Surgical Robotics Environment for NVIDIA Isaac Sim

EN.601.456.01.SP24 Computer Integrated Surgery II

#### Team #8 Project Technical Approach Plan

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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. Technical Task**

In short, the task is to find out how well Isaac Sim can create a surgical robotics environment. Several steps include learning about Isaac Sim's ability as a robotics simulator, how it measures against other simulators, and how robust it is for research purposes in areas such as segmentation, connectivity, training, and machine learning.

One of the primary steps at hand requires a thorough collection of expertise on NVIDIA's Isaac Sim application to allow users beyond the scope of the project to utilize its libraries, systems, and applications for further research in the lab for surgical robotics environments. While the simulator is already known to provide an excellent platform for robotic simulations in industry, seeing use cases in places like Amazon™ , one avenue we wish to further develop is its use in medical applications. With this comes an emphasis on other aspects of simulation not as considered in different disciplines, such as its ability to perform soft-body calculations.

| *AMBF Arm, Munawar [7]* | *Nvidia Isaac Sim Arm, Nvidia Omniverse [6]* |
| --- | --- |

In terms of measuring it against other simulators, this step involves comparing Isaac Sim against a simulator based on AMBF (Asynchronous Multibody Framework) which was designed primarily for surgical applications for simulating the dynamics of a kinematically redundant robot.

Finally, we hope to see Isaac Sim's use in an actual surgical robotics setting with concepts such as tool segmentation, real-time feedback, and / or machine learning / reinforcement learning algorithms in a surgical procedure such as suturing a phantom.

## **3. Assumptions**

Several assumptions are made on NVIDIA's Isaac Sim capabilities to create a surgical robotics environment listed in the following for this project:

* Can load in USD and URDF assets
* Allows recording of video
* Can perform rigid-body dynamics
* Can perform soft-body dynamics
* Can perform fluid-body dynamics
* Allows ROS / ROS2 connection
* Allows controller feedback
* Provides Usage Statistics (FPS, Memory use, GPU use, CPU use, etc.)
* Can create solid manipulatable objects
* Allows control of created robots
* Allows algorithms to control created robots
* Provides visual feedback of simulation
* Can simulate closed chain loops robotics
* Can simulate hierarchical articulated robotics
* Allows position control for robots
* Allows velocity control for robots
* Allows torque control for robots

## **4. Goal States**

Broadly, the primary goal is to understand how Isaac Sim could be used as a robotics simulator in the context of a surgical robotics environment, finding out what features it can do well and what it may lack. In more specifics, this goal can be broken down to three sub-goals to achieve for this project in gaining expertise, understanding its performance, and where it could be used.

|  |  |
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*Figure 2. Surgical Robotics Challenge in AMBF 2023-2024 (600.456/496/656 CIS2 Spring 2024 Copyright R. H. Taylor)*

*Sub-Goal Success Requirements:*

* Gaining Expertise
  + Approved Simplified Custom Documentation for Isaac Sim
  + Recreation of the Surgical Robotics Challenge done in AMBF
* Performance Analysis
  + Quantitative Performance Report on Isaac Sim and AMBF
  + Qualitative Performance Report on Isaac Sim and AMBF
* Application
  + Possible use in Sim2Real transfer or ROS/ROS2 connection

The third goal is highly dependent and mutable depending on the results of the first and second goals that would need to be addressed before accurately determining what success would look like for the Application goal.

## **5. Complete Approach**

Here we go in more specific detail on what the complete approach is to achieve the listed goals.

*Gaining Expertise*

* Familiarize downloading and installing Omniverse Isaac Sim from NVIDIA on to machines with GPUs
* Work through the introductory documentation for Isaac Sim
  + Follow tutorials and read explanations on different features, APIs, and usage for Isaac Sim
  + Record / Document all items learned in a separate sheet in a more condensed and brief manner for others to use in the future
* Install and utilize ORBIT as an addon to Isaac Sim, allowing for unified modular control on creating robotic learning environments
* Find and upload relevant files used in the Surgical Challenge 2022-2023 AMBF to Isaac Sim
  + If necessary, write the documentation for a converter code to change ADF files into URDF \*
  + Write a program to convert ADF files to URDF

\* AMBF has 3 types of ADF files (world, models, input devices) while Isaac Sim can import URDF files, however if the joint information is unavailable, rigging / articulating the joints are required

*Performance Analysis*

* Download and install AMBF on to the same machine used to test Isaac Sim
* Technical Analysis on the capabilities of between simulators
  + Write out documentation highlighting the capabilities of Isaac Sim focused on what type of features it has in dynamics, connectivity, feedback, and rendering
  + Write out documentation highlighting the capabilities of AMBF focused on what type of features it has in dynamics, connectivity, feedback, and rendering
* Performative Analysis on Isaac Sim and AMBF
  + Create 3 test environments for each simulator to work on
    - Environment focused on simulating soft-body dynamics
    - Environment focused on simulating fluid dynamics
    - Environment focused on rendering highly detailed objects
  + Using the same world parameters / environments, test computation throughput and accuracy with 1 to N instances of the environment
  + Compare synthetic data generated in each simulator to real-world or theory-based data

*Application*

* Create tool segmentation environment for Isaac Sim

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