

A Playful Toothbrush to Motivate Proper Brushing for Young Children

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Abstract. We have explored the design of a playful toothbrush to assist parents in motivating and getting their young children into a habit of proper and thorough tooth brushing. Our system includes a vision-based motion tracker that recognizes different tooth brushing motions, and a fun tooth brushing game in which a young child cleans a virtual picture of his/her dirty teeth by physically brushing his/her own teeth.

1 Introduction

Proper brushing is essential for cleaning teeth and gums effectively and for maintaining oral hygiene [1]. For many parents, tooth brushing is a required routine for young children before bedtime. However, it is by no means an easy task for parents to get their young children into a habit of brushing their teeth *properly* and *thoroughly*. Several commercial products have been developed to entice a child to tooth brushing, such as sugary toothpaste from Colgate [2], the music-rewarding ToothTune toothbrush from Hasbro [3], etc. Although these products can attract a child's interest in brushing, but they still fall short of getting a child to brush properly and thoroughly. American Dental Association (ADA) recommends proper brushing methods for different groups of teeth [1]. For examples, the outer and inner tooth surfaces should be brushed with a back & forth circular motion, the chewing surfaces of the teeth should be cleaned by holding the brush flat and moving in backward and forward motion, etc.

In this work, we would like to adapt Ubicomp and persuasive technology to help young children learn and develop proper tooth brushing habit as recommended by ADA [1]. Our system is based on the principles of pediatric occupational therapy in which "play is a child's way of learning and an outlet for his innate need of activity" [4]. By embedding an interactive game into a young child's tooth brushing activity, we can make the tooth brushing activity playful to engage the young child into active participation and learn proper tooth-brushing method.

We would like to distinguish between two purposes of the playful toothbrush. First, for children who dislike brushing their teeth, the goal of our playful toothbrush would

be to attract them to perform this task, which is similar to the Hasbro’s ToothTune [3]. For children who already have the habit of brushing teeth routinely but not brushing properly and thoroughly, the goal of our playful toothbrush would be to teach them how to brush their teeth properly and thoroughly. These two purposes are not at the same level and *require different strategies in game design*. For the former purpose, the game should be simple and playful in order to attract children to perform the task of brushing teeth. For the latter purpose, the game needs to engage children to learn brushing teeth properly. To design the game, we not only have to motivate children to do the activity but also need to take into account the requirement of cognitive function for children to learn the proper brushing method through the game. To achieve the learning part, we need to apply teaching-learning theory, such as information processing [5], into the game design. The technical part of our system is consisted of (1) a vision-based brushing motion tracker to recognize child brushing motions, and (2) a playful game to guide and reward proper brushing motions to a child.

Recently, several related projects are embedding digital persuasion into everyday objects for a variety of human behavior modifications. Examples include the “Tooth Tunes” tooth brush [3], the playful eating tray [6], the ViTo TV remote [7], the nutritional-aware kitchen [8], etc. Our playful toothbrush shares a similar goal of adapting technology into human behavior change. However, since a different behavior is targeted, it has different design and technical considerations.

2 Preliminary Design and Implementation

Our system contains the following HW/SW components shown in Fig. 1: (1) a *toothbrush extension* is coded with different LED marker patterns on its four faces to aid the vision-based motion recognition, in which the brush extension can be attached to the end of a child’s standard toothbrush; (2) a *single-camera vision system* captures the top-down view of brushing motions; (3) a tooth brushing game on a LCD display takes a child’s physical brushing motions as game inputs. We will first describe the vision-based brushing motion recognition, followed by the tooth brushing game.



Fig. 1. On the left shows the camera positioned at the top of a child’s head. In the middle is the brush extension with LED marker patterns that can be attached to the end of a toothbrush. On the right shows a child using the playful toothbrush.

Brushing motion recognition. The vision-based approach is adapted to recognize 11 different brushing motions, in which each motion corresponds to brushing a different part of teeth shown in Fig. 2 (a). To recognize these brushing motions, a web camera positioned above a child’s head is used to capture the top-down view of the toothbrush extension. Four rectangular faces (denoted as *A*, *B*, *C*, and *D* on Fig. 2(b), where the face *A* is the same side as the toothbrush bristles) of the box-shaped brush extension are coded with LED markers showing unique patterns distinguishable from computer vision. By analyzing the 2D images from the camera, the orientation of the brush extension and bristle can be reconstructed; furthermore, a child’s current brushing motion can be determined. Consider the example in Fig. 2, to recognize Motion #1 (brushing outer left teeth), the top-down view from the camera would see the brush extension’s face *B*. In addition, the face *B*’s 2D orientation on the flat plane, which can be calculated from the orientation of the LED marker pattern, should fall within 90~130 degrees angle. Since the brush extension’s orientation tells which direction the toothbrush bristle is pointing at, we can infer the target group of teeth being brushed.

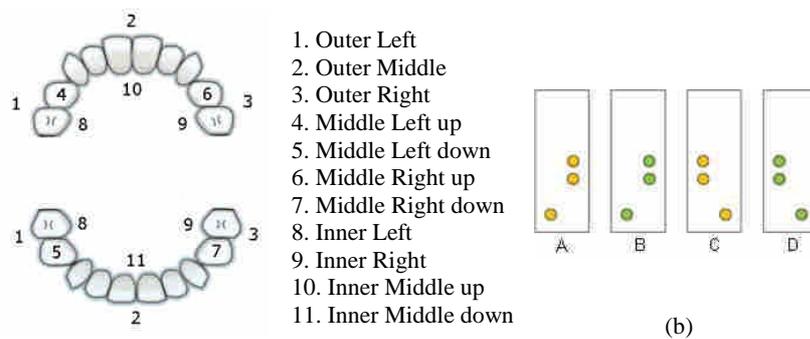


Fig. 2. On the left shows eleven brushing motions corresponding to different groups of teeth. On the right shows four LED markers encoded on the four faces of the brush extension.

Preliminary results. A preliminary experiment was conducted to evaluate the accuracy of our system. The results of three real teeth brushing sessions are shown in Table 1. The *total time* is the time duration of each teeth brushing session, the *error time* is the amount of time when our system fails to recognize correct brushing motions, and the *recognition accuracy* is the percentage of time our system correctly recognizes brushing motions. The average accuracy is 97%, which is high. However, since the tested subjects are adults, not young children, our future work will conduct real tests on young children.

Tooth brushing game. The current game design starts with a virtual picture of dirty teeth shown in Fig 3. The goal is for a young child to thoroughly clean these virtual dirty teeth using his/her own physical tooth brushing motions as game inputs. For example, while a child is brushing his/her outer left group of teeth, it is mapped to cleaning the virtual outer left group of teeth in the game with visible spots of plaques

falling off. Fig. 3 shows two game screenshots. The child needs to finish cleaning all the spots of plaques on a virtual picture of his/her dirty teeth to win the final applause.

Table 1. The error time and the recognition accuracy of the experiment

Sessions	Error Time (sec)	Total Time (sec)	Recognition Accuracy
1	4.5	129	96.5%
2	3	123	97.6%
3	3.7	142	97.4%

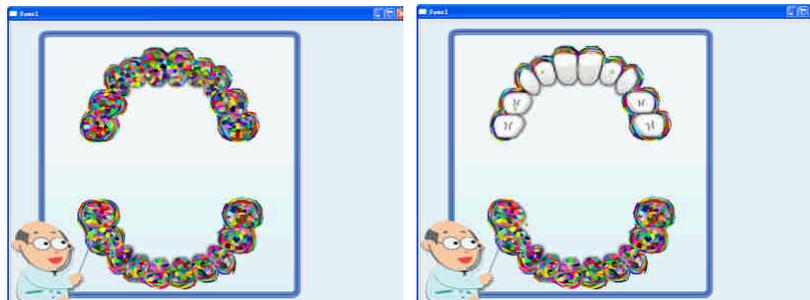


Fig. 3. Two game screenshots: on the left shows dirty teeth at the start of the game, on the right shows when a child is brushing the front biting surface of the teeth.

3 Future Work

Our future work will conduct user study on young children to evaluate effectiveness of our system in changing young children's brushing habit. We are interested in comparing effectiveness between the traditional dental teaching methods versus our tooth brushing game. Furthermore, we will explore different possible designs of tooth brushing games, perhaps creating different versions for boys and girls.

References

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