INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

INTELLIGENT CONTROL OF DC MOTOR USING COMPUTATIONAL INTELLIGENCE TECHNIQUES

MCTA 3371

GROUP 4

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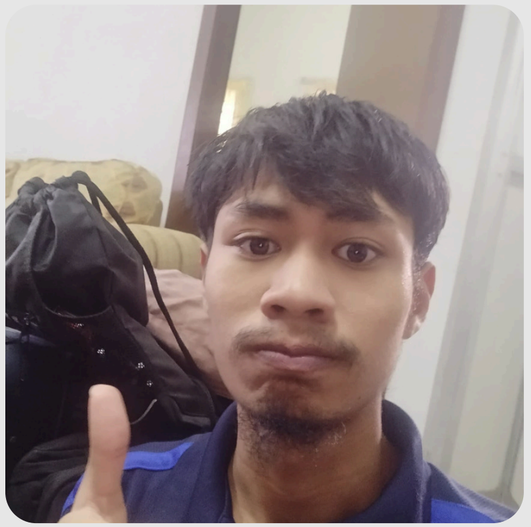

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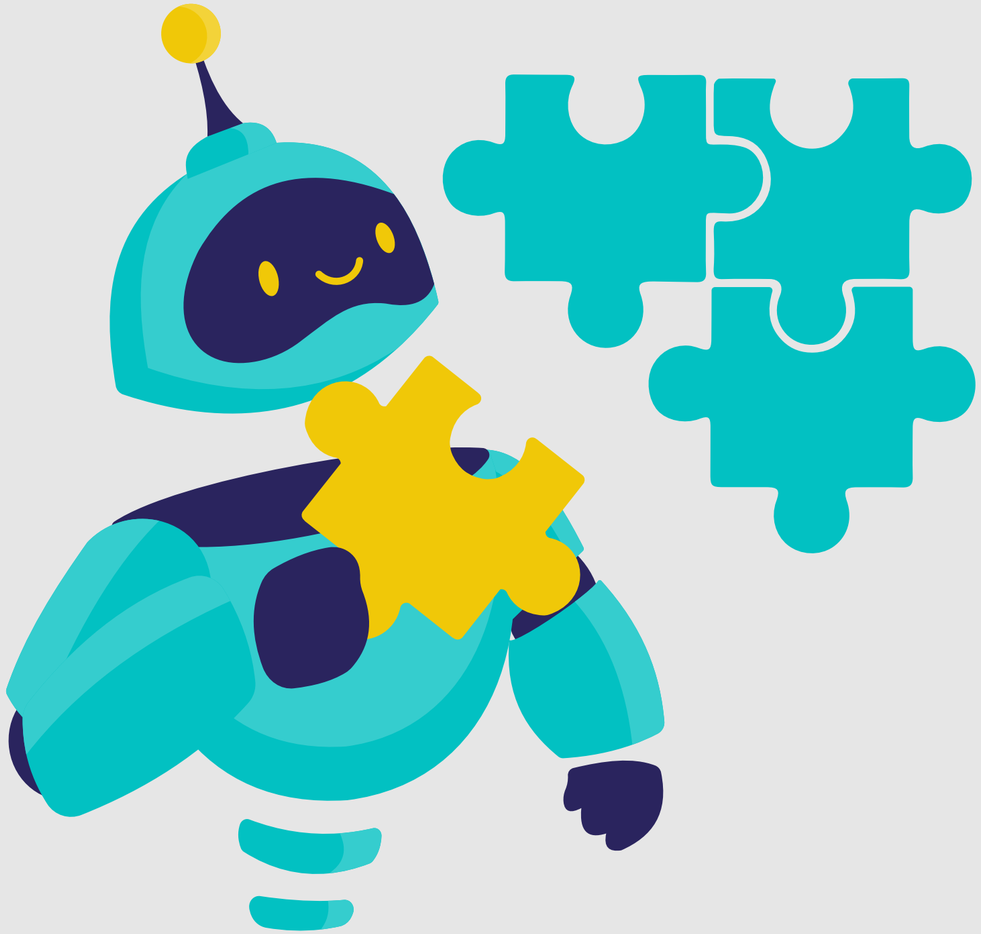
PROJECT OBJECTIVES



1. Model a DC motor using standard electrical and mechanical parameters
2. Design and implement three control techniques :
   - PID Control (Classical)
   - Mamdani Fuzzy Logic Control
   - ANFIS Hybrid Control
3. Compare system responses using MATLAB simulation
4. Analyze controller performance using metrics: rise time, overshoot, settling time, steady-state error, and MSE

DC MOTOR MODELLING

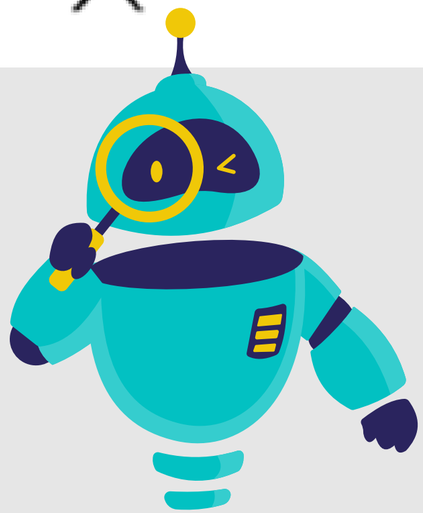
DC Motor Parameters

- R = 1 Ω (Resistance)
- L = 0.5 H (Inductance)
- J = 0.01 kg·m² (Rotor Inertia)
- B = 0.1 N·m·s (Viscous Damping)
- K = 0.01 (Motor Constant)

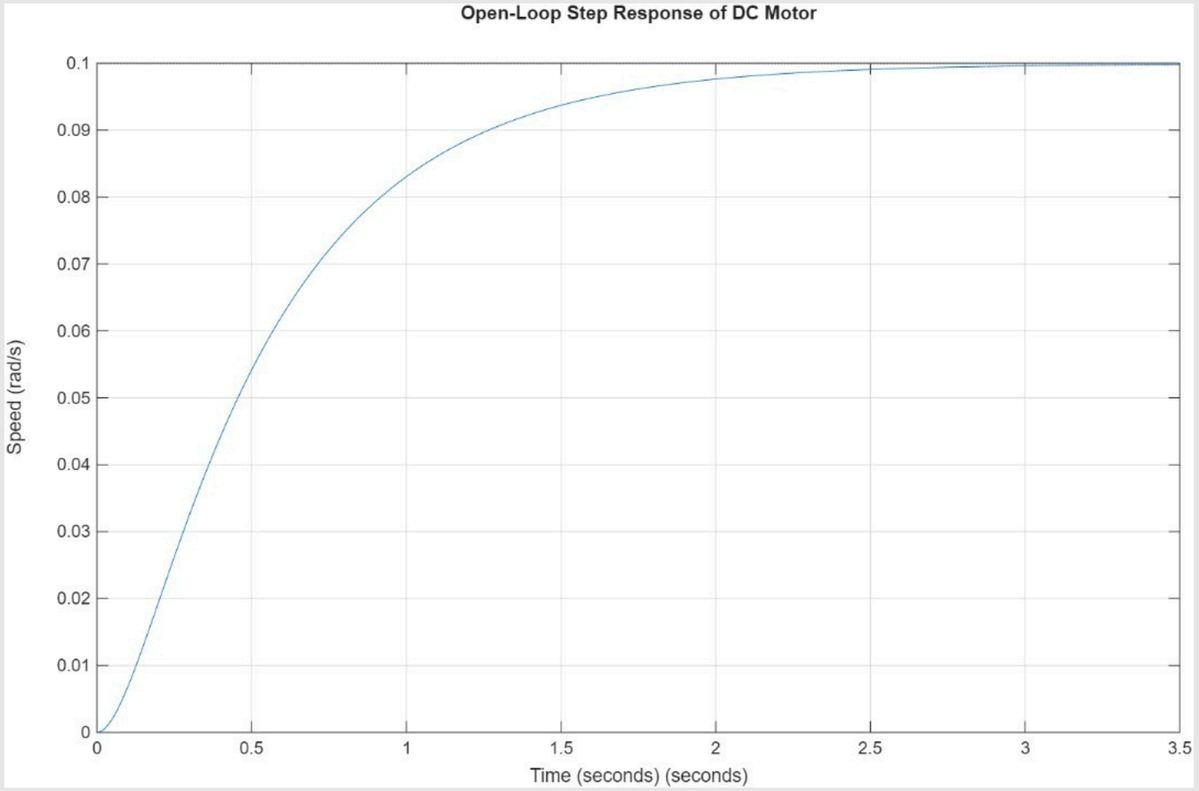
Tool: MATLAB System Modeling
Output: State-space representation (SS)

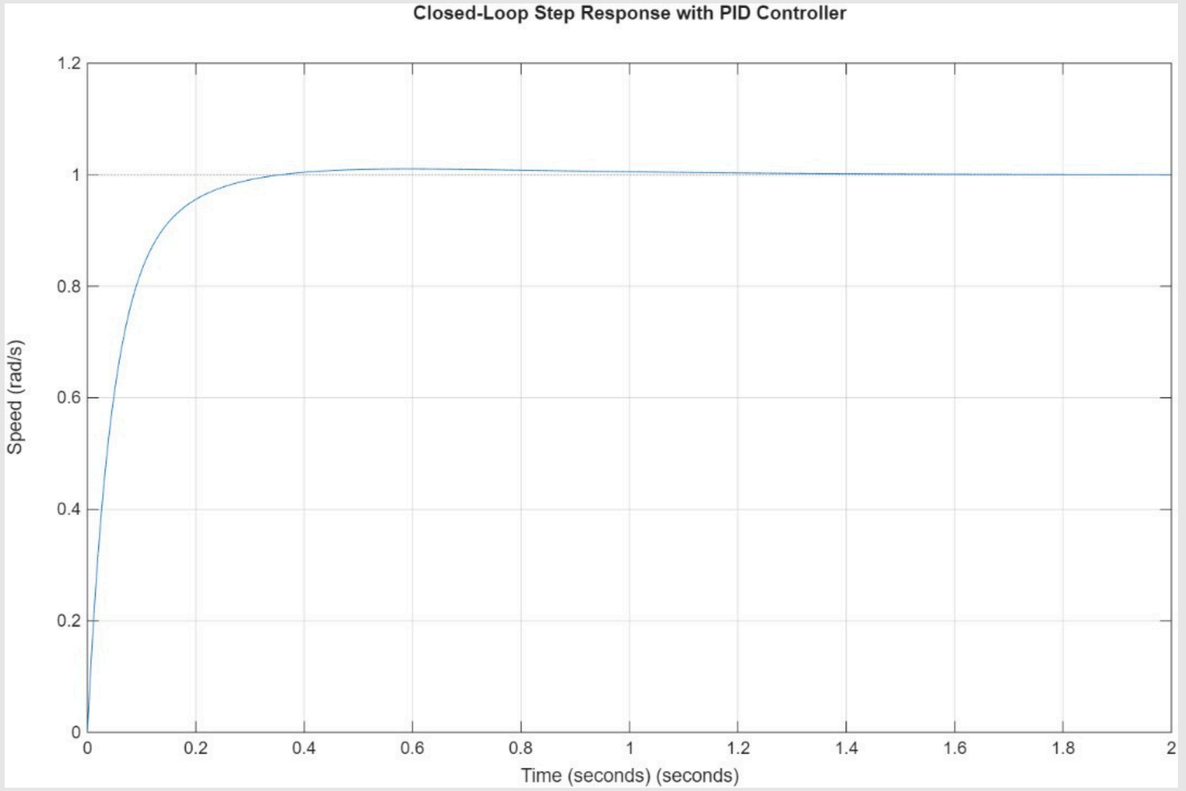
Transfer Function

$$P(s) = \frac{K}{(Js + b)(Ls + R) + K^2}$$

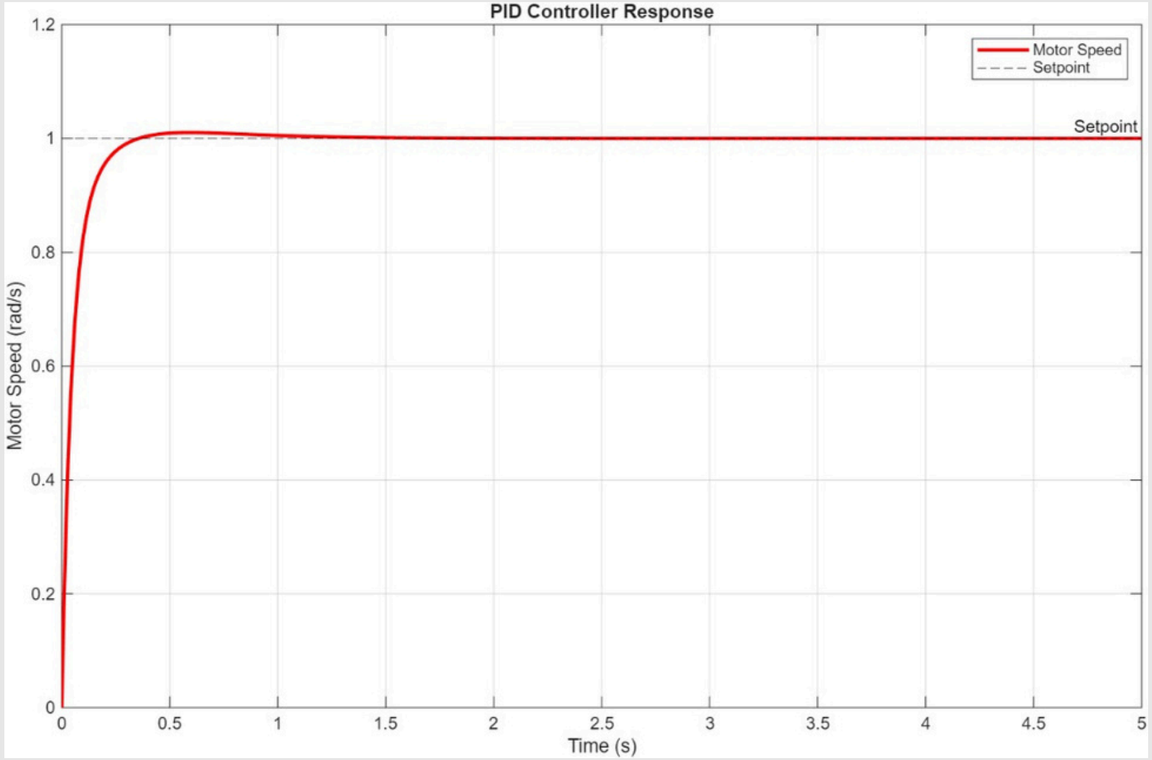


CONTROLLER OVERVIEW





PID CONTROLLER



Gains :

- $K_p = 100$
- $K_i = 200$
- $K_d = 10$

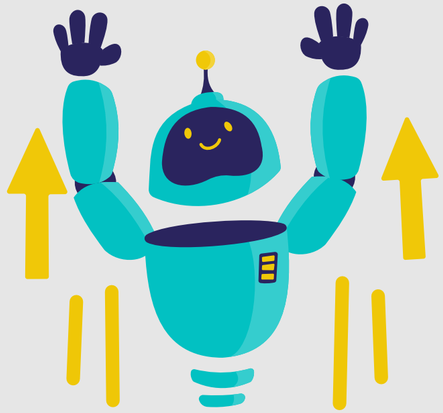
Implemented with MATLAB control system toolbox

Used for performance benchmark

Result:

- **Fast rise time (0.132 s)**
- **Low overshoot (1.03%)**
- **Steady-state error ≈ 0**
- **MSE: 0.00642**

FUZZY LOGIC CONTROLLER

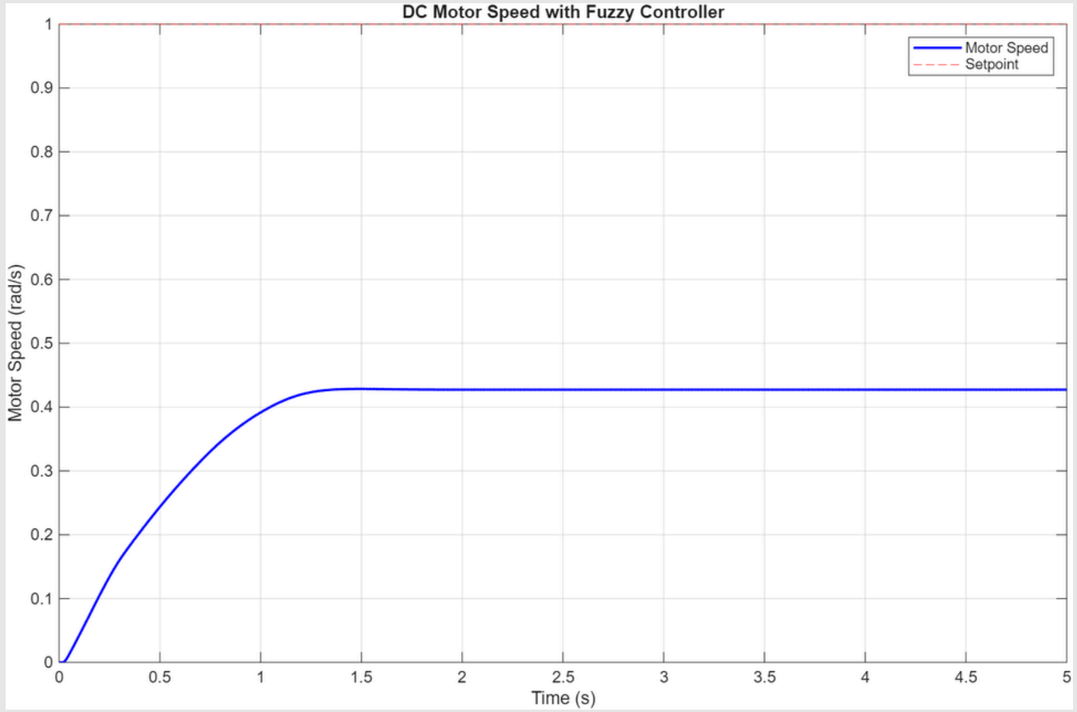


Mamdani Fuzzy Logic

Inputs:
- **Error**
- **Delta Error**

Output:
- **Control effort (scaled to ±12V)**

Performance:
- **Overshoot: 0%**
- **Steady-state value: ~0.37**
- **MSE: 0.45843**



Design Details:
- **Membership functions : NB, NS, ZE, PS, PB**
- **9 Rule Base System**
- **Implemented using evalfis()**

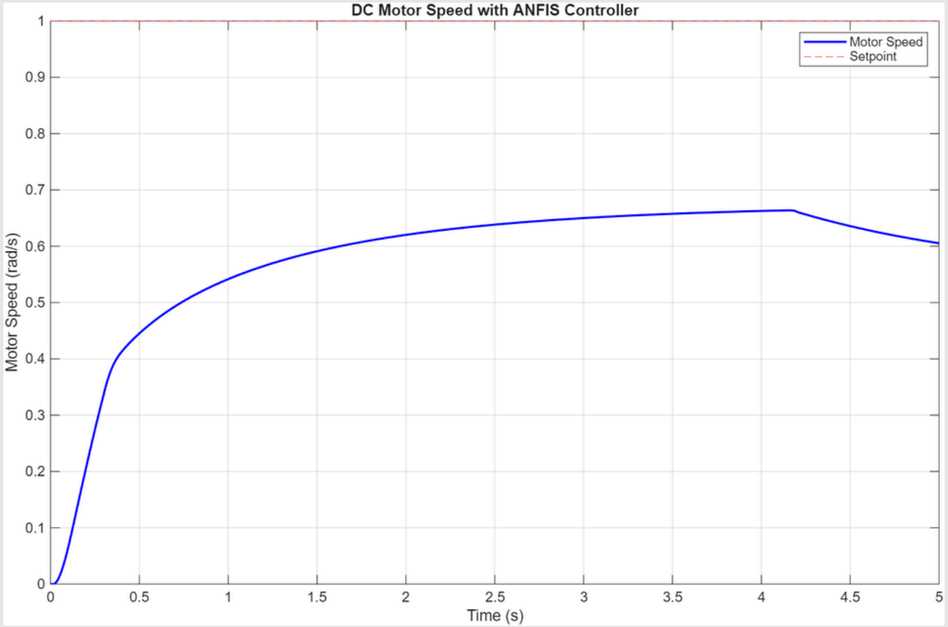
ANFIS CONTROLLER

ANFIS (Adaptive Neuro-Fuzzy Inference System)

- **Input data from fuzzy logic performance**
- **2000 training samples: error, delta error → output**
- **Trained using MATLAB anfisedit GUI**
- **Output scaled ×36 for effective torque**

Performance:

- **Better than Fuzzy Logic**
- **Steady-state value ≈ 0.77**
- **MSE: 0.12409**



SIMULATION ENVIRONMENT

Simulation Details

- **Time domain: 5 seconds**
- **Sampling: dt = 0.01s**
- **MATLAB + Simulink (optional)**
- **Euler integration using state-space model**
- **Step response compared across all controllers**

Metrics Used:

- **Rise Time**
- **Settling Time**
- **Overshoot**
- **Steady-State Error**
- **Mean Squared Error (MSE)**

RESULTS COMPARISON

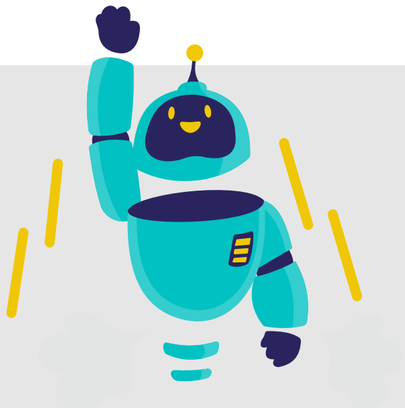
Metric	PID	Fuzzy	ANFIS
Rise Time (s)	0.132	0.805	0.09
Settling Time (s)	0.199	—	—
Overshoot (%)	1.03	0	0
Steady-State Value	1	0.43	0.41
MSE	0.00642	0.38658	0.2244

CONCLUSION

PID: Best accuracy and speed, slight overshoot

Fuzzy: Stable, zero overshoot, but too slow and weak

ANFIS: Improved fuzzy behavior with training, no overshoot, higher steady state



Trade-off:

- PID is ideal for precision
- ANFIS has potential for adaptive systems
- Fuzzy is easy to implement but needs tuning

THANK YOU