Notation and Abbreviations

\( \alpha \)  
Set-point weighting parameter for derivative gain

\( \beta \)  
Set-point weighting parameter for proportional gain

\( \delta_k \)  
Peak value of process response in \( k^{th} \) sampling time

\( \sigma \)  
Integration interval

\( \omega_c \)  
Gain crossover frequency

\( \omega_p \)  
Phase crossover frequency

2DOF  
Two-Degrees-Of-Freedom

3-D  
Three-dimensions

ANFIS  
Adaptive-Network-based-Fuzzy-Inference System

\( b \)  
Bias value of a neuron

\( c \)  
The center of fuzzy inference system

\( C_a \)  
Acceleration error constant

\( C_p \)  
Position error constant

\( cr \)  
Change in reference signal

\( cur_r \)  
Current Region

\( C_v \)  
Velocity error constant

\( dde \)  
Error's second difference signal

\( de \)  
Error's first difference signal

DE_NEG  
Change in error is negative

DE_POS  
Change in error is positive

\( d_i \)  
\( i^{th} \) discriminant function

\( e(n) \)  
Error signal in \( n^{th} \) sampling time (discrete form)

\( E(s) \)  
Error of closed-loop system

\( e(t) \)  
Error signal (continuous form)

E_NEG  
Error is negative
$E_{POS}$  Error is positive
$E_{ZE}$  Error is zero
$eq_b$  Equilibrium
$e_{ss}$  Steady-state error
$f_1$  Fuzzy inference system that produces $k_{p_{scale}}$
$f_2$  Fuzzy inference system that produces $k_{i_{scale}}$ in rise time state (near the set point)
$f_3$  Fuzzy inference system that produces $k_{d_{scale}}$
$f_4$  Fuzzy inference system that produces $k_{i_{scale}}$ in overshoot/oscillation state
$f_5$  Fuzzy inference system that produces $k_{i_{scale}}$ in rise time state (far from the set point)
$f_6$  Fuzzy inference system that produces $offset_{1}$
$f_7$  Fuzzy inference system that produces $offset_{2}$
$FInc$  Fuzzy incremental controller
$fsbmn$  Knowledge-based modular neural network classifier
$FLC$  Fuzzy logic controller
$FP$  Fuzzy proportional controller
$FPD$  Fuzzy proportional derivative controller
$FPD+I$  Fuzzy proportional derivative controller + integral controller
$G(s)$  Transfer Function of open-loop system
$g_1$  A function that produces proportional gain scaling factor
$g_2$  A function that produces integral gain scaling factor
$g_3$  A function that produces derivative gain scaling factor
$G_c(s)$  Transfer Function of controller
$G_{CE}$  Input scaling factor of change in error signal
$G_{CU}$  Output scaling factor of $PI-FLC$
$G_{d}(s)$  Transfer Function of time delay
$GE$  Input scaling factor of error signal
$GM$  Gain Margin
$G_p(s)$  Transfer Function of process
\( GU \) Output scaling factor of PD-FLC
\( H(s) \) Transfer Function of feedback path
\( IMC \) Internal model control
\( I-PD \) Integral controller + Proportional Derivative controller
\( KBMNN \) Knowledge-based modular neural network
\( k_d \) Derivative gain of conventional PID controller
\( k_d' \) Derivative gain of proposed PID controller
\( k_{d,\text{scale}} \) Derivative gain scaling factor
\( k_i \) Integral gain of conventional PID controller
\( k_i' \) Integral gain of proposed PID controller
\( k_{i,\text{scale}} \) Integral gain scaling factor
\( k_p \) Proportional gain of conventional PID controller
\( k_p' \) Proportional gain of proposed PID controller
\( k_{p,\text{scale}} \) Proportional gain scaling factor
\( MIMO \) Multi Input Multi Output
\( MIT\text{ rule} \) The rule that is developed by Massachusetts Institute of Technology
\( MRAS \) Model References Adaptive System
\( net \) Activation value of a neuron
\( NN \) Neural Network
\( o_i' \) \( i^{th} \) output of first combination unit of KBMNN
\( o_i^2 \) \( i^{th} \) output of second combination unit of KBMNN
\( offset1 \) The value to compute the center of fuzzy inference system
\( offset2 \) The value to compute increment of integral action in initial moment of disturbance state
\( P+ID \) Proportional controller + Integral Derivative controller
\( PD \) Proportional Derivative controller
\( PD+I \) Proportional Derivative controller + Integral controller
\( PI \) Proportional Integral controller
\( PID \) Proportional Integral Derivative controller
\( PID-FLC \) Proportional Integral Derivative type Fuzzy logic controller
\( PID\text{NN} \) Proportional Integral Derivative Neural Network
\begin{itemize}
\item \textbf{PM} \hspace{1cm} \text{Phase Margin}
\item \textit{pre_c} \hspace{1cm} \text{Previous Class}
\item \textit{pre_r} \hspace{1cm} \text{Previous Region}
\item \textit{R(s)} \hspace{1cm} \text{Input of closed-loop system}
\item \textit{S(s)} \hspace{1cm} \text{Sensitivity of closed-loop Transfer Function}
\item \textit{SISO} \hspace{1cm} \text{Single Input Single Output}
\item \textit{STR} \hspace{1cm} \text{Self-Tuning Regulator}
\item \textit{T(s)} \hspace{1cm} \text{Transfer Function of closed-loop system}
\item \textit{T1} \hspace{1cm} \text{Tuning strategy for rise time state (delay period)}
\item \textit{T2} \hspace{1cm} \text{Tuning strategy for rise time state (far from the set point)}
\item \textit{T3} \hspace{1cm} \text{Tuning strategy for rise time state (near the set point)}
\item \textit{T4} \hspace{1cm} \text{Tuning strategy for overshoot/oscillation state}
\item \textit{T5} \hspace{1cm} \text{Tuning strategy for steady-state}
\item \textit{T6} \hspace{1cm} \text{Tuning strategy for disturbance state (diverging from the set point)}
\item \textit{T7} \hspace{1cm} \text{Tuning strategy for disturbance state (approaching to the set point)}
\item \textit{T_d} \hspace{1cm} \text{Derivative time constant}
\item \textit{th1} \hspace{1cm} \text{Threshold value to define steady-state}
\item \textit{th2} \hspace{1cm} \text{Threshold value to define classifier’s activation}
\item \textit{T_i} \hspace{1cm} \text{Integral time constant}
\item \textit{TS} \hspace{1cm} \text{Sampling Time}
\item \textit{u_{pid}(i)} \hspace{1cm} \text{Output of PID controller (continuous form)}
\item \textit{u_{pid}(n)} \hspace{1cm} \text{Output of PID controller in } n^{th} \text{ sampling time (discrete form)}
\item \textit{w_i} \hspace{1cm} \text{Weight vector for each neuron}
\item \textit{X} \hspace{1cm} \text{Input pattern vector}
\item \textit{Y(s)} \hspace{1cm} \text{Output of closed-loop system}
\end{itemize}