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# Stream Event Search Plan for Improvement of Situation Recognition Performance in Limited IoT Environments

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***Abstract***
*In this study, a method of determining the central sensor among the sensors grouped in this way is proposed. This is because when the central sensor is determined, it is possible to benefit from situational inference by watching the linkage activities with other sensors based on the sensor. Until now, commercialization models have been able to take measures to determine sensors that are the center of the group based on experts' experiences and opinions, but now it is necessary for the system to intelligently center and determine standard sensors without human intervention. In this study, in order to determine sensor data, which is the center of each sensor and is the standard for sensor data streams for situation recognition, the event frequency is checked, and the reported data stream is determined as the reference data stream.*
***Keywords***
*Context Awareness, Data Stream, Event Search, Internet of Things, Data Analysis*

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## I. Introduction

Intelligent systems that utilize the Internet of Things basically employ numerous sensors. Sensors play a role in detecting various phenomena depending on what is happening. Sensors report such detection results to hosts, and since there are several types of sensors to be used and continuously report detection results over time, it is difficult to respond to such sensor data in a traditional method. On the Internet of Things environment, various sensors report situation-related sensing data to the host, and at this time, a grouping phenomenon in which sensing activities of sensors are linked to each other may occur according to various actual situations. For example, in the event of a fire, temperature sensors, humidity sensors, and carbon monoxide sensors will report the sensed data as significantly changed values. If fog occurs, a city sensor, a humidity sensor, and a fine dust sensor will transmit sensing data related to the safety and development students. The actual situation accompanies various phenomena and sensors that detect each phenomenon may be grouped into one group, and since the situation is so diverse, the sensors belonging to the sensor group may overlap and participate in several groups. It should be noted here that the frequency at which each sensor operates cannot be constantly the same.

Against this background, this study proposes a plan to determine the central sensor among the sensors grouped in this way. This is because when the central sensor is determined, it is possible to benefit from situational inference by watching the linkage activities with other sensors based on the sensor. Until now, commercialization models have been able to take measures to determine sensors that are the center of the group based on experts' experiences and opinions, but now it is necessary for the system to intelligently center and determine standard sensors without human intervention.

The IoT system includes numerous sensors provided in terminals as well as M2M communication methods, and the use of such a large variety of sensors is to infer or recognize situations around numerous objects connected to the IoT and attached sensors. Therefore, determining the center of sensors to be grouped in recognizing this practical situation can be said to be beneficial to rapid situational awareness.

In this study, in order to determine sensor data, which is the center of each sensor and is the standard for sensor data streams for situation recognition, the event frequency is checked, and the reported data stream is determined as the reference data stream.

This study consists of the following. Chapter 2 summarizes related studies. Chapter 3 proposes a plan to explore data stream events in a limited IoT environment, Chapter 4 conducts experiments and evaluations, and Chapter 5 concludes.

## II. Related Works

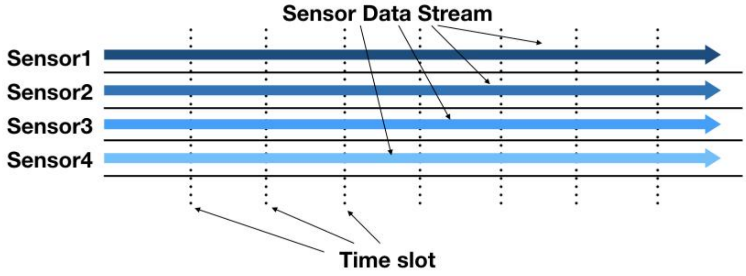
Data can be collected from various sensors and intelligent services can be provided with the development of computing technology and networking functions. Context awareness technology for analyzing user behavior and surrounding situation information is being applied in various fields [1, 9, 10]. Sensing technology for collecting contextual information, technology for inferring higher contextual information, and middleware technology for situations that serve as an intermediary between users and applications have been proposed [2]. Customized services using situational awareness have algorithms for collecting sensor data and inferring upper context information using APIs provided by the system. In this case, as the number of simultaneous applications increases, the number of related API calls increases, and individual upper-level context information inference algorithms must be performed, leading to an increase in computation and a problem of resource waste. Therefore, in order to solve the problem of performance degradation, a plan is proposed to collect and process situation information directly from middleware, infer higher situation information, and transmit it to an application to share complex situation information [3].

There are difficulties in predicting the distribution or size of multiple data streams and processing real-time responses. It is proposed to effectively reduce the load for multi-window join when the memory capacity of the system is exceeded. The selection of throwing away some tuples was difficult to predict tuple productivity unless the distribution of join key values was kept constant [4,11,12]. Therefore, tuple productivity is predicted using the arrival order for the data stream of the tuple instead of the join key value of the tuples. Load reduction can be effectively performed when the arrival order pattern is present in the multi-window join. Load reduction is performed using the arrival order pattern of naturally occurring tuples. It is effective in solving the limitation of determining the possibility of joining the tuple based on the distribution of the join key values. If the join key value is unique or without repetition, the performance is excellent even when the distribution between streams is different [5].

In order to find frequent items in the real-time data stream, the potential tree lattice structure, which is an observation grid, is used, and delay insertion and pruning techniques are used. The estDec technique finds a set of frequent items through the steps of updating factors, updating numbers, delay-inserting, and selecting a set of frequent items [6]. An association rule exploration technique has been proposed to find association rules in the data stream. The association rules are divided into ordered rules and non-ordered rules, and the association rules are created by exploring the observation grid for each rule. According to the dictionary order, the order rule can be expressed in the form of ab→cd, and the non-order rule can be expressed in the form of ad→bc [7]. A data collection situation of a robot capable of collecting various surrounding data using a sensor may be defined as a real-time data stream situation. By applying the theory of association rules of data mining, it is possible to implement a robot's situational cognitive technique. The next behavior can be determined by generating association rules with stream data collected by the robot. Since the association rule exploration technique cannot be applied due to the specificity of the sensor data set that can be collected by robots, a structure of a system that can apply robot context using a situation-action decision technique applicable to the robot's sensor data stream situation was proposed [8].

## III. Data Stream Event Search Plan in a Limited IoT Environment

The emergence of the Internet of Things solved the problem that was an obstacle in the previous ubiquitous environment. In a ubiquitous environment, long-distance transmission of data was difficult, and the power problem of the terminal could not be solved. As a result, situational awareness and intelligent services performed without human intervention were not implemented. Due to the Internet of Things, situational awareness and intelligent services have become possible in various fields. The Internet of Things can be applied even in an open environment in a vast area, and various intelligent services are also possible in places where people cannot live or visit in rugged areas.



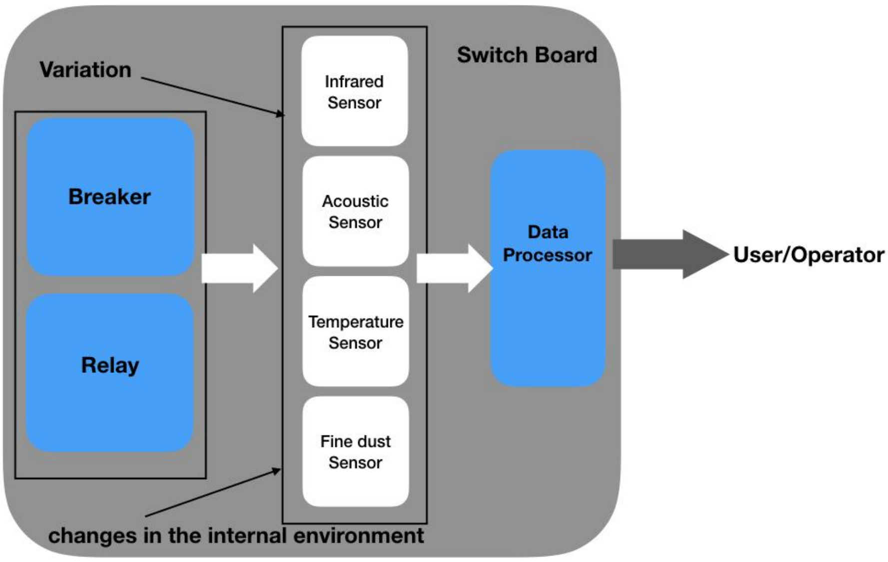

Pic. 1 Data Stream from Sensors

It is essential to select a sensor suitable for acquiring context information, and how to use sensor data detected and reported by these sensors plays an important role. When attempting to run intelligent services in a spatially specific place, it can lead to unexpected costs for the IoT system to occupy the volume or weight that can interfere with the natural work and possibilities of the target space or object. Therefore, it is important to select a suitable sensor necessary for situational awareness, and it can be said that it is a very important issue to analyze data from the sensor efficiently and effectively.

Sensors are usually devices that respond to physical changes, chemical substances, or reactions that accompany the situation rather than recognizing the actual situation itself. The sensor obtains a fine current or voltage value by a material or device that detects a physical, chemical, or biological phenomenon, and then amplifies it to obtain a numerical value that is acceptable to the user. The data detected and sent by sensors may provide a decisive basis for recognizing the situation itself, but in general, it is only quantified after detecting some changes related to the situation. Therefore, in order to increase the level of situational awareness information, it is necessary to comprehensively analyze and utilize the values sent by sensors that have detected various physical and chemical changes.

In this study, it is premised that an integrated analysis of heterogeneous data streams constituted by sensing and transmitting different types of sensors is required to obtain a better level of contextual information. At this time, when several different types of sensors send the detected results for a single situation, it is necessary to link them and analyze them, and at this time, it is necessary to play a central and standard role. If so, there is a need for a plan to determine how to determine the central role of data analysis that serves as such a reference.

In this study, the following methods and procedures are proposed to allow one of the sensor data streams to play this role, and to determine and utilize the sensor data stream to recognize the situation.
1)Sensors continue to report their respective sensed data with the passage of time.
2)Data detected and reported by each sensor may differ for each time zone.
3)A sensor data stream showing a remarkable difference among each sensor is determined as a criterion and a center in linking sensor data streams for context recognition.
4)Group other sensor data streams that report changes in time with significant changes in the data stream that are the basis for context recognition.
5)It analyzes the grouped sensor data streams to infer the situation in the real world.
These methods and procedures are expected to be useful when operating limited sensing assets to recognize various situations or to recognize urgent and important situations with limited system resources. The following is a basic method of recognizing a situation based on a data stream from a sensor.



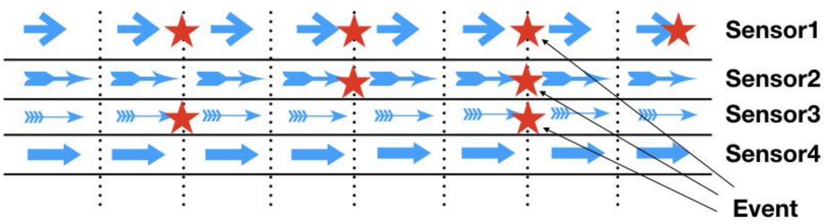

Pic. 2 Work Process in Smart Switch Board

1) s1, s2, … different k sensors required to recognize the situation.…, Let's say sk. If S is a set of sensors, then S = {s1, s2, …… It is, sk}. If S(t) is the set of data values measured at each sensor at any time t, then S(t) = {s1(t), s2(t), s3(t), …… sk(t)}
2) It is determined whether an event occurs at each sensor at an arbitrary time t.
If Sb is the set of reference values for each sensor, then Sb = {sb1, sb2, …… It is, sbk}. Pn = sn(t) / sbn (where

n = 1, 2 …)¨…, k, t t ) ) and by sensor (sb1, sb2, …) at any t time.… sbk) By sensor (s1(t), s2(t), … for reference value…, If the measured P value of sk(t)) is greater than or equal to 1, it is said that an event occurs.
3) Let's say the event set is E
For any time t, the sensors (s1, s2, …).…, sk) The event that was determined and reported as an event after detection is e1(t), e2(t), e3(t) … E = {e1(t), e2(t), e3(t), …… ek(t)}
(However, 1 if en(t) is an event, 0 if not an event, n=1, 2, …).…, k)
4) Sensors report the event value to the host among the detected values.
5) Combine the event data reported to the host.
6) When the event data set combined at arbitrary time t is e1(t), e2(t), and e3(t), the event data set EDset is as follows. EDset(t) = {e1(t), e2(t), e3(t), e1(t)e2(t), e1(t)e3(t), e2(t)e3(t), e1(t)e2(t)e3(t)}
7) The meaning of each event data constituting the event data set is determined.
8) Different event data-based situational recognition is implemented in each situation.

A particular situation occurs when y≧p for any p value

The sensor data stream is continuously flowing in, and each sensor is a different type of sensor. Among these sensors, sensors serving as centers and criteria may vary depending on the situation. The types of situations that can be detected and inferred in this system may be further diversified according to the types of sensors used.




Pic. 3 Events on Data Stream

In Chapter 4, the suggestions in this study are tested using sensors and the results are evaluated.

## IV. Experiment and Assessment

In the experiment of this study, the experimental process and results of three new detection targets made by combining each sensor were shown.

① (current sensor + temperature sensor)

The operating error of the breaker was detected using a current sensor and a temperature sensor. An experiment was conducted to detect an error in the operation of the circuit breaker at a time when the risk of degradation is not high by detecting an increase in current value and temperature that persists when the circuit breaker is not operated.
As a result of the experiment, it was possible to observe the degradation of the conductor when it reached 110 mA and 90°C. It was set based on when the current sensor detects 90 mA and the non-contact temperature sensor detects 70°C, allowing the breaker to detect operational errors before the conductor degrades. If the current sensor detects 90 mA or more and the temperature sensor detects 70°C or more, each sensor outputs a digital signal (HIGH) and inputs it to the AND gate of the logic circuit to detect a circuit breaker operation error. In the experiment, the result notification was set to be turned on the red LED.

② (Non-contact temperature sensor + temperature sensor)

An abnormal temperature increases of the conductor according to the temperature in the switchboard or facility was detected using a non-contact temperature sensor and a temperature sensor. The temperature of the circuit breaker itself and the temperature inside the switchboard increased due to internal and external factors so the wiring breaker was detected to malfunction. It was made to recognize a situation in which the temperature of the wire increases as the internal temperature of the switchboard increases. An experiment was conducted by increasing the ambient temperature by forming an enclosed space. As a result of the experiment, it was observed that the temperature of the wire increased only by the increase in the ambient temperature regardless of overcurrent. The initial ambient temperature, the initial wire temperature, and the later wire temperature were set as criteria to detect the increase in wire temperature due to the increase in ambient temperature. In this case, a digital signal (HIGH) was output from each sensor and input to the AND gate of the logic circuit to output the final 1 (HIGH), thereby detecting an increase in wire temperature due to an increase in ambient temperature and lighting a yellow LED.

③ (current sensor + contactless temperature sensor + temperature sensor)

The purpose of this invention is to detect an abnormal conductor temperature increase due to the magnitude of the allowable current that changes according to the ambient temperature using a current sensor, a non-contact temperature sensor, and a temperature sensor. The ambient temperature of the conductor acts as a negative coefficient for the allowable current. Therefore, when the temperature around the wire is high, the allowable current decreases, and when the ambient temperature is low the allowable current increases. The current and wire temperature at the normal temperature (about 25°C) were measured, and the current and wire temperature at the high temperature (about 40°C) were measured by implementing a situation exposed to a high temperature. At normal temperatures, conductors exhibit degradation around 120 mA and 100°C, and at high-temperature conditions, degradation occurs around 95 mA and 100°C. As the allowable current of the wire decreases, an overcurrent phenomenon in which an abnormal current flow appears faster, and as a result, a temperature increase of the wire also appears faster.

As the ambient temperature increases, the allowable current of the wire decreases, and the wire temperature increases rapidly even with a similar current value compared to when the ambient temperature is low. The ambient temperature was measured with a temperature sensor of 40°C or higher, a current sensor of 80 mA or higher, and a non-contact temperature sensor of 70°C or higher. In the above reference, the digital signal (HIGH) was output from each sensor and input to the AND gate of the logic circuit to output the final 1 (HIGH), thereby detecting the increase in the wire temperature due to the increase in ambient temperature and lighting the green LED.

Evaluation: Through this experiment, it was confirmed that the temperature sensor should be the center for situation recognition in a limited closed space. It was found that inferring the situation based on the temperature sensor is easy to recognize the changing situation and abnormal situation of the internal environment.

## V. Conclusion

In this study, different types of heterogeneous sensors were adopted to improve performance when trying to recognize situations in a limited IoT environment, and sensor data streams reported by each sensor were used to infer or recognize situations.

The values reported by each sensor were compared by time zone, and as a result, the situation was inferred by grouping other sensor data streams based on sensors that frequently report remarkably notable changes. As a future research task, research to select high-quality sensors that play a stable sensing role in situational awareness and secure the sensing data is expected to continue.

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