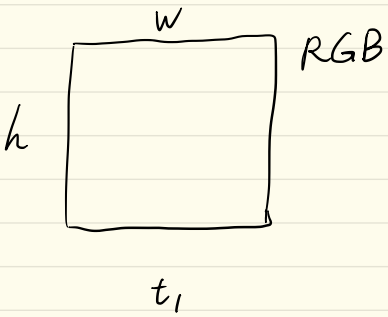
Project Develop

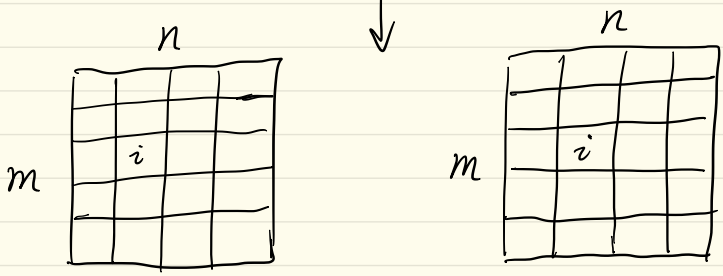
Workflow:

Images of different times



t_1 t_2

Divide into grids



One gaussian distribution for each grid i

$P_{t_1}(i) \sim N(\mu_{ai}, \sigma_{ai})$ $Q_{t_2}(i) \sim N(\mu_{bi}, \sigma_{bi})$

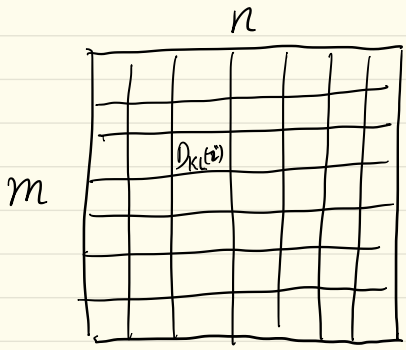
Compute distance for each grid i

$D_{KL}(i) = d(P_{t_1}(i), Q_{t_2}(i)) =$ KL divergence $(P_{t_1}(i), Q_{t_2}(i))$

use symmetric version

obtain a map of KL divergence distance.

D_{KL} map



Model D_{KL} map as GMM and apply clustering for change map

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Determine GMM parameters using EM algorithm

Challenge: determine # of components K, grid size

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Clustering by GMM:

assume $\{x_i = (r, c, R, G, B)\}_{i=1}^{n}$ generated by GMM

$$p(x_i|\Theta) = \sum_{j=1}^{K} \alpha_j N(x_i|\mu_j, \Sigma_j)$$

E-step:

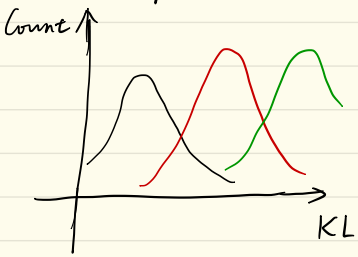
$$p_{ij} = \frac{N(i,j)}{\sum_{l=1}^{K} N(i,l)}$$

M-step:

$$\alpha_j = \frac{1}{n}\sum_{i=1}^{n} p_{ij} \qquad \mu_j = \frac{\sum_{i=1}^{n} x_i p_{ij}}{\sum_{i=1}^{n} p_{ij}} \qquad \Sigma_j = \frac{\sum_{i=1}^{n} (x_i-\mu_j) p_{ij} (x_i-\mu_j)}{\sum_{i=1}^{n} p_{ij}}$$

Converge and choose max α_j as cluster j.

KL map histogram



GMM x_i = KL divergence value

K components

$$N(x_i \mid \mu_j, \sigma_j)$$

GMM Initialization with KMeans

$$\{x_i\}_{i=1}^{N} \xrightarrow{\text{KMeans}} \begin{cases} \{x_1, x_2 \cdots x_i \cdots x_N\} \\ \{C_1, C_2 \cdots C_i \cdots C_N\} \end{cases}$$

$$\rightarrow \begin{cases} \mu_k = \dfrac{\sum_{i=1}^{N_k} x_i \, \delta(C_i = k)}{N_k} \\ \sigma_k = \dfrac{\sum_{i=1}^{N_k} (x_i - \mu_k)^2 \, \delta(C_i = k)}{N_k} \\ \alpha_k = \dfrac{N_k}{N} \end{cases}$$

GMM Convergence Metric using Log Likelihood

$$\ln P(X \mid \mu, \sigma, \alpha) = \sum_{n=1}^{N} \ln \sum_{k=1}^{K} \alpha_k N(x_n \mid \mu_k, \sigma_k)$$