DESIGNING A LOW-COST SIMULATOR FOR ULTRASOUND-GUIDED LIVER BIOPSY WITH INERTIAL TRACKING TECHNOLOGY

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Abstract

This project explored how to integrate smartphone inertial tracking technology and virtual 3D anatomical models in creating a biopsy simulator for ultrasound- guided liver biopsy. The prototype simulator allowed the virtual ultrasound probe and biopsy needle to be tracked by the smartphone's built-in inertial tracking system and ultimately allowed the trainee to control the movement of the virtual probe and needle in a manner similar to a real biopsy technique. It offers a promising low-cost option for simulating medical procedures with motion tracking functionality while maintaining realism to a certain degree.

Introduction

Physician workforce diversity is critical in ensuring medical care equity. Unfortunately, radiology is among the many medical professions that continues to lack workforce diversity. This is due to several reasons, one of which is insufficient specialty exposure.[1] Early exposure programs such as student interest groups have been shown to help recruit underrepresented students into the radiology profession, therefore potentially mitigating the ethnicity- and gender-based diversification barriers.[2]

As one of the most routinely performed procedures in radiology, ultrasound-guided biopsies should be demonstrated in early exposure programs. A biopsy is a procedure where a small sample of tissue is removed from the living body for further pathological diagnosis.[3] An ultrasound is commonly used during the biopsy procedure to increase sampling accuracy.[3] This procedure is often demonstrated to trainees through the use of simulators. Currently existing training simulators balance realism versus cost.[4] Simulators with high realism are shown to better facilitate learning, however, they are usually designed for advanced learners after they enter the radiology specialty.[5] In addition, the devices used in these simulators are often less portable and the costs are prohibitively high, preventing them from being used in training large groups of novice learners.[4] Therefore, there is a need for the development of a low-cost biopsy simulator with realistic human anatomy that can be used in early exposure programs to introduce routine procedures in radiology to novice learners.

Materials & Methods

①&② The virtual ultrasound probe and the biopsy needle were sculpted in Autodesk 3dsMax and imported to Unity.
③&④ A torso and a liver with a tumor mass were created in ZBrush and imported to Unity.
⑤ Real-time ultrasound images of the scanning plane were digitally developed in Unity using the Unity Asset "Cross Section" and customized scripts.
⑥ Customized scripts were attached to each instrument to transform the smartphone accelerometer and gyroscope input into controlling the virtual instrument movement. The accelerometer input was used in controlling the pan of the instrument, while the gyroscope input was used in controlling the rotation of the instrument.

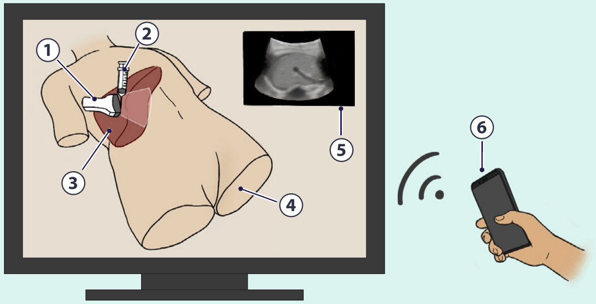

Figure 1. Schematic diagram of the prototype simulator.

Results

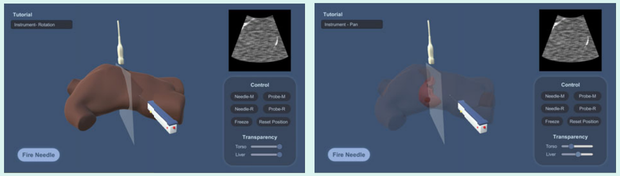

Figure 2. The user can visualize the 3d anatomical models and modulate their transparency. Ultrasound images are digitally developed and shown on the right corner of the user interface. A control panel of the instrument is located at the right bottom corner.

Results

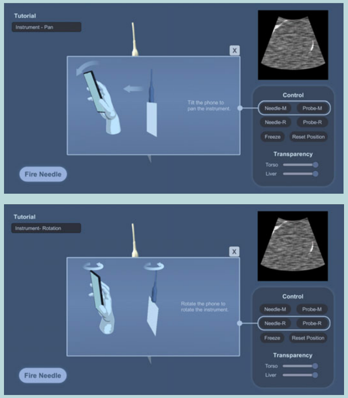

Figure 3. A tutorial instructing how to parallel the movement of the smartphone with that of the virtual instrument one at a time. Pan the instrument by tilting the smartphone (top). Rotate the instrument by rotating the smartphone (bottom).

Conclusions

The stimulus developed for this research will be the first application of a smartphone as a controller in creating a biopsy training simulator, making it highly accessible to a range of audiences. With its low cost and high portability, this simulator will also be suitable to be implemented in hands-on ultrasound workshop for early outreach programs that aim at increasing the interests of pre-med and medical students in exposure to the field of radiology. The workflow used in this project may also contribute to the development of other simulators of various procedures.

References

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