Surgical Robotics Environment for NVIDIA Isaac Sim

EN.601.456.01.SP24 Computer Integrated Surgery II

#### Team #8 System Specifications

Tae Wan Kim (tkim104@jhu.edu)

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## **1. Project Overview**

The primary goal of the project is to find out the potential and limitations of NVIDIA Isaac Sim for surgical robotics environment applications and compare its performance against the Asynchronous Multibody Framework (AMBF) developed by Dr. Munawar. To that end, we hope the simulator is able to do a number of tasks required from a surgical robotics simulator to eventually recreate a Surgical Challenge Video done in AMBF, perform a wide range of dynamics calculations, and provide the added advantage of highly realistic video and images of a simulated environment.

## **2. Functional Specifications**

### **2.1: Isaac Sim Documentation**

* + 2.1.1: The documentation is to concise explain Isaac Sim for future readers
  + 2.1.2: The documentation is to be readily available on the course wiki
  + 2.1.3: The documentation is to cover all basic features of Isaac Sim (All tutorial features)
  + 2.1.4: The documentation is to serve as a quick start guide to Isaac Sim, not a replacement of the full NVIDIA documentation

### **2.2: ADF to URDF File Converter**

* + 2.2.1: The program is available in Python
  + 2.2.2: The program must conserve the model object's size and relative connections to each other
  + 2.2.3: The program comes with thorough documentation covering the details of the program such as input and expected output
  + 2.2.4: The program accounts for existing articulation for a model, conserving articulation into the URDF file or a supplementary file to retain that information

### **2.3: Surgical Challenge Setup**

* + 2.3.1: Models used in the Isaac Sim surgical challenge scene have the same sizes and measurements as in the AMBF scene
  + 2.3.2: Robotic models are readily available for download in URDF on the course wiki
  + 2.3.3: Scene description with lights and cameras are the same to the original positions in the AMBF surgical challenge

### **2.4: Simulator Comparison**

* + 2.4.1: Documentation completely covers all relevant features of surgical robotics in Isaac Sim
  + 2.4.2: Documentation completely covers all relevant features of surgical robotics in AMBF
  + 2.4.3: 3 Testing environments are readily available in both URDF and ADF file formats for testing on course wiki
  + 2.4.4: Testing environments are near identical for both simulator scene set ups
  + 2.4.5: Testing environment 1 provides object that the simulator can use to generate soft-body synthetic data
  + 2.4.6: Testing environment 2 provides object that the simulator can use to generate fluid synthetic data
  + 2.4.7: Testing environment 3 provides high fidelity extremely detailed object to stress test rendering

## **3. Performance Specifications**

While we do hope that Isaac Sim can excel in performing dynamical calculations quickly and efficiently, the exact level is what is to be found out and compared against AMBF. The same goes for its performance on rendering applications as well. However, one should note that the performance can vary and be dependent on the exact workstation specifications used with Isaac Sim, such as the quality of the CPU and GPU.

### **3.1: Synthetic Data Generation**

* + 3.1.1: By default, AMBF will render at 120 Hz and conduct physics calculations at 1000 Hz for haptic applications
  + 3.1.2: By default, Isaac Sim uses 60 Hz for time steps per second for physics calculation, rate limited by FPS

## **4. Design Constraints**

### **4.1 Workstation**

* + 4.1.1: Isaac Sim and AMBF simulations will be done on the LCSR - DVRK - 12 for consistency

### **4.2 Software**

* + 4.2.1: We will use Python to program in Isaac Sim, AMBF, and all other programs is possible

## **5. Reading List**

**Quiroz Omaña**, J. J., Marques Marinho, M., & Harada, K. (2023). *Digital Twin of a Multi-Arm Robot Platform based on Isaac Sim for Synthetic Data Generation* (Version 1.0.0) [Data set]. Zenodo. <https://doi.org/10.5281/ZENODO.7860757>

**Mittal, M**., Yu C., Liu, J., Rudin, N., Hoeller, D., Yuan, J., Tehrani, P., Singh, R., Guo, Y., Mazhar, H., Mandlekar, A., Babich, B., State, G., Hutter, M., & Garg, A. (2023). *ORBIT: A Unified Simulation Framework for Interactive Robot Learning Environments.* [arXiv:2301.04195](https://arxiv.org/abs/2301.04195) [cs.RO]. <https://doi.org/10.48550/arXiv.2301.04195>

**Schmidgall, S**., Krieger, A., & Eshraghian, J. (2024). *Surgical Gym: A high-performance GPU-based platform for reinforcement learning with surgical robots.* [arXiv:2310.04676](https://arxiv.org/abs/2310.04676) [cs.RO]. <https://doi.org/10.48550/arXiv.2310.04676>

**V. M. Varier,** D. K. Rajamani, F. Tavakkolmoghaddam, A. Munawar and G. S. Fischer, *"AMBF-RL: A real-time simulation based Reinforcement Learning toolkit for Medical Robotics,"* *2022 International Symposium on Medical Robotics (ISMR)*, GA, USA, 2022, pp. 1-8, doi: 10.1109/ISMR48347.2022.9807609.

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**J. Collins**, S. Chand, A. Vanderkop and D. Howard, "A Review of Physics Simulators for Robotic Applications," in IEEE Access, vol. 9, pp. 51416-51431, 2021, doi: 10.1109/ACCESS.2021.3068769.

**Muratore F**, Ramos F, Turk G, Yu W, Gienger M, Peters J. Robot Learning From Randomized Simulations: A Review. Front Robot AI. 2022 Apr 11;9:799893. doi: 10.3389/front.2022.799893. PMID: 35494543; PMCID: PMC9038844.

## **6. Change History**

| **Rev** | **Date** | **Description** |
| --- | --- | --- |
| **1** | 2/29/2024 | Initial version by Tae Wan Kim |
| **2** | 3/8/2024 | Updated based on comments by Dr. Kazanzides, and Dr. Munawar |
| **3** | 3/15/2024 | Updated based on comments by Dr. Kazanzides, and Dr. Munawar |