A Three-Layer Educational Control Architecture: Samizo-Lab AITL Controller (A-type)

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***Abstract*—This paper presents a modular and interpretable educational control architecture referred to as the AITL Controller (A-type). The framework consists of three layers: a PID inner loop for baseline stabilization, an FSM supervisory layer governing mode-dependent behavior, and a lightweight LLM-based adaptive mechanism adjusting the proportional gain under large-error conditions. The architecture clearly separates the roles of stability control, supervisory logic, and adaptive response.**

***Index Terms*—PID control, supervisory control, FSM, adaptive systems, LLM-based control**

I. Introduction

Multi-layer control architectures are widely used in practical systems to handle disturbances, nonlinearities, and mode-dependent behavior [1]. Classical PID control is well understood [2], yet educational frameworks often lack clear separation of control-layer roles.

Deterministic finite-state machines (FSMs) provide a structured approach for supervisory switching [3]. Recent progress in AI-assisted control motivates hybrid schemes that include lightweight adaptive elements [4].

The Samizo-Lab AITL Controller (A-type) integrates: (1) a PID baseline stabilization loop, (2) an FSM supervisory switching layer, and (3) an LLM-driven adaptive gain mechanism.

II. AITL Architecture

A. Three-layer Structure

Figure 1 shows the overall structure of the AITL Controller. Each layer plays a distinct role, enabling a clear separation of stabilization, supervisory logic, and adaptive behavior.

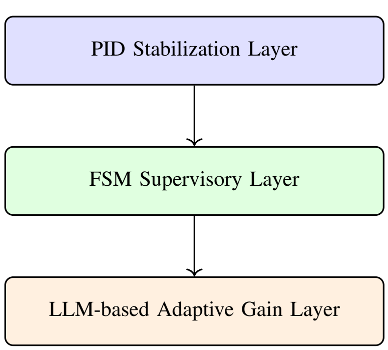

Fig. 1. Three-layer AITL Controller architecture.

B. FSM Supervisory Logic

The FSM switches modes according to:

$$|e(t)| > \theta_{\text{high}} \Rightarrow \text{high-response mode.} \tag{1}$$

Figure 2 illustrates the supervisory state transitions.

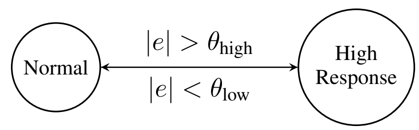

Fig. 2. FSM transitions of the AITL Controller.

C. LLM-Based Adaptive Layer

The LLM adjusts the proportional gain k_p only in the high-response mode, improving transient and disturbance response.

III. Simulation Results

A step input was applied at $t = 0\,\text{s}$, and disturbances at $t = 5\,\text{s}$ and $t = 15\,\text{s}$.

The PID loop ensures stability, the FSM switches modes appropriately, and the LLM enhances transient performance.

IV. Conclusion

The AITL Controller (A-type) provides a clear and modular educational framework combining PID regulation, FSM supervision, and LLM-based adaptive gain tuning. Its structural transparency supports intuitive learning of multi-layer control.

References

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Author Biography

Shinichi Samizo received the M.S. degree in Electrical and Electronic Engineering from Shinshu University, Japan. He worked at Seiko Epson Corporation in semiconductor memory and mixed-signal development, contributing to inkjet MEMS actuators and PrecisionCore printhead technology. He is currently an independent researcher focusing on semiconductor education, memory architecture, and AI-assisted control systems.

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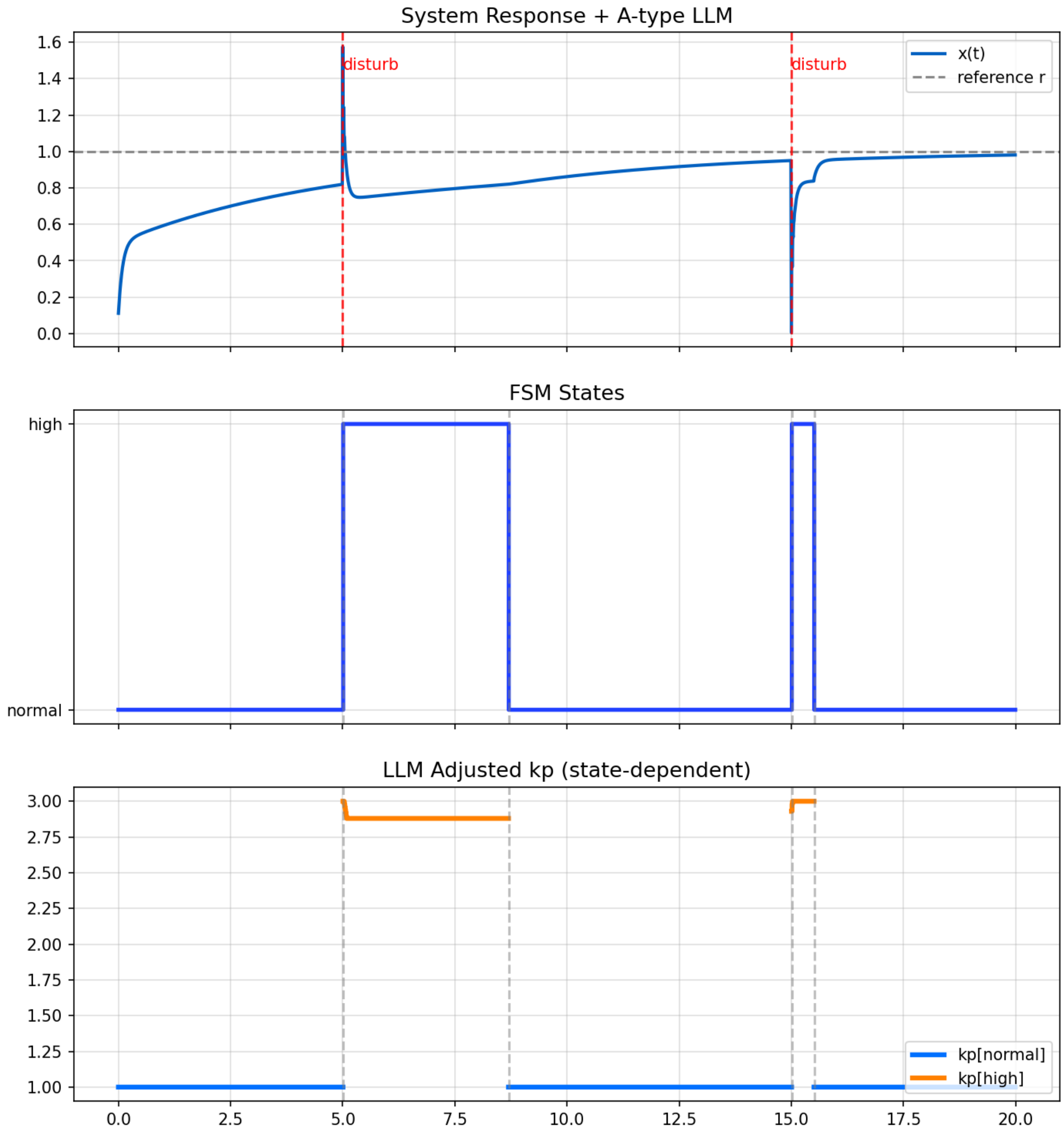

Fig. 3. System response, FSM transitions, and LLM-adjusted proportional gain under disturbance conditions.