Metro Maps of Photos

April Shen
with Carlos Guestrin and Ira Kemelmacher-Shlizerman
MODE Lab
March 6, 2014

Gratuitous kitten picture

Motivation

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April Shen

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Weekend in Transylvania
74 photos

Weekend in Bratislava
58 photos

Weekend in Vienna
36 photos

Southwestern road trip
43 photos

8th grade Williamsburg Trip
48 photos

Music Dept. Trip '06
29 photos

Lamp posts of London, the s...
108 photos

Lamp posts of London, the fi...
195 photos

Michelle's Party '07
51 photos

Ashley's Birthday '07
50 photos

Jodish Journeys, the second
59 photos

Jodish Journeys, the first
50 photos

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Alex Mariakakis commented on Michael R. Gustafson's status: "inb4 safari zone IDC"

Samantha Mycoolmiddlename likes Vincent Wu's status.

Rebecca Shoer likes Madlyn Mgrublian's photo.

Sarah Steurer likes Marty Weinberg's status.

Christa Starr shared Alexandra Rosado's photo.

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Weekend in Transylvania

Updated over a year ago · Taken in Romania

Road-tripped to Romania, returned alive and enlivened.

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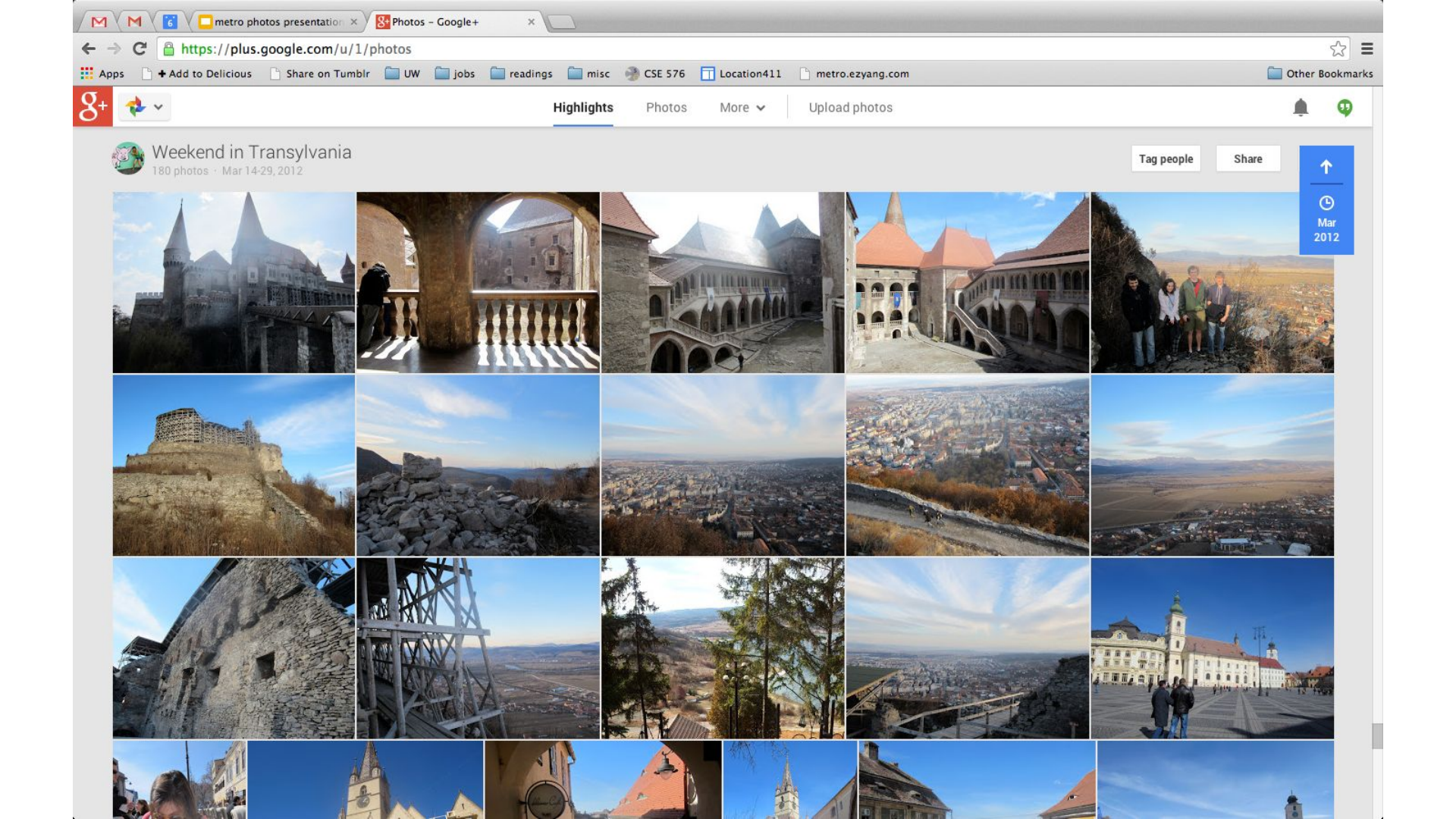
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Motivation

- Most people have a lot of photos, containing a lot of information about their lives (people, places, etc.)
- Want to deal with **information overload** in the context of **personal photo collections**
- Currently focusing on social circles

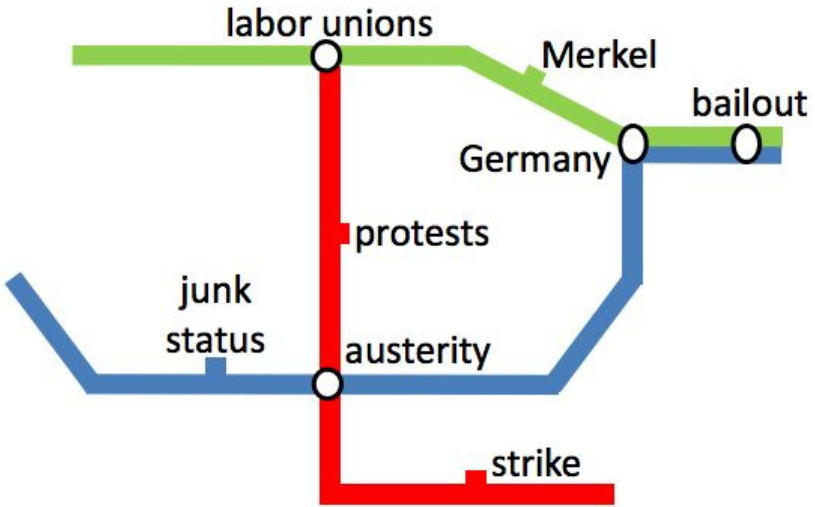
Photobios for Personal Photos

- Exploring photos of an individual over time
- A way of exploring a personal collection, but somewhat limited in scope
- Other user interfaces for viewing photos

[Kemelmacher ‘11]

Metro Maps for News and Science

- Method of gaining big-picture understanding of a complex topic
- Finds important and coherent stories and interactions between them
- Prior work for images limited (though see [Lu ‘13])



[Shahaf ‘12]

Our Goal

- Reformulate the objectives and algorithms of metro maps to provide structured summaries of personal photo collections

Dataset

- Personal photo collections
  - Currently about 1000 from my own collection
- Features include bag of faces and timestamp
  - Potentially location and infinite other possibilities

Objective

Coverage

- Want to represent the important features of the dataset
- For us: choose photos that include many of the people and times that appear in the collection

Coverage

$x = \text{faces}$

$v = \text{images}$

$p = \text{paths}$

$M = \text{map}$

- Photos try to cover faces with some probability
- Just need some photo in the subset to successfully cover a face

$$cover_v(x) = \mathbb{1}(x \in v)$$

$$cover_M(x) = 1 - \prod_{v \in M} (1 - cover_v(x))$$

$$Cover(M) = \sum_x \lambda_x cover_M(x)$$

Coherence

- Each line of the map should tell a consistent story
- For us: the photos in a line should include similar people and times



Coherence

$x = \text{faces}$

$v = \text{images}$

$p = \text{paths}$

$M = \text{map}$

- Use overlap in faces and chronology
- Judge lines by their weakest link

$$Coherence(p) = \min_{1 \le i < |p|} \sum_{x} \mathbb{1}(x \in v_i \cap v_{i+1}) - \alpha \cdot \mathbb{1}[time(v_i) > time(v_{i+1})]$$

Connectivity

- Show the interactions between the different lines
- For us: show who appears in multiple social circles

Connectivity

$x = \text{faces}$

$v = \text{images}$

$p = \text{paths}$

$M = \text{map}$

- For now, simply count number of lines that intersect (i.e., have some faces in common)

$$Conn(M) = |\{(p_i, p_j) \ : \ v_i \cap v_j \neq \varnothing \text{ for some } v_i \in p_i, v_j \in p_j\}|$$

Objective

Find a map M that maximizes $Conn(M)$
such that $Coherence(M) \geq \tau$
and $Cover(M) \geq (1 - \varepsilon)\kappa$.

- Coverage: primary objective
- Connectivity: secondary objective
- Coherence: constraint
- Note that decreasing connectivity pretty much always increases coverage
  - Want to be within epsilon of maximum coverage kappa

Algorithm

Coherence Graph

- Enumerating all coherent paths is intractable
- Create graph where nodes are short coherent sequences and any path in this graph preserves coherence
- Can get short coherent chains through general best-first search
  - Keep a priority queue of subchains
  - Always expand the most coherent chain

Coverage is Submodular

- New goal: find maximum coverage path between any two nodes
- Coverage is submodular (diminishing returns)

> A set function f is submodular if for all $A, B \subset V$ and $v \in V$, we have $f(A \cup \{v\}) - f(A) \geq f(B \cup \{v\}) - f(B)$ whenever $A \subseteq B$.

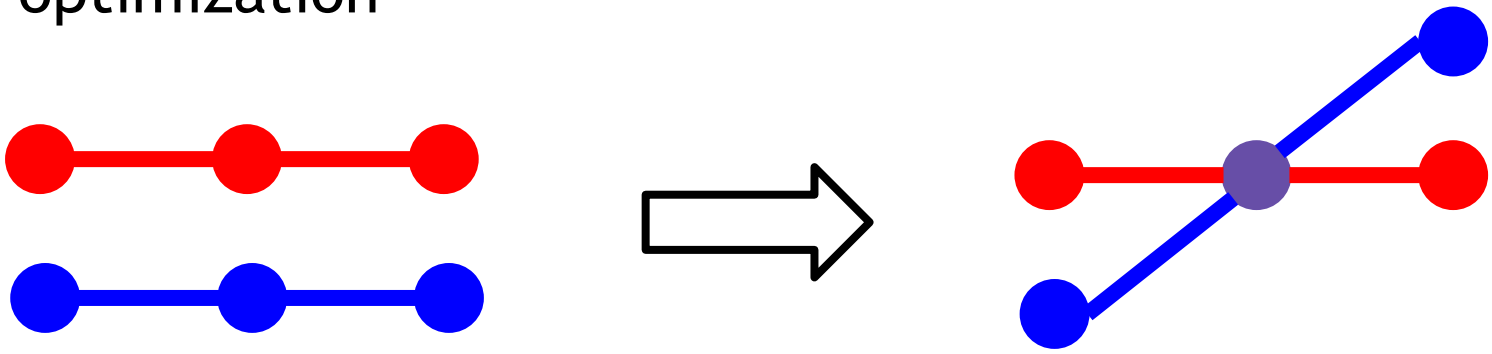
- Maximization is NP-hard, but greedy algorithm gives result within 1-1/e of optimal

Submodular Orienteering

- Greedily maximize any submodular function of a path between two nodes
- Use algorithm of [Chekuri & Pal ‘05]
  - Given start and end node, maximum allowed cost
  - Guess midpoint node and the cost to reach
  - Recursively find path from start to midpoint, then recursively augment with path from midpoint to end
- Gives O(log optimal) result

Improving Connectivity

- Local search for more connected maps
- Try to replace paths so that connectivity increases and coverage decreases by at most epsilon
- Currently, this step is rolled into the coverage optimization



Overall Algorithm

Build coherence graph

For each line in the map:

- Find best-coverage path between each pair of images
  - (using submodular orienteering)
- Choose path that is most connected while being close to best coverage
  - (using greedy algorithm)

Demo

Future Work

- Additional features
  - Photo metadata (GPS, proximity between face regions)
  - More advanced vision features, e.g. learning face or scene detectors on the fly
- Better visualization
- Scalability [Shahaf ‘13]
- Personalization through user interaction
- Evaluation
  - Probably will require user studies
- Other ideas???

References

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