

Representation and Statistical Analysis of Childhood Injury by Bodygraphic Information System

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1 Introduction

Representing medical information of the human body in a standardized and structured form is important for advancing the science and technology of humans such as injury science that this paper focuses on. However, we still do not have a good tool for this purpose. The authors have proposed a useful technology, "a bodygraphic information system" (BIS), that represents human body information by associating the information with a human body coordinate system (Tsuboi, Nishida, Mochimaru, Kouchi, & Mizoguchi, 2008). The concept of BIS is similar to the geographical information system (GIS) (Heywood, Cornelius, & Carver, 2006). BIS enables accumulation, retrieval, sharing, statistical analysis, and integration of human body information across different fields such as medicine, engineering, and industry. To present the usefulness of the implemented BIS, this paper describes application of the proposed system to a field of public health on childhood injury prevention (World Health Organization, 2006; Hyder, 2006; Peden et al., 2008) and reports new statistical analyses of childhood injuries based on a large amount of injury data collected in a hospital.

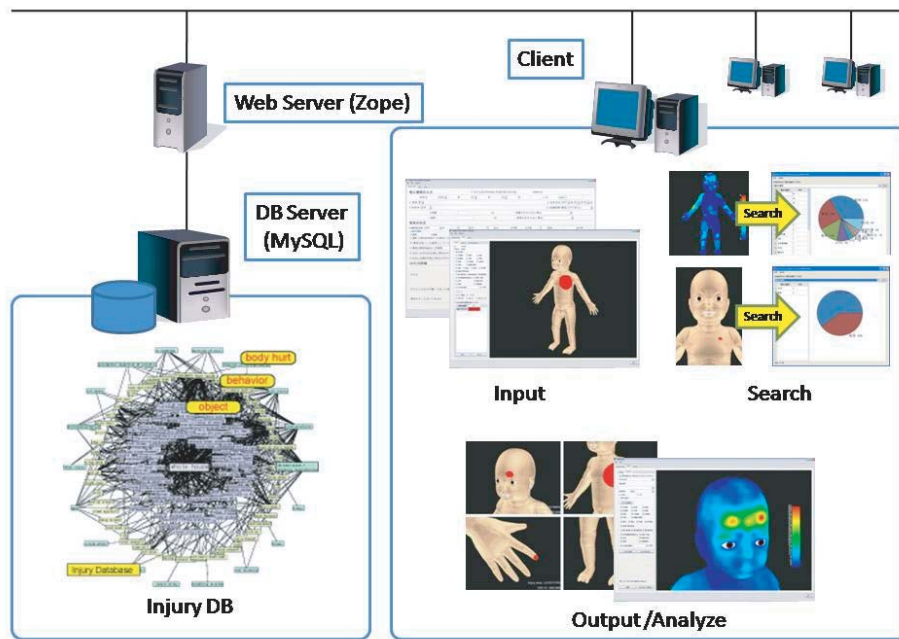


Figure 1: Bodygraphic Injury Surveillance System, which is Application of Bodygraphic Information System

2 Bodygraphic Injury Surveillance System

2.1 Configuration of Bodygraphic Injury Surveillance System

Figure 1 shows the system configuration of the developed system in which a bodygraphic information system is applied for childhood injury surveillance. The bodygraphic injury surveillance system(BISS) consists of an injury database system, a web server, and a client software. The client part of the BISS has four functions: input, retrieval and analysis, database construction, and visualization. In BISS, we can input information by typing in text data or outlining on a three-dimensional human body model with a computer mouse, and then the input data is digitized into a raster model and relevant information can be obtained. All input data is stored in a database for retrieval, analysis, and visualization according to need.

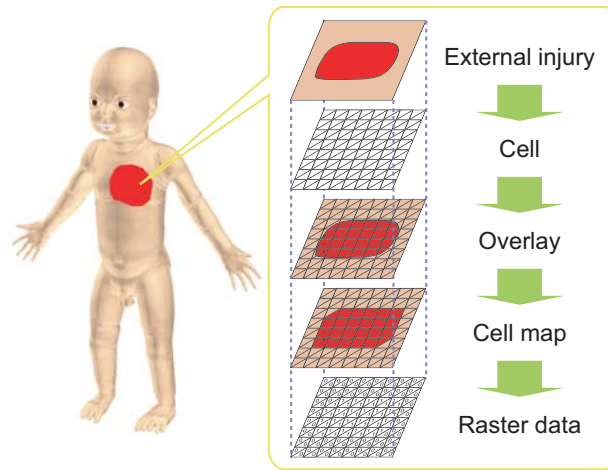


Figure 2: Representation Model by Raster Data

2.2 Representation of Injury Data on BISS

Injury information has three classifications of information: location, shape, and attribute. In the BISS, this information is raster data that is structured as multi-layers based on the location on the human body, as shown in Figure 2. In this paper, raster data indicates an injury as a set of cells sectioned on the body surface. Each cell has a coordinate value in the human body coordinate system. Figure 2 shows input injury data converted to raster data. The injury data is overlaid on cells of the body surface and converted into a cell map. Each cell has information on the type of injury and the degree of severity along with the coordinates in the human body coordinate system.

2.3 Fundamental Functions of BISS

Bodygraphic Injury Surveillance System has the following functions: 1)input/output function, 2)information retrieval function, 3) ICD-10 Code Conversion Function, and 4)statistical analysis function.

As for the function 1), using the BISS, shape data of an external injury is drawn on the three-dimensional human body model with a computer mouse and other text data is typed in with a keyboard. The input injury data is converted to raster data and stored in a database system. Since the standard human body model is used, injury data is normalized.

As for the function 2), the BISS can retrieve target injury data by a spatial query and a text query and show the visual result. For example, by giving "1 year old" and "scald" as text queries, the BISS retrieves all scald data of 1-year-old children. By drawing a spatial query with a computer mouse, the BISS retrieves all injury data of the target body part.

As for the function 3), The International Statistical Classification of Diseases and Related Health Problems (ICD-10), established by the World Health Organization (World Health Organization, 1992), is an international statistical standard of the cause of death and disease. ICD-10 codes include items concerning injuries due to external causes; these items are defined by both the type of injury and the injured body part. ICD-10 codes are widely used at medical institutions worldwide. So, we implemented a BISS function that converts input injury information into ICD-10 codes.

The function 4) is explained in details in the next section.

3 New Statistical Analysis and Injury Modeling by BISS

In order to show the effectiveness of the BIS, we next present three kinds of statistical analyses. We collected 3,585 cases of injuries in children of ages 0 to 18 years in cooperation with a hospital (National Center for Child Health and Development) since 2006. In the following subsection, we describe statistical analyses using the collected data.

3.1 Bodygraphy of Injury Frequency

As one example of data visualization using the BIS, Figs. 3 show injury frequencies visualized by the BISS. Since each instance of injury data is expressed in a normalized and structured form in the BIS, we can superimpose data and count frequencies by summing the data. In the figures, a red color indicates the area with the highest frequency of external injury. It is confirmed that the forehead is a significant high-frequency area. Although the fact that the head part is the most frequently injured is well known in the field of child injury prevention, the BISS allows us to conduct much more extensive analyses of injured body parts. As shown in Fig. 4, we can retrieve and visualize only necessary data on demand. Part A of the figure visualizes the bodygraphic frequency of scald injury, Part B is

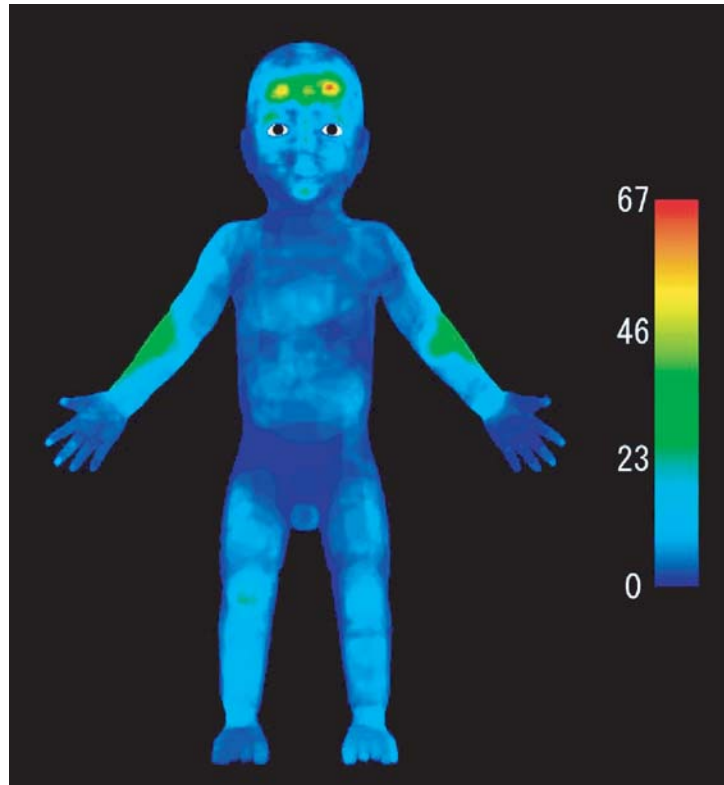


Figure 3: Injury Frequency (Front)

the frequency of injury due to fall by children aged from 1 to 2 year-old, Part C is the frequency of injury due to a slide type of playground equipment, and Part D injury due to all kinds of playground equipments. These analyses would be useful for not only initiating injury science but also designing effective protection, such as helmets.

3.2 Statistical Test Concerning Symmetry of Injury Part

We can conduct another statistical analysis using the BISS. Here, we describe a statistical test with respect to the symmetry of injuries on a human body. To evaluate whether injury frequency is symmetric with respect to the center of the body, we conducted a chi-square test of injury data. Table 1 shows p-values of the chi-square test according to body part. This figure shows that the head and upper

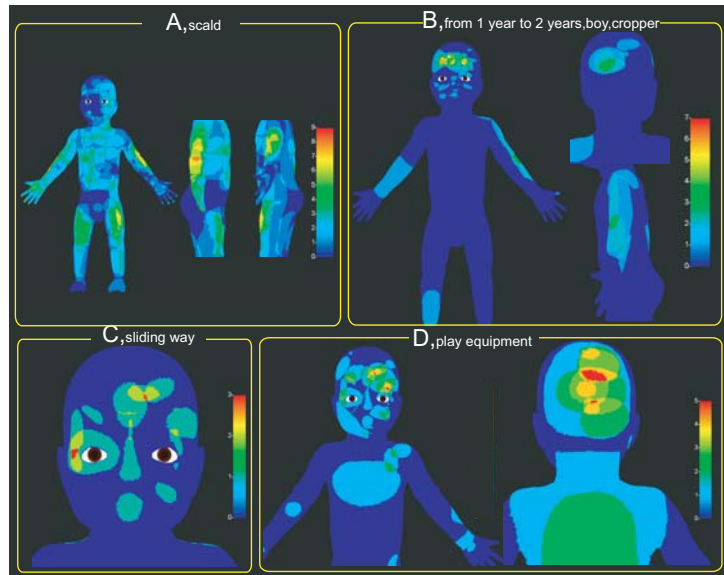


Figure 4: Examples of Injury Retrieval and Frequency Visualization

thigh are significantly asymmetric at the 5% level. In this way, the BISS allows us to conduct a statistical analysis.

	Right	Left	Sum	P-Value
Head	693	792	1485	0.010
Neck	7	7	14	1.000
Thorax	18	12	30	0.273
Abdomen	20	28	48	0.248
Upper Arm	31	27	58	0.599
Forearm	104	117	221	0.382
Hand	138	113	251	0.115
Upper Thigh	55	32	87	0.014
Lower Thigh	40	30	70	0.232
Foot	46	56	102	0.322
Total	1152	1214	2366	0.202

Table 1: Frequency and p-Value of Injury of Each Body Part

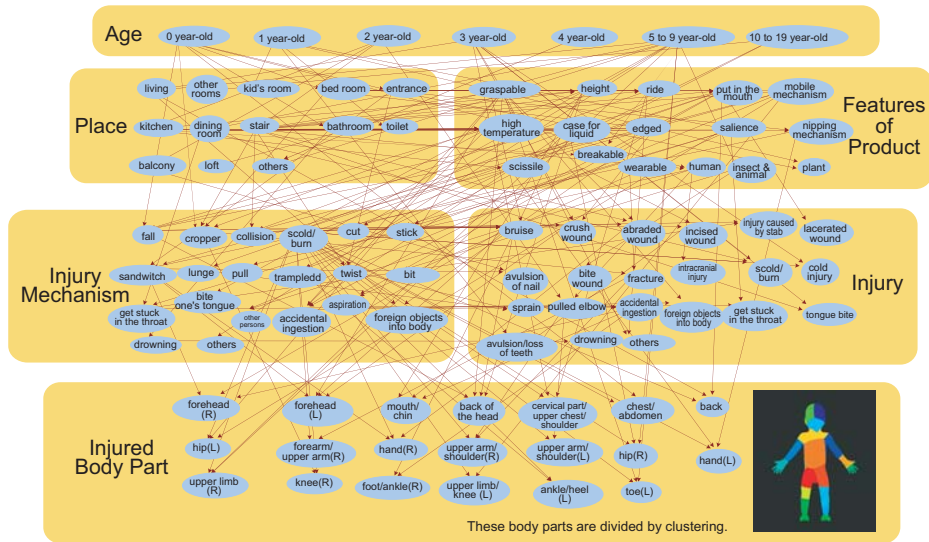


Figure 5: Probabilistic Causal Structural Model of Injury

3.3 Injury Modeling by Bayesian Network

Clarifying the relation among design parameters and injured body regions is useful for improving consumer products. For that purpose, we conducted injury modeling to find a causality model between the attributes of accidents and injured body parts by using the Bayesian Network.

Figure 5 is an example of injury modeling. This figure shows the probabilistic causal structural model of the relation between body parts and accident type, such as falling and scald. Figure 6 shows an example of the results of inference by the constructed model given the conditions of A (age = 0 year-old, place = dining room, object = chair), B (age = 1 year-old, object = door), C (place = living room, object = liquid with high temperature such as coffee) and D (object = cutting tool).

4 Conclusion

This paper proposed the concept of a bodygraphic injury surveillance system (BISS) that represents human body information in a normalized and structured form by associating the information with a human body coordinate system. As an

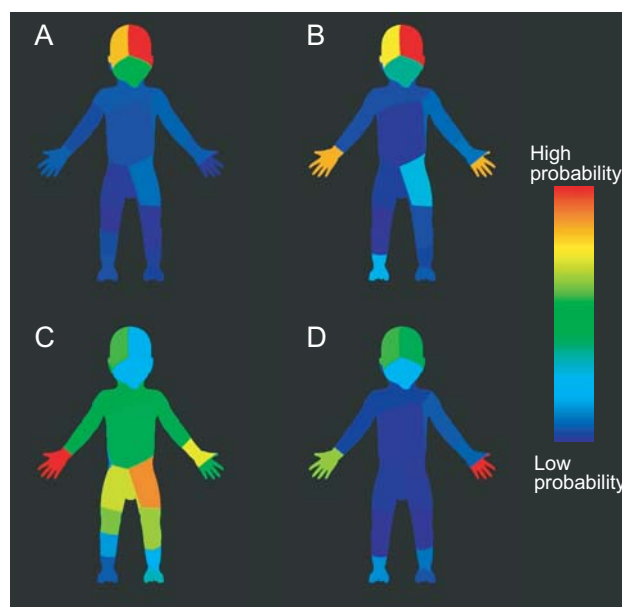


Figure 6: Inference Example of Injured Part

example, we described an application of BISS by using child injury data. We presented data visualization and analyses using BISS. It is the first system to express detailed positions and shapes of external injury data and to analyze the frequency of injuries statistically based on collected data. Thus, the BISS enables us to collect and manage detailed information of external injuries that are difficult to do with conventional methods. This BISS application will open the way for injury science. The authors started disseminating a client BISS software in which a part of functions stated in this paper was available on February 11, 2009¹.

References

- Heywood, I., Cornelius, S., & Carver, S. (2006). *Geographical information systems, 3rd ed.* England: Pearson Education Limited: Harlow.
- Hyder, A. (2006). Childhood injuries: Defining a global agenda for research and action. *Journal of Injury and Violence Prevention, 4*(1), 87–95.

¹At this moment, only the Japanese version is available from the following URL <http://www.cipec.jp/project/index.html>

- Peden, M., Peden, M., Oyegbite, K., Ozanne-Smith, J., Adnan A. Hyder, C. B., Rahman, A. F., et al. (2008). *World report on child injury prevention*. Switzerland: WHO Press.
- Tsuboi, T., Nishida, Y., Mochimaru, M., Kouchi, M., & Mizoguchi, H. (2008). Bodygraphic information system. In *Proc. of the 9th world conference on injury prevention and safety promotion* (p. 79).
- World Health Organization. (1992). *ICD-10: The ICD-10 classification of mental and behavioural disorders : Clinical descriptions and diagnostic guidelines*. Switzerland: WHO Press.
- World Health Organization. (2006). *Child and adolescent injury prevention: A who plan of action 2006-2015*. Switzerland: WHO Press.