Neural Network Based Motion Control Algorithms for Ultra Precision Machine Tools

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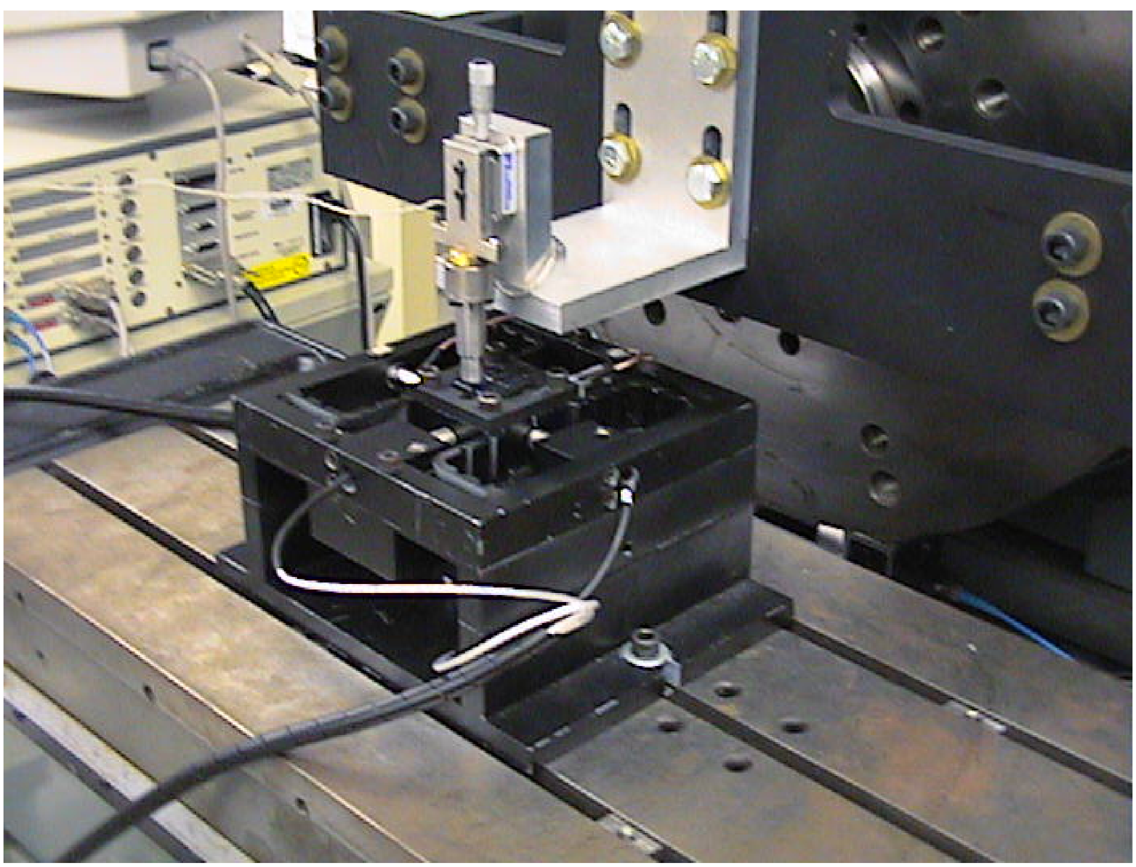
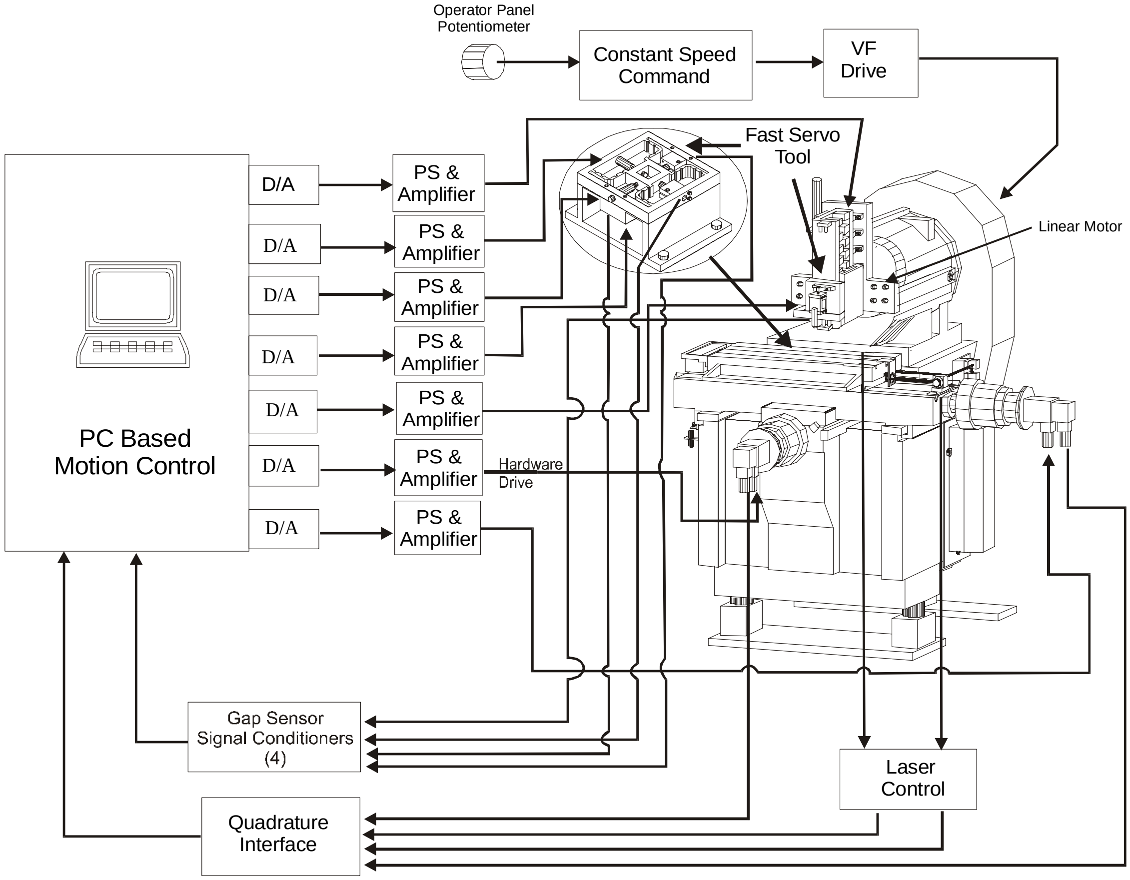
This work is focuses on the real-time computer control aspects of ultra-precision machine tools. By ultra-precision, we mean machining at sub-micron level accuracies. Single point diamond turning is one of the most precise machining processes. Machining of metal mirrors from soft metals (i.e. aluminum, copper) for night-vision cameras, optical systems, copy machines, VCR components, as well as ultra-precision machining of artificial hip-joint replacements are successful applications of ultra-precision machine tools. Our goal is to improve the accuracy of ultra-precision machine tools using advanced computer control algorithms. We are working on self-adapting control algorithms based on a class of artificial neural networks called cerebellar model articulation controller (CMAC). The CMAC based controller has been demonstrated to have the capability of learning the friction and backlash characteristics in machine tool drive systems. Hence, the CMAC based computer control algorithms is successfully implemented to improve the precision of ultra-precision machine tools. We conduct our experiments on a single point diamond turning machine. The test bed, single point diamond turning machine, has been retro-fitted with the proper state of art actuation system (high performance brushless servo motors), and high resolution position sensors (laser interferometers for X and Y axes with 2.5 nanometer resolution). The controller is implemented on an TMS320 DSP chip running on a board which is compatible with PC bus.
Currently, we are able to control the motion of XY table stage of the machine tool with 25 nanometer contour tracking accuracy at low speeds. This represents an almost a factor of 10 improvement over the standard industrial PID motion control algorithms which can provide only 250 nanometer tracking accuracy on the same machine.





Operator Panel
Potentiometer
Constant Speed
Command
VF
Drive
Fast Servo
Tool
Linear Motor
D/A
PS &
Amplifier
Hardware
Drive
PC Based
Motion Control
Gap Sensor
Signal Conditioners
(4)
Laser
Control
Quadrature
Interface