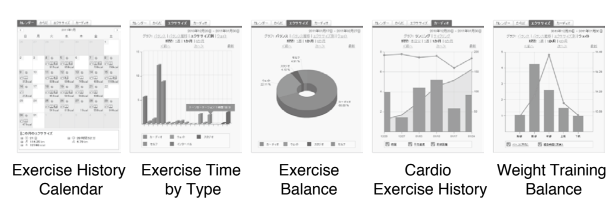



**Figure 5. Visualization of Exercise History**

*2) A portion of this study was conducted as part of the "Research and Development of Ubiquitous Service Platform" commissioned by the Ministry of Internal Affairs and Communications in FY2010.
*3) SNS (Social Networking Service): A community type Web service that facilitates/supports connections between people.

## Context Recognition Technology using Environmentally Placed Radio Sensors

When radio waves strike and reflect off of moving objects, fluctuations occur in the radio waves. Technology to analyze these fluctuations and recognize contexts is categorized as context recognition technology using radio sensors. Radio waves emitted from antennas hung on room walls are reflected back from various objects occupying the room. When there are moving objects present, frequency changes (known as Doppler Effect) and amplitude changes can be observed in the radio waves. Using frequency analyzed signal separation and statistical modeling technique, variety of contexts can be recognized.

Treating human vital signs such as respiratory and heart rates as kinds of context, research and development is underway for a technology to estimate these contexts. Respiratory rate is a oscillating motion of the chest and abdomen with a periodicity around 0.3Hz while heart rate is a fine pulsating of the entire body with a periodicity around 1Hz. These fine movements can be captured as phase changes in the received signal using short wavelength radios such as 10.5GHz or 24GHz frequency band. Efficient remote capture has in fact been confirmed from a distance of a few meters. Doppler Effect is a principle used in speed guns to detect the speed of a moving object. Using this principle, falling people or objects can be detected from the pattern of speed changes that is observed when the event occurs.

If respiratory and heart rates can be accurately detected, the technology can be used to roughly obtain vital signs from people in beds. Furthermore, it can be applied other situations such as detecting a person in complete rest, which is difficult with a conventional infrared pyroelectric sensor, or detecting context changes/mental stress. There are also benefits other than for recognition technology. Since there is no need to expose the sensor unit, it can be used in private spaces without being obtrusive. In a home environment, benefits include the ability to pass through furniture and bedding for very few blind spots, strong resistance to heat and temperature changes caused by heating equipment, and ability to be used in hot/humid conditions of a bathroom.

Although these benefits are suitable for monitoring people (elderly, hospital patients) at home or facility (**Figure 6**), the technology is expected to be expanded for understanding conditions in various other environments such as of workers in offices/factories or animals in agricultural and livestock industry.

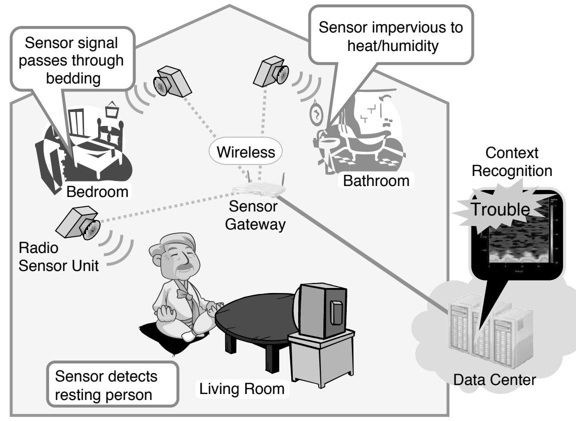



**Figure 6. Example of Monitoring the Elderly**

## Summary

OKI's advanced sensing technologies under development for the smart society have been described.

In the future, these technologies combined with smart awareness will continue to be honed and precision improved. The technologies will be applied to various experiments and advanced practical systems for verification of its usefulness, and results will be fed back for further research and development. ◆◆

## References


1) Shichijo, et al, "GEMITS (Global Emergency Medical supporting Intelligent Transport System)", OKI Technical Review, October 2011/Issue 218, Vol.78 No.1, pp.28-31
2) Tsukamoto, et al, "'RESCAT', The Ad-Watcher's Response Categorizing System Using Human Image Analysis", OKI Technical Review, October 2011/Issue 218, Vol.78 No.1, pp.32-35
3) OKI Press Release: "OKI and Sports Club NAS Begins 'Karada-cise™' an Ubiquitous Health Support Service as Part of Ministry of Internal Affairs and Communications Project", November 9, 2010, http://www.oki.com/jp/press/2010/11/z10084.html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**Note**: Titles and organizations are current as of March 2012

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