

Modeling and Recognition of Landmark Image Collections Using Iconic Scene Graphs

Xiaowei Li, Changchang Wu, Christopher Zach,
Svetlana Lazebnik, Jan-Michael Frahm



THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Motivation

- Target problem: organizing community photo collections of famous landmark sites such as the Statue of Liberty
- We present a unified system for dataset collection, scene summarization, 3D reconstruction, and recognition for landmark images
- Approach: integrate 2D recognition and 3D structure-from-motion techniques for an efficient and scalable solution

Summary of approach

1. Appearance-based clustering

- Run k-means clustering with gist descriptors (Oliva & Torralba, 2001) to find groups of images with roughly similar viewpoints and scene conditions

2. Geometric verification of clusters

- Perform feature-based geometric matching between a few “top” images from each cluster
- Select an *iconic image* for each cluster as the image with the most inliers

3. Construction of iconic scene graph

- Perform geometric matching between every pair of iconic images
- Create an edge for every pair related by a fundamental matrix or a homography

4. Tag-based filtering

- Eliminate semantically irrelevant isolated nodes of the iconic scene graph

5. Structure from motion

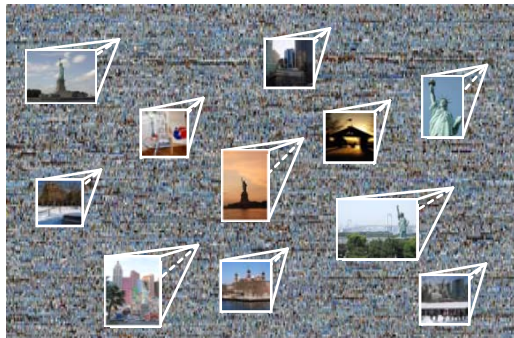
- Run graph cuts to break iconic scene graph into smaller components
- Perform SFM separately on each component. Use a maximum-weight spanning tree to determine the order of incorporating images into the 3D model
- Merge component models using geometric relationships along edges that were originally cut
- Enlarge models by registering non-iconic images

6. Recognition

- Register a new test image to the iconics using gist or vocabulary tree matching (Nister & Stewenius, 2006) followed by geometric verification

Overview

All images



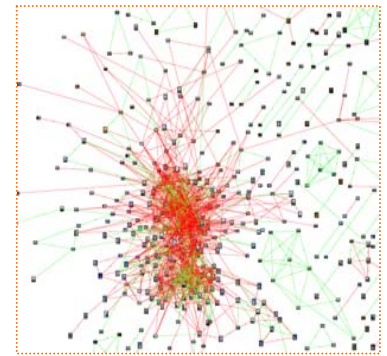
Clustering
with gist,
intra-cluster
verification



Iconic images



Pairwise matching of
iconic images

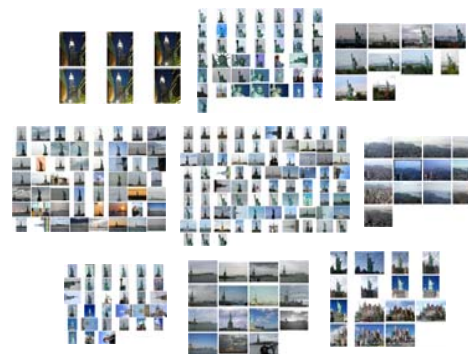


**Iconic scene
graph**

Graph
cut

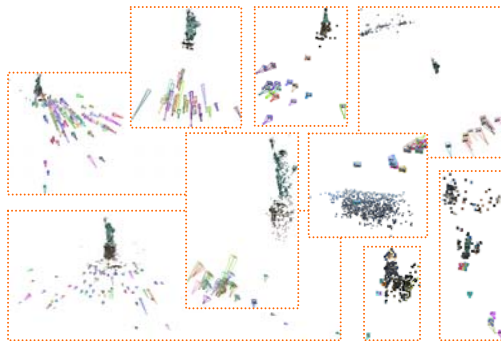


**Components of iconic
scene graph**



SFM

**Reconstructed
components**



Iconic scene graph for browsing

- **Level 1:** components of iconic scene graph
- **Level 2:** iconic images belonging to each component
- **Level 3:** images inside the gist cluster of each iconic

Level 1



Level 2



Level 3



Statue of Liberty results

Originally: 45284 images

196 iconic images



Las Vegas



Tokyo



New York



Registered images in largest model: 871

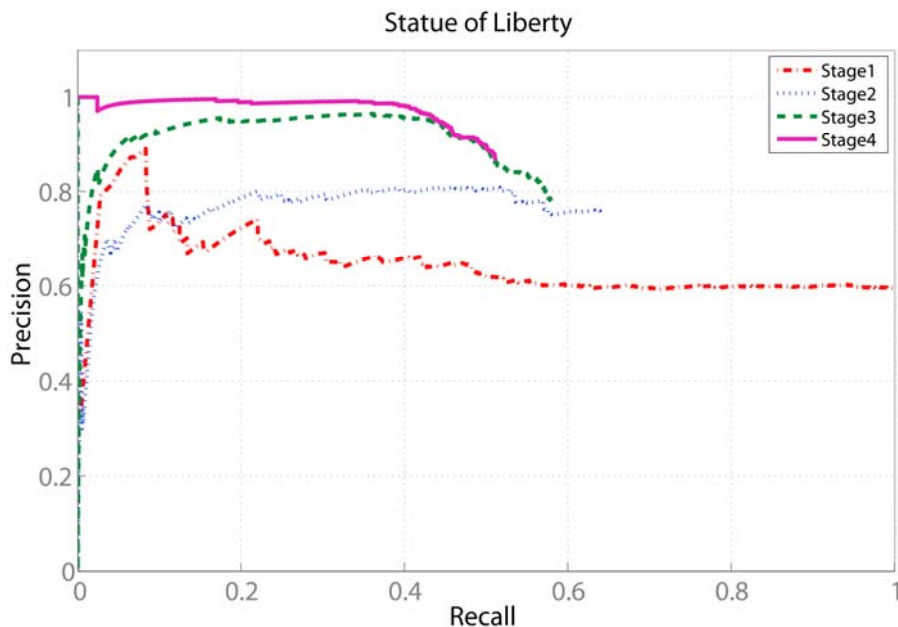
Points visible in 3+ views: 18675

Statue of Liberty evaluation

Modeling

Unlabeled images: 42983

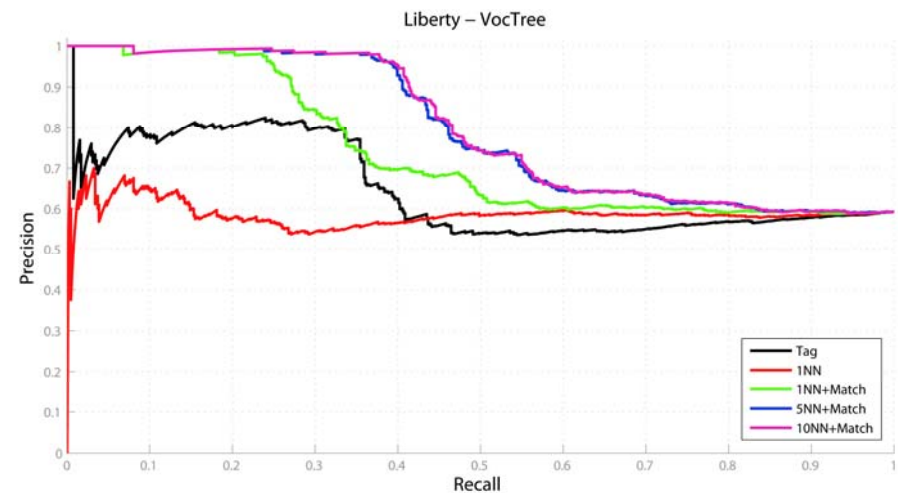
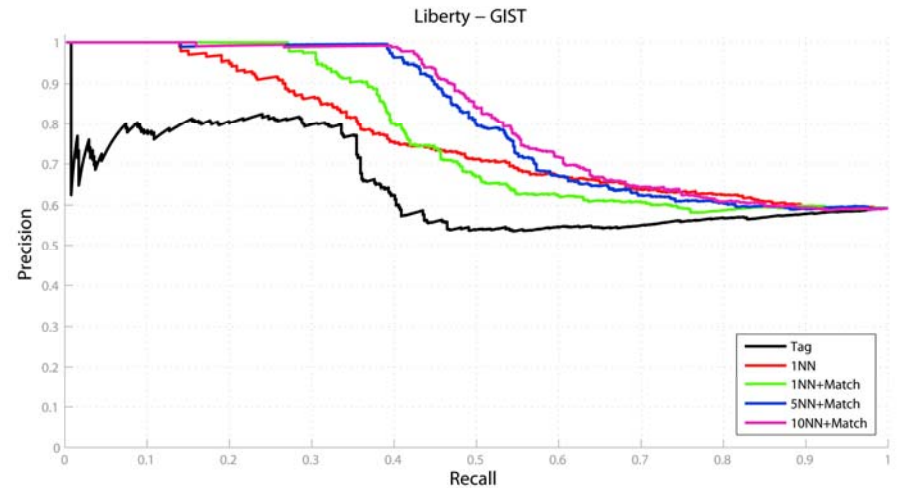
Labeled images: 2301



- Stage 1:** gist clustering
- Stage 2:** per-cluster geometric verification
- Stage 3:** per-image geometric verification
- Stage 4:** tag-based filtering

Testing

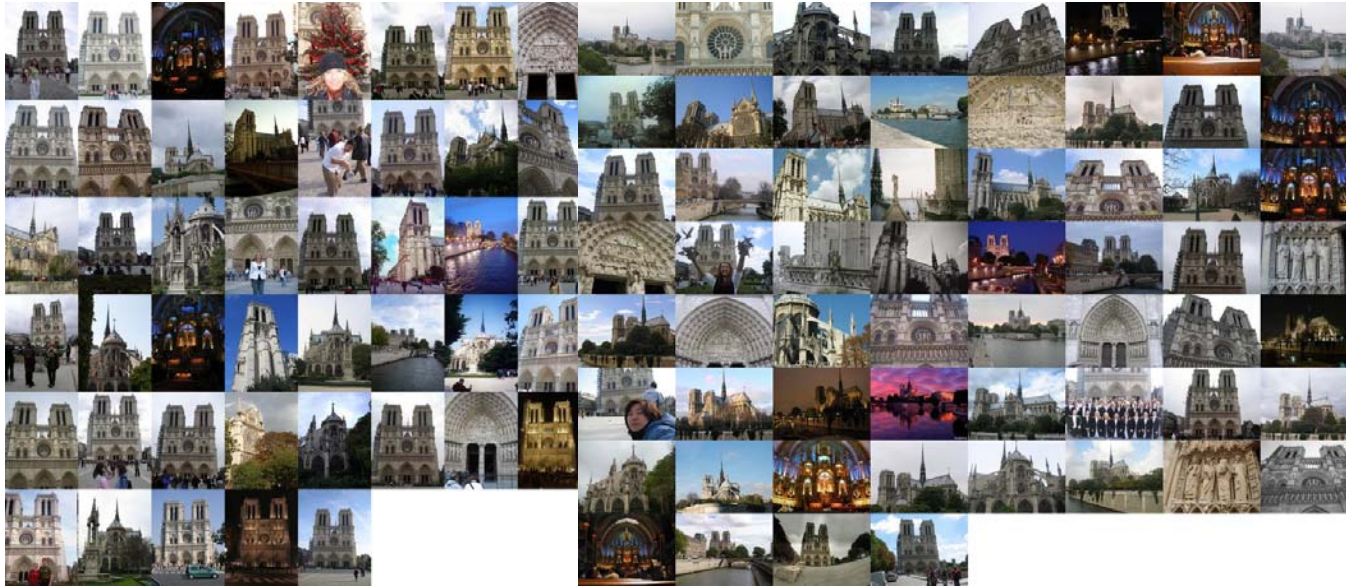
1092 images



Notre Dame results

Originally: 10840 images

105 iconic images



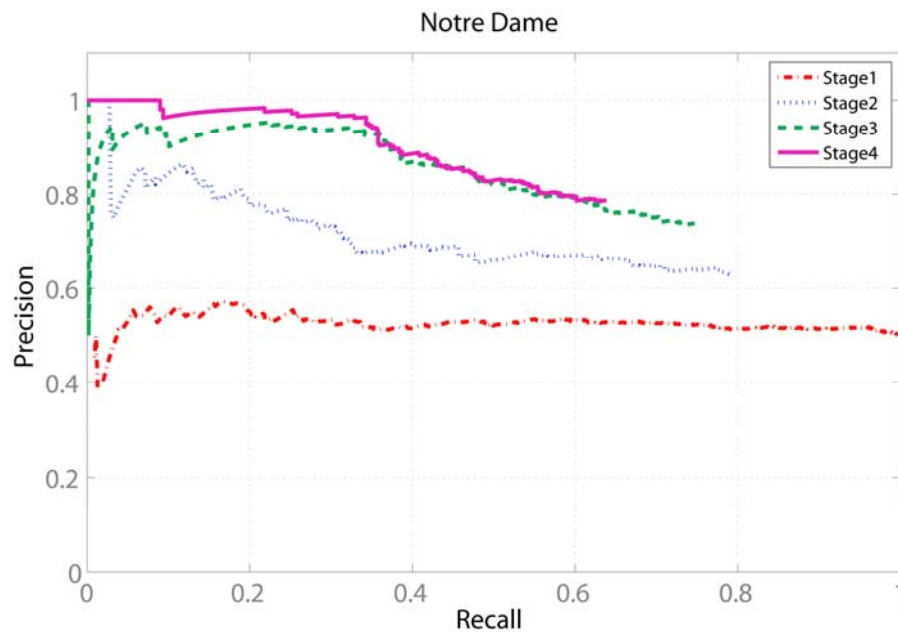
Registered images in largest model: 337
Points visible in 3+ views: 30802

Notre Dame evaluation

Modeling

Unlabeled images: 9760

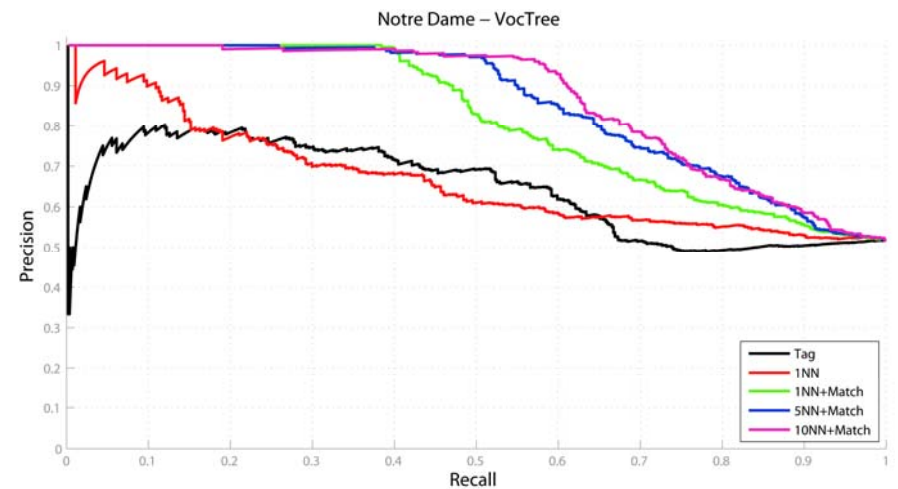
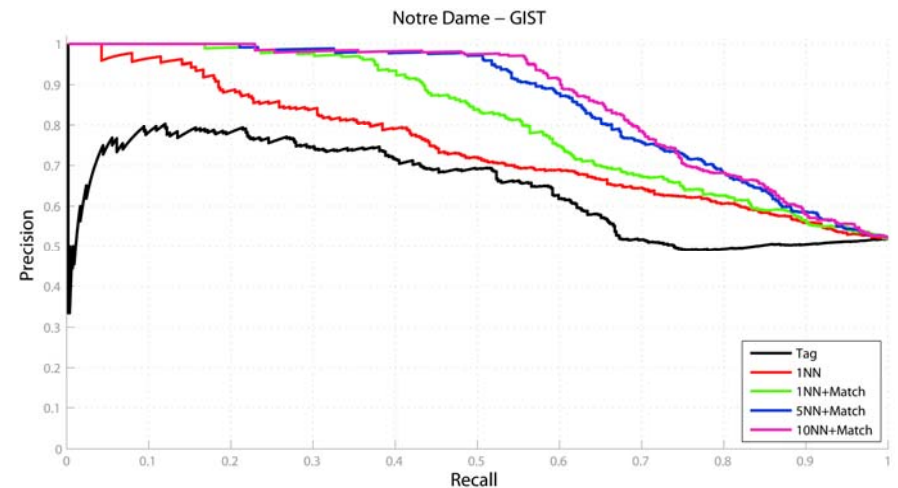
Labeled images: 1080



- Stage 1:** gist clustering
- Stage 2:** per-cluster geometric verification
- Stage 3:** per-image geometric verification
- Stage 4:** tag-based filtering

Testing

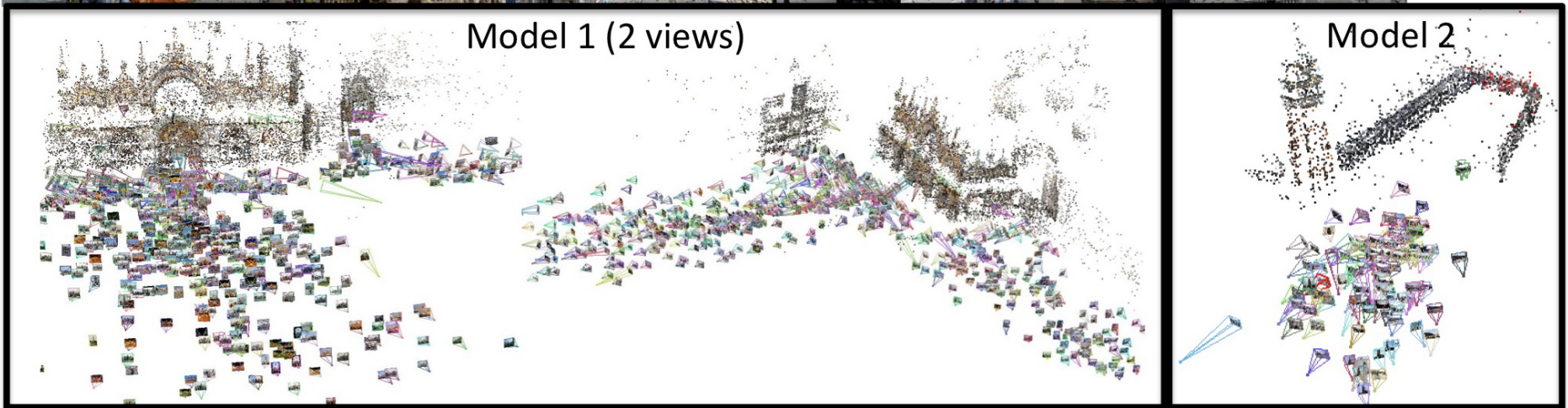
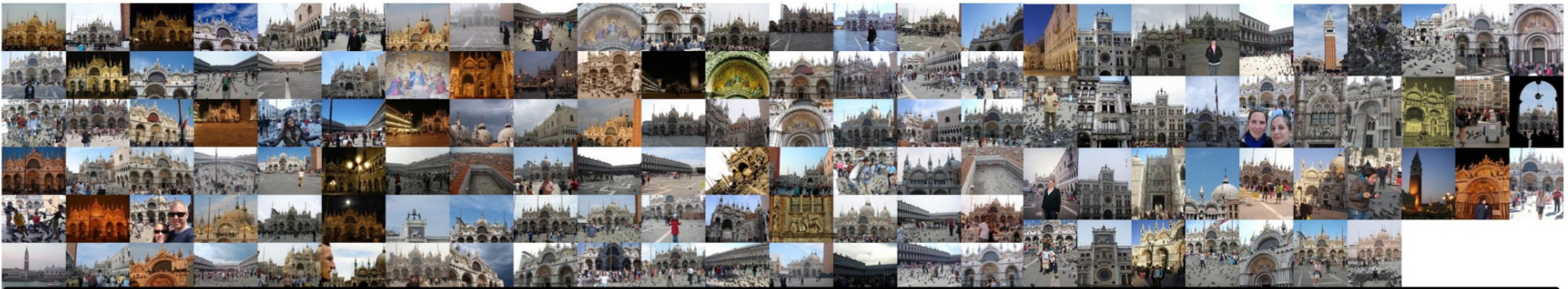
1044 images



San Marco results

Originally: 43557 images

134 iconic images



Registered images in largest model: 749

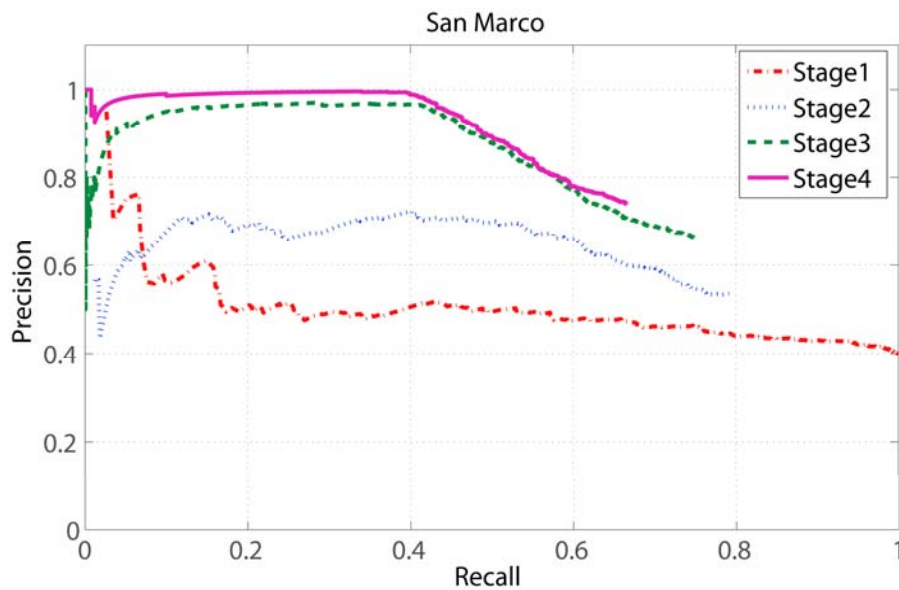
Points visible in 3+ views: 39307

San Marco evaluation

Modeling

Unlabeled images: 38332

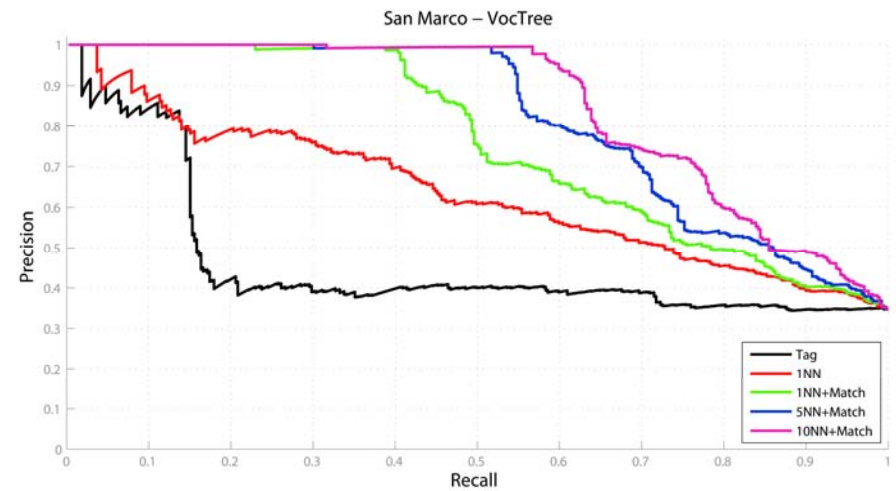
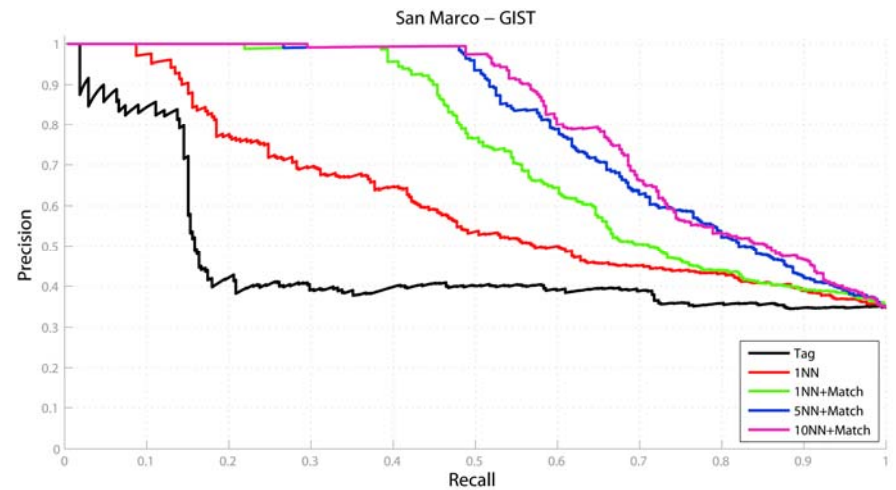
Labeled images: 5225



- Stage 1:** gist clustering
- Stage 2:** per-cluster geometric verification
- Stage 3:** per-image geometric verification
- Stage 4:** tag-based filtering

Testing

1094 images



Computing Iconic Summaries for General Visual Categories

Rahul Raguram and Svetlana Lazebnik

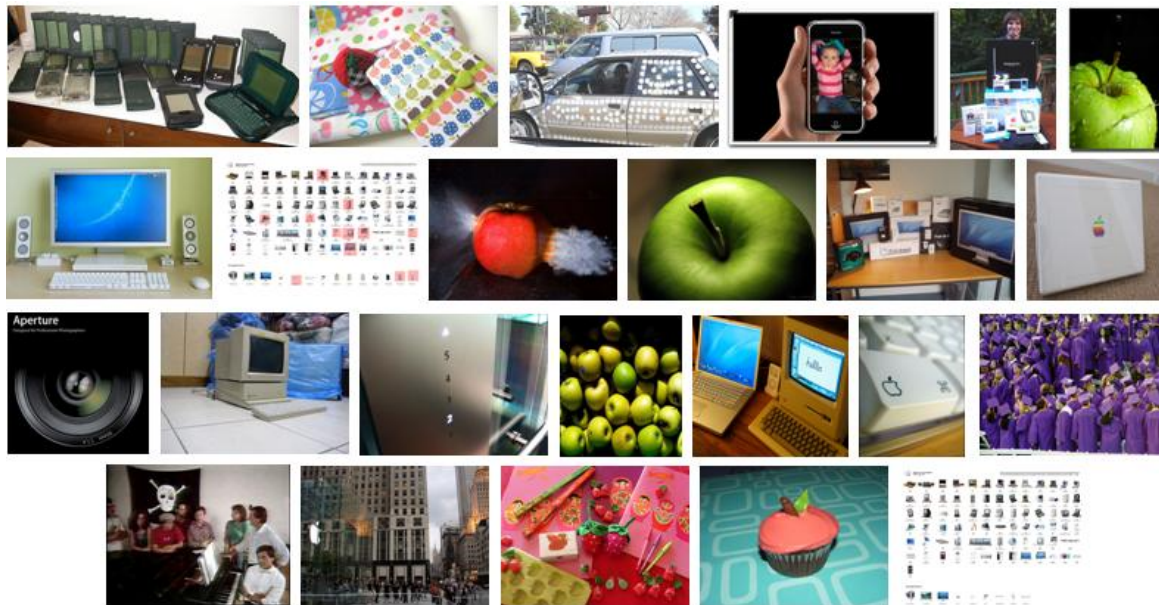
To appear at the First IEEE Workshop on
Internet Vision (in conjunction with CVPR 2008)



THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Motivation

- We want to obtain complete, concise, and visually compelling summaries of image query results for general (and possibly abstract) categories
- At present, photo sharing websites such as Flickr don't do a very good job of this

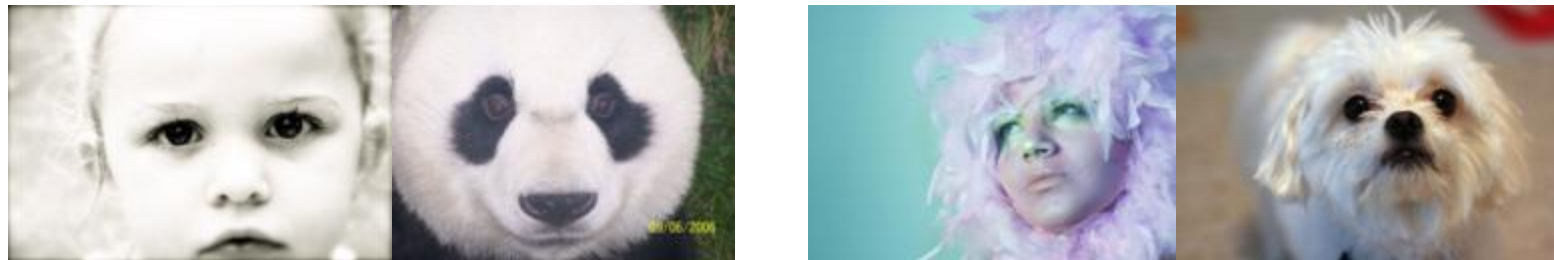
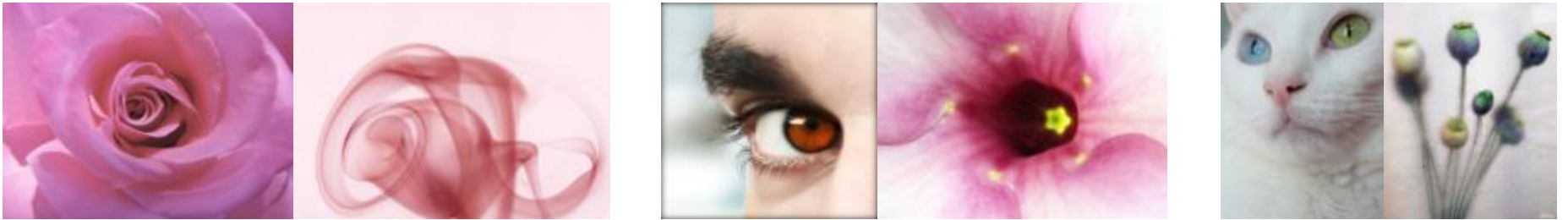


Top 24 “most relevant” Flickr results for the category “apple”

Summary of approach

- **Our definition:** an *iconic image* is a high-quality representative of a group of images consistent both in terms of appearance and semantics
- **Finding iconic images:**
 - Cluster appearance with gist (Oliva & Torralba, 2001)
 - Cluster tags with pLSA (Hofmann, 1999)
 - Form joint clusters by intersecting the two clusterings; retain only joint clusters that are large enough
 - Find representative iconic image for each joint cluster as the image with the highest quality score (Ke et al., 2006)
- **Displaying iconic summaries:** group iconic images by pLSA cluster (theme) and compute layout of pLSA clusters with multidimensional scaling

Interesting effect of joint clustering: “Visual rhymes”



Apple summary

london applestore mac macintosh



A
nyc applestore
newyork
newyorkcity

ipod
unpacking
ipodnano
ipodshuffle



mac macbook
macintosh macmini



B
ipod
nano
mac
shuffle



goods ipod
ipodnano
music



C
mac
macintosh
mini
macmini



desktop mac wallpaper osx



screenshot mac
osx macintosh

logo macbookpro
powerbook mac



D
logo
macintosh
mac
macbook

red
green
fruit
color



E green apples
red tree



F
fruit
red
macro
food



fruit
red
garden
blossom

Apple details



A nyc applestore
newyork newyorkcity



B
apple
ipod
nano
mac



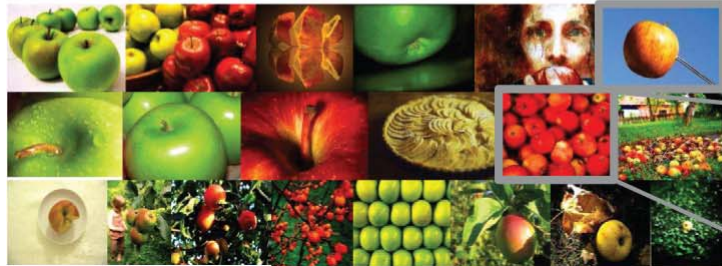
C mac macintosh
mini macmini



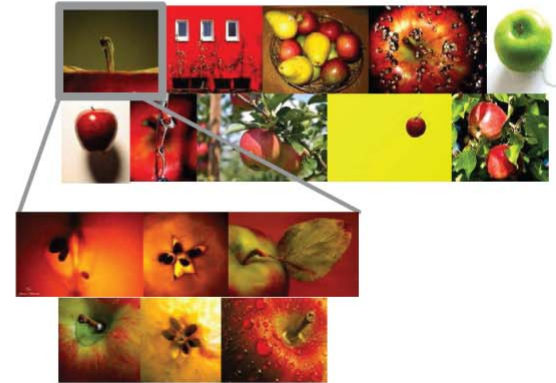
D logo macintosh mac macbook



E green apples red tree



F fruit red macro food



Beauty summary

cute
cat
cats
kitties



california northern
nature beautiful

B
water
nature
beach
ocean



C

sky clouds nature sunset

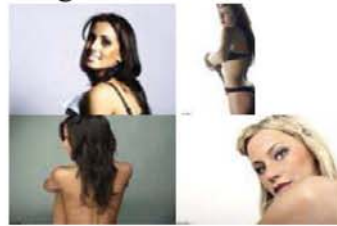
nature
nikon
blue
macro



A portrait woman
beautiful girl



fashion model
glamor studio



flowers nature
flower macro



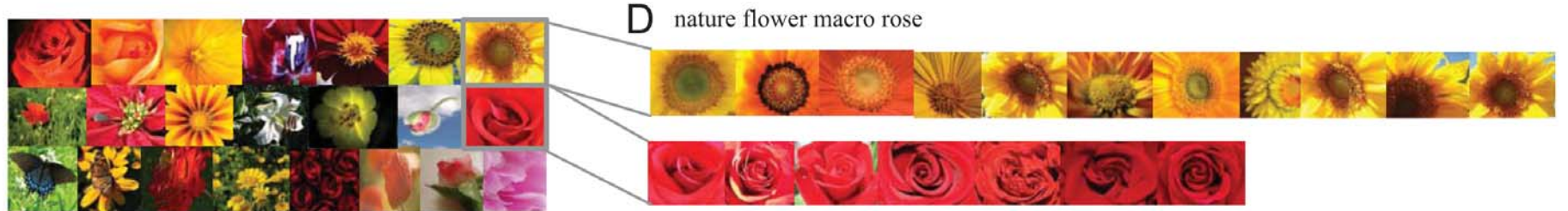
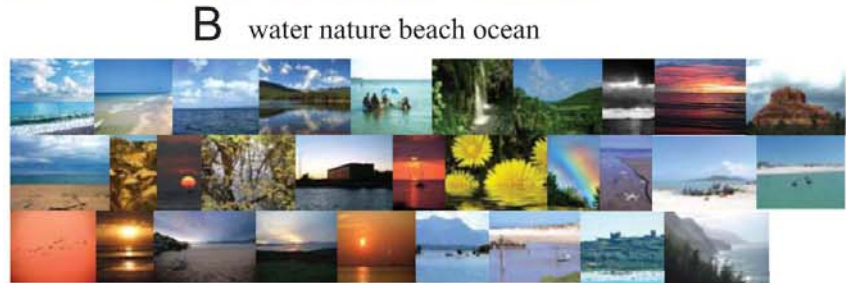
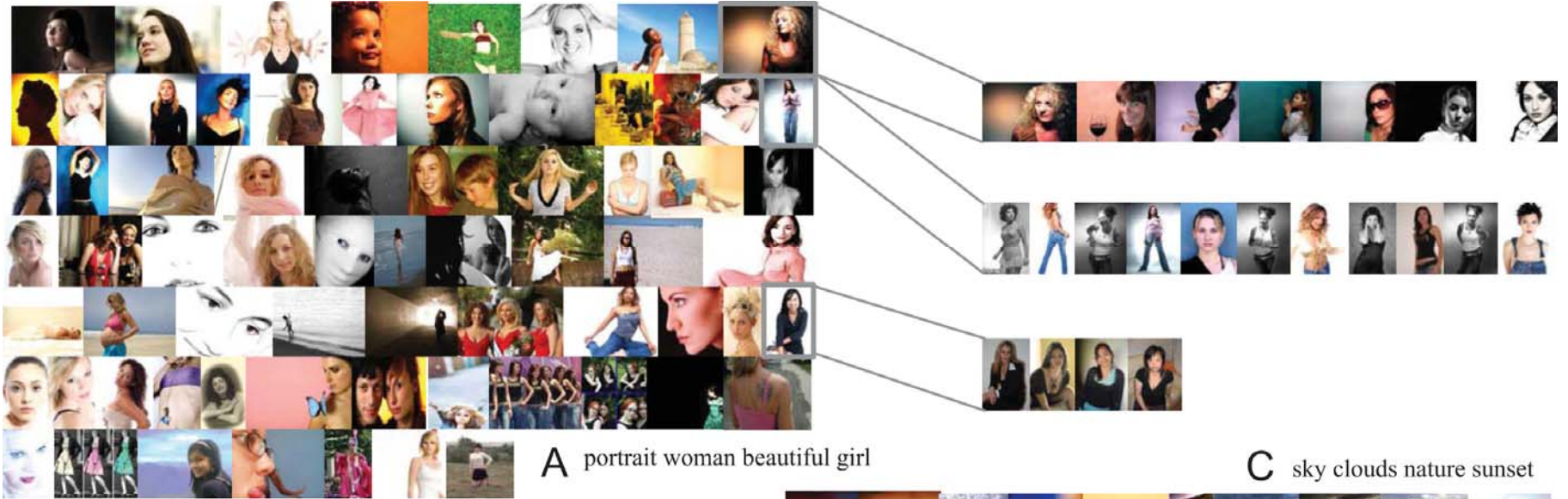
woman girl
portrait nude



japan girls
beautiful nippon

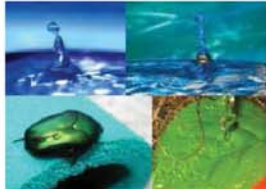
D nature flower
macro rose

Beauty details



Closeup summary

A macro drop splash water



blue abstract
water white



B

bird
nature
flight
gull



insect macro dof nature



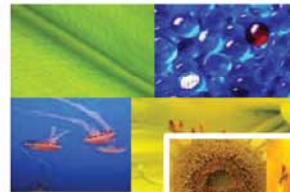
D

eye
macro
eyes
close



C

insect butterfly
macro dragonfly



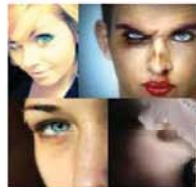
colors
blue
macro
yellow



bee flower yellow
nature



macro
dof
leaf
nature



E portrait face
bw macro



flowers sunflower
yellow nature



flower red
yellow colors



flowers
nature
red
sunflower



insect
macro
nature
garden



baby cute pink boy



F

lips
lip
macro
pink

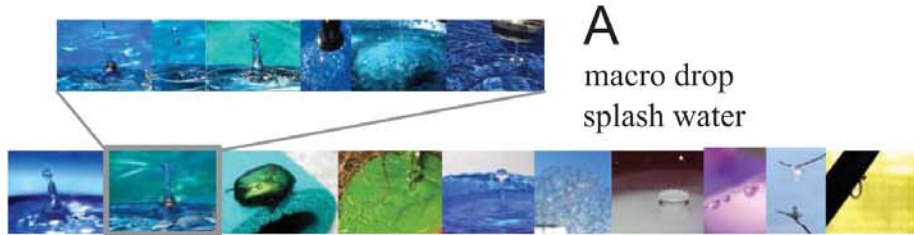


strawberry strawberries
berries red

cat
cute
furry
kitties



Closeup details



A
macro drop
splash water



B
bird nature
flight gull



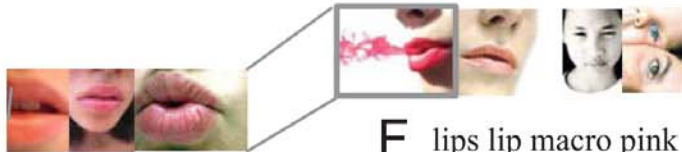
C
insect butterfly
macro dragonfly



D eye macro eyes close



E portrait face bw macro



F lips lip macro pink

Explore / Tags / closeup / clusters

					<p>macro, nature, flowers, green, yellow, pink, red, insect, white, bug</p> <p>→ See more in this cluster...</p>
					<p>flower, purple, garden, orange, plant, spring, petals, bee, nature's finest, flora</p> <p>→ See more in this cluster...</p>
					<p>face, portrait, eyes, cat, girl, woman, animal, bw</p> <p>→ See more in this cluster...</p>

Comparison: Flickr clusters

Love summary

baby
boy
cute
newborn



dog cute pet dogs



color joy wedding blue

sunset sky clouds blue



nature
water
sea
sunset

A portrait people
bw girl



me bw self
selfportrait



B beach
sand
sea
couple



nature flowers
green macro

amore
heart
liebe
explore

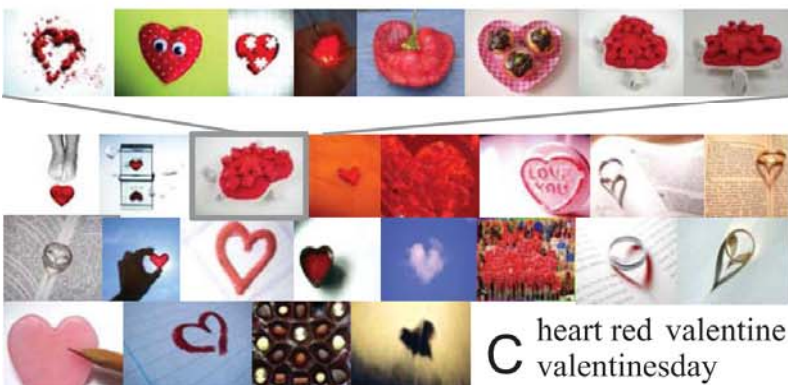
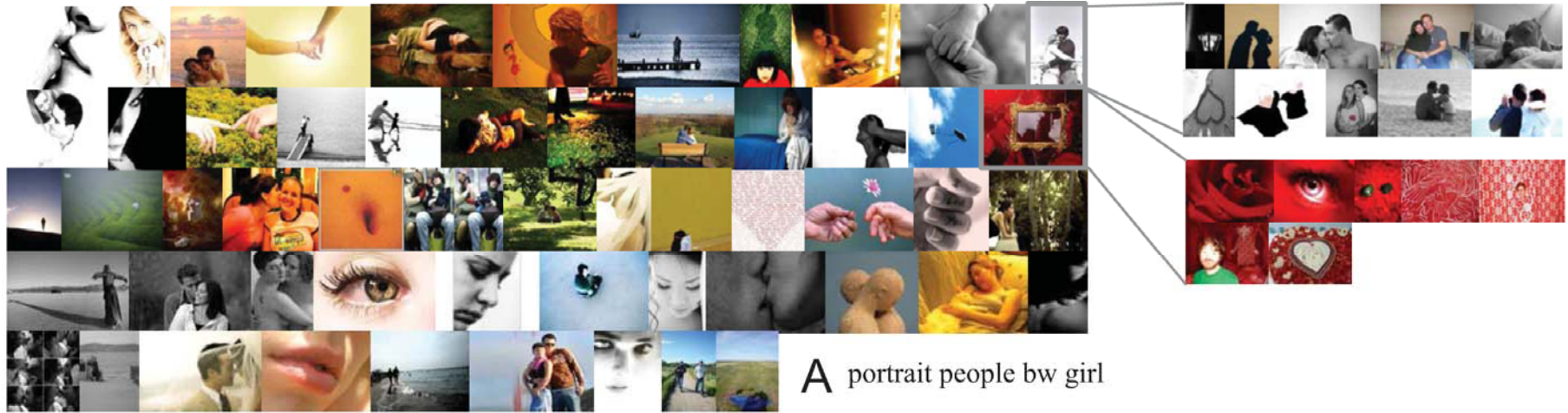


C heart
red
valentine
valentinesday



flower rose
red macro

Love details



Explore / Tags / love / clusters

					<p>girl, family, cute, woman, baby, child, mother, smile, cat, happy</p> <p>➔ See more in this cluster...</p>
					<p>couple, portrait, kiss, bw, people, black, white, face, beach, romance</p> <p>➔ See more in this cluster...</p>
					<p>heart, red, pink, valentine, flowers, nature, rose, macro, valentinesday, light</p> <p>➔ See more in this cluster...</p>
					<p>wedding, bride, groom, marriage</p> <p>➔ See more in this cluster...</p>

Comparison: Flickr clusters