Context Aware Operation Reproduction for Safety Driving

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Abstract

Recent automobiles are equipped with compact appliances of many functions. These appliances provide comfortable time and space for a user while those operations lead to a danger for safety driving. We assume that if operations are eliminated using contexts of a driver and fellow passengers, accidents can be avoided.

We propose an intelligent environment that can acquire a context such as operations and situations of a user using a RFID system and other sensors. In this paper, we propose a method to recognize a human behavioral characteristic for safety driving. The method recognizes the behavioral characteristic from acquired contexts of a user. This context is acquired in the intelligent environment. If a system recognizes a behavioral characteristic, it reproduces an operation that the user took in the past to create comfortable time and space.

1 Introduction

Recently, appliances having many functions such as vehicle navigation system have installed in vehicle. Since their operations ought to be complicated, it would be dangerous for a driver to touch the appliances. This paper proposes a method to reproduce operations from contexts of the driver and someone on a vehicle.

Existing context aware applications are studied to provide a service according to states of a user and those timestamps [3]. Grimm et al. [4] studied to support a user with a wearable device, and Mäntyjärvi et al [7]. [5] studied to recognize a user context in a ubiquitous environment equipped with various sensors. A technique to infer a current action from a past action is studied in [6]. A human has habits. The existing researches can not recognize and can not infer a human behavior aware of his habits. It is necessary to consider for the providing of individual habits service for a user.

We study about an intelligent environment using a RFID system and a ubiquitous base to recognize a human behavior. This paper proposes a method to represent human habits using the Bayesian network [8] for providing a suitable service in the environment. The Bayesian network must be the directed acyclic graph. The K2 algorithm [2] is often used to configure a Bayesian network by cases. The algorithm does not necessarily create a directed acyclic graph. This paper shows heuristics to cut two-way arrows generated by the K2 algorithm. The heuristics can convert many Bayesian networks to a directed acyclic graph. In addition to that we propose a method to infer a human behavior with converted Bayesian networks.

2 TaggedWorld Project

2.1 Recognition of Behavior

Figure1 shows an example of the *TaggedWorld* where *Radio Frequency Identification* (RFID) tags are attached to objects. A user behaves wearing the pocket assistant that is a set of a tiny server and a RFID reader. An access log is a temporally ordered sequence of accesses to the RFID tags. The access log is stored in the disk of the pocket assistant as a user's context. The goal of the TaggedWorld is extraction of a behavioral characteristic of each individual from his context to provide services according to the characteristic.

It is assumed a user spends his everyday life in a house where RFID tags are attached to objects such as a doorknob, tables, and various types of switches. The access log indicating objects a user has touched on his way to go outside is stored in the pocket assistant as a context of a user. The behavior corresponding to going outside is scrutinized using a behavioral characteristic of a user while the user is taking the behavior. If a behavior corresponding to going outside is actually taken, the pocket assistant checks all door lock are well set to prevent a sneak thief from damaging during his absence.

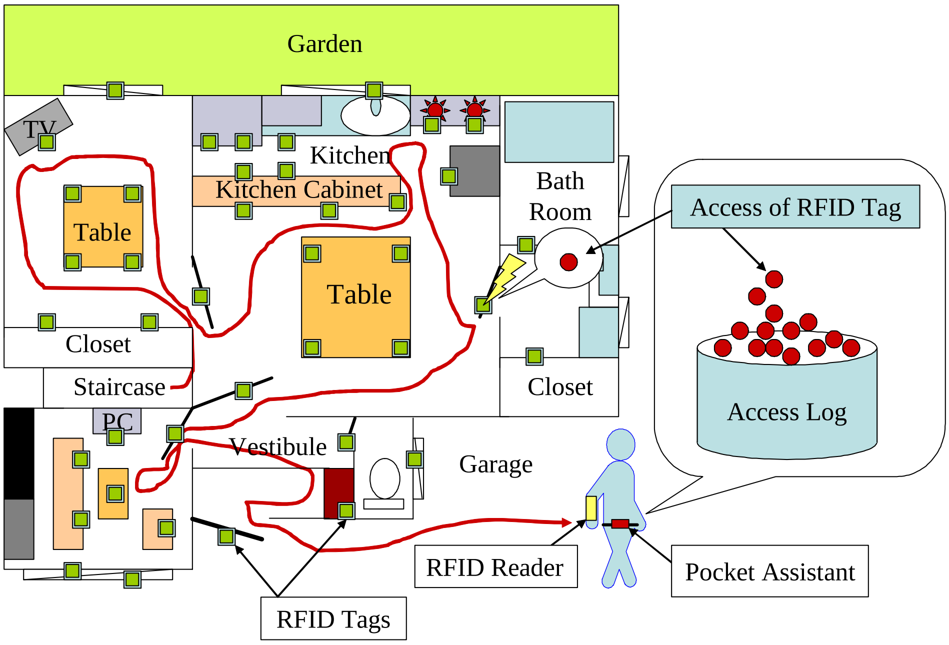

Figure 1: The TaggedWorld.

2.2 Coordination with Ubiquitous Environment

Recently, many recognition methods are studied to identify the human behavior to provide many services according to the recognized behavior of the user. Aoki et al. [1] reported a method using image processing technology in an environment where a camera takes an image of a whole room, to recognize action patterns from movement truck of a user. On the other hand, a method to recognize restricted user behaviors is researched using the RFID system [9].

However, it is difficult that user behaviors are recognized by only using the RFID system or only using the ubiquitous environment like the methods mentioned above. For instance, it is assumed that a father sits on the driver seat, a mother sits on the passenger seat, and child sits on a back seat in the vehicle where RFID tags are attached to volume switches of a vehicle stereo, a steering wheel, and so on. She turns off a vehicle stereo and sets the temperature so that the child can sleep comfortably. In contrast, when the mother does not seat on the passenger seat, the father who is driving a vehicle can not take care of the child as the mother did. Consequently the father can not concentrate on driving the vehicle since the child is not comfortable in the back seat. The father hopes for a system, that provides the services automatically based on the mother's behavioral characteristic when the child is sleeping. In this scene, it is difficult to recognize the child is sleeping using data from the RFID system. Additionally, if an image processing method is used to recognize the human behavior in a vehicle, the space inside the vehicle is too tight to recognize by the method.

The behavior of user is recognized with RFID system coordinated with a ubiquitous environment, and it is memorized as user's context in the TaggedWorld. Therefore, it is possible to provide services according to the behavior which can be inferred using the context. This paper defines a behavioral characteristic common to contexts corresponding to a specific scene as a *Behavioral Scene Characteristic* (BSC). A BSC consists of three sets [see figure 2].

S_1: a set of objects which are accessed when a user is taking a particular behavior,
S_2: a set of signals from ubiquitous environment when a user is taking the behavior, and
S_3: a set of accessed objects and a set of signals from ubiquitous environment when a user is taking behaviors other than the one.

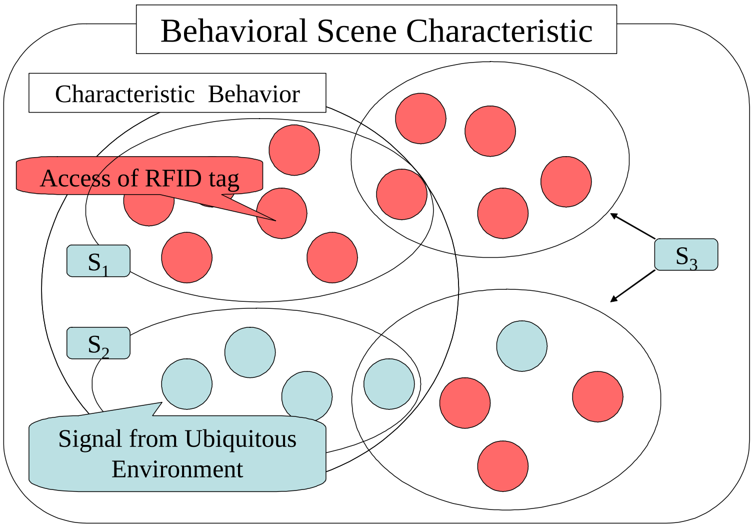

Figure 2: Characteristic Behavioral Scene.

2.3 The Matching Methods of Human Behavior in Tagged World

A user behavior is recognized to provide services according to the goal of the behavior. There are wide varieties of behaviors. It is unrealistic to check all behavior which may be taken on every access to an RFID tag. To reduce the load, the recognition process consists of the following two stages.

> *The first stage*: The BSC created from user contexts is checked with an access log and signals from ubiquitous environment. The check picks up behavior which may be occurring.
>
> *The second stage*: The behaviors which are picked up at the first stage are scrutinized as for the sequence of accesses and durations of accesses in access log, to determine whether the behaviors are really taken.

3 Describing Model of Human Behavior

3.1 K2 Algorithm for configuring Bayesian Networks

A human behavior is expressed with an access log and signals from ubiquitous environment in the TaggedWorld.
An access log indicates the following three points: accessed tags (or tags not to be accessed), the sequence of the access, and the duration of the access.
A human behavior consists of individual acts. In this paper, we define an act is expressed with an access to an object. For instance, a behavior like “taking off a vehicle” is composed of common acts such as “opening the door”, “setting a side brake”, and “setting a steering lock”. Since these acts are indispensable for the behavior, they have a dependency relation. We propose to represent a BSC using the Bayesian network (BN) [8].

In a BN, an aim variable is inferred by using the object which is modeled by probability networks. There is a method of evaluating a conviction level of a probability in each variable state that can happen. Moreover, a BN is a *Directed Acyclic Graph* (DAG) that represents the conditional probabilities with arrows between variables using network structure to signify a complicated dependency relation [8].

If it uses a BN for inferring probability distribution of the aim variable, the result is affected a great deal with the structure of the network. The K2 Algorithm is a well-known method which automatically creates the network structure. The algorithm is a technique for selecting a parent node of certain two dependence nodes from the appearance frequency of the set of the values where two nodes have. However, this algorithm may create a dual directional arrow which represents dependency relationship between nodes. The dual directional arrow interferes with the configuration of a DAG.

3.2 Heuristics in Bayesian Networks as Human Behavior

In this paper, we propose heuristics which are acquired thorough the experimental results to examine the possibility of inferring a human behavior using a BN. One of the heuristics is applied before configuring a BN, and the others are applied after configuring the BN.

> *Heuristic*1. An aim node is excluded from the set of candidate nodes which have a possibility becoming the parent node of all another nodes.

The heuristics prevents the aim node from depending on other node.

If a two-way arrow meaning the interdependence appears in a configured BN, we regard it as two arrows that point mutually at the opposite direction. The original BN is divided into two new BNs each of which has one of the arrows. Let *d* be the number of the two way arrows.
In this process, the number of created BNs increases in proportion 2^d. The processing time to describe a BSC is increases in proportion to number of candidate BNs. The heuristic 2.1 and 2.2 are applied to curtail candidate BNs.

> *Heuristic 2.1.* To cut the arrow that does not influence the aim node.
> *Heuristic 2.2.* To cut the arrow using semantics which the nodes have.

The heuristics 2.1 is applied to prevent an arrow to have nothing with the result from increasing processing time.

The semantics in the heuristic 2.2 is the dependence relationship of objects when a user spends his daily life in the TaggedWorld. For instance, let us assume that a two-way arrow between the “steering lock” node and the ”vehicle key” node that are needed to leave from the vehicle for a long time. The vehicle key is pulled out because the steering lock is set up, but the steering lock is set up because the key is pulled out when the user leaves the vehicle. The relationship based on the semantic is cut by the judgment of the user, because the K2 algorithm is based on the frequency of appearance. It can not understand the semantics.

> *Heuristic 3.* To sort the configured BNs which Heuristic 1, 2.1 and 2.2 are applied in ascending order using true cases and false cases.

The true case is the access log and signals from ubiquitous environment when a user is doing aim behavior such as S_1 and S_2 in Figure 2, and the false case is S_3 in Figure 2, respectively.

Then, the configured BNs are sorted in ascending order based on a difference which is calculated from minimum probability of the aim node which true cases are put into a configured BN, and maximum probability of the node which false cases are put into the same BN. The high rank BN of the sorted configured BNs are adopted to describe the BSC.

On first stage, the configured BNs which are applied the heuristics are used to pass the set of candidate behavior through a sieve as a BSC.

4 Verification of Model

4.1 Experiment

An experiment is taken using the following scenarios for examining an availability of the proposed method.

Scenario 1: If a user leaves valuables in a vehicle when he leaves from vehicle for a long time, a system notifies him that valuables may be stolen by ruining on the vehicle.
Scenario 2: If a child sitting on the rear seat sleeps, a system turns off a vehicle stereo and sets the temperature so that the child can sleep comfortably.

RFID tags are attached to a door lock, a door knob, a key, a switch which control window, a switch to open a gas tank, a side brake, a steering lock, a cap of the gas tank. They recognize a BSC of a user sits on the driver seat in scenario1. RFID tags are attached to surfaces of rear sheets, a switch that controls the temperature of the vehicle, a switch to control volume of a vehicle stereo. They recognize a BSC of a mother who sits on the passenger seat and her child who sits on the rear seat in scenario2. A microphone to recognize voices of the child is installed into the rear seat. In scenario1, only driver wears a set of a RFID reader and a Personal Data Assistant (PDA). In scenario2, the father, the mother, and the child wear the device. An access log is stored in a database through the wireless network. Two or more RFID tags are attached to objects. If a RFID reader accesses arbitrary tags of certain objects, it is recognized that the person touches the object. If the device of a child stands still continuously for a while a system judges he dose not move.

In scenario1, an experimental set of cases that contain six types of true cases is assumed in a set by three times for each, and three types of false cases are assumed to be repeated six times for each. Total 324 cases of the experiment are acquired because this set is taken nine times. In scenario 2, an experimental set of cases contain six types of true cases. Each case is repeated two times. There are six types in false cases. Each case is repeated two times for each. Total 144 cases of the experiment are acquired because this set is taken six times. A set of candidate BNs based on the heuristics which are shown in section 3.2 is configured by using those cases.

4.2 Analysis of experimental result

A BN shown in figure 3 is configured based on the heuristics 1 to represent the driver behavior in the scenario1. The BN has six two-way arrows. The heuristic2.1 and 2.2 are applied to the BN for cutting the two-way arrows such as *1 and *2 in figure 3. Since the arrow *1 does not have a direct effect on the result of the BN, it is applied the heuristic2.1 to cut it. The arrow *2 is cut because it has the reason described in a part of the heuristic2.2. It cannot be judged whether the other two-way arrow should be cut or not. New BNs are created from the remaining two-way arrows. The number of configured BN is in proportion to raise the second power of the number of two-way arrows. Finally, in this experiment, the number of the BN decreased from 64 to 16 because it is applied the proposed heuristics. It has a uniform effect in the scenario2 too.

The configured BNs which applied the heuristic 1, 2.1 and 2.2 are applied to true cases and false cases in the scenario1. Figure 4 shows as the probability graph of highest ranked, second of highest ranked, lowest ranked, and second of lowest ranked BNs which applied the heuristic3 on the behavior of the driver who leaves from vehicle in the experimental cases. The BN1 is the highest ranked based on dp1 which the difference of the minimum probability in true cases from the maximum probability in false cases. The BN2 is the lowest ranked based on dp2. The BN applied the heuristics can detect a human behavior as shown in figure 4.

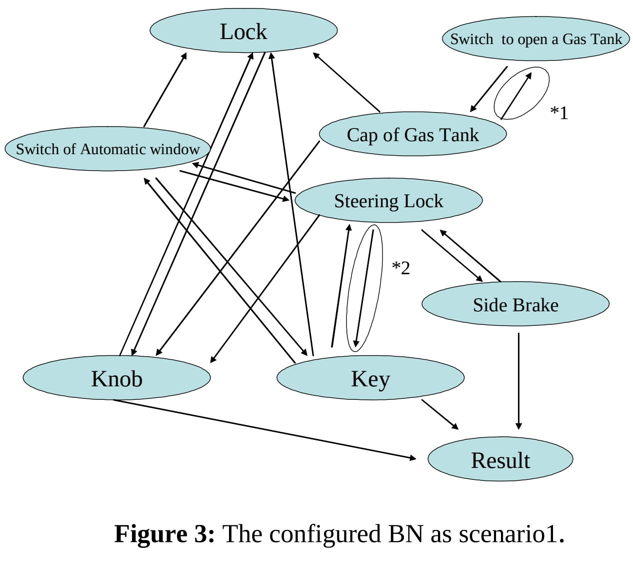

Figure 3: The configured BN as scenario1.

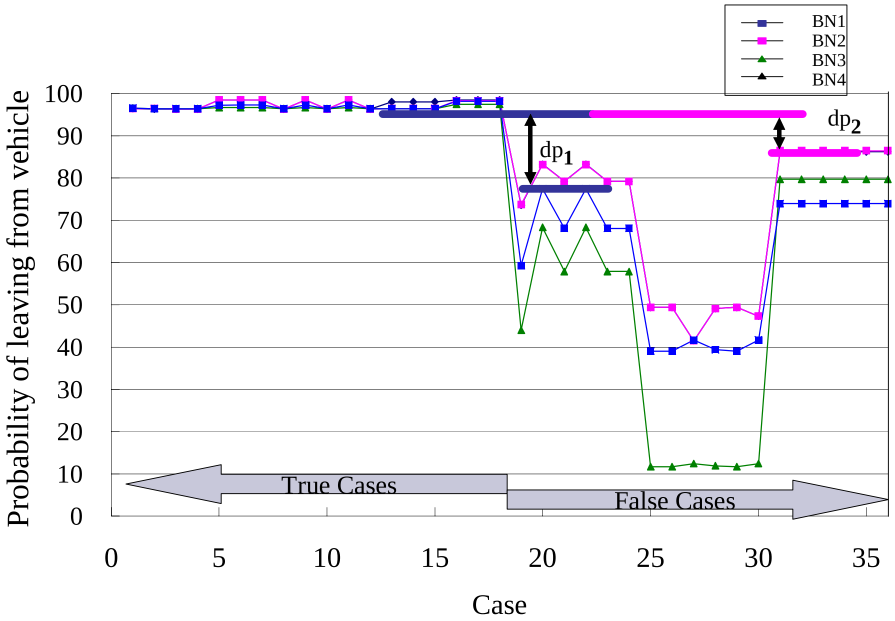

Figure 4: The Graph of experimental result of scenario1.

In section2, we describe that too difficult to recognize human behavior with only the RFID system. Figure 5 shows as an experimental result to validate that a RFID system need to coordination with a ubiquitous base to recognize a human behavior. If a RFID system is not coordinated with a ubiquitous environment, it is not able to recognize a human behavior because there is no meaningful difference of the probability in true cases and false cases as shown in figure 5.

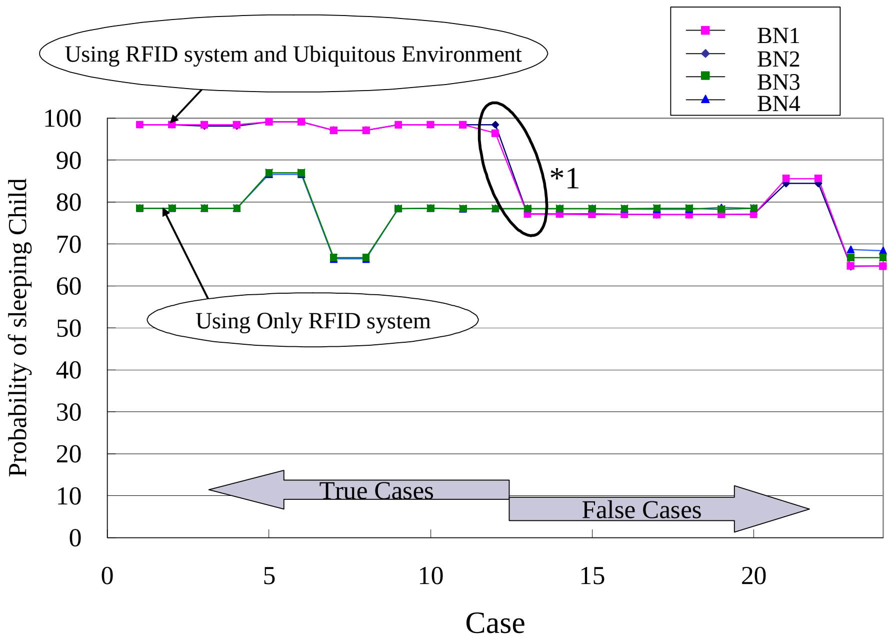

Figure 5: The Graph of experimental result of scenario2.

However, sometimes, the number of BNs may be huge even if proposed the heuristics is applied. From the experience in this experiment, the number of the node composes BN which represent a human behavior is not too many, and the possibility that two-way arrow is generated between all nodes is low. If the heuristic2.1 and 2.2 are applied before the configuration of BNs based on the K2 algorithm, the difference of the probability would be wider. This technique reduces the degree of the freedom of the K2 algorithm. It is not preferable to use the technique.

5 Conclusion and Future works

We have proposed a method to acquire a context of user automatically in the TaggedWorld. A behavioral scene characteristic based on the context is represented with Bayesian networks. The Bayesian networks are created from experimental cases. The Bayesian networks must be a directed acyclic graph for inferring a behavior of a user. We proposed the heuristics to configure behavioral scene characteristic from the context using the K2 Algorithm. The analysis of experimental results shows that the configured Bayesian networks under the proposed heuristics can represent behavioral scene characteristic of a user, and the Bayesian networks can infer a behavior of a user.

We will take more experiment to increase a significance of a proposed method, and increase category of a BSC. Dual directional arrows are cut to configure candidate set of Bayesian networks by using proposed heuristics. One Bayesian network may not still be directed acyclic graph. We will study a countermeasure of this issue.

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