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Design of Cloud-based Context-aware System Based on Falling Type

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Abstract

To understand whether Falling, which is one of the causes of injuries, occurs, various behavior recognition research is proceeding. However, in most research recognize only the fact that Falling has occurred and provide the service. As well as the occurrence of the Falling, the risk varies greatly based on the type of Falling and the situation before and after the Falling. Therefore, when Falling occurs, it is necessary to infer the user's current situation and provide appropriate services. In this paper, we propose to base on Fog Computing and Cloud Computing to design Context-aware System using analysis of behavior data and process sensor data in real-time. This system solved the problem of increase latency and server overload due to large capacity sensor data.

Keywords: Mining Minds, Smartphone, Behavior Recognition, Fog Computing, Cloud Computing, Sensor, Falling, Context-aware, Sensor

1. Introduction

According to Falling-related statistical data provided by WHO(World Health Organization), about 5% of the world population has fatal injuries by Falling[1]. Falling accidents have various risks ranging from abrasions, fractures and even death, based on its type and situation. Therefore, it is not to grasp only the behavior that Falling has occurred, but if grasp the situation and type of before and after Falling, damage by Falling can be minimized.

Behavior recognition research is the main technology for recognizing this Falling. Behavior recognition research utilizes various kinds of sensors such as acceleration sensor, gyroscopic sensor, GPS sensor, and geomagnetic sensor, etc. to recognize the behavior of the user[2-4]. A method widely used among them is a method of obtaining the SVM(Sum Vector Magnitude) value using an acceleration sensor, analyzing it based on the threshold value, and recognizing the behavior[13]. However, such behavior recognition technology only recognizes whether or not the user's behavior has occurred. That is, it is possible to provide services only for specific behavior. Therefore, in the future, it is necessary to provide services suitable for the user's current situation by behavior.

In order to grasp the situation, behavior recognition data is necessary. This behavior recognition data can be obtained by collecting and processing the sensor data. The sensor data required by the behavior

recognition technology is the vast amount of data that is updated in the real-time[5]. So, this is a big-data. For processing these big-data most behavior recognition technology is based on the Cloud Computing. However, since the amount of data increases rapidly, latency time increases and server overload occurs. Fog Computing is necessary to solve these problems.

In this paper, we propose to the Context-aware System which infers the current situation of the user by using behavior recognition data. Also, since the sensor data is big-data, we propose a platform based on Fog Computing and Cloud Computing to process in real-time and solve the increase latency problem and server overload problem. In Fog Computing, design the Behavior Recognition System and in Cloud Computing design the Context-aware System.

The configurations of this paper are as follows. In Chapter 2, we describe Behavior Recognition System, Fog Computing, Cloud Computing, and Context-aware, as related research. In chapter 3, we describe the design, construction, and flow of the cloud-based Context-aware System using analysis of behavior data proposed by this paper. In chapter 4, we discuss the conclusion and supplementary points of this system.

2. Related Works

2.1 Behavior Recognition System

Behavior recognition techniques can greatly assist in inferring human life patterns and grasping health-related habits[2]. In behavior recognition research, sensor data is collected using various sensors such as acceleration sensor, gyroscopic sensor, GPS sensor, geomagnetic sensor, motion sensor, etc., a threshold value is obtained based on the sensor data. And it is analyzed behaviors according to threshold values[3-4]. Recently, since the penetration rate of smartphones has increased, research on behavior recognition technology using sensors of smartphones are actively conducted[6]. Behavior recognition research mainly converts data obtained from acceleration sensor into SVM value and classifies behaviors based on this threshold value. The SVM value can be obtained by the Equation 1.

$$\text{SVM} = \sqrt{Acc_X{}^2 + Acc_Y{}^2 + Acc_Z{}^2} \tag{1}$$

The following figure shows the static behavior using the SVM value and the acceleration sensor. Static behavior is divided into Lying, Sitting, Standing. And correlation by that is shown in the graph.
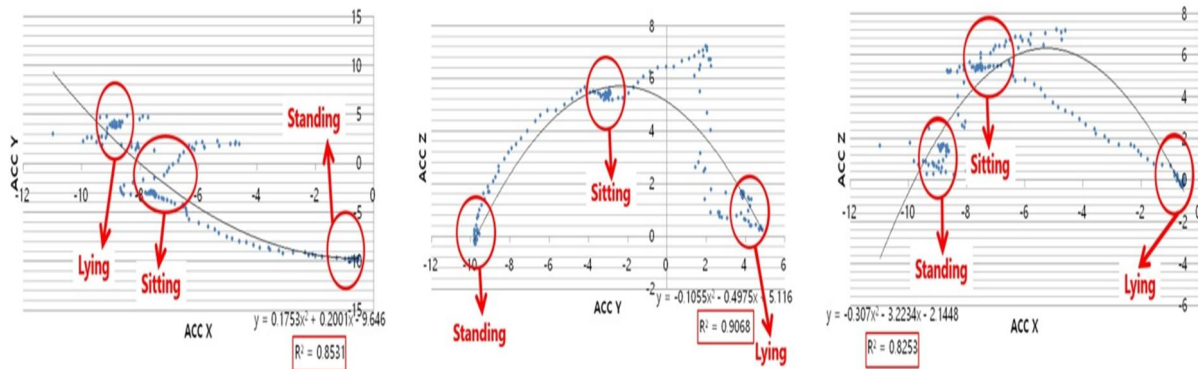

Figure 1. Plan crowding figure for participants "Standing-Sitting-Lying-Sitting-Standing

In the above figure, you can see that in the case of Lying from Standing, the behavior in the Sitting state is displayed [7]. As a result, it is understood that the behavior data are not independent values, but are connected to each other.

2.2 Fog Computing

Fog Computing is a model that extended existing cloud computing services to edge networks. This Cloud Computing is computing that utilizes the Internet technology to provide "Virtualized Computing Resources" and services based thereon[8]. In other words, it provides an environment that allows easy access to IT resources like servers and applications necessary services for various devices in the Internet environment[9]. However, when processing, storing, and filtering diverse and large amounts of data, ie Big-data only in Cloud, problems of increased latency and server overload have arisen[14]. To solve this problem, Cisco proposed Fog Computing. Fog Computing processes work such as data collection and processing, analysis, filtering to the between the end user and the Cloud server. It can solve the problem such as server overload given to the cloud server and reduce the latency. The following figure is a conceptual diagram of Fog Computing and Cloud Computing.
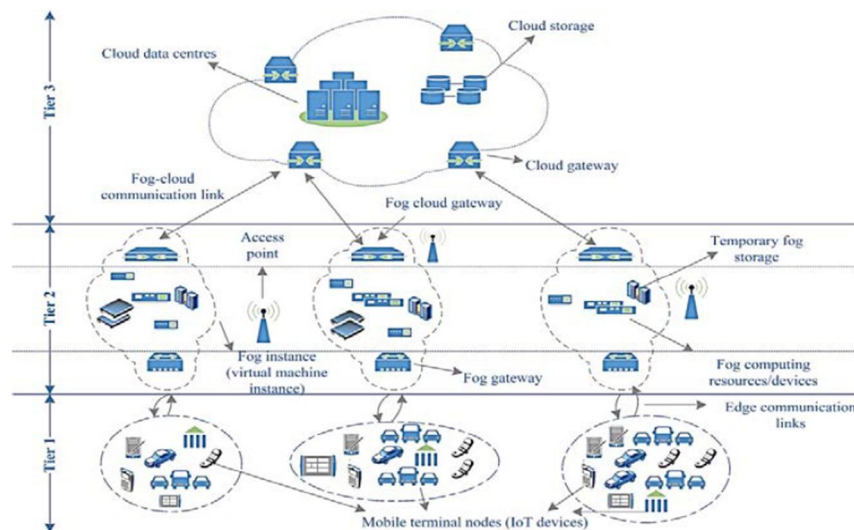

Figure 2. Conceptual Diagram of Fog Computing

2.3 Context-aware Technology

When the information on the current situation of the user is used to provide information or service related to the user's behavior, this is the Context-aware System[10]. A situation means all forms of information that classify something with interaction between a user and a system (people, places, etc.)[11]. Context-aware technology efficiently shares various data collected by sensors located in everyday life with each other efficiently, estimates the situation of users and surroundings, and provides services[12].

3. Proposed System

In this paper, we propose the system that infer the user's current situation from analyze user 's behavior by using acceleration sensor. Since the amount of sensor data received in real-time is large, we will construct a system using Fog Server and Cloud Server for efficient distributed processing. The conceptual diagram of the proposed system is shown in the following figure.
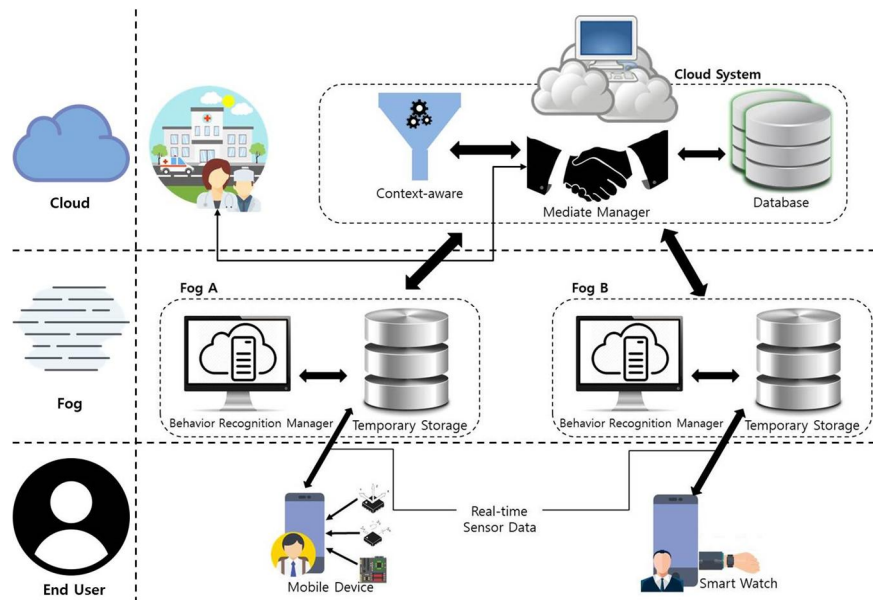
Figure 3. Conceptual Diagram of the Proposed System

This system is divided into End User Area, Fog Area, Cloud Area. In the End User Area, use the sensors to collect sensor data and transfer it to Fog Area. In Fog Area, sensor data sent from End User is sent to Behavior Recognition Manager. In the Behavior Recognition Manager, the SVM value is obtained based on the sensor data, and the behavior is grasped by the threshold range of this value. Behavior data categorized from Behavior Recognition Manager is sent to Cloud's Mediate Manager and saved in Database. If Falling data is detected, the Mediate Manager sends behavior data before and after Falling from the Database to the Context-aware Manager. The Context-aware Manager infer the current situation of the user based on the behavior state diagram.

3.1 Context-aware Manager

The Context-aware Manager in Cloud Sever compares and analyzes the behavior state diagram drawn based on behavior data and behavior data before and after Falling, and infer the current situation of the user. Figure 4 is an example of a behavior state diagram.
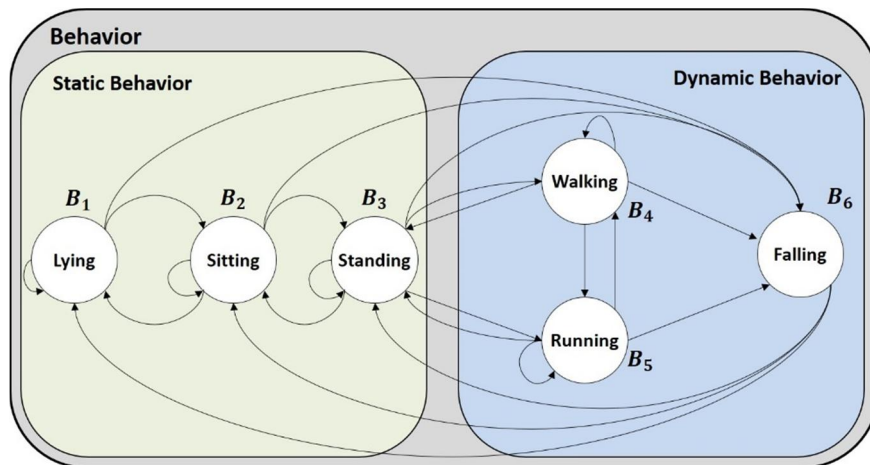
Figure 4. Diagram of Behavior State

The behavior state diagram was created based on the relation between the static behavior of related research[7]. Behavior data are divided into static and dynamic behavior, and they are defined as B_1 to B_6, respectively. The arrows show how the state of each behavior changes. Each behavior has a relationship as shown in the above figure.
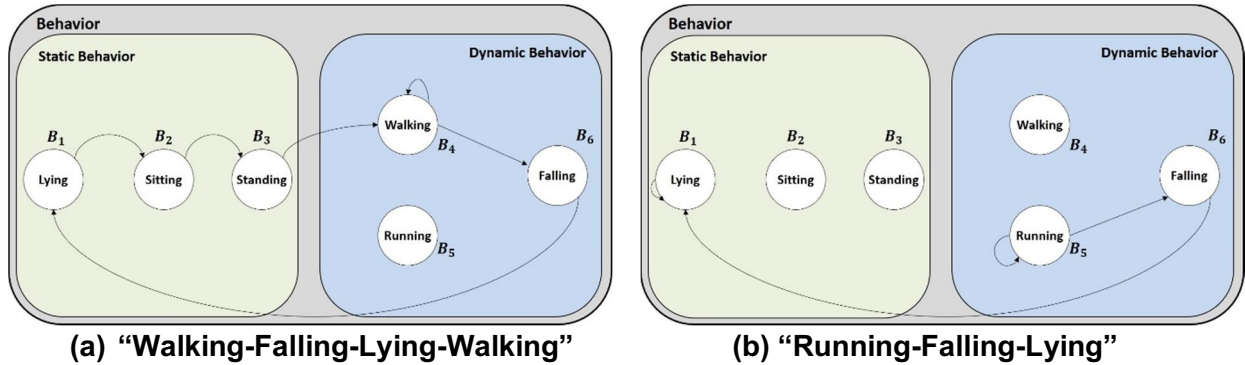

(a) "Walking-Falling-Lying-Walking"   **(b) "Running-Falling-Lying"**

Figure 5. Diagram of Behavior State

Figure 5 (a) shows that, after falling (B_6) during walking (B_4) and transitioning to the state of B_1, the state shifts again to the walking state through the states of B_2 and B_3. In this case, the user collapsed, but since the user is walking up again, so it can be seen that is not a dangerous situation. Figure 5 (b) means that the lying state after the falling continues while running. In this case, it can be inferred that it is a dangerous situation. In this way, the Context-aware Manager of this system analyzes the behavior state diagram and behavior data(before and after the Falling) to infer the current situation.

3.2 Proposed System Architecture

In order to design this system, the following modules are necessary. Figure 6 is the architecture that is necessary for this system.
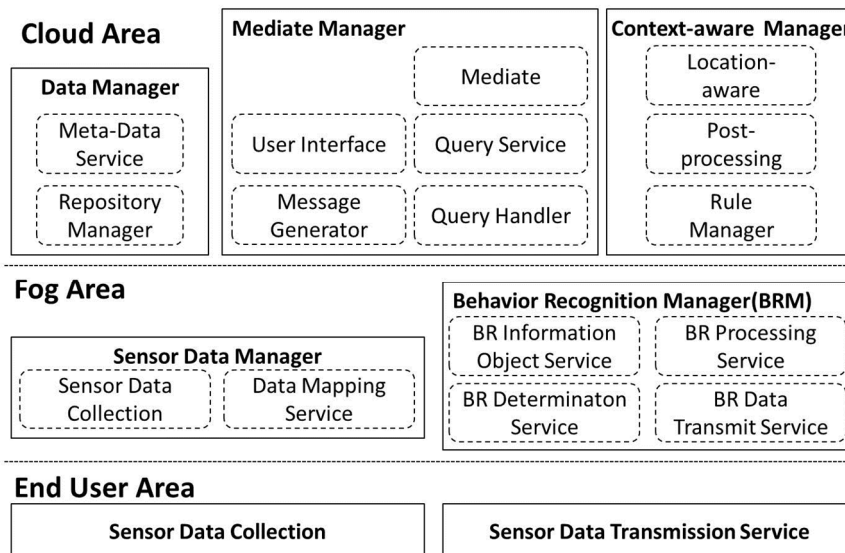

Figure 6. System Architecture

As shown in Figure 6, it consists of three layers, divided into End User, Fog and Cloud respectively. The

End User Area collects sensor data and sends it to Fog Server. The Fog Area consists of Sensor Data Manager for collecting data from End User and Behavior Recognition Manager (BRM) for recognizing behavior based on the collected data. The Cloud Area has the Mediate Manager for communication between Fog Server and Cloud Server, the Data Manager for data management, and the Context-aware Manager for perceiving the user's current situation. The Rule Manager stores data based on the behavior state diagram.

3.3 System Flow

Figure 7. System Flow(I)

Figure 7 is a flow in which the data collected from the End User's sensor is saved in the Database of the Cloud Server. First, the End User sends sensor data to Sensor Data Manager in Fog. After that, it accepts the data format standard from Cloud and matches the format of sensor data of different models. This data is converted into behavior data by Behavior Recognition Manager based on the threshold range. Behavior data is sent to Data Manager using Mediate Manager and saved in Database.

Figure 8. System Flow(II)

Figure 8 is a flow when a Falling situation occurs. When Falling data is detected, data before and after Falling in Database is requested from Data Manager using Mediate Manager. This data is sent to the Context-aware Manager, and the current situation is inferred by the Rule Manager. The inferred data is sent to the Mediate Manager, and when the risk level is high, it provides a notification service to the user.

4. Conclusion

In this paper, we proposed a system that analyzes behavior data and recognizing the user's current situation. Especially in the case of a falling that has a risk of injury, we recognized the user's current situation due to falling and made it possible to carry out quick and accurate treatment. For Context-aware is necessary to analyze based on user's behavior data. In order to recognize this, data from the user's acceleration sensor was collected and classified based on the threshold range of the SVM value. Also, we designed based on Fog Computing and Cloud Computing in order to process large capacity real-time sensor data. By using Fog Computing, we solved the problem of latency increase and server overload which occurs when only Cloud Server processes data. In Cloud Server, behavior data collected from Fog Server is saved in Database. If a Falling occurs, data before and after the Falling was sent to the Context-aware Manager to infer the user's current situation by using the behavior state diagram.

However, current research has limitations to analyze and recognize various behaviors of users. Therefore, in order to obtain more accurate behavior data, we will study behavior recognition technology using Fuzzy Logic and HMM(Hidden Markov Model) etc. and intend to introduce it to this system. Also, to recognize the situation, the current position of the user is also an important factor. So, by adding a GPS sensor, grasp the position of the user, analyze, process and infer with this by the Context-aware System to improve the accuracy.

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