PES UNIVERSITY

Capstone Project Phase-1

Project Title: Using Digital Twinning to enhance Human-Robot Collaboration with augmented reality

Project ID: PW23_AKP_02

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Abstract

Developing an AR/VR tool which can be used to enhance industrial robotics.
A digital twin of the robot is made and simulated to run on an AR/VR interface.

Scope:

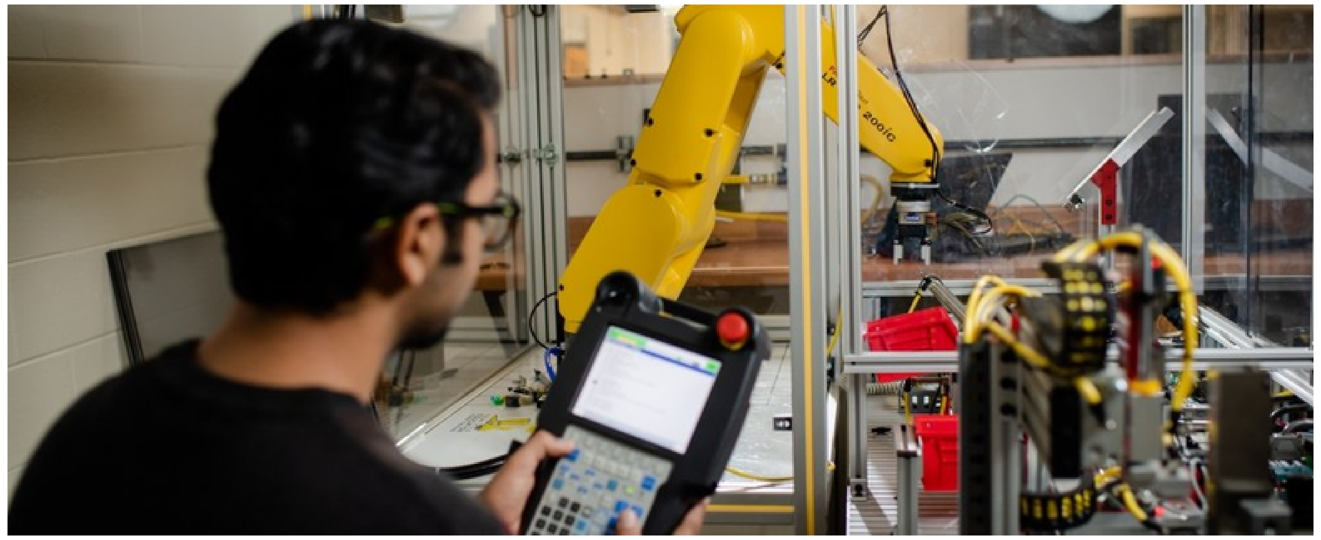
- Real-time monitoring and control of robotic systems
- Predictive Remote maintenance, optimization and programming of operations
- Virtual prototyping and training of robotic systems

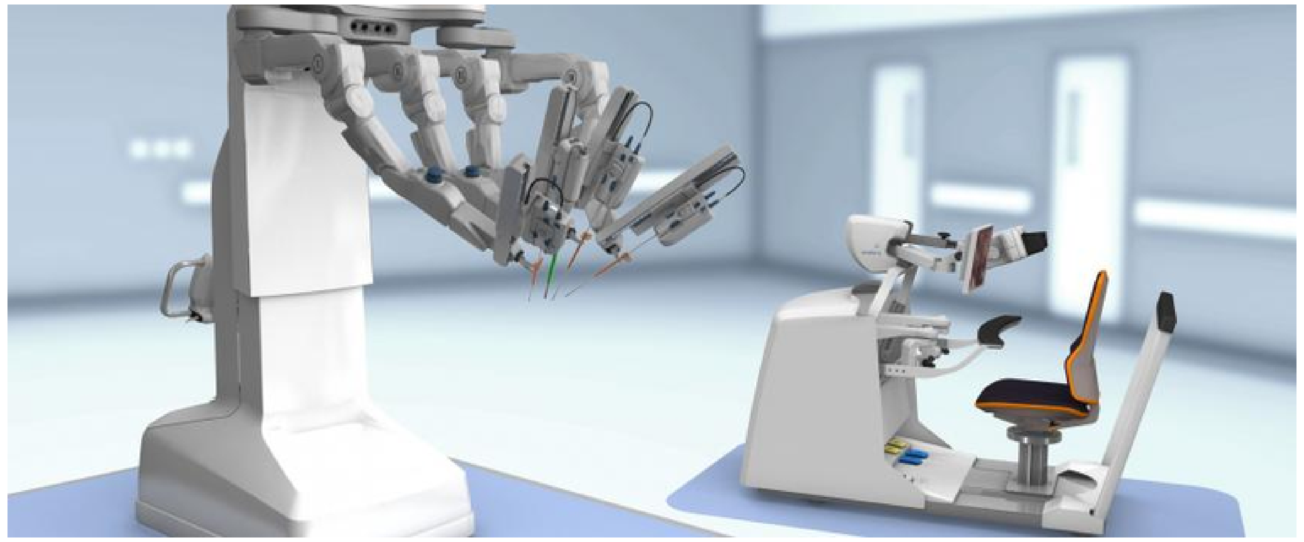
Design Approach

- Data-driven modelling
  - Involves collecting data from the physical robot and using it to build a digital twin.
- Physical modelling
  - Involves creating a digital replica of the physical components and their interactions within the robot.
- Model-based controller
  - Involves using the digital twin to control the physical robot.

Design Constraints

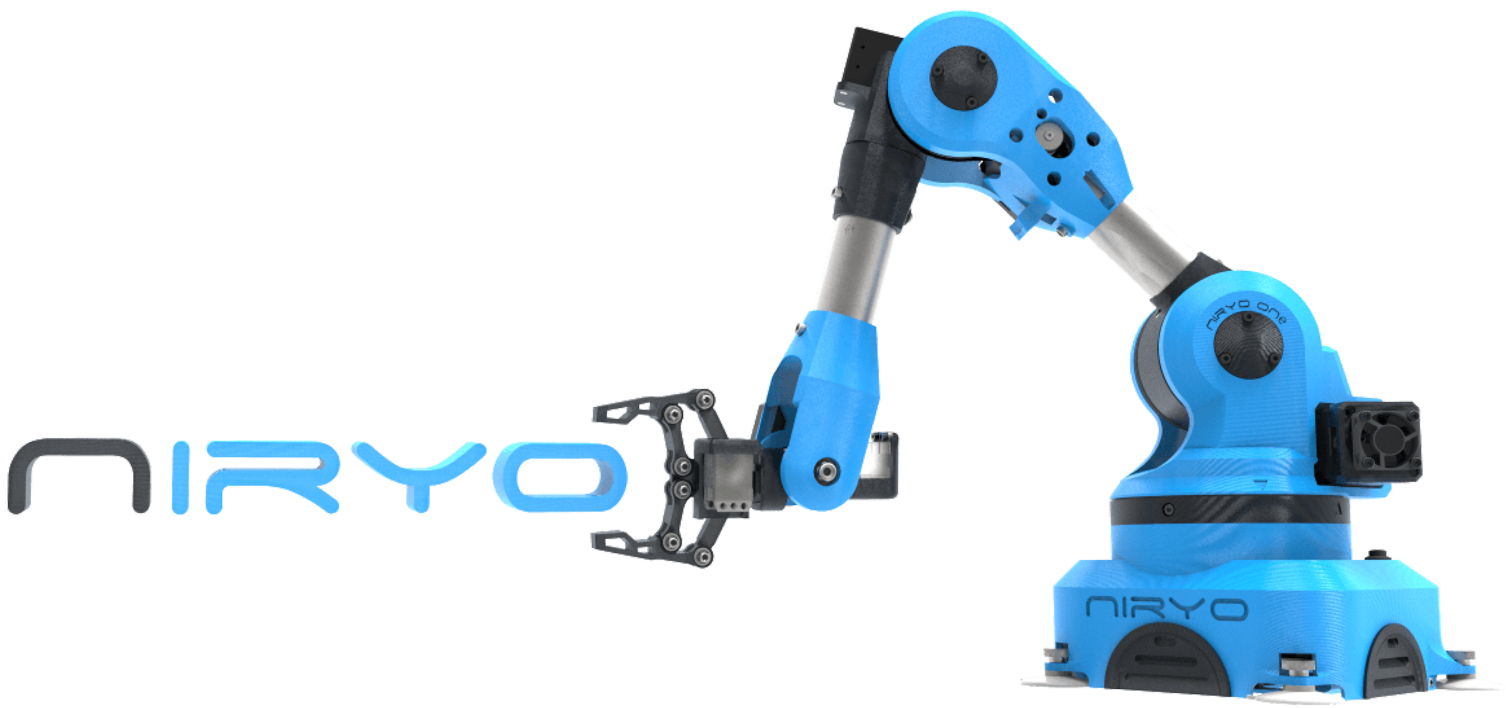
- Constraints:
  - Availability of data and information about the physical robot, including its specifications, component details, and performance data.
  - Computing power and storage capacity required to run the simulation and store the data.
  - Network bandwidth and latency requirements for real-time communication between the physical robot and its digital twin.





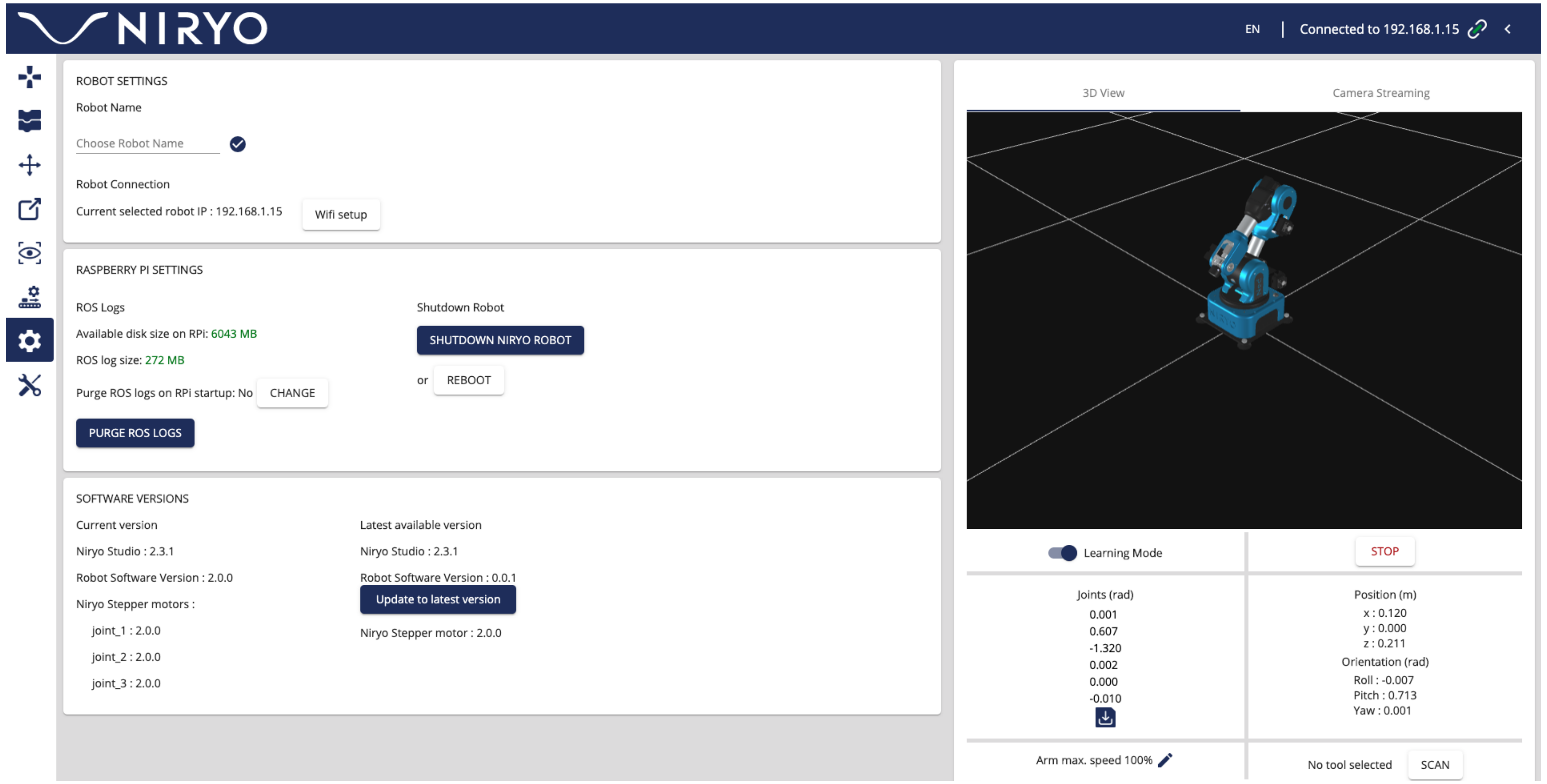
Assumptions

- Assumptions:
  - The accuracy and completeness of the data and information about the physical robot.
  - The reliability and stability of the hardware and software components used to run the simulation.
  - The consistency and accuracy of the mathematical models used to represent the physical robot and its behavior.



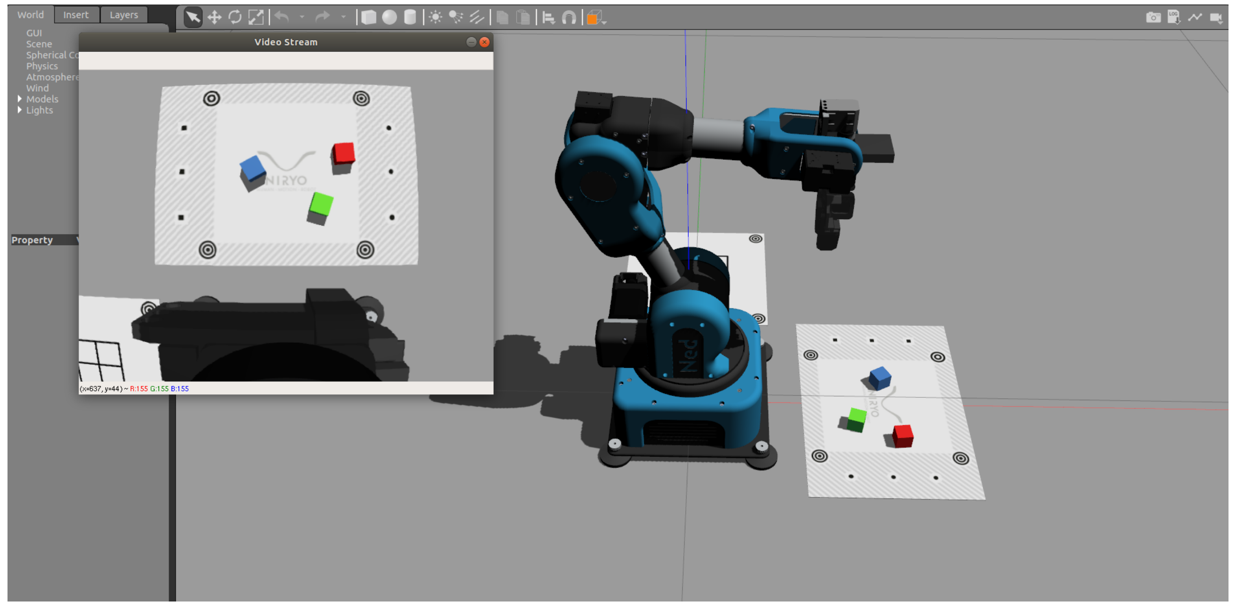
Dependencies

- Dependencies:
  - The availability of software tools and libraries for building and running simulations.
  - The ability to integrate the digital twin with other systems and software, such as control systems, data analytics tools, and visualization software.



Proposed methodology

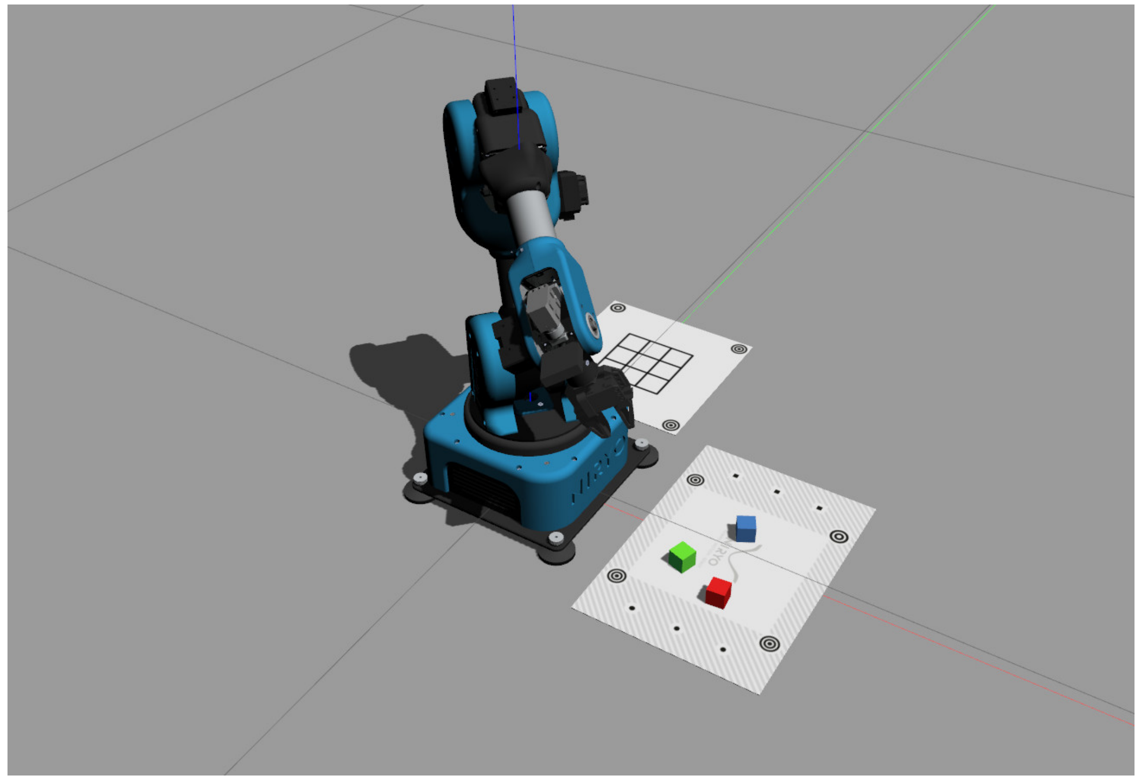
- Model-Based Design:
  - This approach involves creating a mathematical model of the robot's physical components and behavior, which can be used to simulate its operation and predict its performance. The model-based design methodology typically involves the following steps:
  - Gathering data and information about the physical robot, including its specifications, component details, and performance data.
  - Developing mathematical models to represent the physical components and behavior of the robot.
  - Validating the models against real-world data to ensure their accuracy and reliability.
  - Using the validated models to run simulations and predict the behavior and performance of the robot.



Benefits of Proposed methodology

Benefits of Model-Based Design:

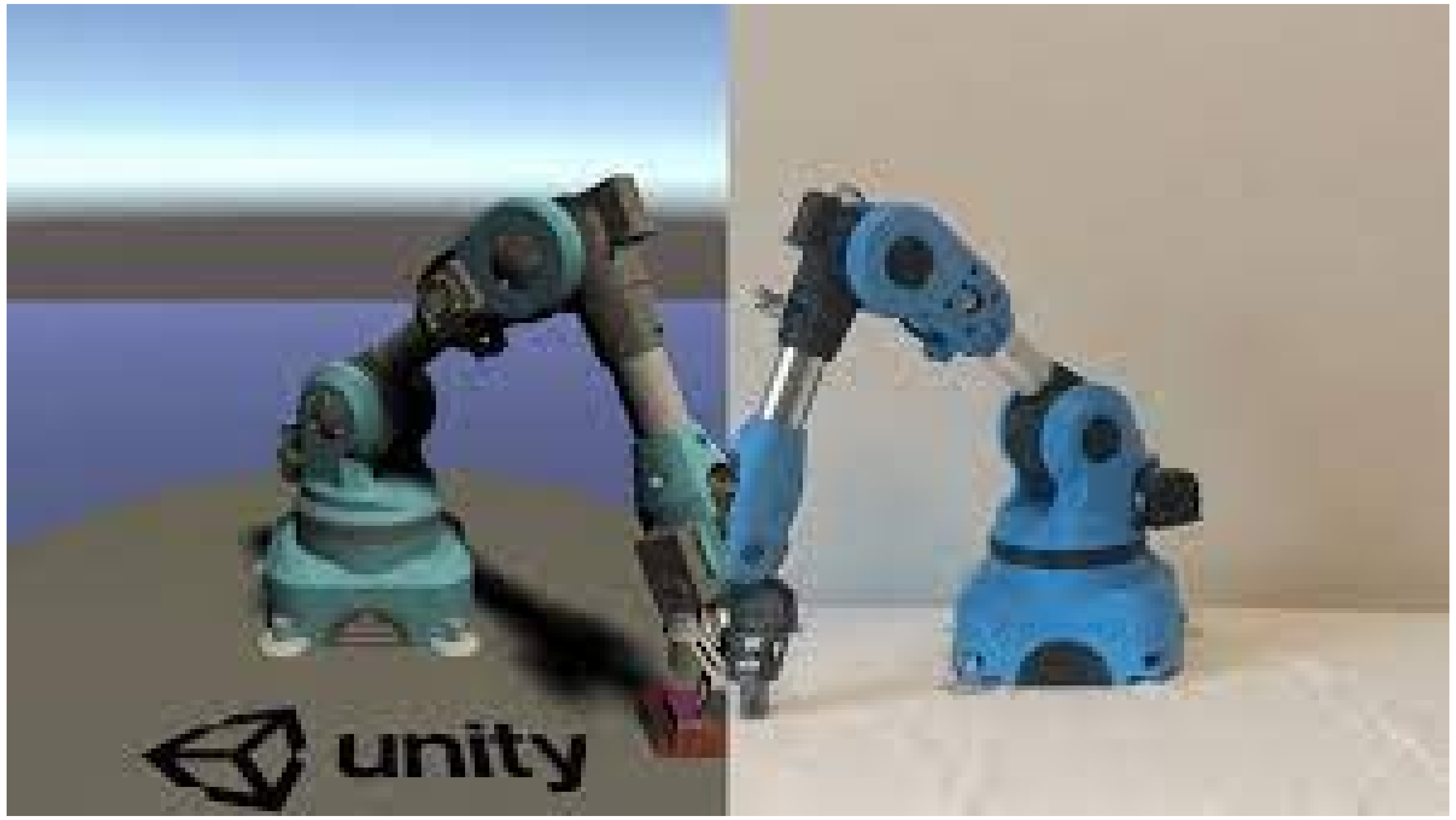
- Improved accuracy: By creating mathematical models of the physical components and behavior of the robot, it is possible to accurately simulate its operation and predict its performance. This can help to identify potential problems and optimize the design of the robot.
- Faster development: By using simulations to test and validate the design of the robot, it is possible to speed up the development process and reduce the need for physical prototypes.
- Better understanding of the system: By visualizing the behavior of the robot in a simulation, it is possible to gain a deeper understanding of its operation and how it responds to different inputs and conditions.



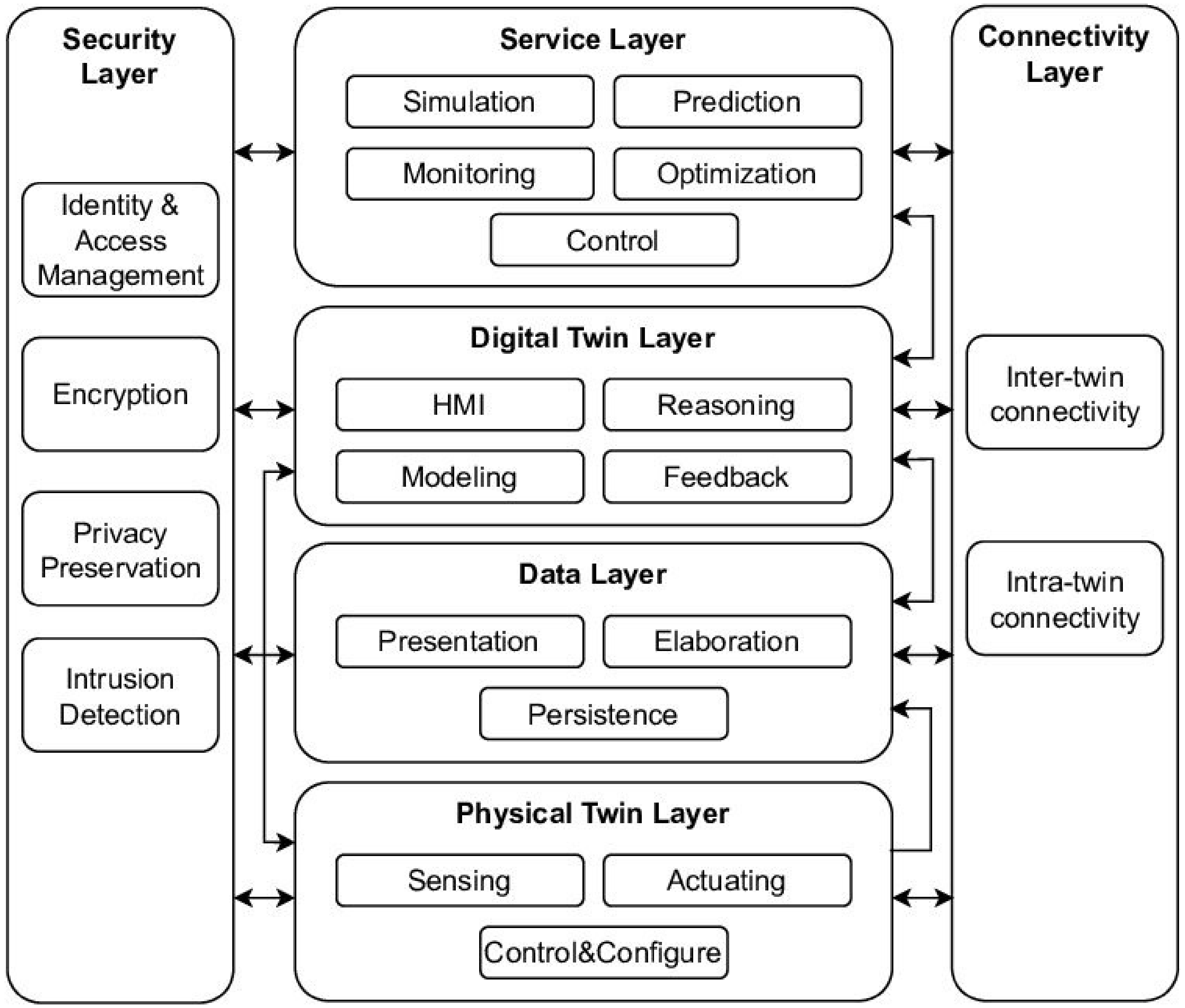
Drawbacks of Proposed methodology

Drawbacks of Model-Based Design:

- Complexity: Model-based design can be complex and time-consuming, particularly for large and complex systems like an industrial robot.
- Model accuracy: The accuracy of the models used in the simulation is critical, and any errors in the models can result in inaccurate predictions of the robot's behavior and performance.



Architecture



Design Descriptions

```
+------------------+               +--------------------+
|  PhysicalRobot   | <-------------|   SimulationModel  |
+------------------+               +--------------------+
| - specifications |               |-mathematical models|
|-component details|               |  -simulation data  |
|-performance data |               +---------+----------+
+------------------+                         |
                                             |
+---------------+                 +--------------------+
| UserInterface | <---------------|  SimulationEngine  |
+---------------+                 +--------------------+
|-visualizations|                 |  -simulation logic |
| -user inputs  |                 |-simulation results|
+---------------+                 +--------------------+

+----------------+                  +-------------------------+
| DataManagement | <----------------| CommunicationInterface  |
+----------------+                  +-------------------------+
| -sensor data   |                  |      -data exchange     |
|-simulation data|                  |    -command exchange    |
+----------------+                  +-------------------------+
```

Design Descriptions

- Logical User Groups:
  - Operators: Responsible for controlling and monitoring the physical robot.
  - Engineers: Responsible for designing, developing, and maintaining the digital twin.
  - Management: Responsible for making decisions about the deployment and use of the digital twin.

- Application Components:
  - Simulation Engine: Responsible for running the mathematical models that represent the physical robot and its behavior.
  - User Interface: Responsible for presenting information to the users and allowing them to interact with the digital twin.
  - Data Management: Responsible for collecting, storing, and analyzing data from the physical robot and the digital twin.
  - Communication Interface: Responsible for exchanging data and commands between the physical robot and the digital twin.
  -
- Data Components:
  - Physical Robot Data: Information about the physical robot, including its specifications, component details, and performance data.
  - Simulation Data: Results of the simulation, including predictions of the robot's behavior and performance.
  - Sensor Data: Data collected from sensors on the physical robot, including information about its current state and environment.
  - Control Data: Commands and instructions sent to the physical robot from the digital twin.

- Interfacing Systems:
  - Control System: System responsible for controlling the physical robot.
  - Data Analytics Tools: Tools used to analyze and visualize the data collected from the digital twin and the physical robot.
  - Visualization Software: Software used to display the results of the simulation and the data collected from the physical robot.

Technologies Used

Tools and processes:

- 3D modeling - blender, Unity3D
- AR platform - Industrial AR tools
- Robotics- Raspberry pi, ArduinoIDE, ROS
- Languages- C++, C#, python.

References

Research done -
https://docs.google.com/spreadsheets/d/1Uet7KWej06JfQ50rUx7eLIetOz4LF18dSRvonRCbmfc/edit#gid=0

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Thank You