Robotic Combat, Control, and Collaboration Through Virtual Twins

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In August 2018, Chatila et. al. stated in *Frontiers in Robotics and AI* "We still lack a genuine theory of the underlying principles and methods that would enable robots to understand their environment, to be cognizant of what they do, to take appropriate and timely initiatives…." We propose, implement, test, and demonstrate a simple and effective framework that addresses this problem. This framework allows for safe human-robot interactions, and can be used to provide haptic feedback in virtual reality. Further, it can be implemented with industrial robots and can improve resource management, data collection, and efficiency.

Underlying Principles

The basis of this framework is a virtual environment with a virtual model of the robot with an inverse kinematics library. To control the robot, we instruct the virtual model of the robot to move in its virtual world. The system monitors the movements of the virtual model and its interactions with its virtual world, and it commands the physical robot to replicate those movements. In this system, the goal is not to make the robot directly aware of its physical environment. Instead, the system exploits its complete knowledge of the virtual environment and the virtual model of the robot. This simplifies the original problem into two parts: interaction between a virtual robot and a virtual environment, and the collection of information about the physical environment and replicating it in the virtual environment.

Implementation & Tests

To test the system, we programmed several scenarios that demonstrate this framework's unique abilities in the Unity game engine. The first scene is a swordfight simulation with a player in VR fighting a knight. For this scene the robot is a 6-axis robotic arm that wields a prop sword and matches the motions of the virtual knight's sword. The models use realistic collision physics so that the opponent's sword - and the robot following it - clash and deflect against the player's sword, and this technique is also used to project a protective barrier around the player's body. The second scene is a VR boxing simulator in which a virtual opponent matches the position of a boxing dummy which is mounted to a moving robotic base. The user fights with the virtual opponent, and his hits impact the dummy which provides force feedback. The final scene is a virtual model of a car assembly process with multiple robotic arms, and all elements can be adjusted in real-time and information can be easily visualized.

Implications & Conclusion

This system demonstrates an intuitive, advanced robotic simulator that can control robots and adapt to the environment in real-time. Further, the framework allows for data to be collected in the virtual environment – this simplifies the implementation of resource monitoring and planning. The implementation with VR allows haptic and force feedback for entertainment, and AR-assisted management and monitoring for industry.

Overall, this is a promising framework for robotic control systems and human-robot interaction.