Design of safe consumer product based on children behavior model constructed from behavior observation: case study of playground equipment

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Project page:
http://www.cipec.jp

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Recent trend of cause of child death

The leading cause is unintentional injury (accidents)

- 959 children (<19 year-old) died per year in Japan

<table>
<thead>
<tr>
<th>Age</th>
<th>First (%)</th>
<th>Second (%)</th>
<th>Third (%)</th>
<th>Forth (%)</th>
<th>Fifth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Birth defect (35.1)</td>
<td>Respiratory disturbance (14.1)</td>
<td>Sudden death syndrome (5.7)</td>
<td>Unintentional injuries (4.9)</td>
<td>Fetal hemorrhagic disorder (3.9)</td>
</tr>
<tr>
<td>1-4</td>
<td>Birth defect (17.7)</td>
<td>Unintentional injuries (16.4)</td>
<td>Malformation neoplasm (9.6)</td>
<td>Heart disease (7.2)</td>
<td>Pneumonia (4.8)</td>
</tr>
<tr>
<td>5-9</td>
<td>Unintentional injuries (25.8)</td>
<td>Malformation neoplasm (20.8)</td>
<td>Heart disease (7.3)</td>
<td>Birth defect (5.4)</td>
<td>Neoplasm (5.2)</td>
</tr>
<tr>
<td>10-14</td>
<td>Malformation neoplasm (19.5)</td>
<td>Unintentional injuries (18.9)</td>
<td>Suicide (11.3)</td>
<td>Neoplasm (7.0)</td>
<td>Heart disease (6.0)</td>
</tr>
<tr>
<td>15-19</td>
<td>Unintentional injuries (31.2)</td>
<td>Suicide (31.2)</td>
<td>Malformation neoplasm (9.7)</td>
<td>Heart disease (4.8)</td>
<td>Cerebrovascular disease (2.6)</td>
</tr>
</tbody>
</table>

(2009, Japan)
### Products related to injury

<table>
<thead>
<tr>
<th>Products</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Bicycle</td>
<td>7.9%</td>
</tr>
<tr>
<td>2nd Stair</td>
<td>7.1%</td>
</tr>
<tr>
<td>3rd Chair</td>
<td>6.7%</td>
</tr>
<tr>
<td>4th Playground</td>
<td>5.9%</td>
</tr>
<tr>
<td>5th Bed</td>
<td>5.1%</td>
</tr>
</tbody>
</table>

Data: 8,334 cases  
(November, 2006 to October, 2009)
New design approach

Consumer product design based on everyday life behavior modeling
Ubiquitous Sensor
for observing everyday life behavior

- Observe child’s everyday behavior data by sensorizing home environment
- Develop quantitative model of child behavior

Ultrasonic location sensor (ultrasonic, low-cost GPS)
Wearable Sensor for observing everyday life behavior

- Observe child’s everyday behavior data by attaching small device onto child body
- Develop quantitative model of child behavior

Wearable EMG sensor for child (small, wireless EMG)

For example,
- How many times does child grasp?
- How many times does child fall?
- When does child perform a certain behavior?
Case study: behavior-model-based playground equipment design

“Stone wall” type of play equipment

50 children (3 to 6 year-old)

Ultrasonic 3D Tag (location sensor) + Wearable EMG (physiological data)
Data collection in kindergarten

In Situ Measure “Playing” Child
(location, EMG, and image sensor)

3D Shape Model
(3D Laser Scanner)
Playing Behavior Model

Bayesian network

Variables related to posture
Other variables
Simulation of Playing Behavior

New design

Terrain map

Easy part

Difficult part
New design of playground equipment based on child’s behavior mode

New stone wall play equipment

Kuwanomi kindergarten
Evaluation

- 4 Cameras were installed

Probability of Location

Behavior data were accumulated for 3 years since Sep. 2007

- About 30% behavior are predictable using the model.
- So far, there have been no serious injuries due to fall for 3 years.
Summary

- New design approach
  “Behavior model based approach”

- New sensing and modeling technology
  - Ubiquitous sensing technology and wearable sensing technology
    (e.g., low-cost location sensor, tiny EMG sensor)
  - Probabilistic modeling technology
    (e.g., large-scale Bayesian network)

- Case study of designing playground equipment using the proposed approach