Abstract

A closed-loop biochemical control system integrates deterministic safety arbitration with an adaptive neural inference layer to regulate multiple physiologic or process variables. A modular sensor array delivers high-frequency measurements of diverse analytes, while replaceable actuator cartridges carry therapeutic agents and embedded metadata defining dose ceilings and incompatibilities. A hierarchical controller enforces hard-limit overrides and guard-rail conflict checks, applies routine feedback optimisation, and overlays a dynamic model that refines patient- or process-specific dose-response relationships by micro-dose probing. Commands are issued every few seconds, always bounded by the fixed safety layers. Redundant controllers, watchdog supervision, cartridge authentication, and a manual override path furnish fail-safe continuity. All sensor readings, control actions, and overrides are time-stamped and cryptographically chained in an immutable audit ledger, ensuring regulatory traceability. The architecture autonomously maintains a subject's biochemical state within a personalised homeostatic envelope while preserving verifiable safety and compliance.