Building a Surgical Simulator that uses Only Free and Open Source Software

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Abstract

The present paper explores the possibility of building a surgical simulator that uses only free and open source software. A careful review of the literature on the software components required for surgical simulation reveals that new free and open source surgical simulation software can be built using already existing free and open source software components. This paper identifies some of the already existing free and open source software components that may easily be put together to create new surgical simulation software. The present paper also discusses how these software components could be assembled together, by developing software that integrates the software components. Creating the new surgical simulation software assumes significance since currently there are few (if any) free and open source surgical simulation software packages available.

Introduction

A surgical simulation system consists of the relevant hardware and software. The hardware needs to be purchased whereas the software may be commercial or free. Again, free software may be closed source or open source.

Commercial software packages used for surgical simulation are expensive. Free alternatives are most of the time closed source software. Currently few (if any) open source software packages are available, although in addition to being free software, an open source software package allows for customization, modification, or feature enhancement/addition.

The components of a surgical simulation software package are: operating system, 3D reconstruction software for obtaining 3D models of biological organs from 2D scanned images, software for simulating mechanical behaviour of biological organs, software for visualizing biological organs, and finally software that integrates the previously mentioned software components.

The present paper is organized as follows. The next section deals with identifying the already existing free and open source software components that may be used to create a new surgical simulation software package. The section identifies software relevant to the different components mentioned in the previous paragraph. The subsequent section discusses how these software components could be assembled together to create a new surgical simulation software package. The last section concludes the paper.

The applications [1] and [2] for Indian patent are related to the development of surgical simulators. Although the core software in these products is free and open source, they also include software which is not free and open source (e.g., they both use Windows operating system).

Identifying the Software Components

Operating System

Linux may be used. A flavour of Linux called CAELinux may be more useful since many of the software packages mentioned in the next subsections are already packaged into it.

Software for 3D Reconstruction

ImageJ, ITK-SNAP, and MeshLab are free and open source software that are useful for 3D reconstruction of biological organs from 2D scanned images. Using these software for 3D reconstruction is explained in [3] to [5]. Of course, these software packages are a part of CAELinux as has been pointed out in [6].

Simulation Software

Many of the simulation software-packages that are a part of CAELinux may be used. These are finite-element based packages. On the other hand, free and open source software that is not a part of CAELinux may also be used ([7] to [12]).

Visualization Software

Visualization software is helpful for tasks such as rendering. Visualization software available from within CAELinux may be used. Or any other free and open source visualization software may be used. Many free and open source libraries or software packages are available.

Software for Integrating the Other Software Components

This is software that wraps the rest of the software to make a free and open source surgical simulation software package. This software is also responsible for the user interface. Those who create surgical simulators are the ones who create this software. This software may be released as free and open source software after testing/evaluation.

Assembling the Software Components

The software that integrates the other software components (discussed in the last subsection of the previous section) does the task of assembling different software to create a new software package. It also provides a single interface to the user.

Concluding Remarks

It is possible to create a new surgical simulation software package by just assembling already existing free and open source software, extra software being only the one that is required to integrate the already existing free and open source software. This extra software may be made available to anyone as free and open source software.

Future work could be to really build such a simulator, and test/validate it. Releasing all the software as free and open source software could encourage the use of the simulator. It could also encourage further development of the simulator by others. It would also be possible for others to customize/improve/modify the simulator, without there being the necessity to spend for the purpose.

Creating a surgical simulator that uses only free and open source software could also result in more and more use of surgical simulators by medical professionals.

References

[1] Kirana Kumara P, 2016, A surgical simulator for training surgeons in a few tasks related to minimally invasive surgery, Application Number (Indian patent): 201641031739, Filing Date: September 17, 2016, Date of Publication: September 30, 2016, Official Journal of the Patent Office, Issue Number 41/2016, Page Number 69455

[2] Kirana Kumara P, 2017, A hyperelastic-boundary-element based surgical-simulator for training surgeons in a few eye-hand-coordination tasks related to minimally invasive surgery, Application Number (Indian patent): 201741022553, Filing Date: June 28, 2017, Date of Publication: July 7, 2017, Official Journal of the Patent Office, Issue Number 27/2017, Page Number 22533

[3] Kirana Kumara P and Ashitava Ghosal, 2011, A Procedure for the 3D Reconstruction of Biological Organs from 2D Image Sequences. In: International Conference on Biomedical Engineering and Assistive Technologies (BEATs-2010), 17-19 December, 2010, Dr. B R Ambedkar National Institute of Technology, Jalandhar, India.

[4] Kirana Kumara P, 2011, Reconstructing Solid Model from 2D Scanned Images of Biological Organs for Finite Element Simulation, Preprint, Available from: http://eprints.iisc.ernet.in/39721/ (accessed November 17, 2017)

[5] Kirana Kumara P, 2012, Extracting Three Dimensional Surface Model of Human Kidney from the Visible Human Data Set using Free Software, Leonardo Electronic Journal of Practices and Technologies (LEJPT), Issue 20 (January-June), 2012 (11), p. 115-126

[6] Kirana Kumara P, 2012, Demonstrating the Usefulness of CAELinux for Computer Aided Engineering using an Example of the Three Dimensional Reconstruction of a Pig Liver, International Journal of Advancements in Technology, 3 (4), pp. 301-309

[7] Kirana Kumara P, 2012, A MATLAB Code for Three Dimensional Linear Elastostatics using Constant Boundary Elements, International Journal of Advances in Engineering Sciences(IJAES), 2 (3), pp. 9-19

[8] Kirana Kumara P, 2014, Codes for solving three dimensional linear elastostatic problems using constant boundary elements while ignoring body forces, Preprint, Available from: http://eprints.library.iisc.ernet.in/48088/ (accessed November 17, 2017)

[9] Kirana Kumara P, 2014, A Study of Speed of the Boundary Element Method as applied to the Realtime Computational Simulation of Biological Organs, Electronic Journal of Boundary Elements, 12 (2), pp. 1-25

[10] Kirana Kumara P and Ashitava Ghosal, 2012, Real-Time Computer Simulation of Three Dimensional Elastostatics Using the Finite Point Method, Applied Mechanics and Materials, Vols. 110-116, pp. 2740-2745

[11] Kirana Kumara P, 2015, Simulations using meshfree methods, arXiv:1506.02808

[12] Kirana Kumara P and Ashitava Ghosal, 2011, Graphics Processing Units for the Real-time Linear Elastostatic Simulation of Liver, International Conference on Advanced Computing & Communication Technologies (ACCT11), 20-22 January, Rohtak, India.