ABSTRACT

A closed-loop system for automatically maintaining human biochemical homeostasis is disclosed. Thirteen detachable sensor modules furnish ≥ 140 parallel measurements—including electrolytes, metabolites, cytokines, coagulation factors, blood gases and pathogen antigens. A hierarchical arbiter ranks each measurement by harm-severity and time-to-harm, resolves inter-analyte conflicts through a quadratic constraint graph, and issues deterministic pump commands every 5 s. Five reagent-cartridge bays store EEPROM descriptors with drug-class codes, cumulative dose ceilings and incompatibility tags; a cartridge whose code conflicts with an already-active code is automatically locked out. Real-time events are hashed into an immutable audit ledger that supports cryptographically-verified over-the-air updates. The architecture achieves single-fault tolerance, 21 CFR §820.70(i) traceability and plug-in extensibility for future biomarkers—without firmware change.

TraceLoop-MX is a modular closed-loop platform that **simultaneously senses up to 140 biochemical, physiologic, infectious, and toxicologic markers** and autonomously adjusts infusion, chelation, adsorption, ventilation, and renal-replacement actuators to maintain patient homeostasis. The target setting is high-acuity care (ICU, ECMO, CRRT, trauma, oncology) where biochemical states can change in minutes and manual titration error drives significant morbidity, mortality, and cost.