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Knowledge acquisition and circulation for childhood injury prevention and safety promotion

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***Abstract*— In the field of computational intelligence, knowledge acquisition is major theme and important. To develop useful system with computational intelligence, it is important to develop information to offer sustainably and to acquire personalized knowledge dynamically through interacting with users. The authors proposed a system with like this frame for preventing child's injury as an example of concrete application. The system develops contents to offer through collecting user's data by offering childhood injury scene videos to parents on the web. To develop the system, functions for generating child's behaviors like a real child and updating based on evaluation the contents are necessary. We developed a system for simulating child's behaviors on a virtual environment by modeling child's developmental behaviors and environment probabilistically. We created child's injury scene videos using the simulator and we provided them to parents on the web. We are trying to establish the computational model for evaluating and optimizing contents based on the data that users input and responded to the questionnaire. In this paper, we described how to develop child behavior simulator and our system for providing injury scene videos. Lastly, we described about collected users' feedback data through the system and the way to use of it.**

I. Introduction

In the field of computational intelligence, knowledge acquisition is major theme and there are various methods for it. Since conventional method has been developed to be able to use generally, knowledge is static and constant. So, it is difficult to develop really useful computational intelligence system. To develop useful system, it is necessary to be able to acquire information sustainably and acquire personalized knowledge dynamically through interacting with users. We think that like this frame can be fundamental technology of computational intelligence. So, it is necessary to carry out a feasibility study with a concrete application. The authors research on child's injury as an example.

Child safety is a global concern, as witnessed by one of the largest injury surveys made by the National SAFE KIDS Campaign (now Safe Kids Worldwide) of the U.S. According to the report[1], childhood injury mortality below the age of 14 has decreased by about 40% in the last ten years, but its top cause has been unintentional injuries. In the United States, unintentional injuries kill 5,600 or more children each year — an average of 15 children a day. In Japan, childhood injuries are the top cause of death, accounting for 21.7% of mortality due to childhood injuries. This report made it clear that childhood injuries must be recognized as a general health issue rather than as the result of uncontrollable injuries. A technique is required that analyzes child behavior to prevent unintentional injuries in the home and design environments safer for children.

There are some injury surveillance systems all over the world[2], [3], [4]. They gather a lot of injury data and analyze them, they have provided injury information like the number of injury, the ratio of injury and so on. These information are useful for figuring out actual situation of injuries from macro point of view. But if we don't know detail of injuries, it is difficult to devise effective solution. Some books, magazines, web sites and so on have provided injury information. But these information have been used for only alerting and they haven't evaluated the effectiveness of the information.

We think that important thing is providing information which is reflected users' feedback for preventing childhood injury, in other words, it's knowledge circulation. We proposed system such as Fig. 1 as a concrete example of knowledge circulation. In this system, to begin with, we create contents including injury information and provide it on the web. Users watch the contents inputting some data for getting proper information for themselves. After watching the contents, users ask the questionnaire. We can get users' data that they input for getting proper information and they asked to the questionnaire. We can know that which information should be imparted. So, we can update and optimize contents. We created childhood injury scene animations as the contents. For this purpose, behavior model for generating child's behavior based on age and environment, visualization function based on the behavior model and computational model for optimizing our contents are necessary.

In this paper, the authors describe about modeling child's behavior and computational model for optimizing the contents. We describe the web system for knowledge acquisition and circulation developed integrating these two models.

II. Child's behavior modeling

A. Key factors in childhood injuries

Let us consider a concrete example of an injury in order to analyze key factors in childhood injuries.

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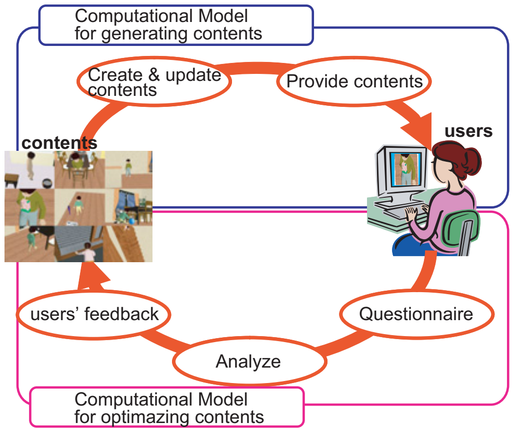

Fig. 1. Sustainably developing Contents

"A child wanted to drink orange juice and found a cup in the cabinet. He climbed up on a chair to get the cup, but he couldn't reach it. So he stood on tiptoe. Then he lost his balance and fell to the floor. He hit his forehead against the floor."

From this example, it can be seen that the injury is deeply related to the objects around the child and his capability of performing behaviors. In this case, objects such as the cup, the chair, the cabinet, and the floor were involved in the injury. The boy grew until he could walk, climb, and stand on his tiptoes. This fact suggests that we must model both environmental factors and developmental behavior factors.

B. Constructing child's behavior model

In this paper, we constructed child's behavior model by modeling child's developmental behavior and surrounding environment and integrating them base on the analysis of the preceding section. Details of developmental behavior model, environment model and the way to integrate them are described below.

1) Developmental behavior model: Developmental behavior model is created using DENVER II [5] which is used for checking developmental stage by pediatricians and our observation and its analysis data of infant. We adopt infant age as one of various factors related to infant developmental behavior. Because in DENVER II, most influential relationship between developmental behavior and age is adopted although mother's academic background, mother's ethnic background and so on are tried to consider.

DENVER II provides relationship between age and ratio of infant who can take a certain behavior (Figure 2). For example, when infant is 7 months, 25% of infants can take "stand up using objects", when infant is 8.4 months, 50% of infants can, when infant is 11.1 months, 90% of infants can.

We could got ratio of behavior which infant takes at a certain age from our observation and its analysis data. For example, infant begin to crawl when he/she is about 8 months old, he/she becomes better as he/she grows, but he/she doesn't crawl much if he/she begins to walk. That is to say, ratio of infant behaviors changes as he/she grows.

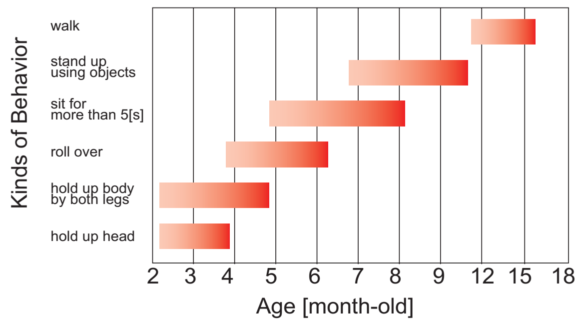

Fig. 2. Example from the DENVER II

Developmental behavior model can be divided developmental possible behavior and developmental appearance behavior. Developmental possible behavior means that behaviors which infant can take at a certain age. Developmental appearance behavior means that behaviors are appeared as infant behavior at a certain age.

Developmental possible behavior is composed of developmental stage of infant behavior and state transition. Developmental stage of infant behavior is modeled interpreting the ratio of infant who can take a certain behavior as developmental stage of infant behavior when he or she is a certain age. For example, developmental stage of "pull oneself up" is 25% when infant is 7 months and 50% when 8.4 months. In fact, it represents probability of development of infant behavior.

As for state transition, it is modeled base on following idea. A behavior which infant can take in the next moment depends on previous behavior including current behavior. In our research, we focus on a behavior which infant took right before a certain behavior and which is able to be related certainly, because the number of behavior steps which are related to next behavior changes based on each behavior and surrounding environmental situation and it is complex. In particular, using physical possibility as criteria, probability of a behavior in the next moment can be transited from each behavior which is assumed in our simulator is represented as 1/the number of a behavior which can transit, probability of an impossible behavior is represented 0. For example, if assuming behaviors are lie down, sit, stand, walk and jump, lie down, sit and stand can transit but walk and jump can't transit from sit state. In this situation, state transition probability of each behavior which transit from sit state is 0.33 as for lie down, sit and stand, 0 as for walk and jump. In fact, it indicates state transition probability of next behavior which transits from a certain behavior. Figure 3 indicates an example of state transition diagram.

2) Environmental model: In this paper, we focus on "function of inducing infant interest" which environment has for modeling grasping achievement behavior, we create environmental model. We model a function of inducing

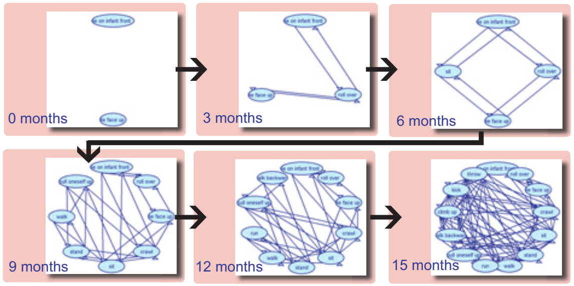

Fig. 3. Example of state transition diagram

infant interest and a function of inducing infant intention as an environmental model. The function of inducing infant intention means an inducing function in case of regarding a behavior which infant takes to a certain object as a behavior which infant takes inducing infant interest and intention.

A function of inducing infant behavior is modeled relating a physical object and induced behaviors. Kind of induced behavior is selected from behaviors which are used by creating the developmental behavior model. We think that locomotion, crawl, walk and run, are induced by all physical objects, they are associated with all physical objects. A way to associate physical objects with induced behavior is that we created a list of all induced behavior corresponding with each object, we labeled 1 as induced behavior and 0 as behavior which is not induced. We used 0 or 1 as probability because there isn't data for calculating such kind of probability, although we will change these values into probability in the future. In fact, a function of inducing behaviors indicates probability of induced behavior.

As for function of inducing infant interest, we think that colors, shapes, feature of physical object (i.e. movement or function) and so on are related to infant interest to physical objects. We searched relationship between frequency of infant interest to physical objects and distance between infant and physical objects, weight of physical objects and size of physical objects, which are able to measure. We found that distance between infant and physical object is a most important factor because contribution ratio in result of principal component analysis is 88.1% as for distance between infant and physical objects, 8.0% as for weight of physical objects and 3.9% as for size of physical objects. So, function of inducing infant interest is modeled focusing on distance between infant and physical objects. In particular, it is modeled using relationship between the distance and interest induction probability which is knowledge obtained from infant behavior measurement. When infant is interested in a certain physical object, we assume that the object induces infant interest, probability of inducing the interest is called interest induction probability. We mention about infant behavior measurement, after that, we mention about a way to derive interest induction probability below.

a) Infant behavior measurement: In our research, we measure infant behavior for collecting data related to infant behavior. Measurement situation is that an infant and a mother spend an hour in a room in which about 30 kinds of toy and furniture is put at random.

Measured data are position of an infant, a mother, toys and furniture and images from a camera which is installed on ceiling. The position is measured using ultrasonic location system [6], [7](Figure 4). Ultrasonic location system is composed of ultrasonic receiver and transmitter, the receivers are installed on walls and a ceiling. The system can measure position of transmitters. In our infant behavior measurement, transmitters are attached to an infant, a mother, toys and furniture.

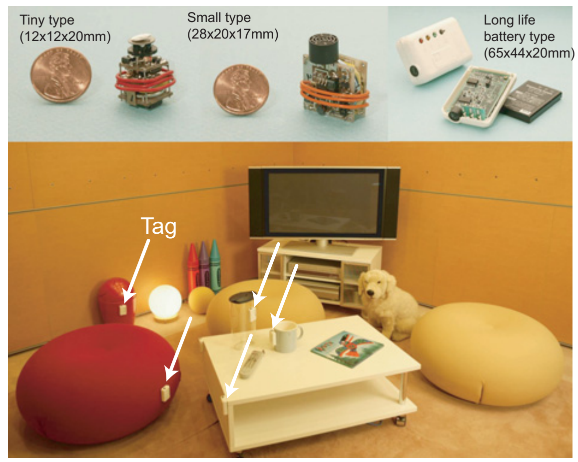

Fig. 4. Ultrasonic location system

The measured data are analyzed using captured images and trajectories data manually. We developed software for analyzing the data. The software has a function that helps the user to label behavior while replaying the captured images and trajectories. Kinds of the labels are behavior label, grasping object label and interest label. Behavior label is defined cutting out redundant behaviors and special behaviors from the Denver II and adding behaviors which is necessary for representing daily behaviors. Behavior labels are Sit, Stand, Walk, Run, Climb up, Climb down, Lie down, Roll over, Jump, Lean, Crawl and Fall down. As for grasping object label, name of toys and furniture is used as name of label and the label used for describing objects which infant grasps. As for interest label, name of objects which infant is interested in is used as name of the label. We estimate a point of beginning of infant interest tracking back from when infant grasps an object or when infant takes a behavior to an object and observing the line of sight.

We evaluated reliability [8] in intra-observer and inter-observer for confirming the reliability of labeling. We calculated Peasrson's correlation coefficients. The reliability of labeling is high because they are over 0.7 in both intra-observer and inter-observer.

b) Derivation of interest induction probability: Figure 5 shows the interest induction of an object in relation to the infant's distance from the object. The y-axis is calculated using the following equation to eliminate the effect of the arrangement of the objects.

$$P(Interest|Distance) = \frac{P(Interest \cap Distance)}{P(Distance)}$$

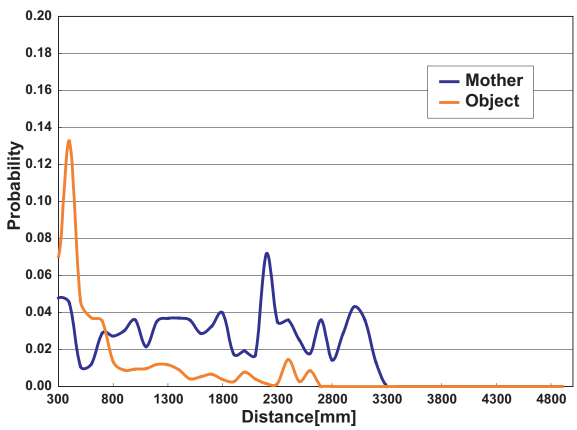

Fig. 5. Analysis of the interest induction of an object in relation to the infant's distance from the object

3) Modeling infant behavior by probabilistic integration: The developmental behavior and environmental interest induction models discussed in Sections 3.1 and 3.2 were used to create the infant behavior model shown in Fig. 13 in which an infant at a certain age in months or years would demonstrate a certain behavior at a certain time (t) in a certain environment. The model is expressed as the joint probability of a certain behavior ($Behavior_t$) at a certain time, environmental factors ($Variables_{env}$), and developmental behavior factors ($Variables_{dev}$), shown in Equation (1).

An application of the model assumes, for example, that the user uses the virtual environment in the computer to design a safe environment, freely arrange objects in the virtual environment, or set the monthly or yearly age of an infant to foresee the infant's behavior.

$$P(Behavior_t, Variables_{env}, Variables_{dev}) \quad (1)$$

Our work is based on the concept of affordance[9], and assumes that capabilities of infants emerge only in certain behavior among that induced by the environment. Modeling thus assumes that environmental and developmental behavior factors are independent parameters, i.e., Equation (1) can be rewritten as follows:

$$\begin{aligned} P(Behavior_t, Variables_{env}, Variables_{dev}) &= \\ P(Behavior_t, Variables_{env}) &\times \\ P(Behavior_t, Variables_{dev}) & \quad (2) \end{aligned}$$

Below we discuss the detailed environmental and developmental behavior factors and how to derive Equation (2).

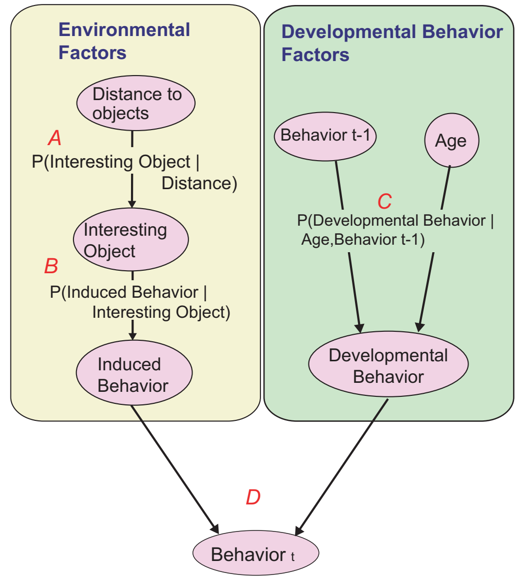

Fig. 6. Behavior generation procedures

4) Modeling of environmental factors: We select the distance ($Distance$) from an infant to an object and an interesting object ($InterestingObject$) as environmental factor variables ($Variables_{env}$) for modeling environmental factors in infant behavior generation and models behavior taken by the infant with age unspecified, i.e., modeling is done by deriving $P(Behavior_t, Distance, InterestingObject)$.

a) Interest induction model to objects (A in Fig. 13):: The probability of interest induction due to objects is related to multiple elements such as age and development, but it is difficult to deal with all at the present stage, so we focus only on major factors. As mentioned above, the distance from an infant to an object had the strongest effect observed among elements related to interest in objects. Assuming that the probability measure is affected only by the distance and that infants pay attention to a single object, conditional probability $P(InterestingObject|Distance)$ is used for modeling interest induction due to the object.

b) Object behavior induction model (B in Fig. 13):: Our work is based on the concept of affordance[9], and assumes that an interesting object induces behavior and that this interest is a major factor. Induced behavior is affected only by the object and conditional probability $P(InducedBehavior|InterestingObject)$ is used for modeling interest induction due the object. With this assumption, $P(Behavior_t, Distance, InterestingObject)$ is calculated as follows:

$$\begin{aligned} P(Behavior_t, Distance, InterestingObject) &= \\ P(Behavior_t|InterestingObject) &\times \\ P(InterestingObject|Distance)P(Distance) & \quad (3) \end{aligned}$$

5) Modeling of developmental behavior factors (C in Fig. 13): We select the age, in months or years, of an infant and behavior ($Behavior_{t-1}$) one-step preceding time as developmental behavior factor variables ($Variables_{dev}$) for modeling developmental behavior factors and models behavior taken by an infant of a certain age (Age), i.e., modeling is done by deriving $P(Behavior_t, Age, Behavior_{t-1})$. Assuming that the behavior possibly taken by infants of a certain age is mutually independent of behavior physically shown by infants from the behavior at time (t-1) one step before a certain time (t), the equation is deformed shown in Equation (4).

$$\begin{aligned} P(Behavior_t, Age, Behavior_{t-1}) &= \\ P(Behavior_t, Age) \times P(Behavior_t, Behaviort_{t-1}) &= \\ P(Behavior_t|Age)P(Age)\times & \\ P(Behavior_t|Behaviort_{t-1})P(Behaviort_{t-1}) & \end{aligned} \quad (4)$$

Conditional probability is detailed below.

a) Physical constraint in behavior transition: : If physical constraint in behavior transition is assumed to have Markoff's nature, the behavior at a certain time (t) is affected by that at time (t-1) one step before that time, written as conditional probability $P(Behaviort_t|Behaviort_{t-1})$.

b) Constraint by developmental degree of behavior: : For constraint by the developmental degree of behavior, factors other than age were taken into account when Denver II was developed as a checklist to determine the developmental stage of infants, as described. Because since the significance of age was the highest, the relationship between age and behavior was used[5]. We also pay attention to age as a major factor. We thus assume that the possible behavior taken by infants of a certain age is affected only by age. This is modeled as conditional probability $P(Behavior_t|Age)$.

6) Integration of environmental models and developmental behavior models (D in Fig. 13): Calculating Equation (2) is discussed below. Environmental and developmental behavior factors are as follows:

$$Variables_{env} = \{Distance, InterestingObject\} \quad (5)$$

$$Variables_{dev} = \{Age, Behaviort_{t-1}\} \quad (6)$$

Equation (2) can be rewritten as Equation (7):

$$\begin{aligned} P(Behavior_t, Distance, InterestingObject, & \\ Age, Behaviort_{t-1}) &= \\ P(Behavior_t, Distance, InterestingObject) \times & \\ P(Behavior_t, Age, Behaviort_{t-1}) & \end{aligned} \quad (7)$$

The following equation is found by substituting Equations (3) and (4) into Equation (7):

$$\begin{aligned} P(Behavior_t, Distance, InterestingObject, & \\ Age, Behaviort_{t-1}) &= \\ P(Behavior_t|InterestingObject) &\times \\ P(InterestingObject|Distance) &\times \\ P(Behavior_t|Age) &\times \\ P(Behavior_t|Behaviort_{t-1}) &\times \\ P(Distance)P(Behaviort_{t-1})P(Age) & \end{aligned} \quad (8)$$

For example, when the age (Age), behavior ($Behavior_{t-1}$) at one-step preceding time, and distance ($Distance$) to an object are given, this equation enables the probability of possible behavior ($Behavior_t$) by infant at the next time (t) to be calculated as shown below because Age, $Behavior_{t-1}$, $Distance$ are assumed to be independent.

$$\begin{aligned} P(Behavior_t, InterestingObject| & \\ Distance, Age, Behaviort_{t-1}) &= \\ P(Behavior_t, Distance, InterestingObject, & \\ Age, Behaviort_{t-1}) &/ \\ (P(Distance)P(Behaviort_{t-1})P(Age)) &= \\ P(Behavior_t|InterestingObject) &\times \\ P(InterestingObject|Distance) &\times \\ P(Behavior_t|Age) &\times \\ P(Behavior_t|Behaviort_{t-1}) & \end{aligned} \quad (9)$$

III. ACQUISITION OF PARENTS' AND CHILDREN'S INFORMATION BASED ON WEB CONTENTS

Our child's behavior model outputs next behaviors with probability by inputting child's are, current behavior and the relative distance between physical objects and the child. We realized visualization function of child's behaviors by building the model into Virtools, 3d game engine. As one of applications of child behavior simulator, creating child's injury scene is possible using the behavior model and visualization function. This is useful for supporting education of parents. Because raising parents' awareness to "unknown injury" is possible using injury scene animations created the simulator. We describe about the process of creating injury scene animation and the system for raising parents' awareness to unknown injury below.

A. Selection of injury scene and method in animation development

We created 114 animations, which we categorized into 28 (=4 x 7) types; 4 types are based on the age of the child (9 months, 1 year, 1.5 years and 2 years) and 7 types are based on the room in which the injury occurs (living room, kitchen, bathroom, washing room, restroom, veranda and entrance/stairs). We selected the above ages based on major changes in development according to the following list.

- 9 months old: crawls
- 1 year old : pulls themselves up, starting to walk
- 1.5 years old: walks steadily without supported
- 2 years old : runs

As for room type, we selected rooms that are present in a normal house. We must select the type of injuries based on the degree of severity or the frequency by analyzing injury data. However, there aren't any surveillance systems for overall injuries in Japan. Thus, we selected severe injury and high frequency injury based on injury data which is provided from a practicing pediatrician (Dr. Yamanaka). As for some injuries, it is difficult to depict danger in the animations, it is necessary to consider ethical issues such as the depiction of blood in order to realistically show the occurrence of injuries; such matters were not covered in this study.

In order to create injuries scene animations, it is necessary to use a 3D visualization engine, 3D model data for children, motion data for children and 3D model data for creating virtual environments. We used Virtools (Dassault Systems) for the 3D visualization engine, which we also used for developing child behavior simulator. Since there are no 3D child models available that reflect Japanese height, leg length, etc., we created our own models based on data (height, total head height, leg length and length of the upper extremity) that are used in the academic field of physical development [10]. Also, since there is very little children's motion data available, we used data that we obtained using a motion capture system. As it is difficult to obtain data for potentially dangerous actions such as tumbling, falling down, etc. we used the software package Endorphin (Natural Motion, Ltd.) which generates motion data based on muscle models and physical models. For creating the environment, we used an available furniture model for general furniture items, while we created our own furniture models for objects specific to children (e.g., baby beds, baby chairs, toys), objects specific to Japan (e.g., rice cookers, Japanese-style toilets, bowls of miso soup) and miscellaneous small items (e.g., fruit juice cartons, detergent packages, coins).

Fig. 7 shows some examples of injury scene animations created as above.

Fig. 7. Example of children's injury scene videos

B. Service offering injuries scene animations on the internet and collection of information of parents

In this study, we provide a service that makes childhood injuries scene animations available on the internet in collaboration with Benesse Corp.

On the internet site, by selecting the child's age (2-3 months, 4-5 months, 6 months, 7 months, 8 months, 9 months, 10 months, 11 months, 1 year, 1 year and 1-3 months, 1 year and 4-6 months, 1 year and 7 months - 2 years, 2 years and 1 - 6 months, 2 years and 7 months - 3 years) and developmental stage (roll over, sit/crawl, pull themselves up/walking with support/beginning to walk, walk by themselves/walk steadily and run/jump), the system provides animations of injuries that frequently occur to children of the specified age and developmental stage. After the animations have been viewed by parents, we ask the following questions and the parents select from the following options.

"Have you ever seen or heard about the injury depicted in this animation? Do you think that the possibility of this injury occurring in your house is high?"

1) I have seen or heard about this injury; I think the possibility of it occurring in the future is high.
2) I have seen or heard about this injury, but I think the possibility of it occurring in the future is low.
3) I have never seen or heard about this injury, but I think the possibility of occurring it in the future is high.
4) I have never seen or heard about this injury; I think the possibility of it occurring in the future is low.

We can obtain information about the age of the user's children and their developmental stage at that age from the inputted information. We can also acquire data related to users' awareness to various injuries from the questionnaire results. Thus we can collect useful data through our service without the user being aware of it.

For example, the probability of a child being at a certain developmental stage based on their age can be derived using the acquired data for their age and developmental stage. Furthermore, it is possible to investigate users' awareness concerning injuries from their responses to the questionnaire given after watching the animations. This gives us valuable knowledge for bridging the gap between the actual situation and the parent's perception, which will assist us in providing education for preventing childhood injuries. A good example of this gap between parent's perceptions and reality is given in a study by Kanti[11] where she found that parents watch a child very carefully when the child is alone, but they do not watch so carefully when two children are together since they think that this situation is safer. By contrast, injury data shows that the frequency of injuries occurring is greater when two children are together than when a child is alone. Kanti pointed out the importance of bridging the gap between parents' perception of the danger of injuries occurring and the actual probability.

For example, in our study, it can be regarded as a widespread perception that there is no gap between the awareness and the real situation for an injury for which many users select option "1)" in the questionnaire. If there is a high possibility of a certain injury occurring in the future, and yet many users select option "2", it is important to bridge this gap between common perception and reality. As for animations which many users select option "4)", it maybe necessary to reconsider the content itself. Thus, by continually repeating this evaluation and improving the contents sustainably, we are able to optimize the contents and provide the best support for educating parents.

IV. Utilizing Data Collected by this Service

Table I shows the number of users, the number of valid responses to the questionnaire for the internet contents described in section . In this section, we describe how the collected data can be utilized.

A. Derivation of prior probability of child's developmental behavior

The relationship between each developmental behavior (sitting, crawling, standing, walking, running, jumping) and the proportion of children that can take each that behavior

Number of times site was accessed (excluding multiple accesses)	4921
Number of times site was accessed (including multiple accesses)	79906
Number of valid responses for which age/developmental stage were input	4461
Number of times animations were downloaded	61024
Number of valid responses to questionnaire after viewing animations	21439

TABLE I
THE NUMBER OF ACCESSES AND VALID RESPONSES

for each age group can be derived using the following formula based on the data for the children's ages (Fig. 8) and the children's developmental stage that users inputted in our internet contents service. Figure 9 shows a derived result. This is useful for determining prior probability when modeling children's developmental behavior.

$$\frac{N\_Bi}{N\_All}$$

N_Bi: Number of children who can take behavior$_i$ at a certain age
N_All: Number of children in a certain age range

As similar knowledge, there is Denver II[5] which is a check sheet for checking developmental stage by medical practitioners; it was created based on data obtained from 1819 people. In this study we used the internet over about a year to collect data from 4921 people. Thus, by using the internet, it is possible to collect a considerable amount of data in a short period of time.

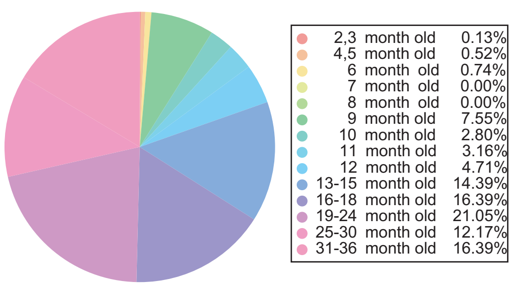

Fig. 8. Rate of age of users' children

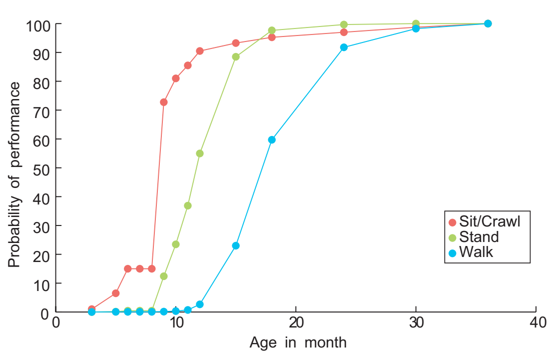

Fig. 9. Relationship between age and developmental behavior

B. Investigation of parents' awareness to injuries for optimizing contents

As we described in the preceding section, we conducted questionnaires for investigating parents' awareness to injuries after they had viewed animations on the internet contents service we created for providing childhood injuries scene animations. Figure 10 shows the results. The explanations of the text in the figure are given below. Based on these results it was found that about sixty percent of the animations we created were well known and perceived by parents.

1) Known injury ⇒ High probability: I have seen or heard about this injury; I think the possibility of it occurring in the future is high.
2) Known injury ⇒ Low probability: I have seen or heard about this injury; I think the possibility of it occurring in the future is low.
3) Unknown injury ⇒ High probability: I have never seen or heard about this injury; I think the possibility of it occurring in the future is high.
4) Unknown injury ⇒ Low probability: I have never seen or heard about this injury; I think the possibility of it occurring in the future is low.

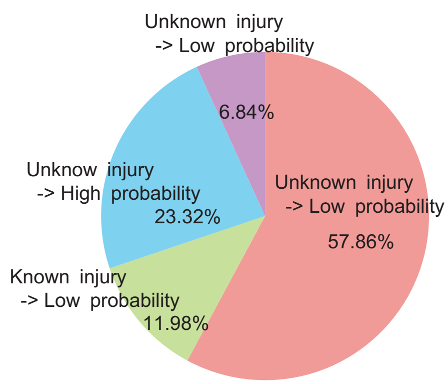

Fig. 10. Perception of childhood injuries

We assumed that the injuries depicted in all animations were well known high and had a high possibility of occurring, since the injuries were selected on the basis of injury data collected by Dr. Yamanaka. Furthermore, if we assume that no gap exists between perception and reality only for the animation which users selected "I have seen or heard about this injury; I think the possibility of it occurring in the future is high" and that there is such a gap when the other three options are selected, the perception of each animation could be assessed using the following formula. In the formula, the weight given to an animation depicting a recogized injury is 1 while the weight given to an animation depicting a unrecognized injury is -1.

$$Visibility = \frac{KH_i}{V_i} - \frac{KL_i}{V_i} - \frac{UKH_i}{V_i} - \frac{UKL_i}{V_i}$$

Vi: The number of times the i th animation was viewed

The number of responses for each option in the questionnaire for i th animation
KH_i: Known Injury ⇒ High Probability
KL_i: Known Injury ⇒ Low Probability
UKH_i: Unknown Injury ⇒ High Probability
UKL_i: Unknown Injury ⇒ Low Probability

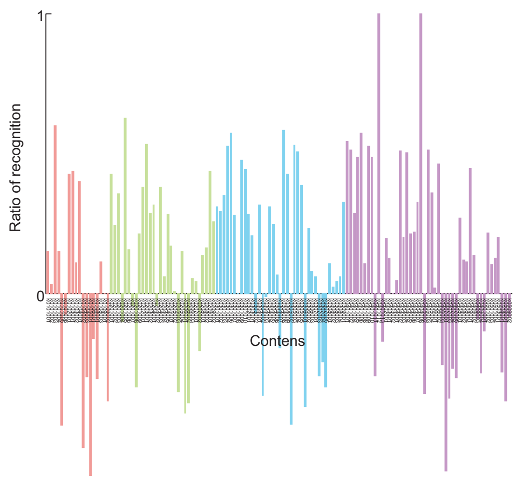

Fig. 11. Recognizability of injury scene videos

The results of calculating the recognizabilities using the equation are shown in Fig. 11. Some of the injuries that had low recognizabilities are listed below.

1) Mother put a 9 month old child on the cover of a bathtub, the child fell down while mother was cleaning.
2) An 18 month old boy stepped on a shampoo bottle in the bathroom, lost his balance and fell down.
3) An 18 month old boy was interested in the washing machine. He tried to look inside by climbing on a cardboard box. He lost his balance and fell into the washing machine.
4) An 18 month boy climbed onto the toilet seat and attempted to jump, but lost his balance and fell down.

We investigated in detail parents perception of the first injury, since many parents responded ”Unknown Injury ⇒ Low Probability”. Since this injury is classified as a typical bathroom injury in some books, it is considered to be an injury that has a probability of occurring. But we conjecture that the action of a mother putting a child on the cover of the bathtub while cleaning was considered by many to be unrealistic. As for second, third and fourth injuries, many parents responded ”Unknown Injury ⇒ High Probability”, indicating these are injuries for which there is a gap between perception and reality.

Thus, by not only providing animations depicting occurrences of injuries but also using the results of the questionnaire, we can evaluate which animations are useful for bridging the gap between perception and reality and which are effective for educating parents, and on the basis of this information we can update and improve the quality of the online content. Currently, we use subjective analysis, but we are attempting to establish a computation theory for optimizing the online content by incorporating injury data collected by an injury surveillance system which is being developed in our research group. This will allow us to calculate the recognizability of injuries quantitatively.

V. Conclusion

The authors described that it is important to develop information to offer sustainably and to acquire personalized knowledge dynamically through interacting with users the system with computational intelligence. We proposed a system with like this frame for preventing child's injury as an example of concrete application and carried out out feasibility study of the system.

We proposed that the system which is possible to provide injury information and educate parents, to collect users' information and to update contents using the feedback data collected by providing injury scene videos on the web. For creating the system, child's behavior model for generating behaviors based on age and environment and computational model for evaluating and optimizing the quality of contents based on feedback data are necessary.

We developed the child behavior simulator by modeling child's developmental behavior and environment compositely. We realized the function for visualizing child's behavior by building the simulator into the 3d game engine. We described about the service for providing injury scene videos created using the simulator on the web and how to collect users' data. By using collected data, we derived the relationship between age and developmental behaviors for using behavior model as the prior probability of developmental behavior and calculated visibility of each video for optimizing contents.

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