Understanding and Predicting Importance in Images

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Presented by: Niveda Krishnamoorthi
CS395T Visual Recognition
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Agenda

• Problem Overview
• Motivation
• Approach
• Experiments
• Discussion
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Problem Overview

• Predicting the importance of visual content of images in natural language sentences using
  – Compositional factors
  – Semantic factors
  – Contextual factors
• Problem Overview

• Motivation

• Approach

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Why is this important?

“A raft with 3 adults and two children in a river.”
“Four people in a canoe paddling in a river lined with cliffs.”
“Several people in a canoe in the river.”
Applications

- Image/Video search
- Generating human-like descriptions for images and videos
• Problem Overview
• Motivation
• **Approach**
• Experiments
• Discussion
Approach

1. Gathering data, content labels and descriptions
2. Mapping from content to description
3. Exploring importance factors
4. Building and evaluating models to predict importance
Data

**ImageCLEF Dataset**

- Collection of 20K images covering various aspects of contemporary life, such as sports, cities, animals, people, and landscapes.
- IAPR TC-12 Benchmark includes a free-text description for each image.
- Each image is also segmented into constituent objects and labeled according to a set of (275) labels.

**UIUC Pascal Sentence Dataset**

- Consists of 1K images sub-sampled from the Pascal Challenge
- 5 descriptions written by humans for each image
- Annotated with bounding box localizations for 20 object categories
UIUC example

- One jet lands at an airport while another takes off next to it.
- Two airplanes parked in an airport.
- Two jets taxi past each other.
- Two parked jet airplanes facing opposite directions.
- Two passenger planes on a grassy plain
ImageCLEF example
Discussion

• The ImageCLEF dataset contains images with only one sentence description per image while UIUC Pascal dataset has 5.

Is it fair to use only a single annotation to represent what most humans perceive as important?
Collecting Content Labels and Mapping them to Descriptions

Human description: A man is riding a brown horse

Amazon Mechanical Turk
Discussion – Handling complex cases

Objects: man, woman, white, dress, church,…

Human annotation: Royal wedding
Exploring Importance Factors

Compositional factors:

Size

Location

“A sail boat on the ocean.”

“Two men standing on beach.”
Influence of Compositional Factors

Location

Size

probability of being described

central 1 2 3 4 5 6 7 8 9 10 peripheral

smaller 1 2 3 4 5 6 7 8 9 10 larger
Exploring Importance Factors

Semantic factors:

Object Type

Scene Type & Depiction Strength

“Girl in the street”

“kitchen in house”
### Influence of Semantic Factors (Object)

<table>
<thead>
<tr>
<th>Top10</th>
<th>Prob</th>
<th>Last10</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>firework</td>
<td>1.00</td>
<td>hand</td>
<td>0.15</td>
</tr>
<tr>
<td>turtle</td>
<td>0.97</td>
<td>cloth</td>
<td>0.15</td>
</tr>
<tr>
<td>horse</td>
<td>0.97</td>
<td>paper</td>
<td>0.13</td>
</tr>
<tr>
<td>pool</td>
<td>0.94</td>
<td>umbrella</td>
<td>0.13</td>
</tr>
<tr>
<td>airplane</td>
<td>0.94</td>
<td>grass</td>
<td>0.13</td>
</tr>
<tr>
<td>bed</td>
<td>0.92</td>
<td>sidewalk</td>
<td>0.11</td>
</tr>
<tr>
<td>person</td>
<td>0.92</td>
<td>tire</td>
<td>0.11</td>
</tr>
<tr>
<td>whale</td>
<td>0.91</td>
<td>smoke</td>
<td>0.09</td>
</tr>
<tr>
<td>fountain</td>
<td>0.89</td>
<td>instrument</td>
<td>0.07</td>
</tr>
<tr>
<td>flag</td>
<td>0.88</td>
<td>fabric</td>
<td>0.07</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Prob-ImageCLEF</th>
<th>Prob-Pascal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animate</td>
<td>0.91</td>
<td>0.84</td>
</tr>
<tr>
<td>Inanimate</td>
<td>0.53</td>
<td>0.55</td>
</tr>
</tbody>
</table>

UIUC
Influence of Semantic Factors (Scene)

Discussion: Is scene description strength a good indicator of scene importance in human descriptions?

<table>
<thead>
<tr>
<th>Office</th>
<th>Airport</th>
<th>Kitchen</th>
<th>Dining Room</th>
<th>Field</th>
<th>Living Room</th>
<th>Street</th>
<th>River</th>
<th>Restaurant</th>
<th>Sky</th>
<th>Forest</th>
<th>Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.29</td>
<td>0.13</td>
<td>0.36</td>
<td>0.21</td>
<td>0.16</td>
<td>0.13</td>
<td>0.18</td>
<td>0.1</td>
<td>0.28</td>
<td>0.18</td>
<td>0.0</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Probability of description for each scene type

<table>
<thead>
<tr>
<th>Rating</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prob</td>
<td>0.15</td>
<td>0.21</td>
<td>0.21</td>
<td>0.22</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Probability of scene term given scene depiction strength
Exploring Importance Factors

Context factors:

Unusual object-scene Pair

“A tree in water and a boy with a beard”
Influence of Context Factors (Object-Scene)
Discussion

• How do the authors handle cases when there are no images or relatively few images for the object-scene combination being considered?
Influence of Context Factors (Attribute-Object)
Discussion

• Humans tend to describe unexpected objects in scenes or unexpected attributes in objects.

• Can the technique proposed by Farhadi et al. for detecting unexpected attributes be used for predicting context factors instead?
Problem Overview
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Predicting Importance

Known Image Content → Random Split → Discriminative Models (Logistic Regression) → Predict Accuracy

Estimated Content → Random Split → Discriminative Models (Logistic Regression) → Predict Accuracy

Object → Scene → Attribute

Random Split

Repeat 10 times, measure mean and standard deviation
Object Prediction: Baseline

PREDICT

ALL THE OBJECTS
Results: Predicting objects in sentences (UIUC+ImageCLEF)

<table>
<thead>
<tr>
<th>Model</th>
<th>Features</th>
<th>Accuracy% (std)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (ImageCLEF)</td>
<td>$K_o^s + K_o^l$</td>
<td>57.5 (0.2)</td>
</tr>
<tr>
<td>Log Reg (ImageCLEF)</td>
<td>$K_o^c$</td>
<td>60.0 (0.1)</td>
</tr>
<tr>
<td>Log Reg (ImageCLEF)</td>
<td>$K_o^c + K_o^s + K_o^l$</td>
<td>68.0 (0.1)</td>
</tr>
<tr>
<td>Log Reg (ImageCLEF)</td>
<td>$K_o^c + K_o^s + K_o^l$</td>
<td>69.2 (1.4)</td>
</tr>
<tr>
<td>Baseline (UIUC-Kn)</td>
<td>$K_o^s + K_o^l$</td>
<td>69.7 (1.3)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Kn)</td>
<td>$K_o^c$</td>
<td>69.9 (0.6)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Kn)</td>
<td>$K_o^c + K_o^s + K_o^l$</td>
<td>79.8 (1.4)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Kn)</td>
<td>$K_o^c + K_o^s + K_o^l$</td>
<td>82.0 (0.9)</td>
</tr>
<tr>
<td>Baseline (UIUC-Est)</td>
<td>$E_o^s + E_o^l$</td>
<td>76.5 (1.0)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Est)</td>
<td>$E_o^c$</td>
<td>76.9 (1.1)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Est)</td>
<td>$E_o^c + E_o^s + E_o^l$</td>
<td>78.9 (1.4)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Est)</td>
<td>$E_o^c + E_o^s + E_o^l$</td>
<td>79.52 (1.2)</td>
</tr>
</tbody>
</table>
Results: Predicting scenes in sentences (UIUC)

<table>
<thead>
<tr>
<th>Model</th>
<th>Features</th>
<th>Accuracy% (std)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (UIUC-Kn)</td>
<td></td>
<td>86.0 (0.2)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Kn)</td>
<td>$K_s^c + K_s^r$</td>
<td>96.6 (0.2)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Est)</td>
<td>$E_s^d$</td>
<td>87.4 (1.3)</td>
</tr>
</tbody>
</table>

Discussion: It would have been useful to know how the model performed based on scene category only.
Results: Predicting attributes in sentences (UIUC)

<table>
<thead>
<tr>
<th>Model</th>
<th>Features</th>
<th>Accuracy% (std)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (UIUC-Kn)</td>
<td></td>
<td>96.3 (.01)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Kn)</td>
<td>$K^c_a + K^c_o$</td>
<td>97.0 (.01)</td>
</tr>
<tr>
<td>Log Reg (UIUC-Est)</td>
<td>$E^d_a + E^c_o$</td>
<td>96.7 (.01)</td>
</tr>
</tbody>
</table>

Experimental weakness: Accuracy is known to not be a good evaluation measure when there are a high number of false positives. Precision would be a better measure in such cases as we are measuring the fraction of true positives instead.
Strengths

• This paper evaluates the importance of scene and attribute information in human descriptions

• They define importance as the probability of image content appearing in natural language descriptions

• Importance factors are examined on a larger scale (1K-20K images)
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Memorability and Predicting Importance

- Some images are memorable, while some are not. However, while predicting importance, all images are assumed to have some important element(s).

- Both tend to give importance to animate objects. Memorability features can definitely be used for predicting importance.
Saliency and Predicting Importance

- Saliency: what grabs visual attention in an image?
- Humans tend to talk about salient objects and hence they are important
- While scene elements may be predicted as important, they are rarely considered salient on their own.
Questions?