ReinforCell - Reinforcement Learning Solution to Engineer Robust CAR-T Cells for Cancer Patients

Goddla, Yashvini (School: Detroit Country Day School)

Chimeric Antigen Receptor T-cell (CAR-T) therapy is a breakthrough cancer treatment that genetically engineers patients' immune cells to target and destroy malignancies. While highly successful in hematologic cancers, ongoing research aims to extend CAR-T efficacy to solid tumors. However, T-cell exhaustion remains the primary challenge, both in ex vivo manufacturing environments and post infusion, in the human body, due to their interaction with the tumor microenvironment. This challenge can be abstracted to a stochastic optimization problem where sequential decisions about manufacturing protocols and clinical intervention timing must be made under biological uncertainty. The system is probabilistic because of variations in patient biology, fluctuations in manufacturing conditions, and unpredictable shifts in tumor microenvironments. These conditions create a complex decision space where outcomes can only be optimized through data-driven strategies and cannot be perfectly predicted. I present ReinforCell to address this from bioreactor to bedside through three integrated AI solutions. The Ex Vivo Manufacturing Module features a reinforcement learning agent to maximize T-cell yield while minimizing exhaustion in bioreactor environments. The In Vivo Prediction Engine leverages longitudinal single-cell data from the Ledergor dataset and integrates heuristics, ensemble, and neural network models to predict patient-specific exhaustion trajectories and outcomes. The Clinical Action agent uses these predictions to guide optimal intervention timing through rules based and reinforcement learning policies. With these three components, ReinforCell aims to revolutionize autologous and allogeneic CAR-T therapy and make it more affordable and accessible.

Awards Won:
Fourth Award of $600