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Integrating Generative Adversarial Networks and Cell-Cell Communications in Axonal Injury

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Axonal injury is the physical damage of axons that impairs neuronal communication. Unlike the peripheral nervous system (PNS), which have the ability to regenerate itself, the central nervous system (CNS) shows a markedly restricted capacity for repair. Therefore, understanding axonal injury in the PNS is important, as it may provide insights into repair processes in the CNS. Following dorsal root ganglion injury in PNS, regeneration involves various cell types, including neurons, myelin-forming glia, and immune cells. To capture these complex cellular dynamics, we analyzed single-cell RNA sequencing (scRNA-seq) data and developed generative models. Generative Adversarial Networks (GANs) can model scRNA-seq data by learning its distribution and co-expression patterns. However, existing approaches typically focus on a single cell type, limiting the ability to capture dynamic changes across interacting various cell populations. In this study, we trained a separate GAN for each cell type to generate expression profiles, assigned time labels reflecting biological changes, and grouped cells for cell-cell communication (CCC) analysis. We then applied tensor decomposition to identify interaction patterns among diverse cell types and their temporal dynamics. Together, this integrative framework provides a systems-level view of intercellular communication during DRG regeneration and supports to understand pathway activity in the progression of axonal repair.