

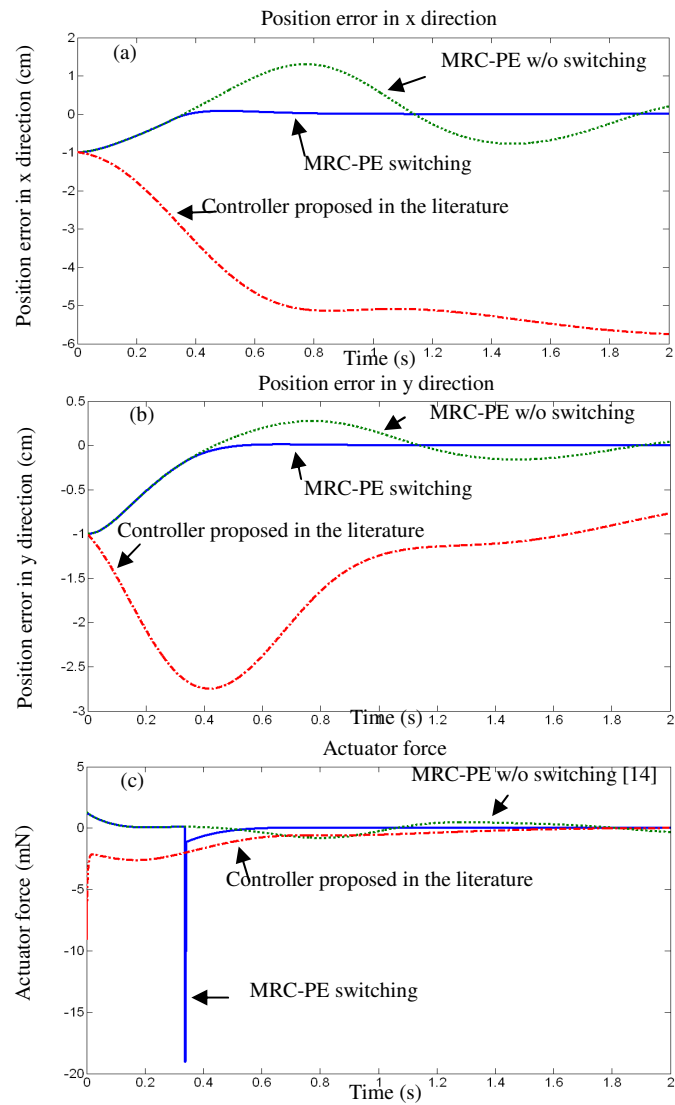
Nanoobject and Nanofiber Manipulation:

B.1. Nano-Robotic Manipulation Using a RRP Nanomanipulator:

A three degree of freedom (3 DOF) nanomanipulator with revolute revolute prismatic (RRP) actuator structure, named here MM3A, can be utilized for a variety of nanomanipulation tasks. We are working on developing mathematical modeling and a memory-based robust adaptive controller for the nanomanipulator driving principle. Unlike widely used Cartesian-structure nanomanipulators, the MM3A is equipped with revolute-piezoelectric actuators which result in outstanding performance in controlling the nanomanipulator's tip alignment during the nanomanipulation. However, the RRP structure of the nanomanipulator introduces complicity in kinematic and dynamic equations of the system which needs to be addressed in order to control the nanomanipulation process. Dissimilar to the ordinary piezoelectric actuators which provide only a couple of micrometers working range, the piezoelectric actuators utilized in MM3A, namely Nanomotors[®], provide wide range of action (120° in revolute actuators and 12mm in prismatic actuator) with sub-nanoscale precision (0.1 μ rad in revolute actuators and 0.25 nm in prismatic actuator). This wide range of action combined with sub-nanoscale precision is achieved using a special stick/slip moving principle of the Nanomotors[®]. However, such stick/slip motion results in stepping movement of the MM3A. Hence, due to the RRP structure and stepping movement principle of the MM3A nanomanipulator, development and implementation of an appropriate controller for such nanomanipulation process is not a trivial task. In this research, a novel memory-based robust adaptive controller is proposed to overcome such shortfalls. Following the development the controller, numerical simulations are preformed to demonstrate the positioning performance capability of the controller in a variety of nanomanipulation tasks.



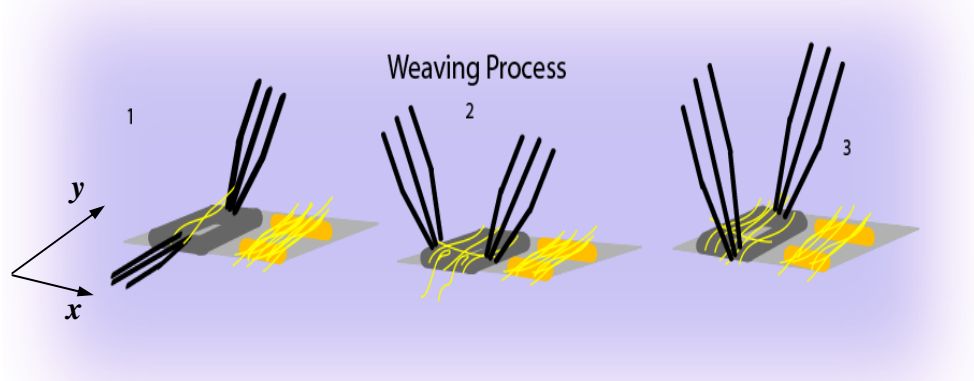
MM3A nanomanipulator at Clemson University, Smart Structures and NEMS Laboratory (SSNEMS).



Simulation results for: (a) Position error in x , (b) position error in y direction, and (c) actuator force.

B.2. Automated Manipulation of Active Nanofiber Fibrils Systems:

Funded by the Department of Commerce through National Textile Center, we are currently investigating polymeric fibrous materials with sensing and actuation capabilities. The ability to manipulate (thru a robot with proper grippers) and characterize these fibrous materials can result in different functions, and henceforth, lay the foundation for new structure design and manufacturing. Along this line, we are extending our currently funded project to explore and exploit the properties of active polymeric fibrous materials through an automated manipulation. Our currently funded project has yielded functional fabrics using a novel automated electrospinning method. The automated manipulation proposed in his work will utilize multiple active probe-based manipulators (as grippers attached to the end of robot arms) in combination with the 3D visual feedback from a stroboscopic video microscopy (SVM). As a demonstrable device fabrication, we aim to create complex 2D and 3D twisted fiber structures for different textile related applications.



Weaving process: (1) fibers placement, folding in warp direction, (2) fiber placement in the weft, and (3) unfolding warp fibers.