Immersive Game for Dental Anesthesia Training with Haptic Feedback

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Figure 1: (a) syringe movements B-Splines; (b) visual and tactile assistance; (c) head model; (d) HMD and haptic device.

ABSTRACT

Training anesthetic application is a challenge for teaching dentistry, given the complexity of the procedure and the risks involved. Through an immersive virtual reality environment, the system presented here offers a playful way of learning, through game elements. This serious game allows the user to practice anesthesia technique with or without aids (tactile or visual) and to receive scores at different levels of difficulty. An important differential is the possibility of the syringe being driven automatically (tactile aid) in order to reproduce trajectories inserted by experienced instructors. Thus, the student can feel as if the instructor was conducting the learner's hand while guiding her or him.

CCS CONCEPTS

• **Applied computing** → **Education**; *Health informatics*; • **Human-centered computing** → *Gestural input*;

KEYWORDS

Simulation, Virtual reality, Dentistry, serious game. gamification

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1 INTRODUCTION

For performing dental procedures of anesthesia, sensory-motor coordination is fundamental [Luck et al. 2000], as well as a deep knowledge of anatomy and physiology of the buco-maxillary region, which requires intense training. However there are many challenges preventing students from having training situations closer to the reality of an actual dental office. In general, mannequins or mechanical simulators are used, but they are very far from the experience of applying anesthesia to a real patient. Simulators with haptic interfaces [Poyade et al. 2014] [Corrêa et al. 2018] help in the development of tactile skills, but the existing ones are neither immersive nor offer evaluation and aid in the execution of the trajectories of instruments by the learner. In this context, an immersive and haptic environment for anesthesia training of the inferior alveolar nerve called VIDA Odonto [Tori et al. 2018] was developed at the Interlab (Laboratory of Interactive Technologies) of the School of Engineering (Escola Politécnica) of USP, with FAPESP funding, in a collaboration with the LaSiT (Laboratory of Simulation and Training) of the School of Dentistry of Bauru (FOB-USP) and LApIS (Laboratory of Computer Applications in Healthcare) of the School of Arts, Sciences and Humanities (EACH-USP). Although this system helps to solve the mentioned problems, there is room for improvement, such as the inclusion of gamification elements to make it a serious game [Ribeiro et al. 2017] as well as visual and tactile aid. So, we developed a serious game for training conducting needle trajectories that allows students to practice anesthesia technique with or without aids (tactile or visual) and receive scores at different levels of difficulty. An important differential is the possibility of the syringe being driven automatically (tactile aid) reproducing trajectories previously recorded by instructors. Thus, the learner can feel as if the teacher was aiding his/her hand while performing the trajectory.

2 THE GAME

The game is able to record the syringe movements generated during the plays, allowing the user to review them (Figure 1a). Two kinds of assistance are available for the player: visual and tactile [Ribeiro et al. 2018]. The tactile aid is generated from the Geomagic Touch haptic device (Figure 1d), which produces force feedback to guide the user in conducting the ideal trajectory for the applying dental anesthesia. The ideal trajectory is captured by recording a set of points in a syringe trajectory while an expert performs the anesthetic procedure. The raw data are filtered to remove redundant points (overlapping or being very close to existing ones) as well as points located very far from the head. After this, the set is divided into two subsets: points recorded before (forward trajectory) and points recorded after (return trajectory) the insertion of the anesthetic. Each subset is fitted in a B-Spline curve and for each pair of points of that curve a cylinder is rendered (Figure 1b) representing that curve segment, with length equal to the distance of the points and adjustable thickness, according to the intended difficulty. Each cylinder has a collider, able to perceive the touch of the needle tip, and a color, initially blue. For the user to achieve satisfactory performance in the trajectory, he/she must go through the cylinders sequentially. If a cylinder is touched correctly, it will be marked green or yellow, depending on the angle of the syringe. Otherwise, it will be marked with red color. If haptic aid is selected, a force is created from the vector subtraction of the position of the tip of the syringe and the center of the next cylinder to be touched. The visual immersion is provided by an HMD (Head-mounted display) Oculus Rift. The virtual camera was placed close to the head, as this allows the user to appropriately orient himself/herself as soon as the game begins. The HUD (head-up display) of the game remains in a plane close to the head, where it is located the user point of interest. The interface contains elements such as score, alerts, timer and errors log, as well as the requirements needed to pass the current level. Figure 1d shows the user's viewpoint. The 3D modeling and texturing of the virtual head (Figure 1c) was created starting from the bony structure of the skull, which then received layers of facial tissues, such as muscles, vases and nerves, present in the maxillary region of a typical boy in the 7-12 age range [Tori et al. 2018]. The physical and real characteristics presented by each tissue (soft tissues, muscles, nerves) were taken into account to realistically simulate the face anatomy.

3 THE GAMIFICATION

The game elements and strategies implemented were [Ribeiro et al. 2017]:

- flow of the game and dynamics of the procedure (Figure 2);
- scores (successes and errors), time counting and error log;
- levels, with varying difficulties for each scoring metric;
- icons, informational sounds, background music, and identification of irregular punctures;
- visual assistance for executing the task;
- ranking, both personal and general;
- achievements and Trophies;
- main menu: levels, instructions, ranking and login screen;
- Mouse and keyboard option for respectively controlling the syringe movement and the anesthetic release.

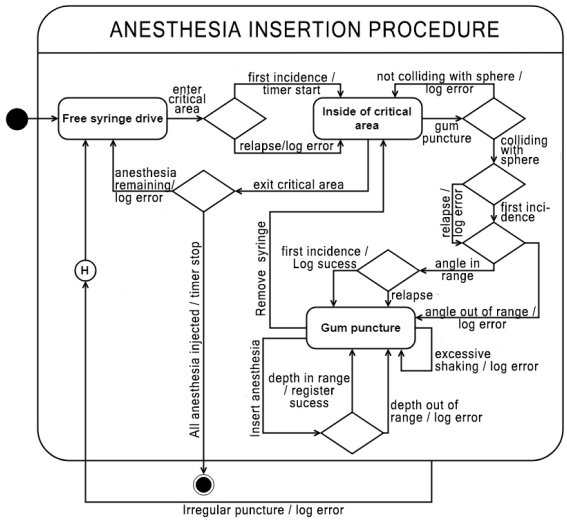

Figure 2: Game Flowchart [Ribeiro et al. 2018]

4 FUTURE WORKS

Our next step is performing three kinds of experiments: a) technical validation of the game by dental professionals; b) validation, by professors, students and professionals, of: learning effectiveness related to aspects of immersion as well as visual and haptics aids; and the game play and the interface effectiveness. Based on the results of the experiments, a new version of the game will be developed both the game play as a pedagogical tool.

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