DIGITAL TWIN MODEL OF TWO-ARM COLLABORATIVE ROBOT AND HUMAN-CPS FOR HUMAN ARMS MOTION SIMULATION

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2021 Reimagining innovation TECHNOLOGY SYMPOSIUM

Summary

Digital Twin (DT) Model is a digital replica of an entity/process/system. It can be deployed to simulate human arms motion as well. The process started with the CAD files of the collaborative robot. The Part-CAD files were converted into VRML files adding Rotation-Translation features with proper orientation. The rotation axis vector & translation data were calculated from the position of the parts in the assembly file. These data were used to assemble the parts in 3D world Editor. A Human-Cyber Physical System was also created the same way for transferring the motion data from Human to Digital Twin. Finally, an application interface was created in the MATLAB® App Designer platform to regularize the Digital Twin manually. Using both the Digital Twin model and Human-CPS in the same platform the Deep Reinforcement Learning will be implemented to synchronize the Digital Twin model with Human motion simultaneously.

Motivation

Digital Twin is the outcome of an infrastructure that combines the Internet of Things (IoT), Big Data Analytics, Cyber-Physical System (CPS) that is materializing the Industry 4.0 concept. The research had been done on digital twin, collaborative robot, deep reinforcement learning related to other aspects but using digital twin concept for collaborative robot to automate the process using deep reinforcement learning and human motion had never been done before which could lead to highly operational and automated process module for flexible manufacturing system as well as a repetitive system.

Questions

1. How to build a real-time applicable Digital Twin Model?
2. How to feature a Human-CPS for 3D World Editor?
3. How to create an interface for Digital Twin Model regulation?

Research Outline

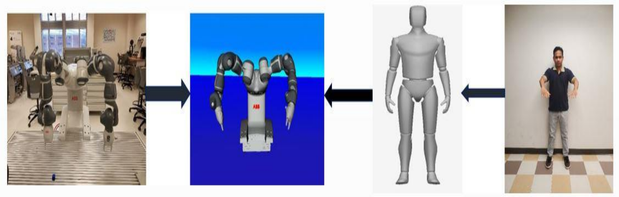

Fig 1: An Illustration of Digital Twin Model Assembly for Human Motion Simulation

Project Description

The advancement of technology and development of cheaper computation technology makes the Digital Twin one of the most feasible iterative innovation. Digital Twin helps to store data from several components, to homogenize the entire data collection, and to understand the pattern of data for insightful analysis as well as run on it. To automate the system regardless of the field, Digital Twin is the best alternative these days.

The goal of this project is to

1. Assembled Digital Twin Model with proper features.
2. Study and addition of features/constraint and part orientation and necessary data to equip the model.
3. Featuring the Human-CPS model for transferring motion data from human to Digital Twin
4. Build up an application interface for controlling the digital twin model as well as Human-CPS Model.

Methodology

The steps are to develop the two-arm collaborative Digital Twin Model, Human-CPS model, and Application Interface. To do so,

1. Rotation and translation features were added with proper orientation in each part file and converted into VRML files from CAD files.
2. The data measurement was required for Rotational Axis Vector and Translational positioning
3. The VRML files were assembled sequentially in 3 World Editor.
4. The Human-CPS model was featured for transferring the data from Human to Digital Twin.
5. An application interface was created to regularize the Digital Twin model.

Results

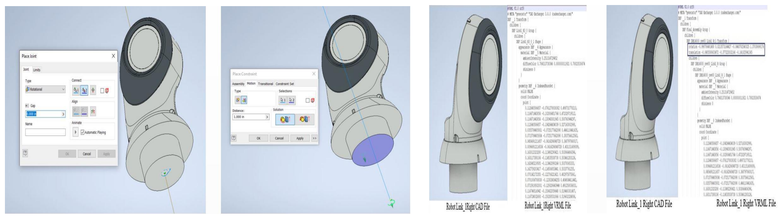

Fig 2: An Outline of CAD file conversion to VRML file

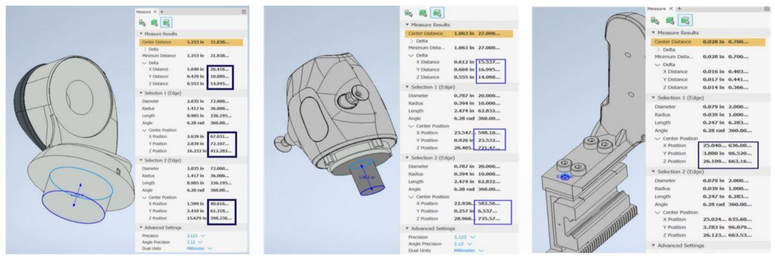

Fig 3: Co-ordinate data collected from CAD file for 3D world Editor

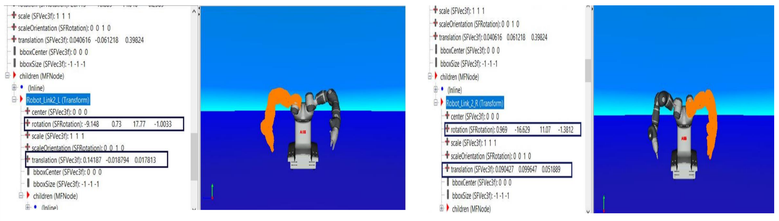

Fig 4: Digital Twin Model Assembly using Rotation & Translation Data in 3D World Editor

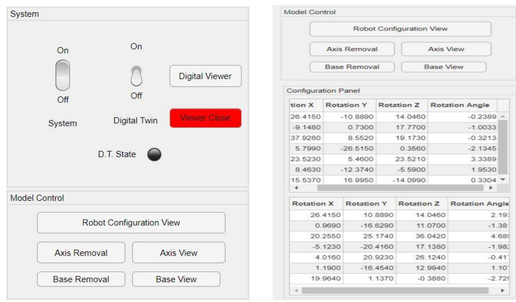

Fig 5: Application Interface of System Initialization, Model

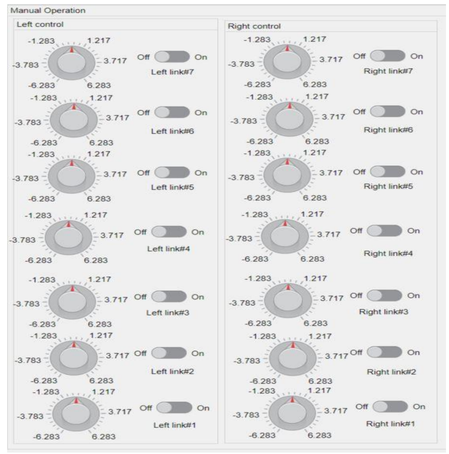

Fig 6: DT Model Manual Control Interface

Discussion

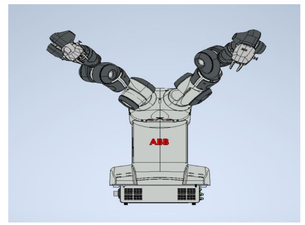

Fig 7: CAD file to Editor File Conversion

- Part-CAD files were added features, proper orientation, and converted into VRML files.
- Rotation & Translation data were processed:
  Rotation, R = (Sel.1 – Sel.2)
  Translation, T = [Sel.2(Present Link) – Sel.2(Previous Link)]/1000

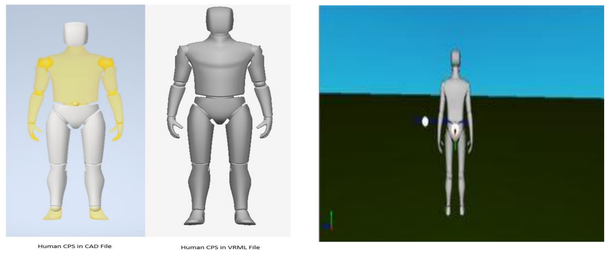

Fig 8: Human-CPS Model in CAD-VRML & 3D Editor

- The Human-CPS was featured and reoriented for transferring data from human to DT model.

Fig 9: Application Interface for Gripper control part

- The DT model gripper can be regularized with this panel.

Future Challenges

- Transferring Human motion data to CPS Model.
- Converting Human motion (3 DOF) data from Human-CPS to Robot Links (7 DOF) data.
- Virtual Commissioning issues

Conclusion

- Feature's addition and orientation were done using reverse engineering.
- The features data should be processed carefully for precise model positioning.

References

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- Neverova, N. (2016). *Deep learning for human motion analysis.* Université de Lyon