Improvement of Contouring Accuracy for Computer Numerically Controlled Milling Machines

Problem:

Currently, CNC machines use traditional fixed control methods such as PID to control the velocity and position of the machine axes. These controllers result in undesirable steady-state errors for multi-dimensional contour tracking. The performance of these controllers also degrades as the system varies from its nominal operating point. An improved control scheme is needed to improve contour tracking which will also maintain performance in the presence of time-varying system dynamics.

Approach:

- Develop a multivariate adaptive controller design to minimize tracking error and contour error for two-dimensional machining systems.
- Design and construct a PC-based open architecture Computer Numeric Controller (CNC) to allow the implementation of the adaptive controller design.
- Perform computer simulations of the new algorithms and verify the design with experimental results via the open architecture controller.

Results:

- A PC-based open architecture CNC controller was designed and implemented for a multi-axis milling machine (Figures 1 and 2).
- A multivariate adaptive control technique was designed to reduce the tracking and contour errors of a two-dimensional contour on a milling machine.
- The experimental results for the new adaptive algorithms show a reduction in the contour error. Figure 3 presents the contour error reduction for a straight line at -135°, and figure 4 presents the contour error reduction for a circular contour of radius 75 mm.

Conclusions:

- The multivariate adaptive controller results in significant reduction of system errors.
- The open architecture controller provides a flexible platform for the implementation of experimental control algorithms for milling machines.

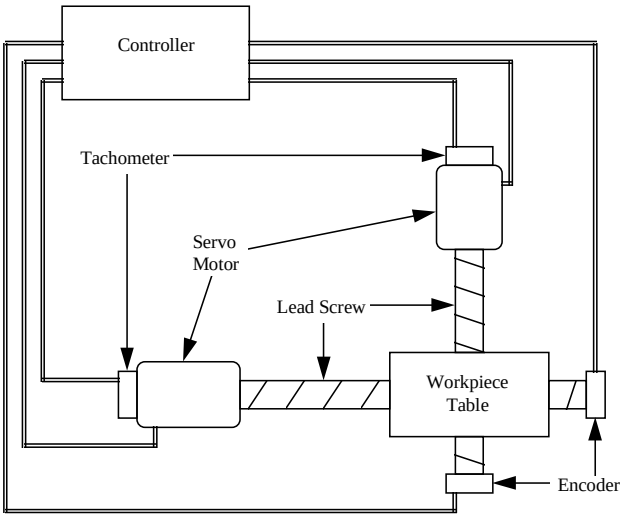

Figure 1 Layout of Two-Axis Positioning System for Milling Machines

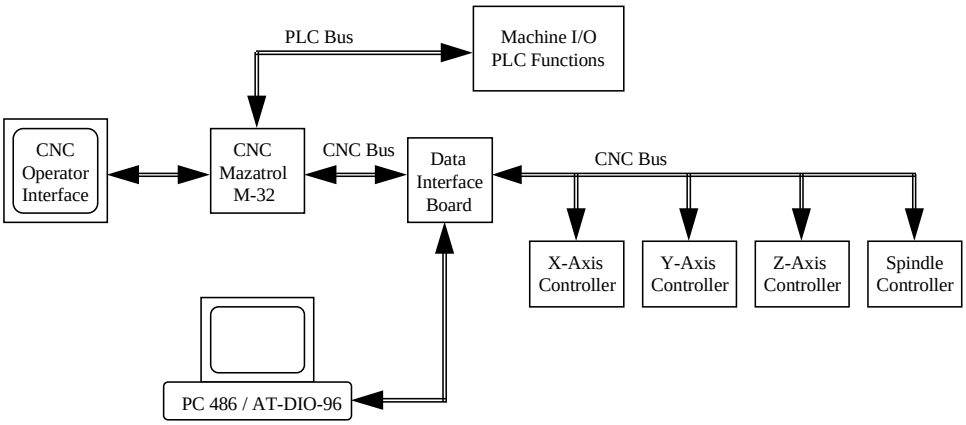

Figure 2 Electrical Layout for PC-Based Open Architecture CNC System

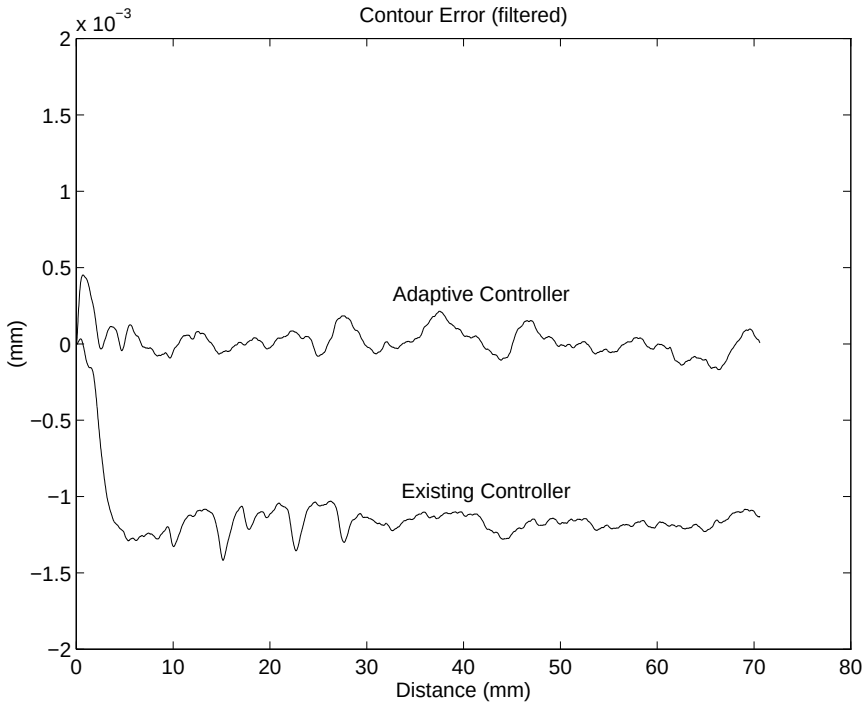

Figure 3 Contour Error for Line at -135° (Existing Controller vs. Adaptive Controller)

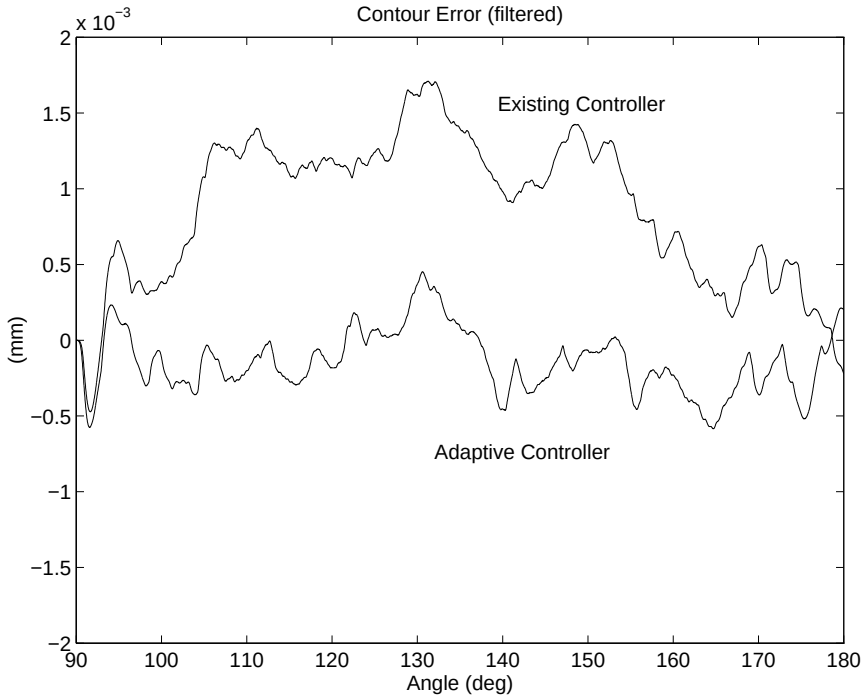

Figure 4 Contour Error for Circle (Radius = 75 mm)
(Existing Controller vs. Adaptive Controller)