Toward Simulation-based Medical Device Design: Integrating High Performance Cloud FEA Computing into Intuitive Design Modeling

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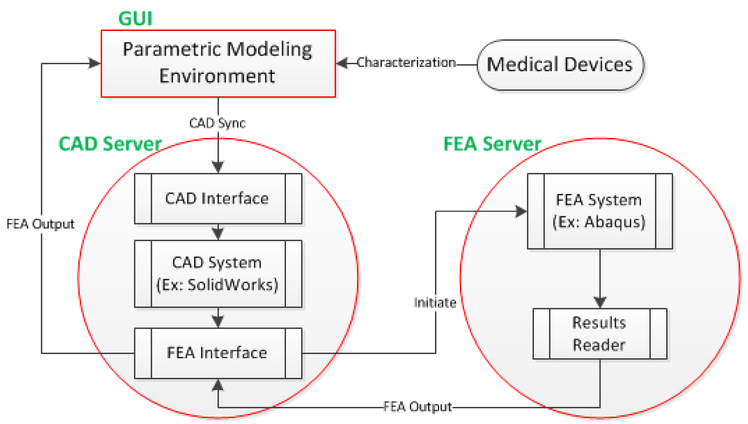
Abstract

We present a new approach to simulation-based medical device design by integrating current CAD and FEA systems and developing natural human-computer interfaces to control the resulting integrated system. In order to utilize the high performance FEA computing power, a network communication program was developed and a Python script was used to initialize simulations and read calculated results. A complete design process of a breast biopsy cannula was demonstrated.

Methods

System Framework



Parametric Modeling Environment

The graphics of the parametric modeling environment are implemented using OpenGL. A natural mouse-based user interface is provided to control the system.

CAD Synchronization

Through the CAD interface, the design model created in the modeling environment is simultaneously submitted to the CAD server to maintain a CAD model equivalent. This interface is implemented using SolidWorks API.

FEA Server

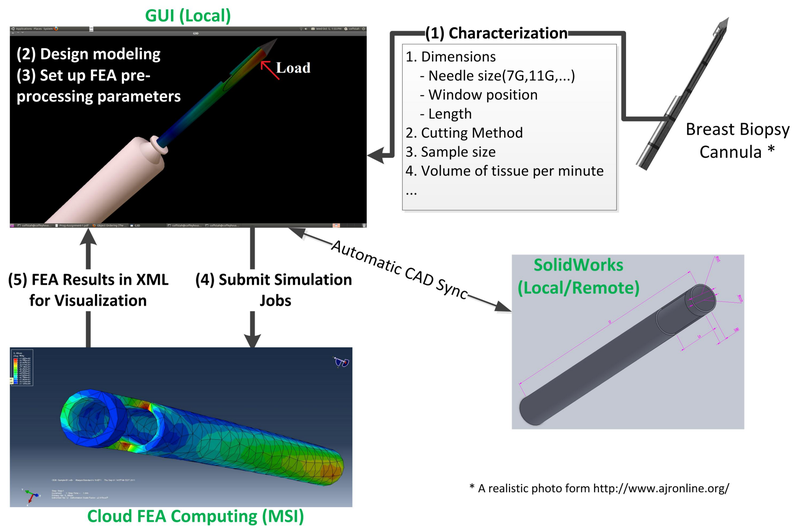
The MSI machines are utilized as a cloud FEA computing unit. A FEA interface was developed using SSH protocol and Python scripts. The model along with the pre-processing parameters, such as material properties, boundary conditions, etc, are submitted through the interface, and then a FEA simulation is automatically initialized.

Data Communication

Standard XML format is used for data communication between each components.

Case Study

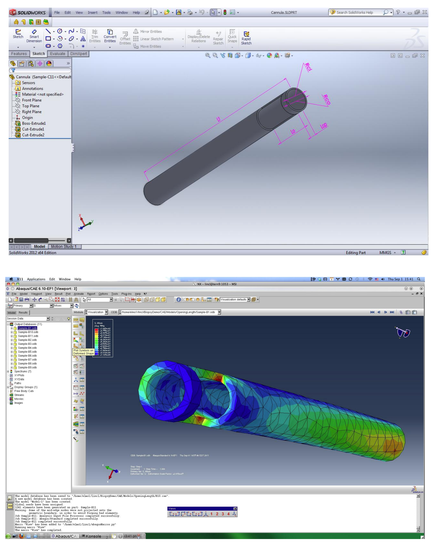
The working end of a breast biopsy device was designed and analyzed using the described system. The complete process is shown below:



* A realistic photo form http://www.ajronline.org/

Results I

The SolidWorks Model (.SLDPRT) and the Abaqus Ouput Database (.odb) of the Final Design



The SolidWorks model was automatically updated during the design. The Abaqus output shows the simulation results of a stainless steel cannula with a fixed proximal end and a concentrated load applied close to the tip.

Results II

Sample XML Output Data Returned to the GUI

The XML output data was returned in less than 3 seconds after submitting the simulation job.

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Conclusions

The process of designing and analyzing the cannula of a breast biopsy device has been significantly changed by utilizing this system. The all-in-one GUI improved the efficiency of the typical process. Moreover, this framework is capable of exporting CAD/FEA models to other stand-alone systems, and has the potential to support multiple alternative CAD/FEA systems.

Future Work

1. Expand the parametric modeling environment to an immersive virtual reality environment with interactive user interfaces.
2. Further development of the CAD sync and the FEA interface for more complex design/analysis jobs.
3. Support multiple CAD/FEA systems.

Acknowledgements

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