A Novel Clinically-Validated Deep RL Agent for Personalized Crohn’s Disease Treatment

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Crohn's Disease (CD) is a chronic autoimmune condition characterized by intense inflammatory flares. CD is incurable, and available medications carry severe side effects. With few head-to-head RCTs comparing treatments, clinicians manage the disease largely through trial-and-error. Reinforcement learning (RL), which learns to optimize sequential decision-making, is uniquely suited to address this. I created CROHNOS, a deep RL system to optimize and personalize CD treatment using UCSF EHR data from 7,500 patients. I designed three custom architectures to augment patient states: a reward-regularized variational autoencoder for state compression, a gated LSTM for patient history, and cross-modal attention over LLM-summarized clinical notes. Using behavior cloning as a baseline, I trained three offline RL models. RL agents made rational improvements over clinician behavior: reducing steroid intensity, escalating to biologics earlier, and identifying a subcohort where upadacitinib (FDA black box warning) should be replaced with the safer ustekinumab. Off-policy evaluation estimated model-recommended treatments would yield better patient outcomes than observed clinician decisions (+0.08 quality-adjusted life years and $4,000 in savings per patient annually). For clinical validation, I reconstructed patient cohorts of two major RCTs. Agents independently replicated the primary conclusions of both trials: therapeutic equivalence of adalimumab and ustekinumab, and superiority of top-down biologic treatment. CROHNOS is the first offline RL system for any chronic disease to be validated against gold-standard clinical trials. Trained on retrospective health records, it learned treatment truths that took prospective trials years and millions of dollars to establish.

Awards Won:
Fourth Award of $600