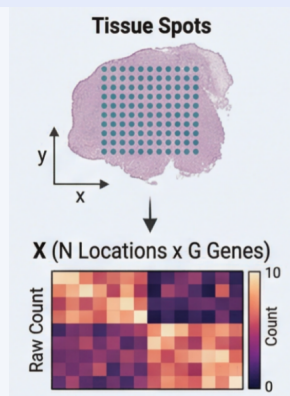


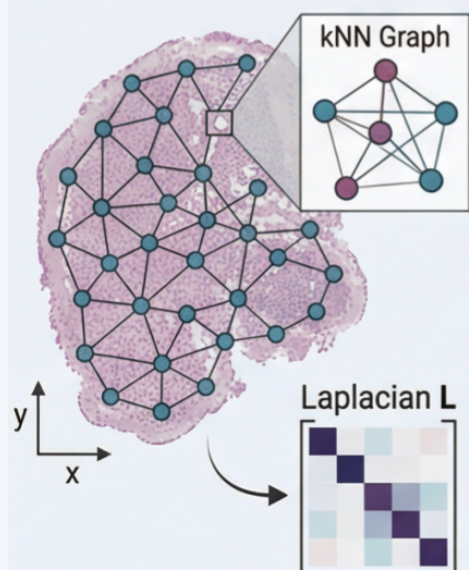
1

## Input & Graph Construction



HVG/SVG/ALL

## Spatial Graph Construction



2

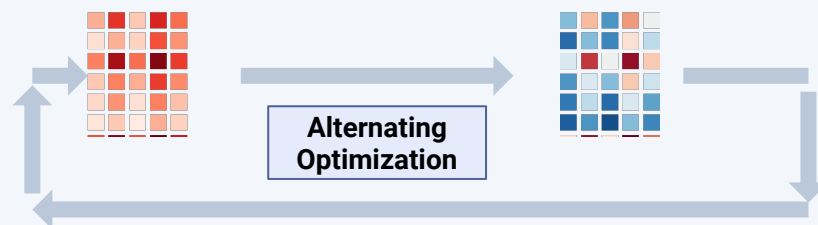
## Poisson NMF+Graph Regularization&Optimization

$$\min_{W,H} [\text{Poisson Loss}(X, WH) + \alpha \cdot \text{tr}(W^T L W) + \lambda_1 \|W\|_1 + \lambda_2 \|H\|_1]$$

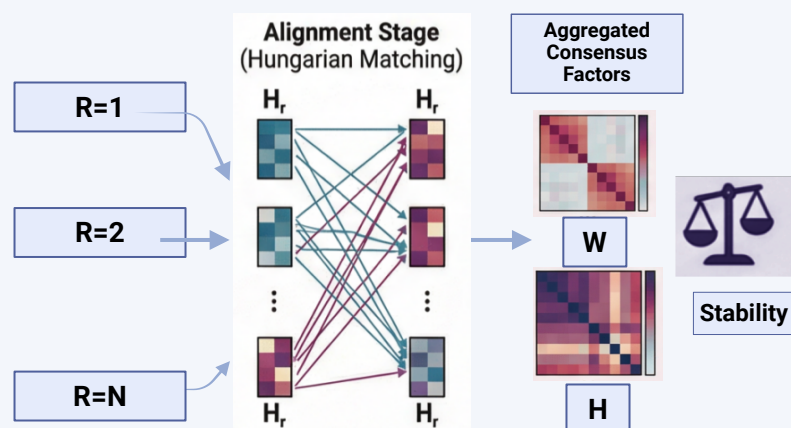
Poisson Loss(KL)  
-Fitting CriterionSpatial  
SmoothnessL1 Sparsity Terms on  
W and H

3

## Core Optimization: Alternating Optimization Loop

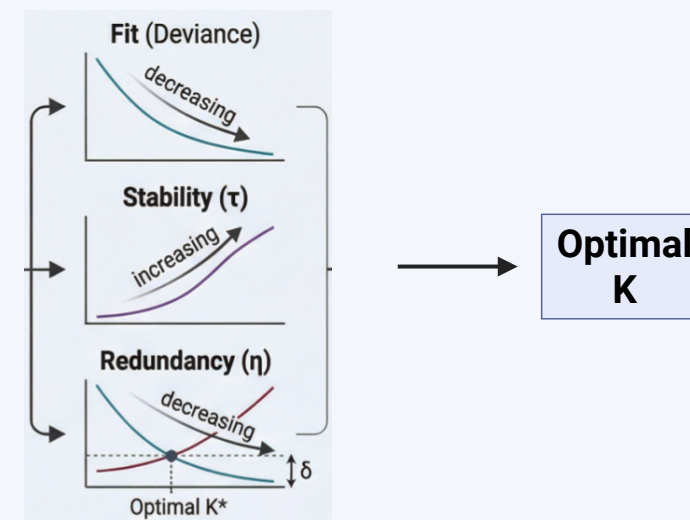


## Poisson NMF+Graph Regularization&Optimization



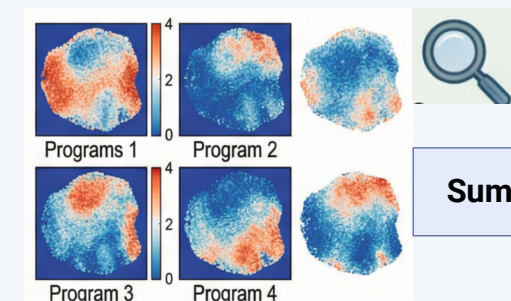
4

## AutoK Selection



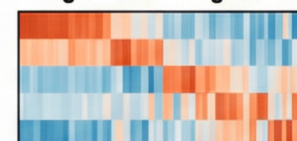
5

## Output



## Summary & Insights

### Program Gene Signatures



1. Stable Spatial Patterns
2. Consensus Gene Programs
3. Biological Insights
4. Enhanced Interpretation