An Explainable Rule Extractor for Personalized Patient-State Tracking with No More Than Three Channels per Rule *

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Abstract

Background: In intensive care and emergency settings, continuous high-frequency monitoring produces more data than clinical staff can readily interpret, which can delay the recognition of physiological deterioration. Machine-learning methods can process such data but often lack the transparency clinicians require for decision-making. This work continues a line of research that transfers interpretable bioprocess soft-sensor methodology to medicine (Survyla et al., 2021; Kemesis et al., 2023; Survyla et al., 2023).

Objective: We present an explainable, patient-specific rule extractor for tracking patient state from multi-parameter vital-sign time series, built on a decision table and a finite state machine and intended for real-time monitoring.

Methods: Each vital-sign channel is first categorized as Low, Normal, High, Increasing or Decreasing using age-adjusted normative thresholds and temporal trends. Seven rule templates, each drawing on no more than three channels so that every rule remains readable by a clinician, expose hyperparameters that are left unset a priori. For an individual patient, these hyperparameters are tuned against the patient's clinician-annotated state labels (four classes, 0-3), and the subset of templates that best reproduces those labels is retained, yielding up to seven explanatory rules specific to that patient. Rule outputs are combined in a decision table using majority-rule and rule-matching logic, which drives a finite state machine over four clinical states: Stagnant, Worsening, Recovering and Other. The framework was implemented in Python.

Results: In a proof-of-concept study on one patient's continuous longitudinal record collected by the authors, the seven patient-specific rules reproduced the clinician's state labels at 78% of time steps on the same record used for tuning. Every predicted state can be traced to the specific templates and channels that fired. Conclusions: With 78% agreement on a single patient, a small library of low-order rule templates combined with patient-specific tuning offers an interpretable and computationally lightweight route to personalized state tracking. These single-patient, in-sample results establish feasibility only; evaluation on held-out data, on additional patients, and against established early-warning scores is required before any clinical claim can be made.

References

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