An Intelligent Control Approach for Defect-Free Friction Stir Welding

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Abstract

An intelligent control approach is proposed as an alternative for the friction stir welding of an aluminum alloy. A validated empirical model is re-written from transfer functions to a set of ordinary differential equations, allowing to observe the force dynamics as a function of inputs of interest. A defect-free set-point is proposed for exploiting available labeled experimental data which defines operational boundaries and a region in which the probability of achieving defect-free welds with good mechanical properties is the highest. An intelligent controller in the fashion of a Recurrent Neural Network is constructed. Computational experiments were carried out to verify the adequacy in disturbance rejection as well as to visualize the capabilities in achieving the proposed defect-free set-point by the controller. The intelligent approach is compared with a set of decoupled proportional-integral controllers and a linear model predictive control strategy. From this study it is concluded that the intelligent controller shows superiority and good applicability for the studied problem.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the latest manuscript can be downloaded and accessed as a PDF.

Figures

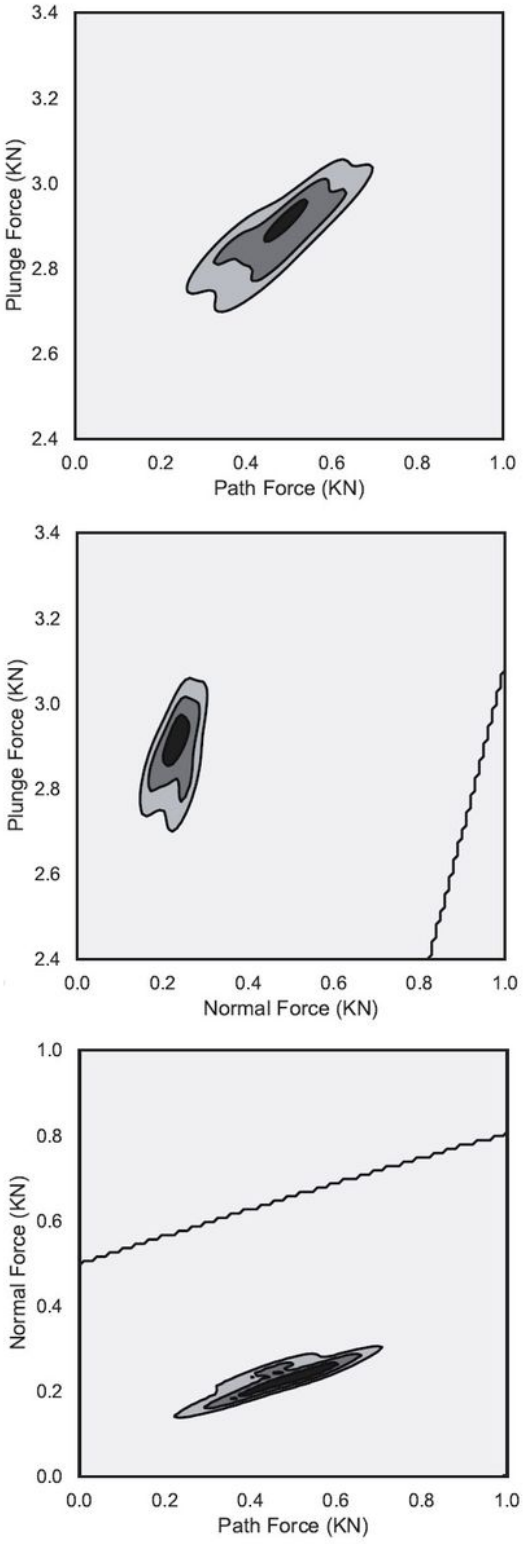

Figure 1

Density plot of defect-free welds.

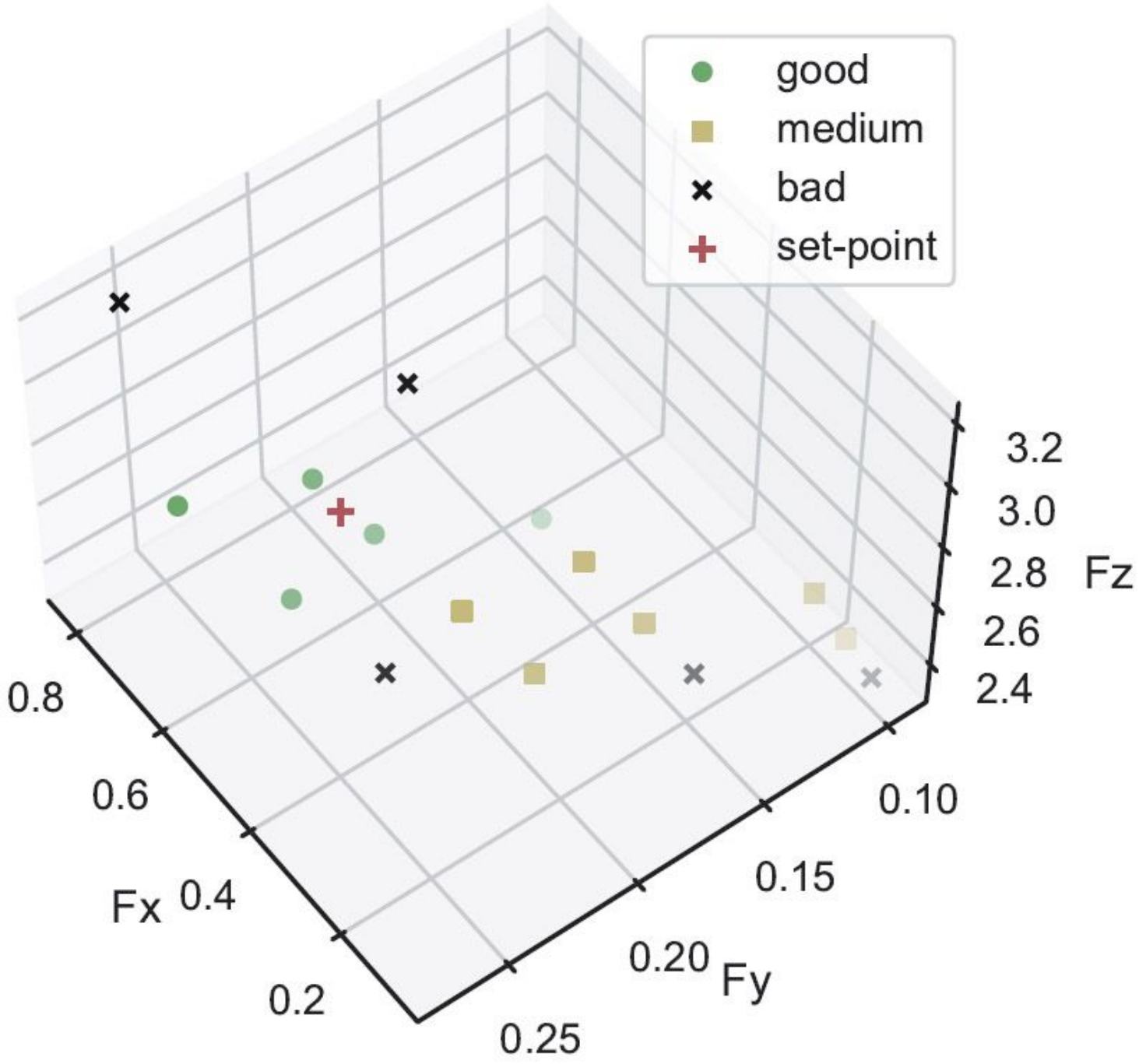

Figure 2

3D view of the data in the force space.

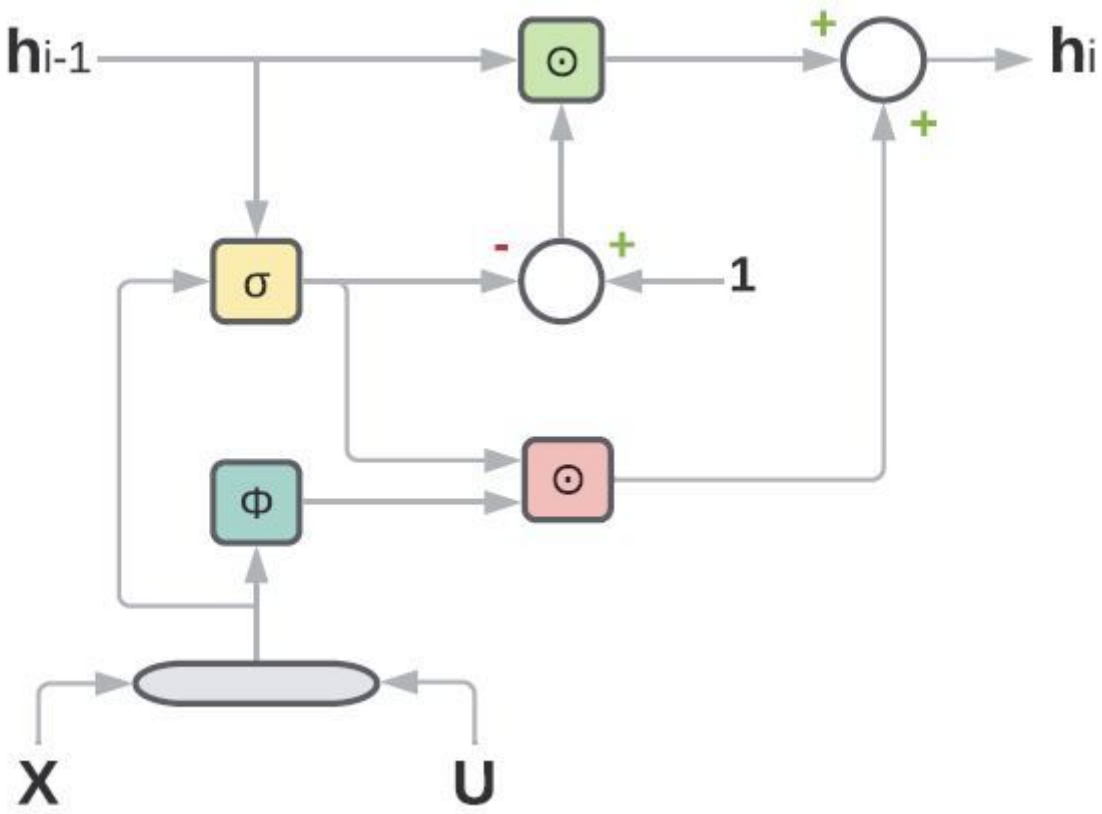

Figure 3

Block diagram representation of a minimal GRU module.

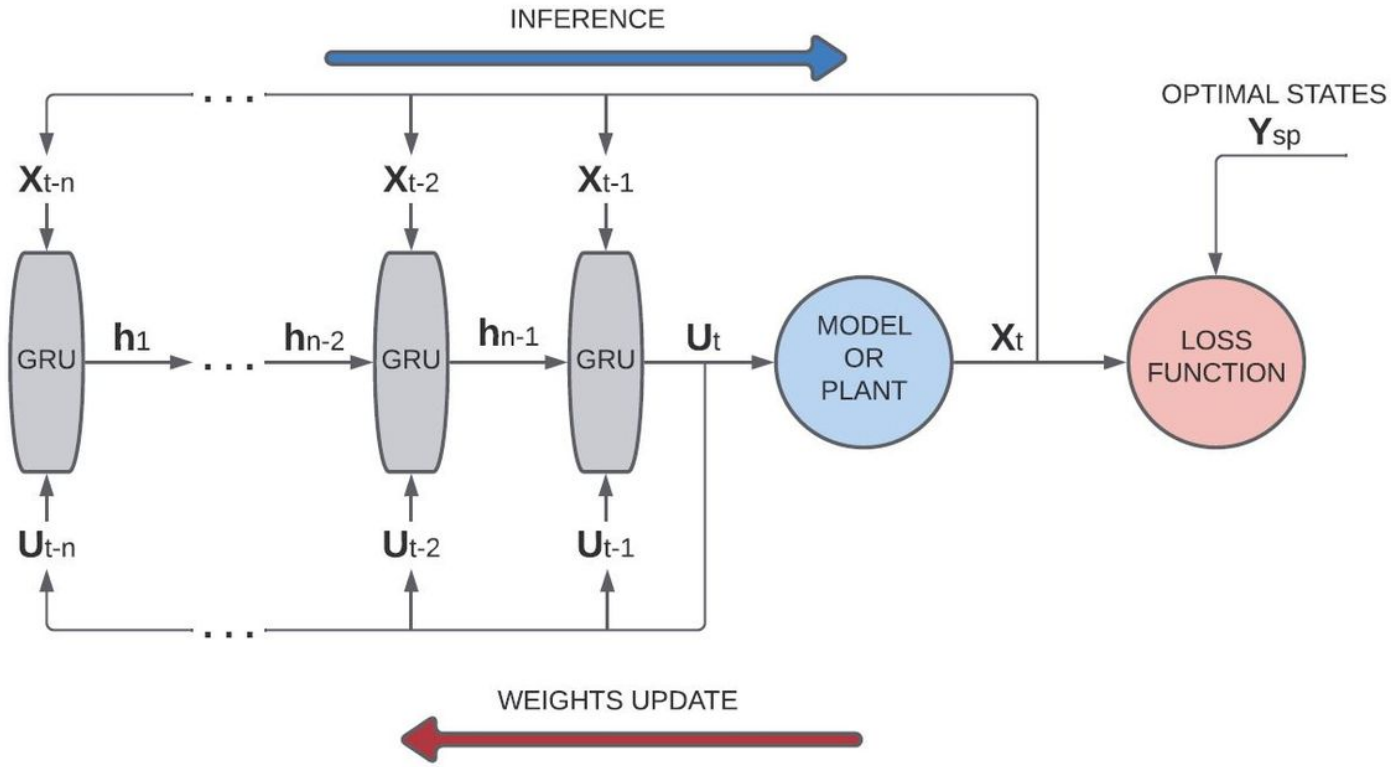

Figure 4

Closed-loop process diagram employing the proposed control system.

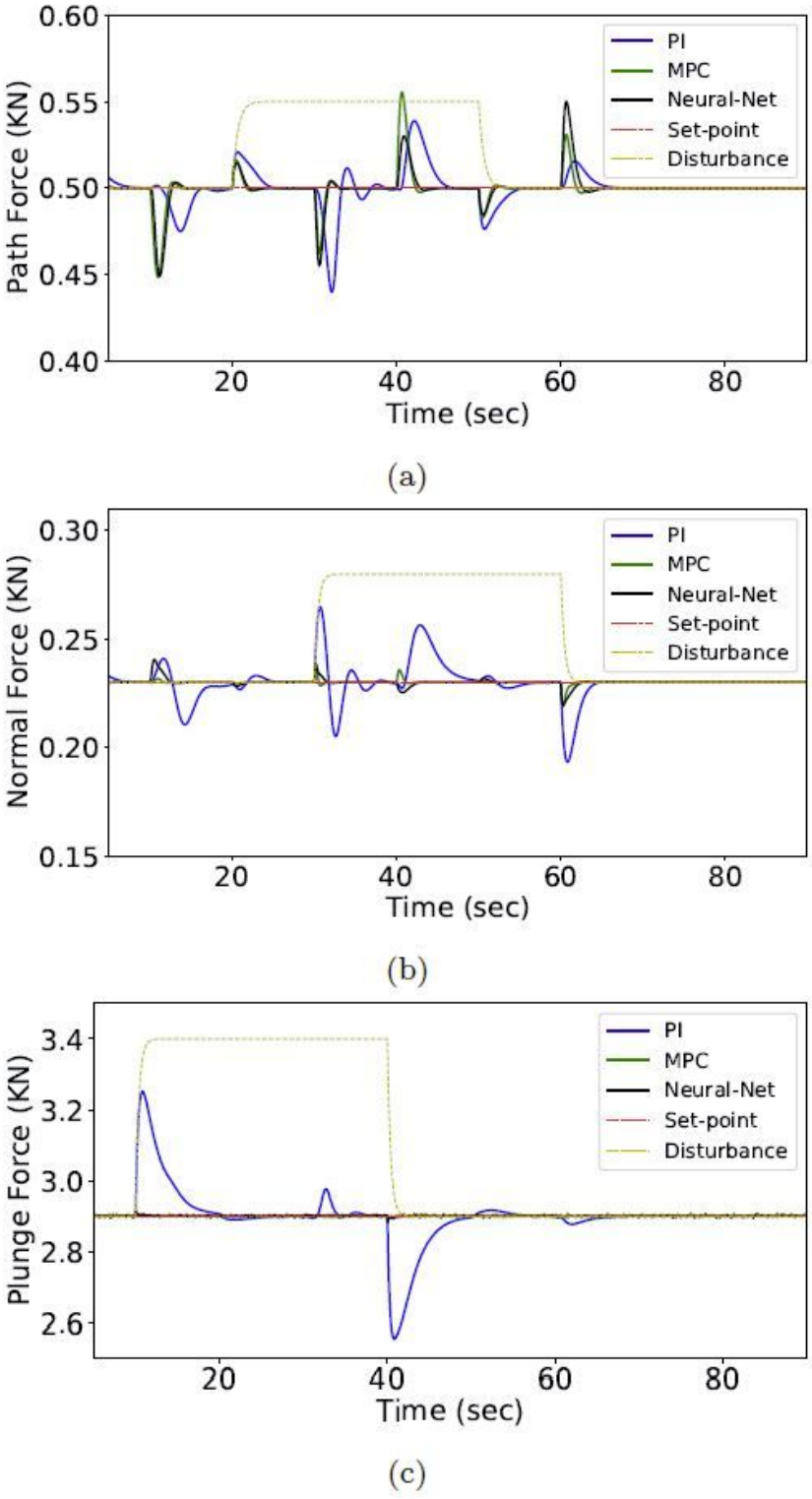

Figure 5

Response comparison between different control systems in disturbance rejection. (a) Path Force. (b) Normal Force. (c) Plunge Force.

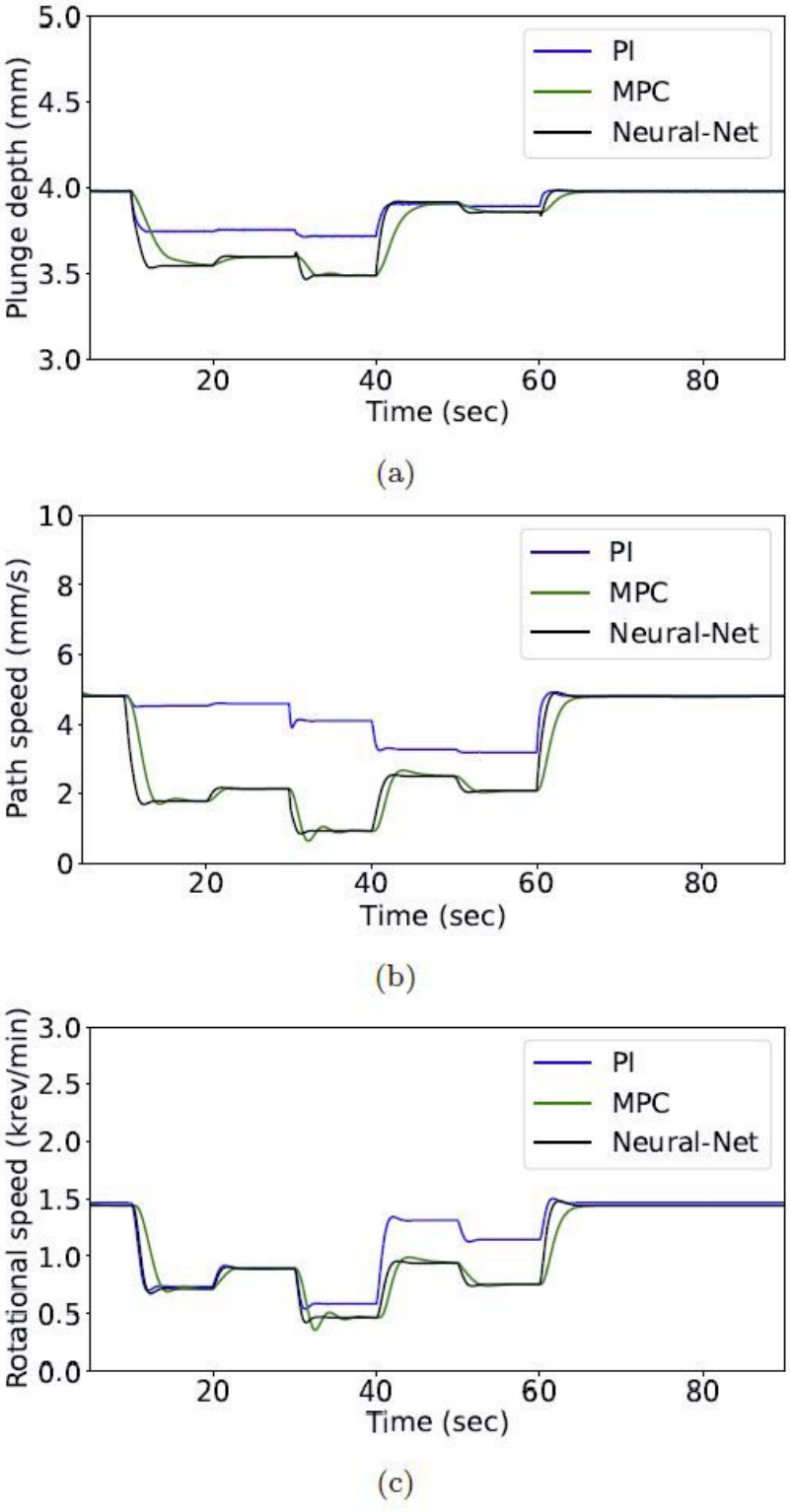

Figure 6

Controller signal comparison between different control systems in disturbance rejection. (a) Plunge Depth. (b) Path Speed. (c) Rotational Speed.

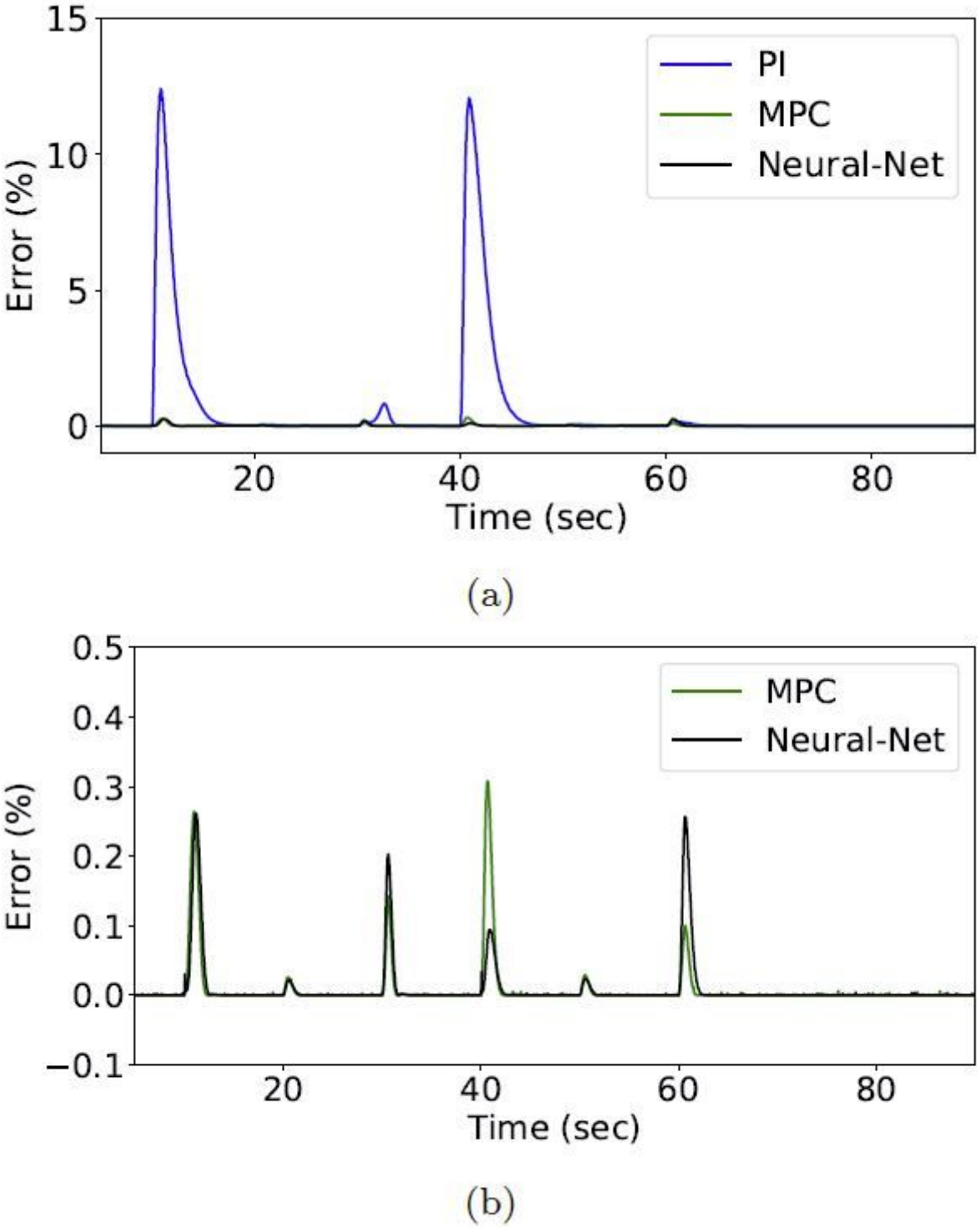

Figure 7

Error time series of the controllers on the dis- turbed system. (a) Error comparison of the three controllers. (b) Close-up view of the MPC and Intelligent controllers.