A Haptics-enabled Simulator for Transperineal Ultrasound-Guided Biopsy

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Introduction

We present work-in-progress on the development of a transperineal prostate biopsy simulator, with high-fidelity haptic feedback. Our aim is to create a low-cost simulation by integrating off-the-shelf components.

Prostate cancer remains one of the most common causes of cancer for males, throughout the world. Treatment is usually preceded by a screening process or biopsy. Ultrasound-guided, transperineal biopsies have grown in popularity, especially in Europe (see Fig. 1, below).

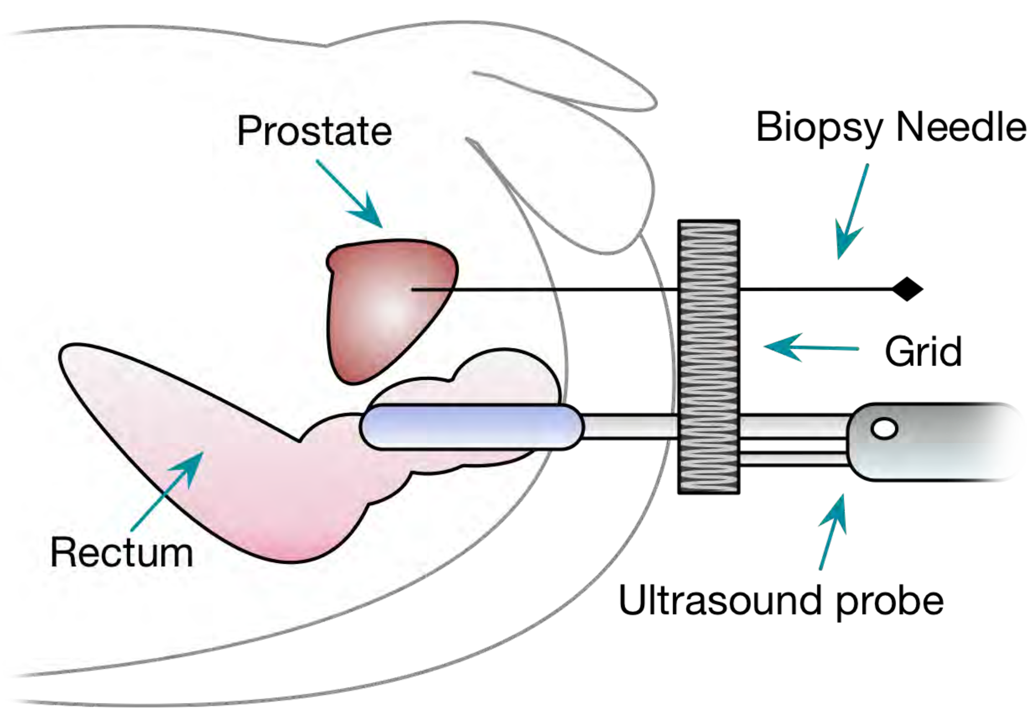

Figure 1: Diagram outlining a transperineal prostate biopsy. During the procedure, which is performed under general anaesthesia, an ultrasound probe is inserted into the back passage and the prostate is scanned. A grid (template) with holes every 5mm is placed against the perineum. A biopsy needle is inserted through each hole, allowing sampling of the prostate gland every 5mm.

Background

Current training methods include:

i) biopsy phantoms, made out of composite materials and shaped to represent the prostate; these are expensive, wear out and have generic gland shapes.
ii) cadavers, which are not easily accessible and their tissue behaviour is unlike those of a living person.

However, healthcare professionals can use high-fidelity virtual training simulation (VTS) so that necessary procedures may be practised and refreshed before operating on a real person.

VTSs do not wear out and can be programmed for simulating alternative scenarios, introduce zero patient risk, allow for the development of psychomotor skills required for the operation of the medical tools and the opportunity to experience challenging 'what if' scenarios.

Motivation

Currently very few training simulators address transperineal prostate biopsies, and those that have been developed do not represent common procedural features such as tissue deformation as the needle is injected, needle bending or prostate bleeding.

Moreover, the guidance grid is represented virtually. We believe that using the actual grid adds to the VTS realism and familiarises the user with the prostate biopsy resolution available during the procedure.

Our approach

Our current VTS prototype comprises mainly of three modules (see Figure 2):

i) the biopsy needle module, which uses the haptic plug-in by Poyade et al. [2] and a Geomagic Touch,
ii) the ultrasound guidance module, built around a G-Coder Simball 4D joystick and a custom C++ wrapper, and
iii) a physical prop for the patient's body, with a web-cam tracking needle insertions through the grid, mounted at the back.

As the user inserts the needle through the grid, the haptic behaviour of each virtual organ encountered by the virtual needle counterpart, is applied through the Touch. The haptic profile of each virtual object is determined by means of *in vitro* measurements, following the procedure described in [1].

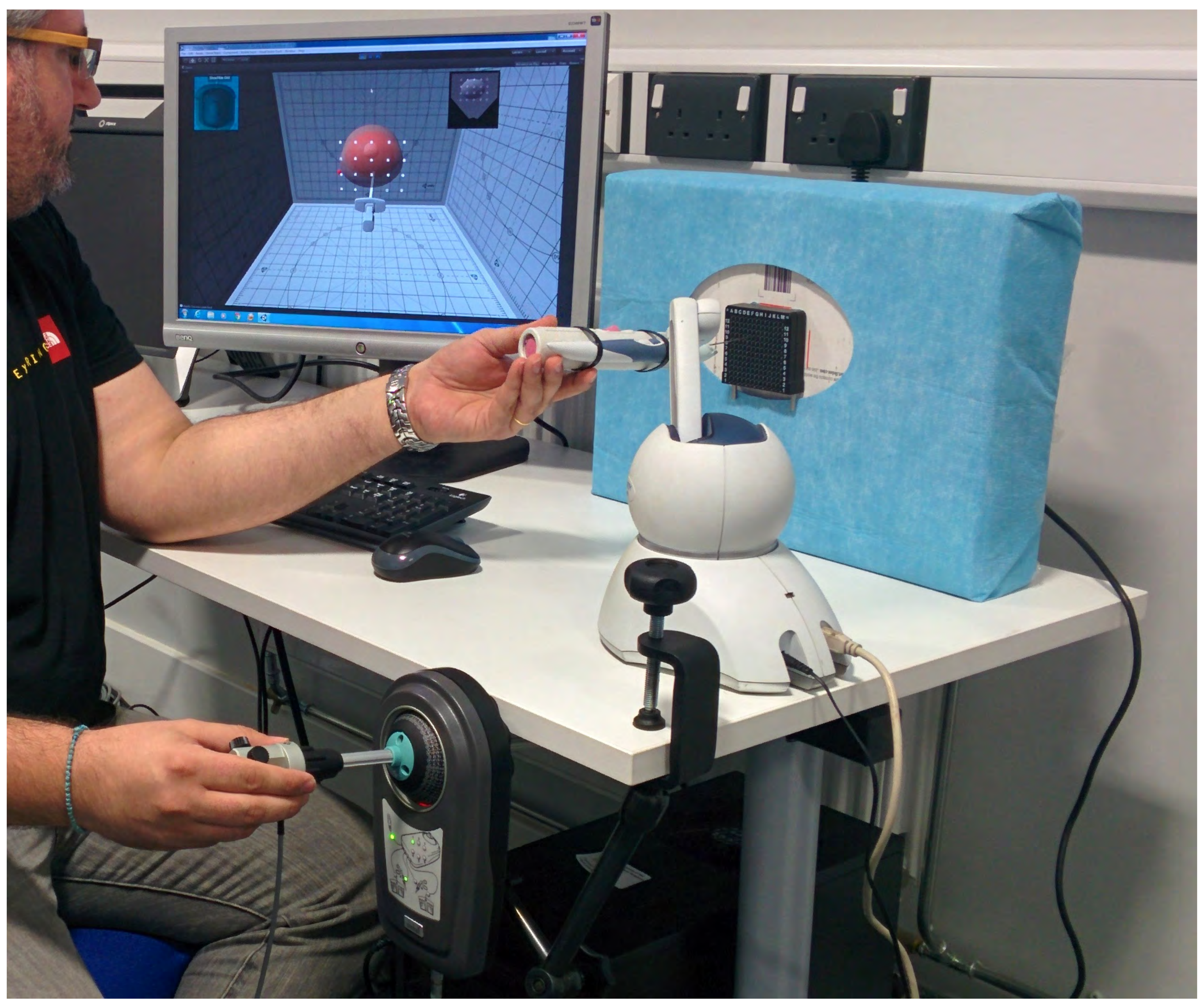

Figure 2: Calibration prototype of our VTS, showing the arrangement of the haptic devices which allows for a larger frontal operating volume for the prostate needle attachment.

Future Work

Feedback on our VTS, from our medical collaborators, regarding the usability of our prototype has been very positive. Current development is focused on increasing the fidelity of the ultrasound display and the visualizations depicting the biopsy needle bending. Future versions of the system will be using the buttons on the Touch to simulate sampling with force-feedback, triggering prostate bleeding visualization and thus increasing simulation fidelity.

Acknowledgements

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References

[1] M. R. Edwards, N. John, L. ap Cenydd, and I. Shergill. Force sensitive embedded glove to measure axial needle forces with a case study for transperineal prostate biopsies. In *EG VCBM*, 2014.

[2] M. Poyade, M. Kargas, and V. Portela. Haptic Plug-In For Unity, 2014. Digital Design Studio (DDS), Glasgow School of Art, Glasgow, United Kingdom.