Personalized Image/Video Recommendation

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Outlines of Presentation

- Research Motivation
- Integrating Concept Network for **Query Concept Recommendation**
- Interactive **User’s intention** capturing
- **User-Adaptive Image/Video Recommendation**
- Algorithm Evaluation
1. Research Motivation

- Large amount of images are available on Internet
- Large amount of videos are available on various TV channels

a. Hard for Query Formulation
b. Information Overload
1. Research Motivation

- **Applications**
  - Second-Generation Internet Search Engines
  - Family Photo Organization System
  - Digital Library
2. Key Research Components

- How can we provide a good **global overview** of large-scale image/video collections?

- How can we capture the **users’ query intentions** easily and effectively?

- How can we **recommend** the most relevant images/videos according to the users’ intentions?
2. Key Research Components

- **Concept Network** for providing a good **global overview** of large-scale image/video collections;

- **Interactive Visualization** for capturing the **users’ query intentions** easily and effectively;

- **Interestingness Matching** for **recommending** the most relevant images/videos according to the users’ intentions.
3. Concept Network Construction

What can concept network represent?

- Global overview of large-scale image/video collections;

- Context among the concepts;

- Good navigation or browsing structure for accessing large-scale image/video collections.
3. Concept Network Construction

- Major steps for concept network construction
  - Natural language processing for entity extraction;
  - Word frequency estimation;
  - Keyword extraction;
  - Context determination.
3. Concept Network Construction

- Co-Occurrence Probability
  \[ \rho(C_i, C_j) = \frac{P(C_i, C_j)}{P(C_i)P(C_j)} \]

- Semantic Similarity
  \[ \pi(C_i, C_j) = -\log \frac{\text{length}(C_i, C_j)}{2D} \]

- Distribution Similarity
  \[ \phi(C_i, C_j) = -D(C_i, C_j)\log \frac{D(C_i, C_j)}{D(C_i)D(C_j)} \]
3. Concept Network Construction

- Context between concepts

\[ S(C_i, C_j) = \beta \rho(C_i, C_j) + \varepsilon \pi(C_i, C_j) + \alpha \phi(C_i, C_j) \]

\[ \text{Link}(C_i) = \text{TopK}\{S(C_i, C_j) \mid j \in \Omega\} \]
3. Concept Network Construction
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3. Concept Network Construction
4. Concept Network Visualization

- **Interestingness of concept**

\[
\varphi(C_i) = \varepsilon \cdot \frac{e^n(c_i) - e^{-n(c_i)}}{e^n(c_i) + e^{-n(c_i)}} + \eta \cdot \frac{e^l(c_i) - e^{-l(c_i)}}{e^l(c_i) + e^{-l(c_i)}}
\]

- **Constraint-based concept clustering**

\[
\phi(C_i, C_j) = \left[ -\nu \cdot \log \frac{l(C_i, C_j)}{2D} + \alpha \cdot \gamma(C_i, C_j) \right] \times \begin{cases} 
\frac{-d^2(C_i, C_j)}{\sigma^2}, & \text{if } d(C_i, C_j) < \delta \\
0, & \text{otherwise}
\end{cases}
\]
4. Concept Network Visualization

- Change of Focus---Poincare Mapping

\[ z_t = \frac{\theta z + P}{1 + \bar{P} \theta z} \]

\[ d = \sqrt{\left(\frac{(1 - s^2) \sin(a)}{2s}\right)^2 + 1 - \frac{(1 - s^2) \sin(a)}{2s}} \]
4. Concept Network Visualization

- Change of Focus---Poincare Mapping
4. Concept Network Visualization

- Change of Focus---Poincare Mapping
5. Interactive Query Specification

- Concept Network Navigation
5. Interactive Query Specification

- Personalized concept network generation
6. Most Representative Image Recommendation

- Image Content Representation
6. Most Representative Image Recommendation

- Image Similarity Characterization
- Color Histogram Kernel

\[ \chi^2(I(u), J(v)) = \frac{1}{2} \sum_{i=1}^{16} \frac{|I(u_i) - J(v_i)|^2}{I(u_i) + J(v_i)} \]

\[ K_c(I, J) = e^{-\chi^2(I(u), J(v))/\delta} \]
6. Most Representative Image Recommendation

- Image Similarity Characterization
- Wavelet Filter Bank Kernel

\[
K_t(I, J) = e^{-\sum_{i=1}^{m} \chi_i^2(h_i(I), h_i(J))/\omega_i}
\]

\[
K_t(I, J) = \prod_{i=1}^{m} e^{-\chi_i^2(h_i(I), h_i(J))/\omega_i}
\]
6. Most Representative Image Recommendation

- Image Similarity Characterization
- Interest Point Matching Kernel

\[ D(I(Q), J(P)) = \frac{\sum_{i=1}^{MQ} \sum_{j=1}^{NP} \gamma_{ij} d(q_i, p_j)}{\sum_{i=1}^{MQ} \sum_{j=1}^{NP} \gamma_{ij}} \]

\[ K_p(I, J) = e^{-D(I(Q), J(P))/\rho} \]
6. Most Representative Image Recommendation

- Image Similarity Characterization
  ---- mixture of kernels

\[ K(x, y) = \sum_{i=1}^{K} \alpha_i K_i(x, y) \]

Multiple kernel learning for determining weighting parameters!
6. Most Representative Image Recommendation

- Kernel-Based Image Clustering

\[
S_w^\phi = \frac{1}{N} \sum_{l=1}^{\kappa} \sum_{i=1}^{N} \beta_{li} \left( \phi(x_i) - \mu_i^\phi \right) \left( \phi(x_i) - \mu_i^\phi \right)^T
\]

\[
\mu_i^\phi = \frac{1}{N_l} \sum_{i=1}^{N} \beta_{li} \phi(x_i)
\]

\[
Tr \left( S_w^\phi \right) = \frac{1}{N} \sum_{l=1}^{\kappa} \sum_{i=1}^{N} \beta_{li} \left( \phi(x_i) - \mu_i^\phi \right)^T \left( \phi(x_i) - \mu_i^\phi \right)
\]
6. Most Representative Image Recommendation

- **Support Vector Machine**
  
  \[ f_{c_j}(X) = W_j^T X + b \]

  - positive images
  - negative images
  - positive support vectors
  - negative support vectors
  
  margin
6. Most Representative Image Recommendation

- Representativeness of image

\[
\rho(x) = e^{-d^2(x, \Theta)} + e^{-d^2(x, \Theta)} \times \frac{e^{UR(x)} - e^{-UR(x)}}{e^{UR(x)} + e^{-UR(x)}}
\]

\[
d(x, \Theta) = \sum_{x_i \in \Theta} \alpha_i \kappa(x, x_i)
\]
6. Most Representative Image Recommendation

- Most Representative Image Selection

- Most representative images come from all these clusters and distribute according their coverage percentages;

- Images close to decision boundaries;

- Most frequent accessed images
7. Most Representative Image Visualization

- Kernel PCA

\[ K\vec{v} = \lambda M\vec{v} \]

- Similarity-Preserving Image Projection

\[ \min \left\{ \sum_{i=1}^{M} \sum_{j=1}^{M} |\kappa(x_i, x_j) - d(x'_i, x'_j)|^2 \right\} \]
7. Most Representative Image Visualization

- Hyperbolic Image Visualization

\[ d\rho = \frac{2}{1 - r^2} \cdot dr \]
7. Most Representative Image Visualization
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7. Most Representative Image Visualization
8. User-Adaptive Image Recommendation

- User Intention Capturing
8. User-Adaptive Image Recommendation

- Personalized Interestingness of Image

\[ \rho(x) = \rho_{org}(x) + \rho_{org}(x) \times e^{-\kappa(x, x_a)} \]

\[ \kappa(x, x_a) = \sum_{m=1}^{3} \alpha_m \kappa_m(x, x_a) \]
8. User-Adaptive Image Recommendation
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