

## ch1: Hypergraph

理解:

$$V = \{v_1, v_2, v_3, v_4\}$$

$$E = \{e_1, e_2, e_3\}$$

$$G = \{V, E\}$$

$$D = \begin{bmatrix} 3 & & & \\ & 1 & & \\ & & 1 & \\ & & & 1 \end{bmatrix}$$

$$A = \begin{bmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & & \\ 1 & & 0 & \\ 1 & & & 0 \end{bmatrix}$$

$$L = D - A = \begin{bmatrix} 3 & -1 & -1 & -1 \\ -1 & 1 & & \\ -1 & & 1 & \\ -1 & & & 1 \end{bmatrix}$$

$$L_{sym} = D^{-1/2} L D^{-1/2} = I - D^{-1/2} A D^{-1/2}$$

$$L_{rw} = D^{-1} L = I - D^{-1} A$$

$$|\lambda I - L| = 0$$

$$L \vec{u} = \lambda \vec{u}$$

$$L = U \Lambda U^T = \sum_1^N \lambda_k u_k \cdot u_k^T$$

$$\forall s \in R^N \quad p_k = |s| \cos \theta_k = \frac{u_k^T \cdot s}{|u_k^T|} = u_k^T \cdot s$$

$$p = U^T s \quad s = U p$$

$$TV(s) = s^T L s = s^T U \Lambda U^T s = (U^T s)^T \Lambda (U^T s) = p^T \Lambda p = \sum_1^N p_k^2 \lambda_k \geq 0$$

$$E(s) = |s|^2 = (U p)^T \cdot (U p) = p^T p = \sum_1^N p_k^2$$

## ch2: Hypergraph Learning Architecture

### (1) Features

$$s_{in} \left( \sum_1^N p_k u_k \right) \rightarrow H \rightarrow s_{out} \left( \sum_1^N p'_k u_k \right)$$

$$s_{in} \left( \sum_1^N p_k u_k \right) \rightarrow H(filter) \rightarrow s_{out} \left( \sum_1^N h(\lambda_k) p_k u_k \right)$$

$$s_{out} = H s_{in} = \sum_1^N h(\lambda_k) p_k u_k$$

$$= \begin{bmatrix} u_1 & u_2 & \dots & u_n \end{bmatrix} \begin{bmatrix} h(\lambda_1) p_1 \\ h(\lambda_2) p_2 \\ \dots \\ h(\lambda_n) p_n \end{bmatrix} = U \begin{bmatrix} h(\lambda_1) & & & \\ & h(\lambda_2) & & \\ & & \dots & \\ & & & h(\lambda_n) \end{bmatrix} \begin{bmatrix} p_1 \\ p_2 \\ \dots \\ p_n \end{bmatrix}$$

$$= U \begin{bmatrix} h(\lambda_1) & & & \\ & h(\lambda_2) & & \\ & & \dots & \\ & & & h(\lambda_n) \end{bmatrix} U^T \overset{\rightarrow}{s_{in}} H = U \begin{bmatrix} h(\lambda_1) & & & \\ & h(\lambda_2) & & \\ & & \dots & \\ & & & h(\lambda_n) \end{bmatrix} U^T = U \Lambda_h U^T$$

### (2) Transformation

#### Reductive Transformation

$(E, X, Y) \Rightarrow A$  hyperedges to edges  
 clique expansion + adaptive expansion

#### Non-reductive Transformation

star/line/tensor expansion

### (3) Message

whose: v-v v-e e-v

what : e-consistent + e-dependent

how : fixed-pooling + learnable-pooling

### (4) Training