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How To Realize Content Analysis in Web-Scale Multimedia Image Search

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July 7, 2010 – CIVR 2010 – Xi'an, China

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Towards Web-Scale Content-Aware Internet Multimedia Search

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Lead Researcher, Microsoft Research Asia

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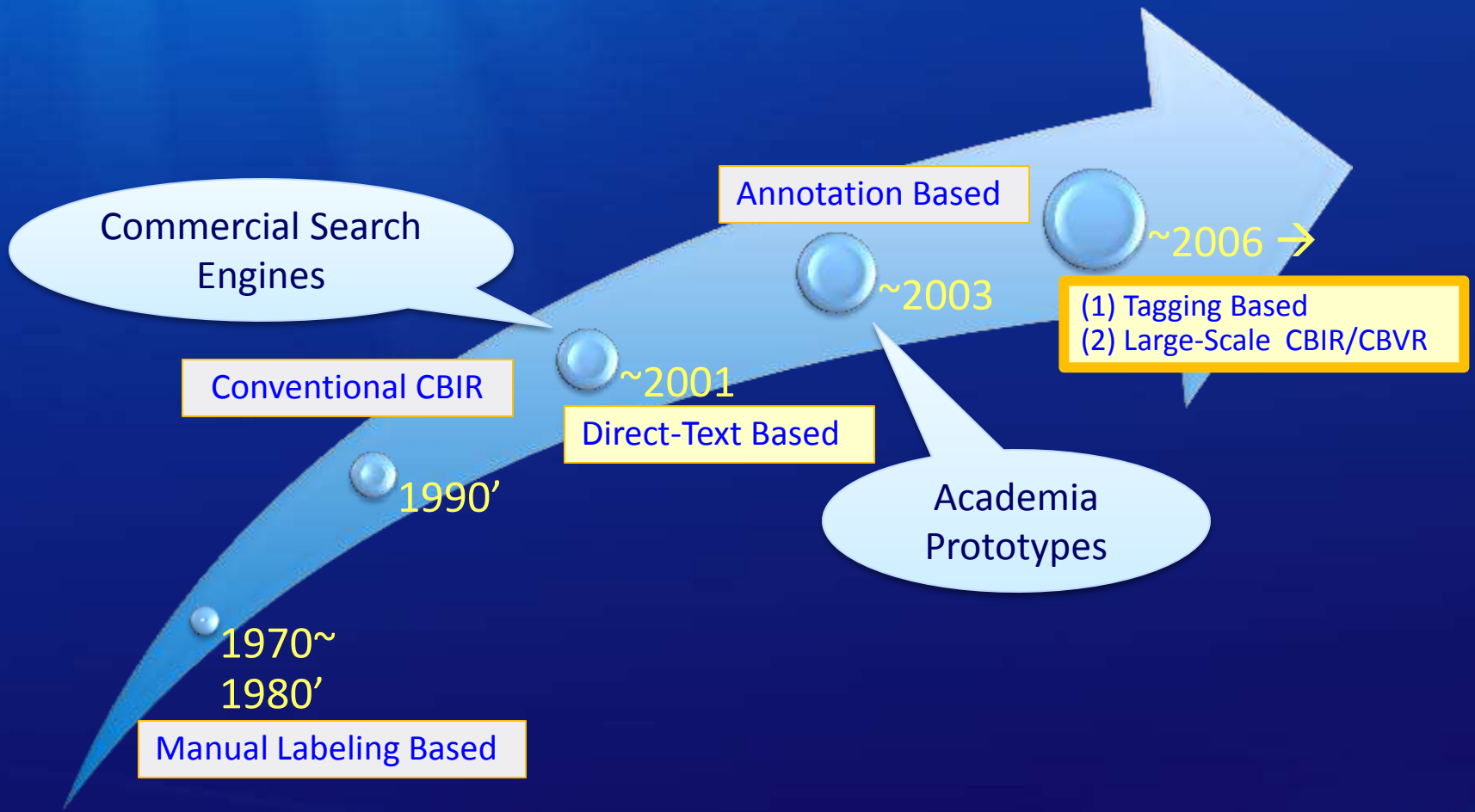
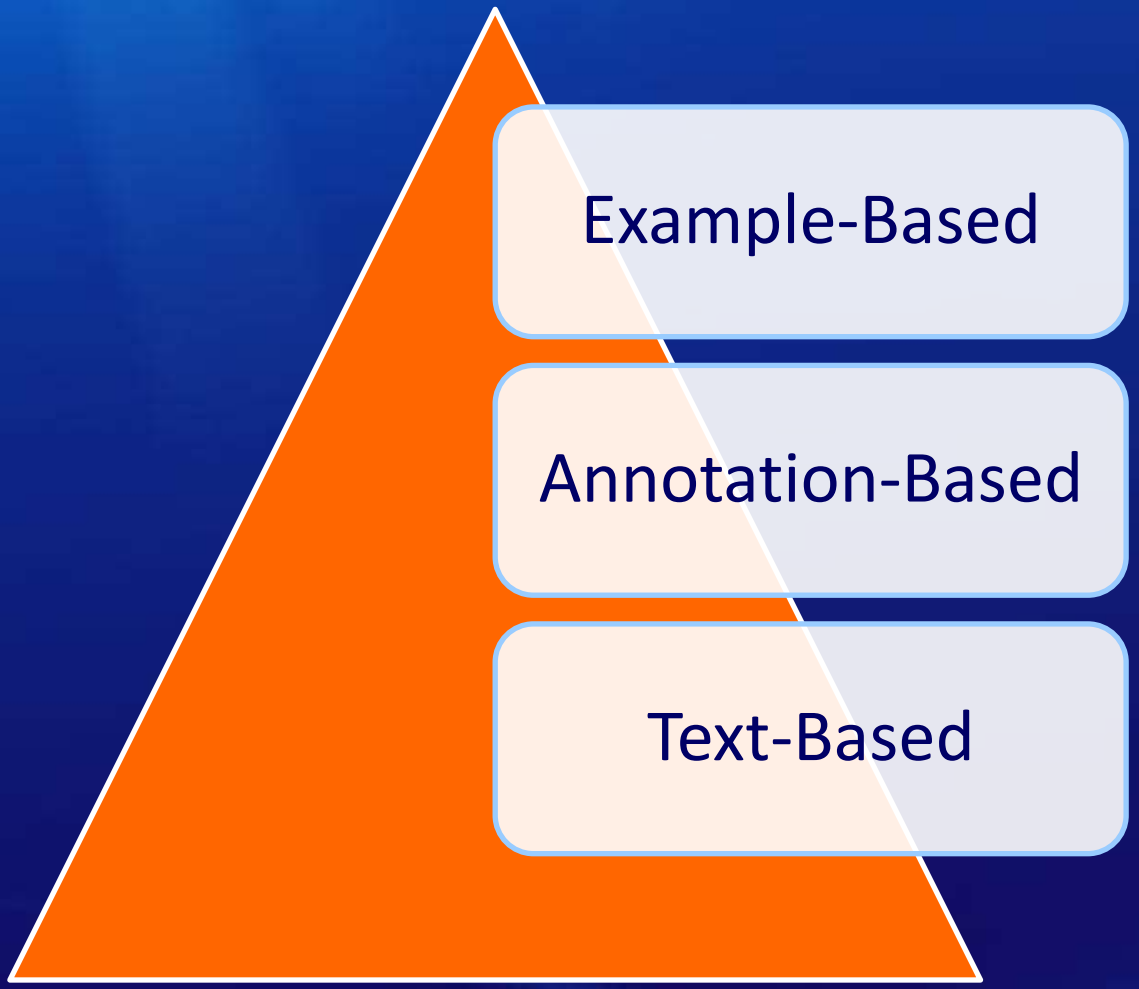
About the Title

- Towards Web-Scale Content-Aware Internet Multimedia Search
  - Towards …
  - Web-Scale …
  - Content-Aware …
  - Internet …
  - Multimedia …
  - Search …

Evolution of CBIR/CBVR



Three Schemes



Limitation of Text-Based Search

Limitation of Text-Based Search

- High noises
  - Surrounding text: frequently not related to the visual content
  - Social tags: also noisy, and a large portion don't have tags
- Mostly only covers simple semantics
  - Surrounding text: limited
  - Social tags: People tend to only input simple and personal tags
  - Query association: powerful but coverage is still limited (non-clicked images will never be well indexed)

A complex example:

Finding Lady Gaga walking on red carpet with black dress

Lady Gaga walking on red carpet and wearing in black - Google Search - Windows Internet Explorer

http://www.google.com/images?hl=en&source=imghp&q=Lady+Gaga+walking+on+red+carpet+and+wearing+in+black&gbv=2&aq=f&aqi=&aql=&oq=&gs_rfai=

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Lady Gaga walking on red carpet and wearing in ...

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Lady Gaga walking on red carpet and wearing in black Search

SafeSearch moderate ▾

About 125,000 results (0.20 seconds) Advanced search

Everything
Images
More

Any size
Medium
Large
Icon
Larger than...
Exactly...

Any type
Face
Photo
Clip art
Line drawing

Any color
Full color
Black and white

LOVES **Gaga's**.
461 × 533 - 66k - jpg
blog.kimmydavis.com
Find similar images

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490 × 361 - 52k - jpg
lifeanddeathclothing.net
Find similar images

Gaga hits the VMA **red carpet**,
465 × 570 - 93k - jpg
cultureflyy.com

Picture of **Lady Gaga walking**
309 × 400 - 41k - jpg
galechesterwhittington2...

Lady Gaga wanted to **walk** down
300 × 300 - 17k - jpg
contactmusic.com
Find similar images

There was **Lady Gaga** in her
600 × 400 - 282k
fashionist.ca

red carpet wearing a black
321 × 512 - 31k - jpg
examiner.com

Lady Gaga wanted to **walk** down
500 × 500 - 66k - jpg
thebosh.com

A-list star **walking** the **red**
353 × 512 - 48k - jpg
examiner.com

Lady Gaga
293 × 473 - 142k - jpg
uk.eonline.com

Lady Gaga wore a spiraled
500 × 398 - 70k - jpg
poshposh.com

lady gaga 2
409 × 570 - 102k - jpg
fashionfeen.wordpress.com
Find similar images

Lady Gaga Viva Glam Disease
423 × 580 - 58k - jpg
rickey.org

Photo of **Lady Gaga** arriving at
331 × 400 - 52k - jpg
galechesterwhittington2...

Walking the **red carpet** of the
600 × 559 - 117k - jpg
aceshowbiz.com
Find similar images

Lady Gaga walking the **Red**
480 × 360 - 14k - jpg
dipity.com

Outrageous: **Lady Gaga** poses on
468 × 594 - 86k - jpg
dailymail.co.uk

She is a **walking** art piece!
405 × 567 - 36k - jpg
posh24.com

Goooooooooogle ▶

1 2 3 4 5 6 7 8 9 10 Next

http://www.google.com/imgres?imgurl=http://www.aceshowbiz.com/images/news/00022249.jpg&imgrefurl=http://www.aceshowbiz.com/news/view/000222

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Limitation of Annotation-Based Search

- Low accuracy
  - The accuracy of automatic annotation is still far from satisfactory
  - Difficult to be solved
- Limited coverage
  - The coverage of the semantic concepts is still far from the rich content that is contain in an image
  - Difficult to extend
- High computation
  - Learning costs high computation
  - Recognition costs high if the number of concepts is large

Still has a long way to go

Limitation of Large-Scale Example-Based Search

- You need an example first
  - How to do it if I don't have an initial example?
- Large-scale (semantic) similarity search is still difficult
  - Though quite a few approaches were reported (e.g., LSH and its variations)
  - Though the performance of large-scale (near) duplicate detection is acceptable now

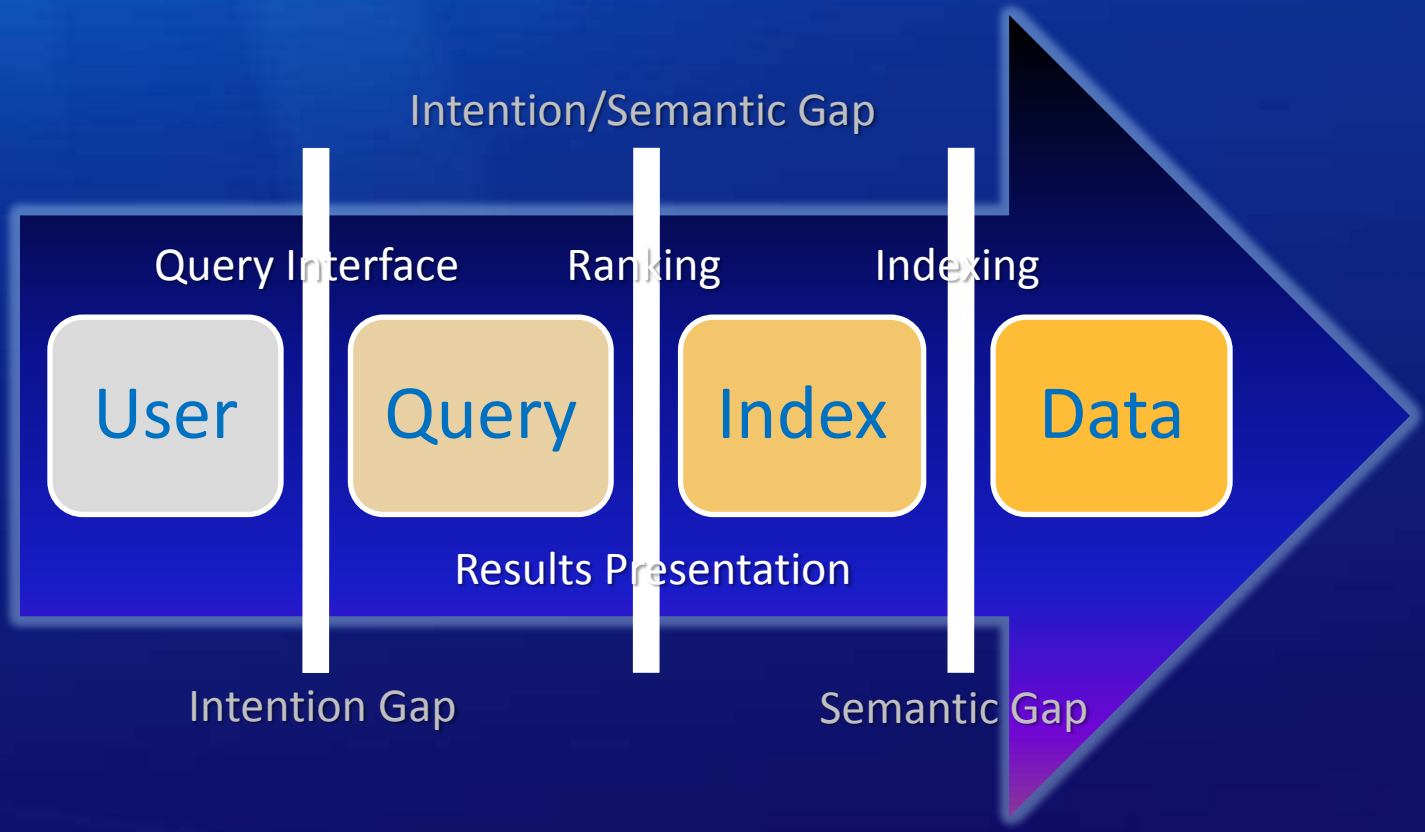
An example: TinEye

Possible Way-Outs?

- Large-scale high-performance annotation?
  - Model-based? Data-driven? Hybrid? …
- Large-scale manual labeling?
  - ESP game? Label Me? Machinery Turk? …
- New query interface?
  - Interactive search?

Or … To combine text, content and interface?

Internet Multimedia Search



Practical Solutions

- Working on search results
  - Search result presentation
  - Re-ranking
  - …
- Leveraging text based indexing
  - Combining text and content (large-scale text & small scale content)
  - Indexing content like indexing text (large-scale content)
  - …
- Interacting with users
  - Dialog-based
  - Interactive query interface
  - …

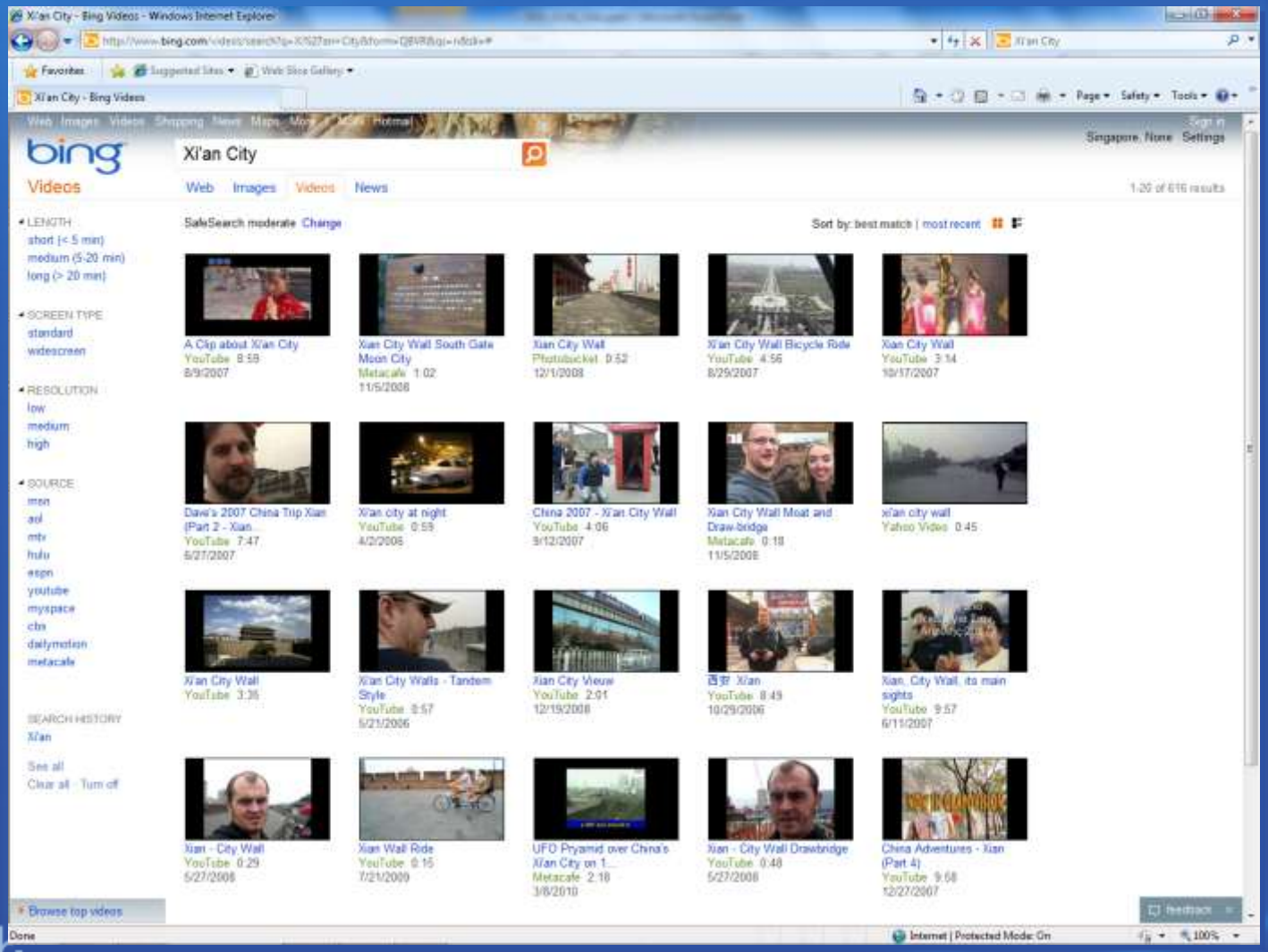
Examples

- Five exemplary technologies
  - Four are shipped features in Microsoft Bing
  - One is a research project

Ex1: Smart Video Thumbnail

- Shipped in Bing in 2007
  - Credit: Xian-Sheng Hua, et al.
- Basic technology
  - Video summarization (static and motion)
- Special requirement
  - Align the first frame of the motion thumbnail with the static one
  - Low computation cost and storage cost
- Scalability
  - Thumbnail generation: offline but need to be quick enough
  - All videos in Bing has static thumbnail
  - Around half of the videos in Bing index have motion thumbnail

Ex1: Smart Video Thumbnail in Bing



Ex1: Extension - Smart Video Player

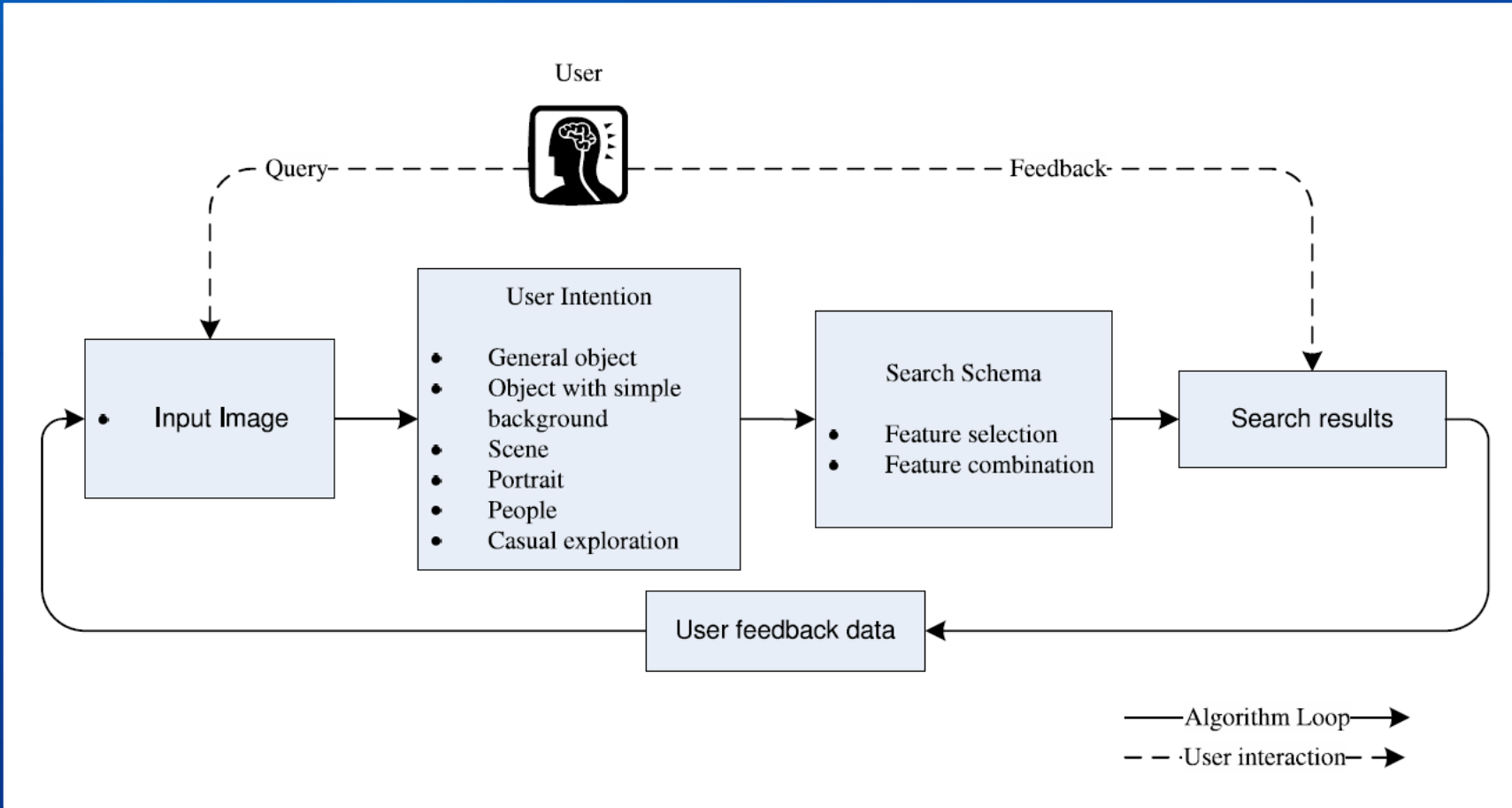
Smart Video Thumbnail

A good example of applying heavy content analysis on web-scale videos through an offline process, and showing the outputs in the search result page in realtime.

Ex2: Show Similar Images

- Shipped in Bing in 2009
  - Credit: Fang Wen, Jian Sun, Jingyu Cui, et al.
- Basic technology
  - Re-rank the search results according to the selected image
  - CBIR on text-based search results (<= 1000 images)
- Key idea
  - Estimate users' intent by image categorization (an effective similarity measure)
- Scalability
  - Feature extraction: offline but need to be quick enough
  - Working on web-scale data though each time only need to compare less than 1000 images

Ex2: Show Similar Images



Xi'an City - Bing Images - Windows Internet Explorer

http://www.bing.com/images/search?q=Xi%27an+City&form=QBIL&qs=n&sk=#

Xi'an City

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Xi'an City

Images

Web Images

1-30 of 154,000 results

SafeSearch moderate Change

SIZE
Small
Medium
Large
Wallpaper

LAYOUT
Square
Wide
Tall

COLOR
Full color
Black & white
Specific color

STYLE
Photograph
Illustration

PEOPLE
Just faces
Head & shoulders

SEARCH HISTORY
Xi'an City
grass
bingmayong
Xi'an
url:http://www.deviantart.com/downl...

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Clear all · Turn off

Picture of **Xian City** Wall ...
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Xi'an City - Bing Images - Windows Internet Explorer

http://www.bing.com/images/search?q=Xi%27an+City&sk=&simid=166785791771#

Xi'an City

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Xi'an City

Images

Web Images

1-30 of 60 results

SafeSearch moderate Change

SIZE
Small
Medium
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Wallpaper

LAYOUT
Square
Wide
Tall

COLOR
Full color
Black & white
Specific color

STYLE
Photograph
Illustration

PEOPLE
Just faces
Head & shoulders

SEARCH HISTORY
Xi'an City
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Show Similar Images

A good example of applying CBIR/re-ranking on image search results, which works well on web-scale image data.

Ex3: More Sizes

- Shipped in Bing in early 2010
  - Credit: MSR SVC and Bing Multimedia Search
- Basic technology
  - Large-scale duplicate/near-duplicate image detection
- Scalability
  - Working on the entire Bing image index

Xi'an City - Bing Images - Windows Internet Explorer

http://www.bing.com/images/search?q=Xi%27an+City&cbir=vw&mid=0D4D62A788BCF449BD3818E6A9513EDA7CC80457#

Xi'an City

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Xi'an City

Images

Web Images

1-3 of 4 results

SafeSearch moderate Change

Back

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Wallpaper

LAYOUT
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Wide
Tall

COLOR
Full color
Black & white
Specific color

STYLE
Photograph
Illustration

PEOPLE
Just faces
Head & shoulders

SEARCH HISTORY
Xi'an City
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More variations of the following image:

littleredbook_dot_cn_city ...

800 x 600 · 82 kB · jpeg

Go to page: http://www.littleredbook.cn/2009/02/01/xian-city-snapshot/

Title	Source	Resolution	File Size	File Type
Bell Tower Photo, Bell ...	www.chinahighlights.com	800 x 602	74kB	jpeg
Bell Tower Photos	www.chinahighlights.com	150 x 113	4kB	jpeg
Забележителнос ...	www.travelagent.bg	130 x 100	12kB	jpeg

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Internal preview Help improve Bing

http://www.bing.com/images/search?q=3322d+d439b+d4566+bf85a+97aca+d92a3+34380+41696+49e2e+43523+3057e+2500f+3bdd7+5eefb+3176e+5eeaf+5e

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More Sizes

A good example of applying large-scale duplicate/near-duplicate detection on web-scale image data.

Ex4: Image Search by Color Sketch

- Shipped in Bing in June 2010
  - Credit: Jingdong Wang, Xian-Sheng Hua, et al.

Seems It Is Not New?

- "Query by sketch" has been proposed long time ago
  - But on small datasets and difficult to scale up
  - And seldom work well actually
  - Not use to use – "object sketch"

Query by Sketch in Image Databases - Windows Internet Explorer
http://www.lems.brown.edu/vision/researchAreas/indexing/index.html
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Favorites
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Web Slice Gallery
Query by Sketch in Image Databases
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Query by Sketch in Image Databases

The database used here consisted of 137 typical images drawn from the web. The geometric search engine was developed by Princeton University and Z. Lei, of our laboratory. We desire to find an image containing a car pointing at roughly 40 degrees with respect to the viewer of the image. This is a difficult shape for most people to draw, and is very difficult to draw for someone devoid of artistic skill. The idea is to proceed interactively with the database system, letting the system help the user in making an appropriate sketch. The user begins by sketching an easy shape, e.g., a side view of a car, the first Figure, and indexes into the database. The 8 highest ranking returns are shown: the 5th is a car pointing 60 degrees to 70 degrees with respect to the viewer. With that outline as a guide, the user modifies the outline into the sketch in the second Figure, which is the users attempt at sketching the desired shape. Upon indexing into the database again, The 5th image in the highest ranking 8 returned is an example of what is desired. This is an example of interacting with the database by letting the database help based on what is in the database rather than interaction by using a set of generic primitives for querying the database. Using generic primitives seems to be impractical if the database is generic containing a broad range of object types.

This figure, illustrates a different search concept for a car. An initial sketched curve fragment results in no useful return because it is insufficiently restrictive. A 2nd iteration involving the sketching of additional structure does result in some car hits among the 8 highest ranking returns.

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It is based on a SIGGRAPH 95's paper:

C. Jacobs et al. Fast Multiresolution Image Querying. SIGGRAPH 1995

on small scale image set and difficult to scale-up (0.44 second for 10,000 images)

GazoPa similar image search - Windows Internet Explorer

http://www.gazopa.com/

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GazoPa changes the way of image search.

New flower photo community

GazoPa bloom

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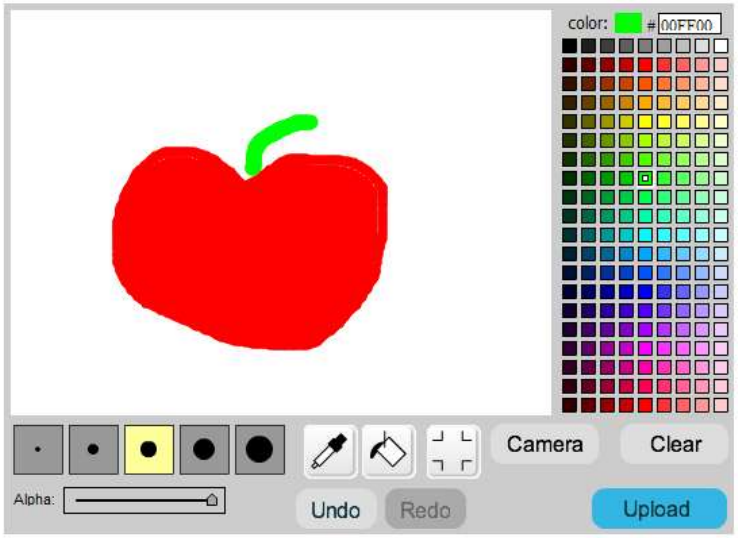
Sign in is required to publish your drawing to Twitter etc.



Post to Twitter | Post to Facebook | Like 813

Sample images

Done

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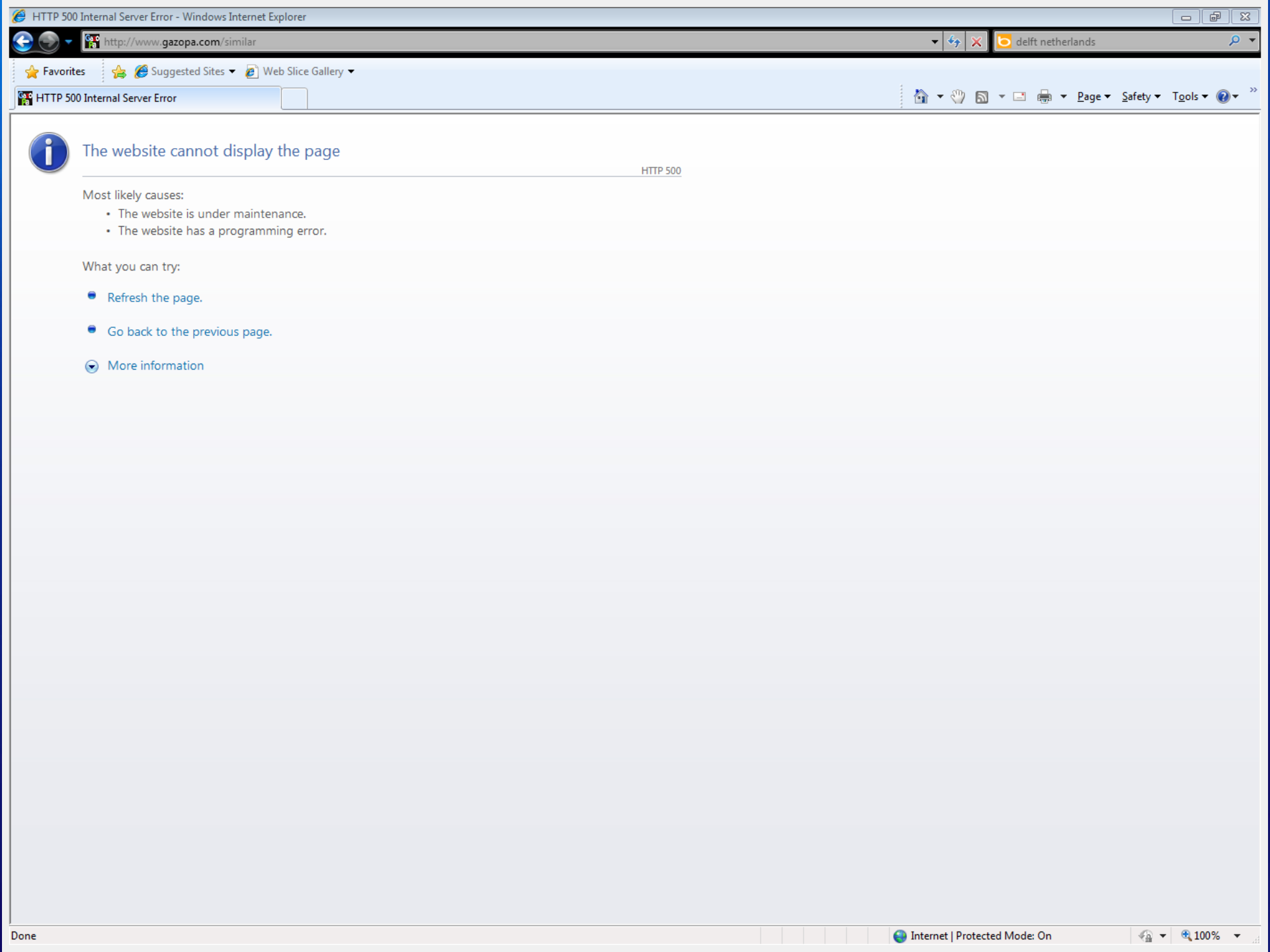
HTTP 500 Internal Server Error - Windows Internet Explorer
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The website has a programming error.
What you can try:
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Our Approach

- Color sketch …
  - Is not “object sketch”
  - But only rough color distribution
  - Supports large-scale data
  - And uses text at the same time

apple - Bing Images - Windows Internet Explorer

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apple

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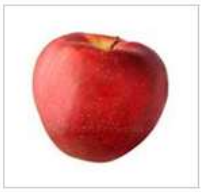

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COLOR

All
Full color
Black & white
Specific color

STYLE
PEOPLE

SEARCH HISTORY

apple

Specific color

Filter using sketch

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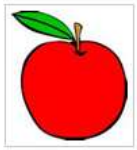

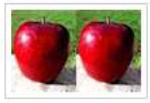

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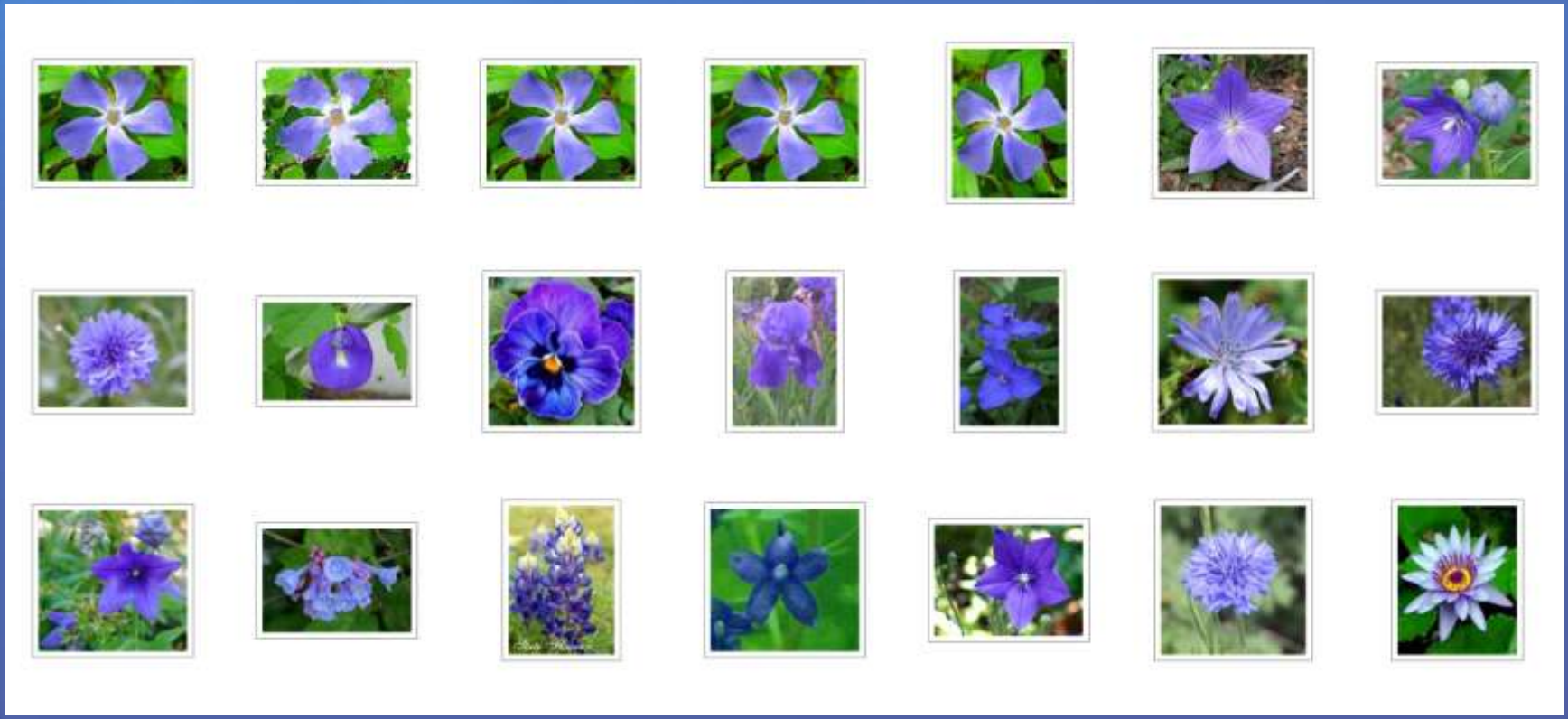
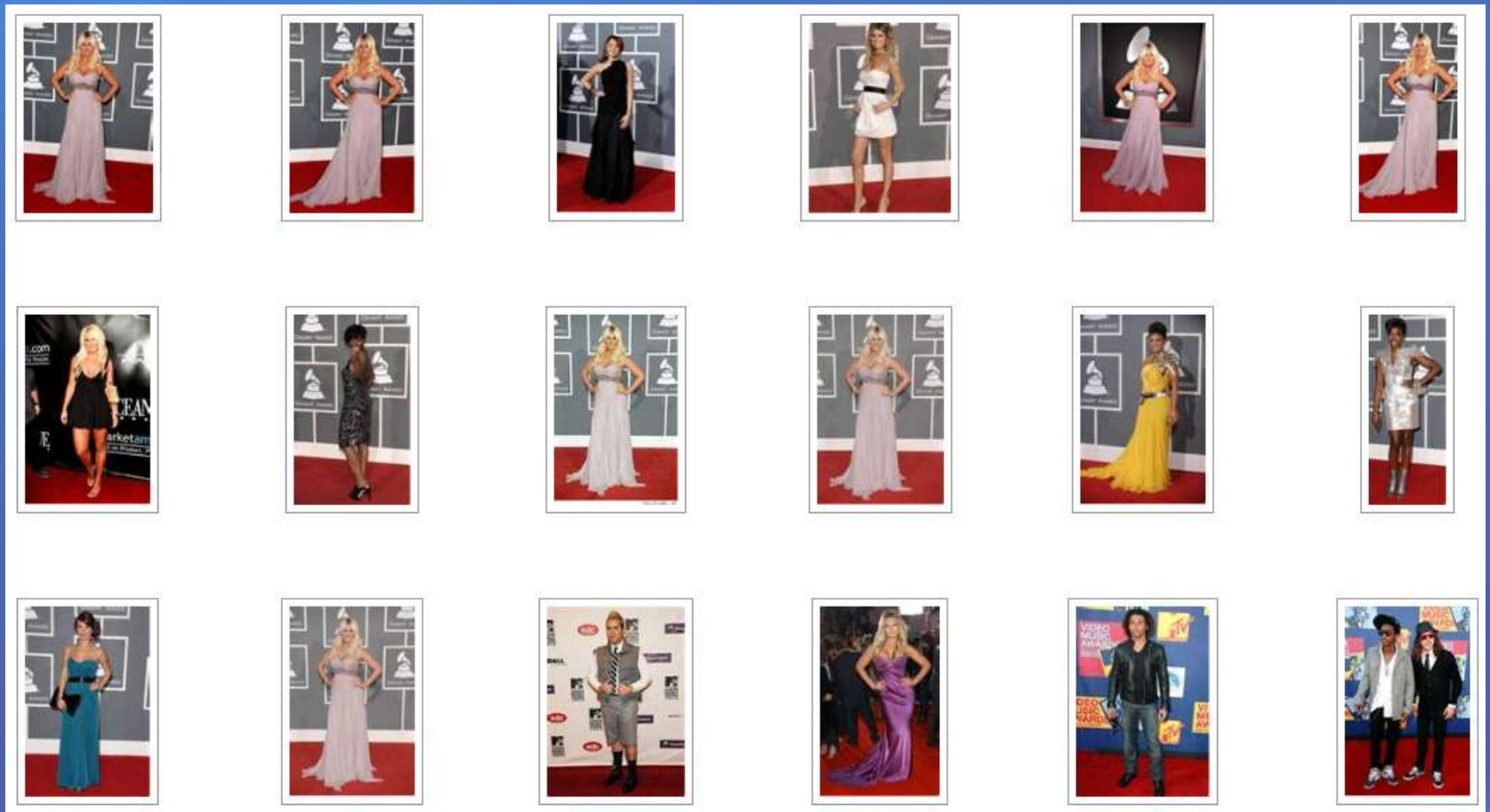
Our Approach

- Color sketch is not “object sketch”
  - But only rough color distribution
  - Supports large-scale data
  - And uses text at the same time
- Advantages of “Color Sketch”
  - More presentative than dominant color (and text only)
  - More robust than “object sketch”
  - Easy to use compared with “object sketch”
  - Easy to scale up

Example: Blue flower with green leaf

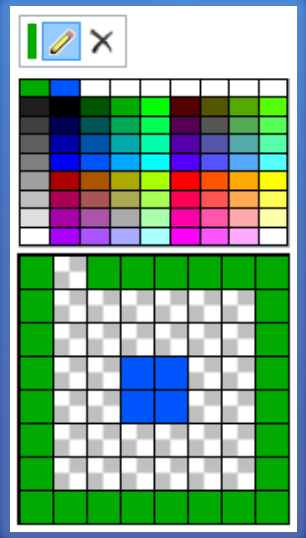


Example: Brooke Hogan walking on red carpet



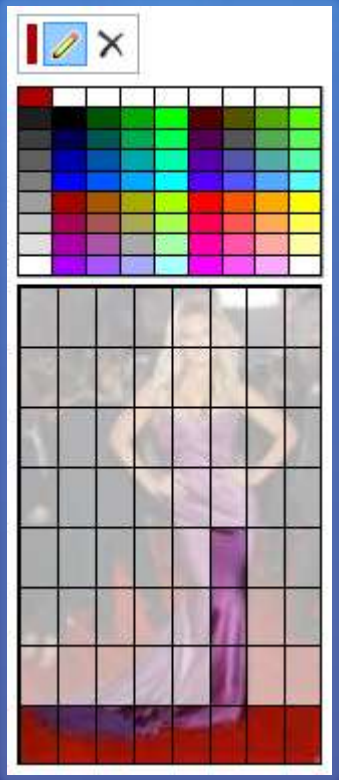
Color Sketch Is More Powerful

Blue Flower with Green Leaf



Brooke Hogan walking on red carpet

Color Sketch Is More Powerful



The Techniques

- Color Sketch: Image Representation
  - Capturing both color and spatial information
  - Low computation and storage costs
- Intention Map: Intention Representation
  - Rough: Tolerance to the errors in the colors and positions of the strokes
  - Sparse: Intention estimation from sparse strokes
- Similarity Evaluation
  - Effective and fast

grass - Bing Images - Windows Internet Explorer

http://www.bing.com/images/search?q=grass&form=QBIR&qs=n&sk=&sc=8-5#

grass

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ALL RESULTS

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- Grass Field
- Beach Grass
- Lemon Grass
- Tall Grass
- Cotton Grass
- Grass Carp
- Mondo Grass
- Grass Texture

SIZE

LAYOUT

COLOR

STYLE

PEOPLE

SEARCH HISTORY

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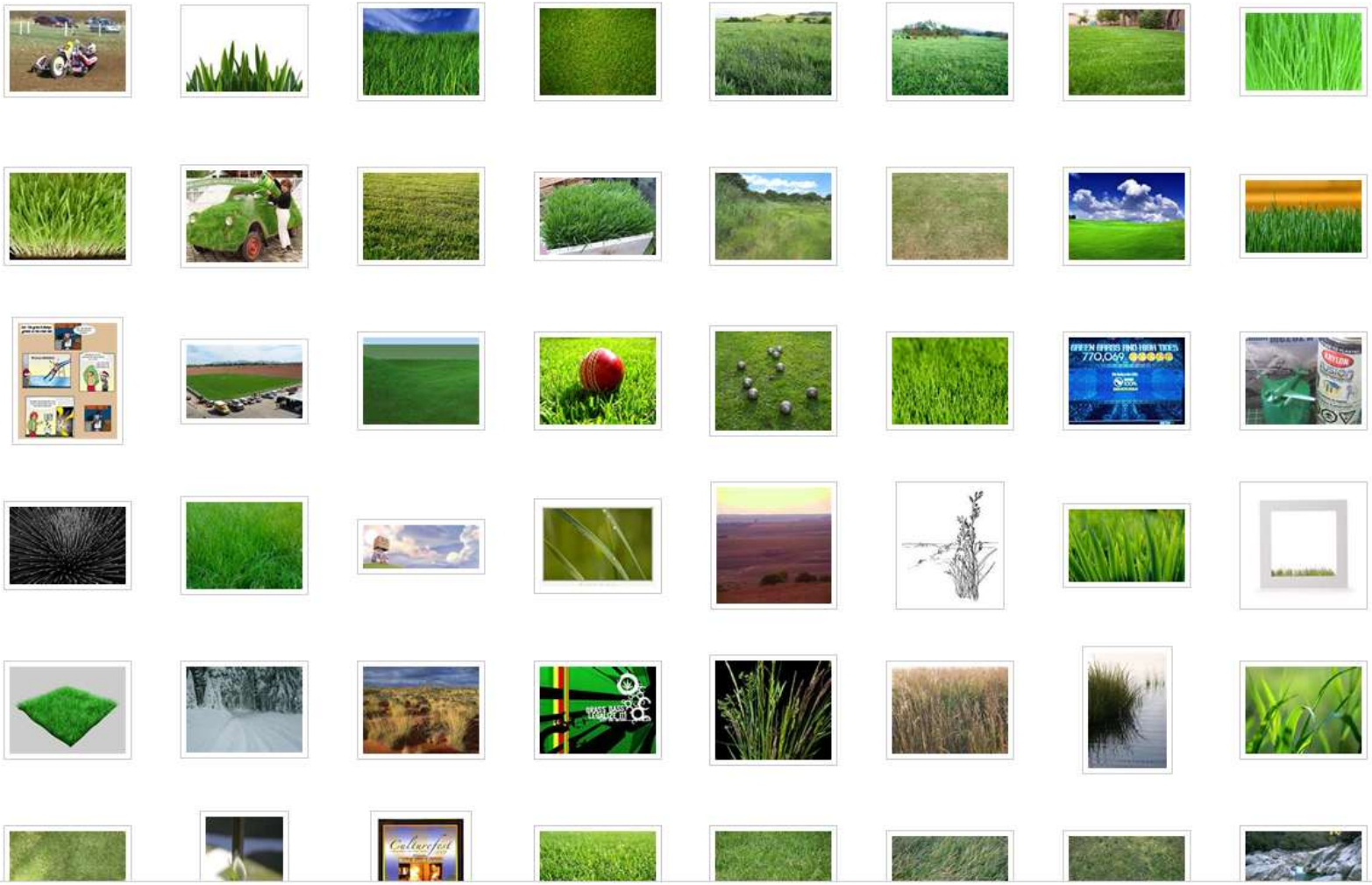
- flower
- url:http://concordcritters.com/Phot...
- url:http://emiliewood.com/photos/ju...
- apple

See all

Clear all · Turn off



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grass

Make Bing your decision engine

ALL RESULTS

Images of Grass

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Cotton Grass
Grass Carp
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SIZE

LAYOUT

COLOR

All
Full color
Black & white

Specific color

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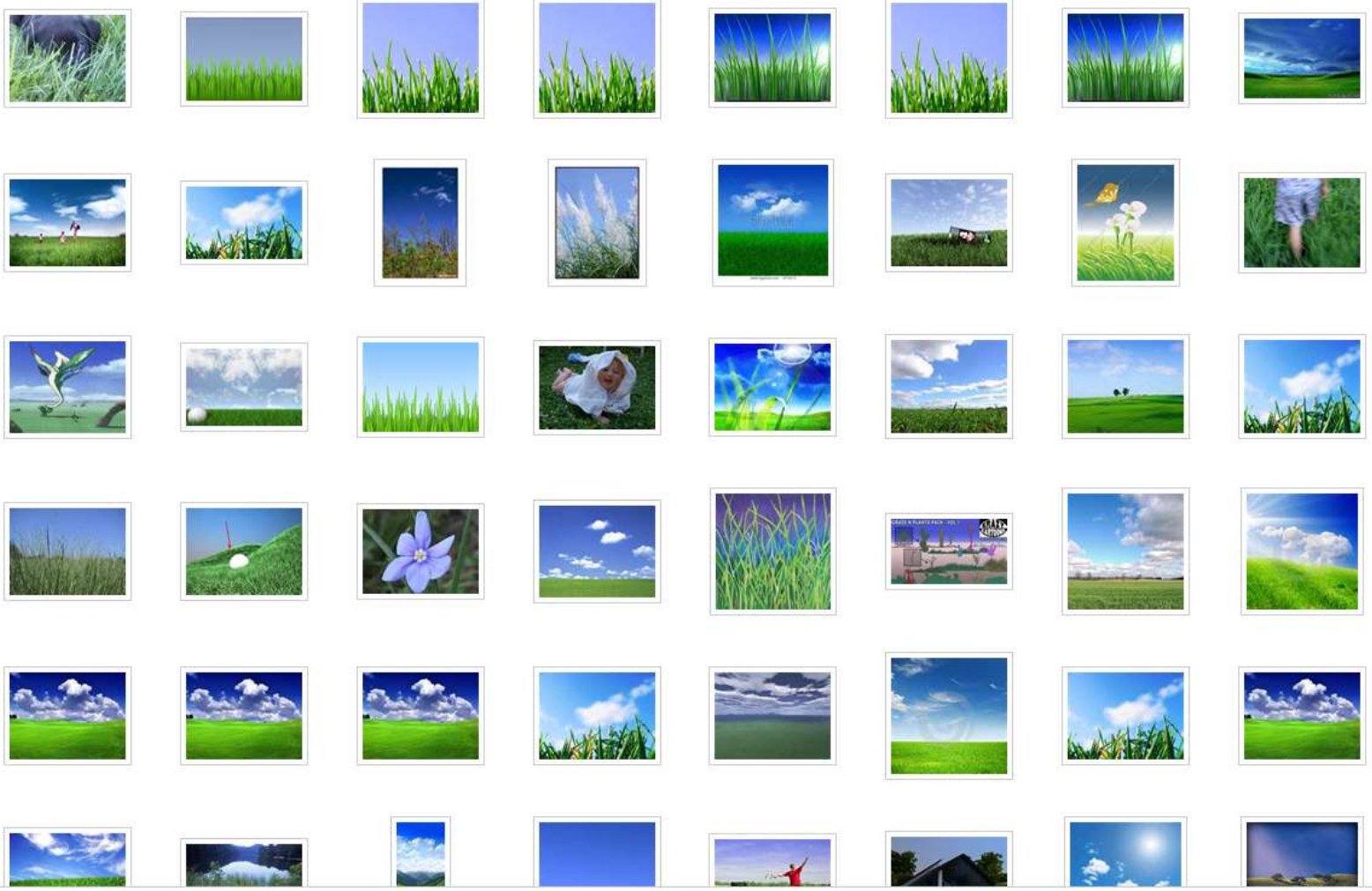

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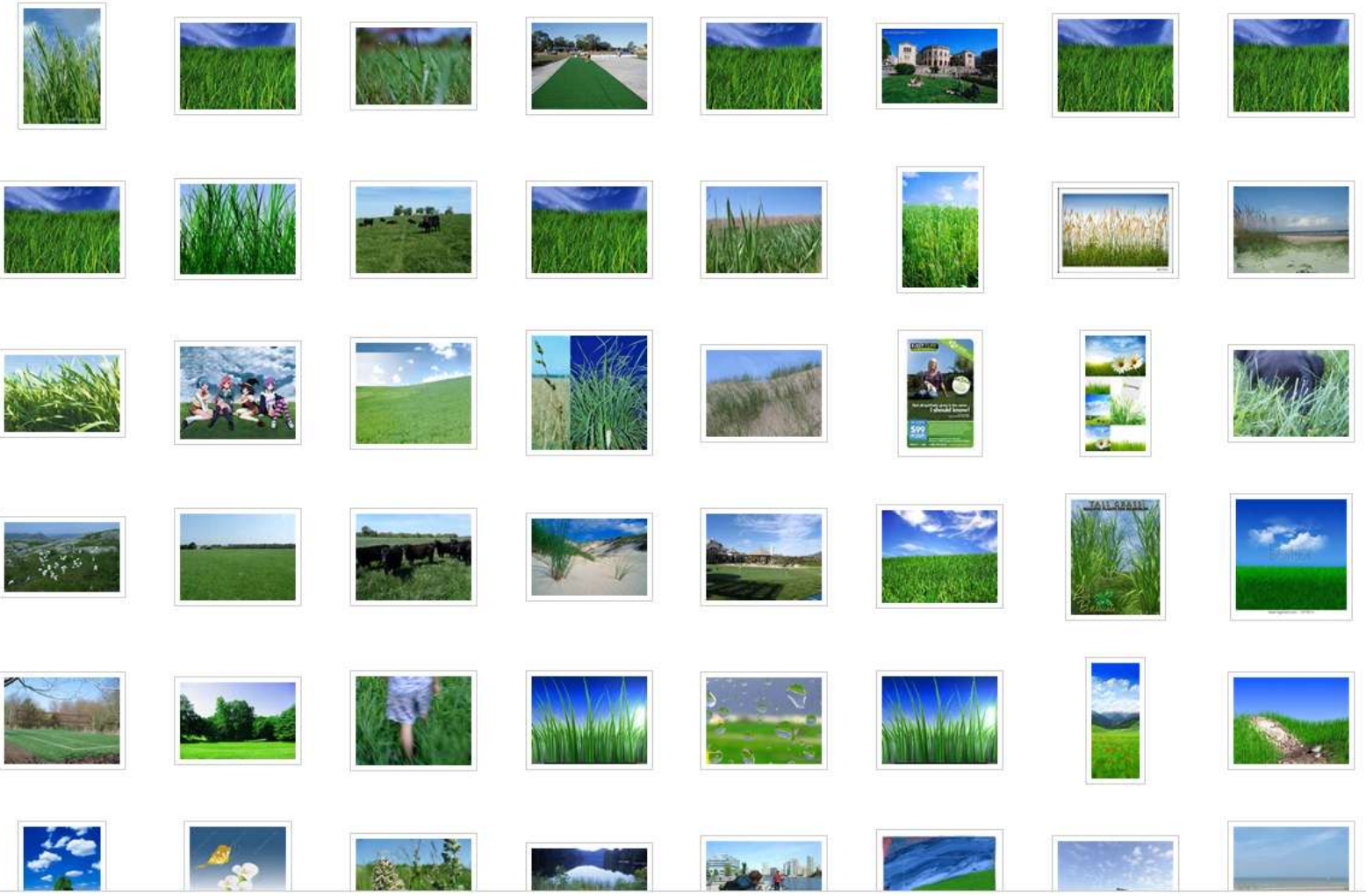

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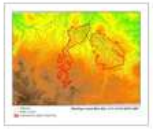

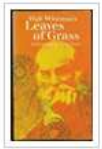

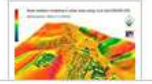

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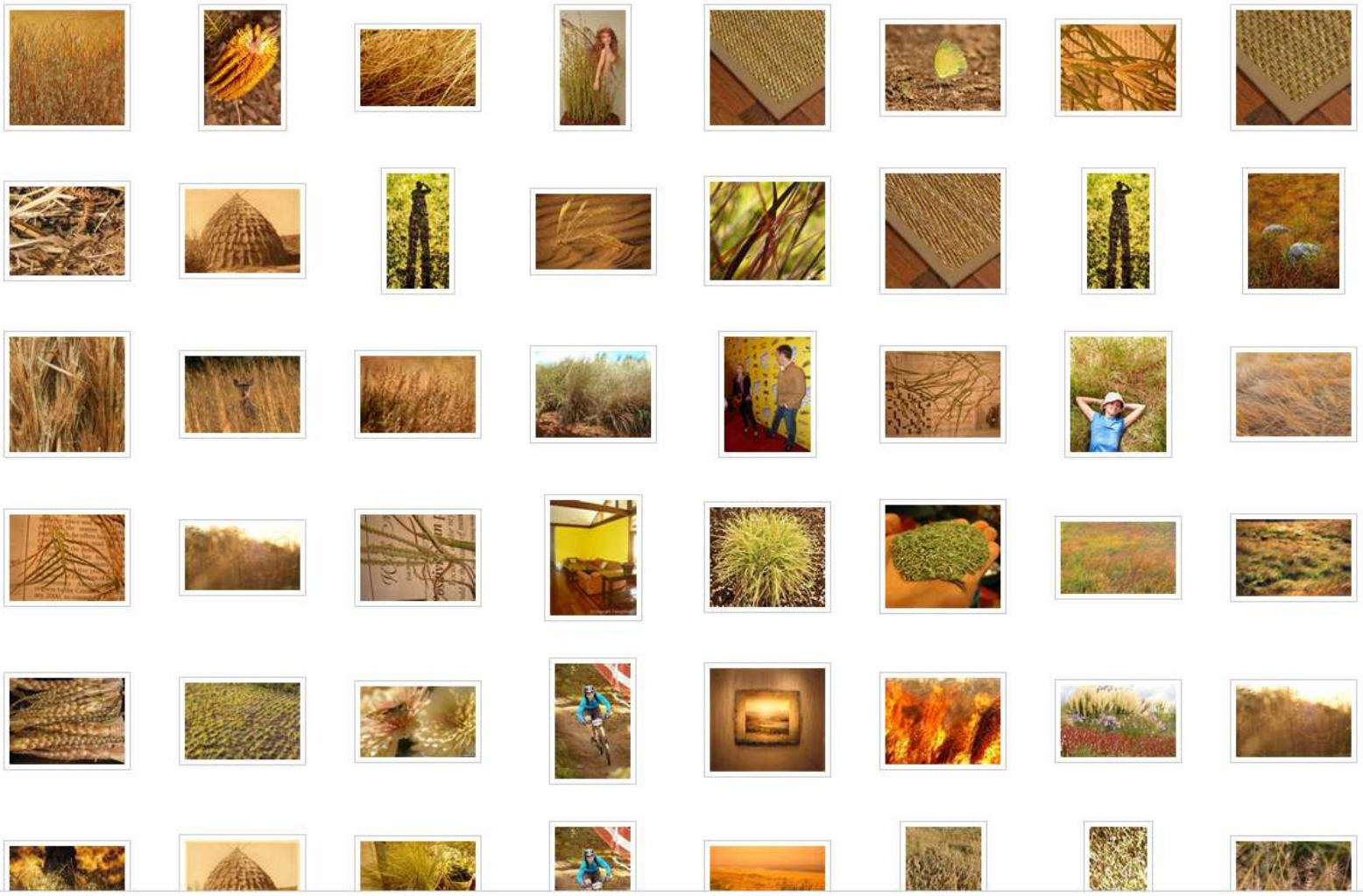

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COLOR

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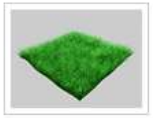

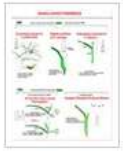

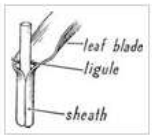

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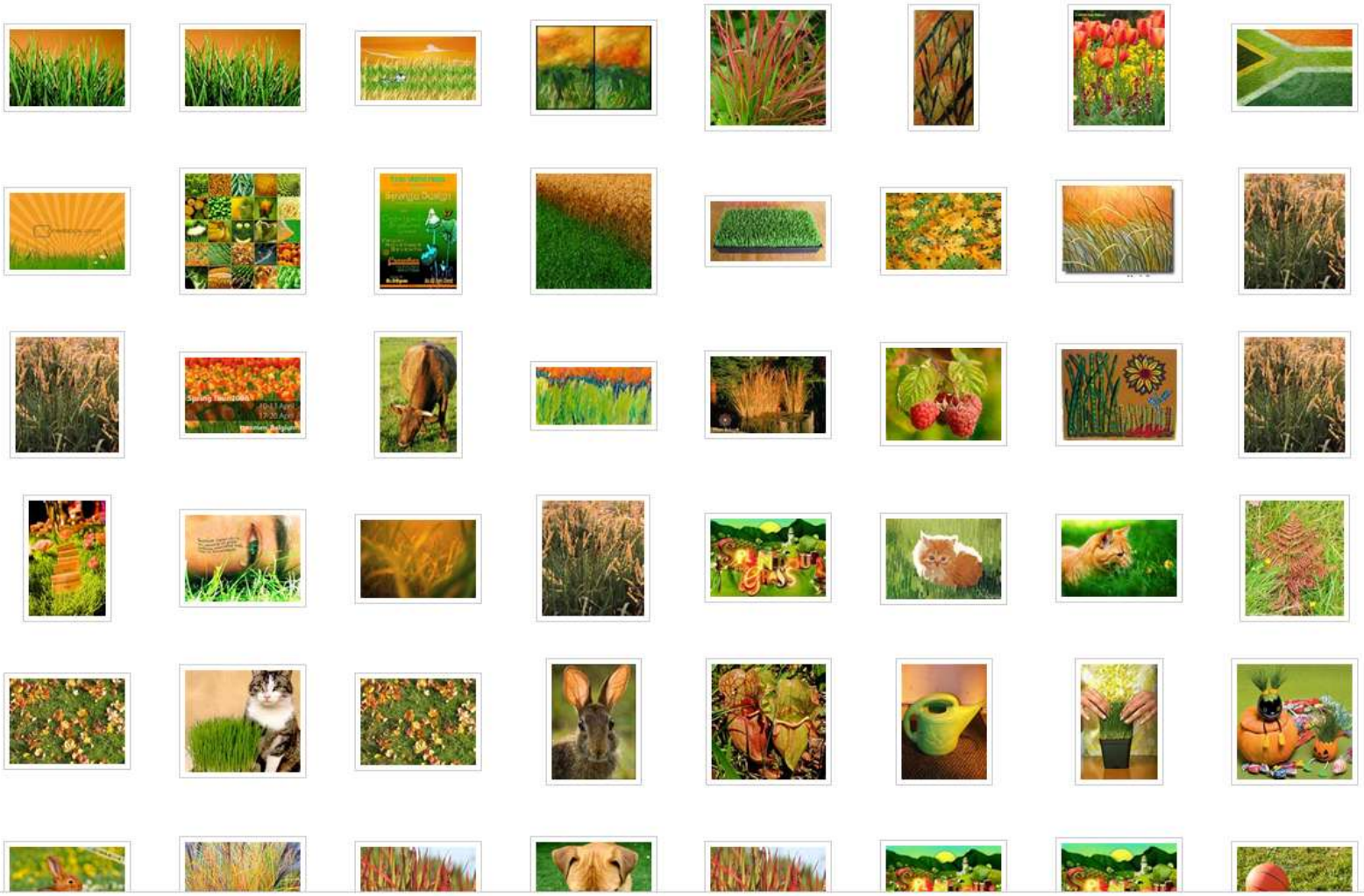

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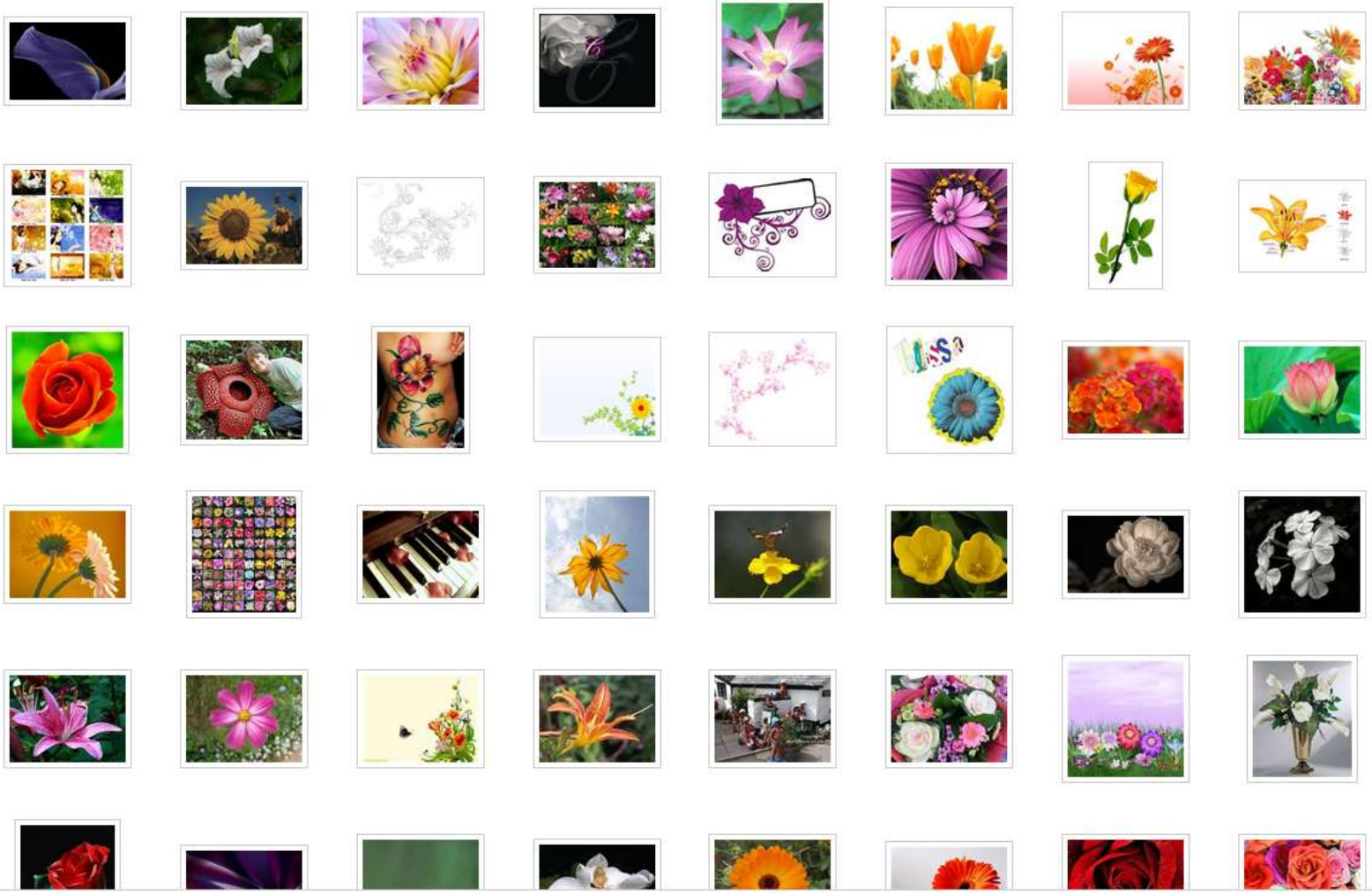

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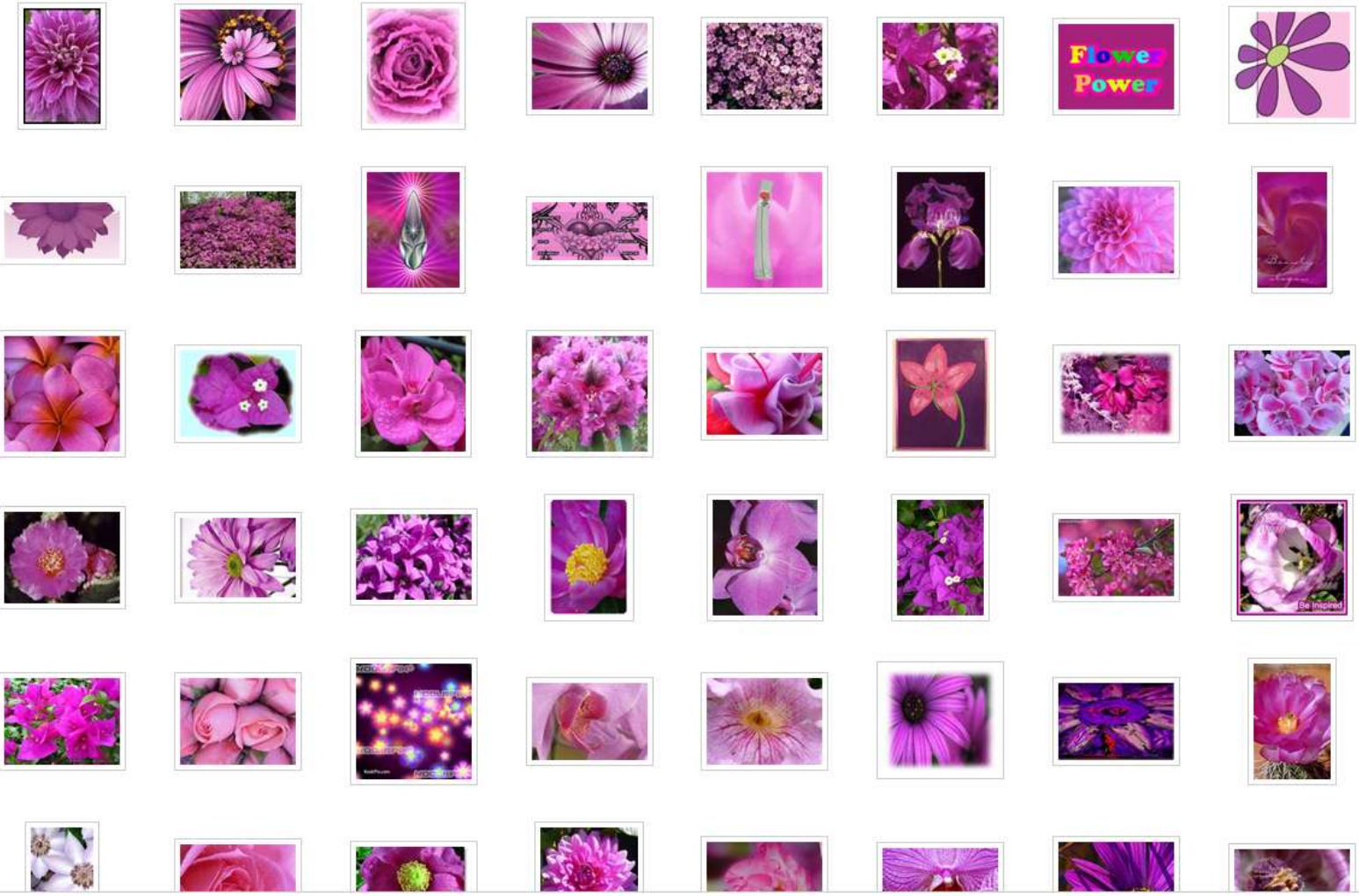

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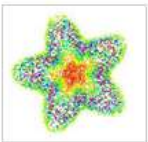

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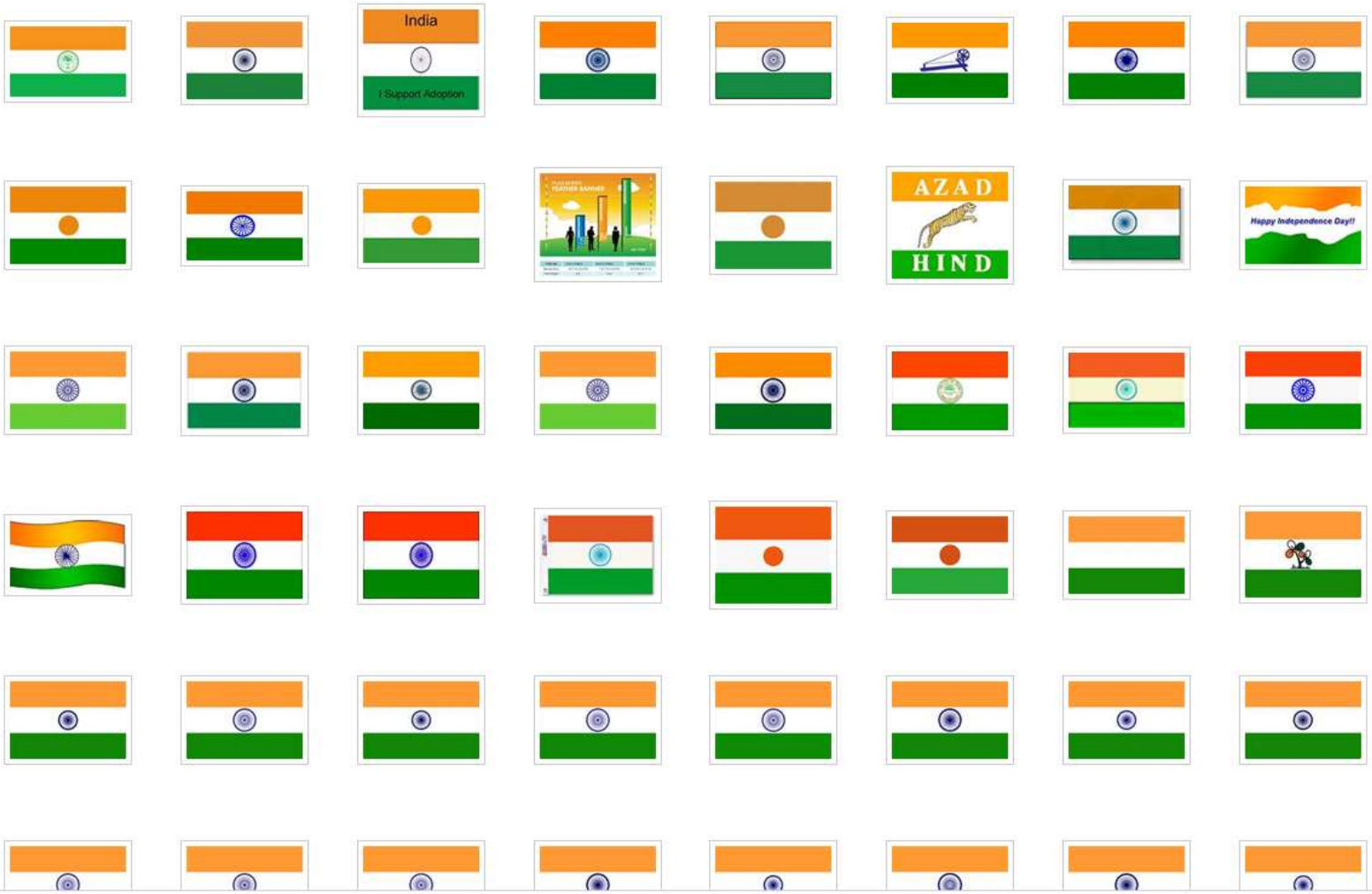

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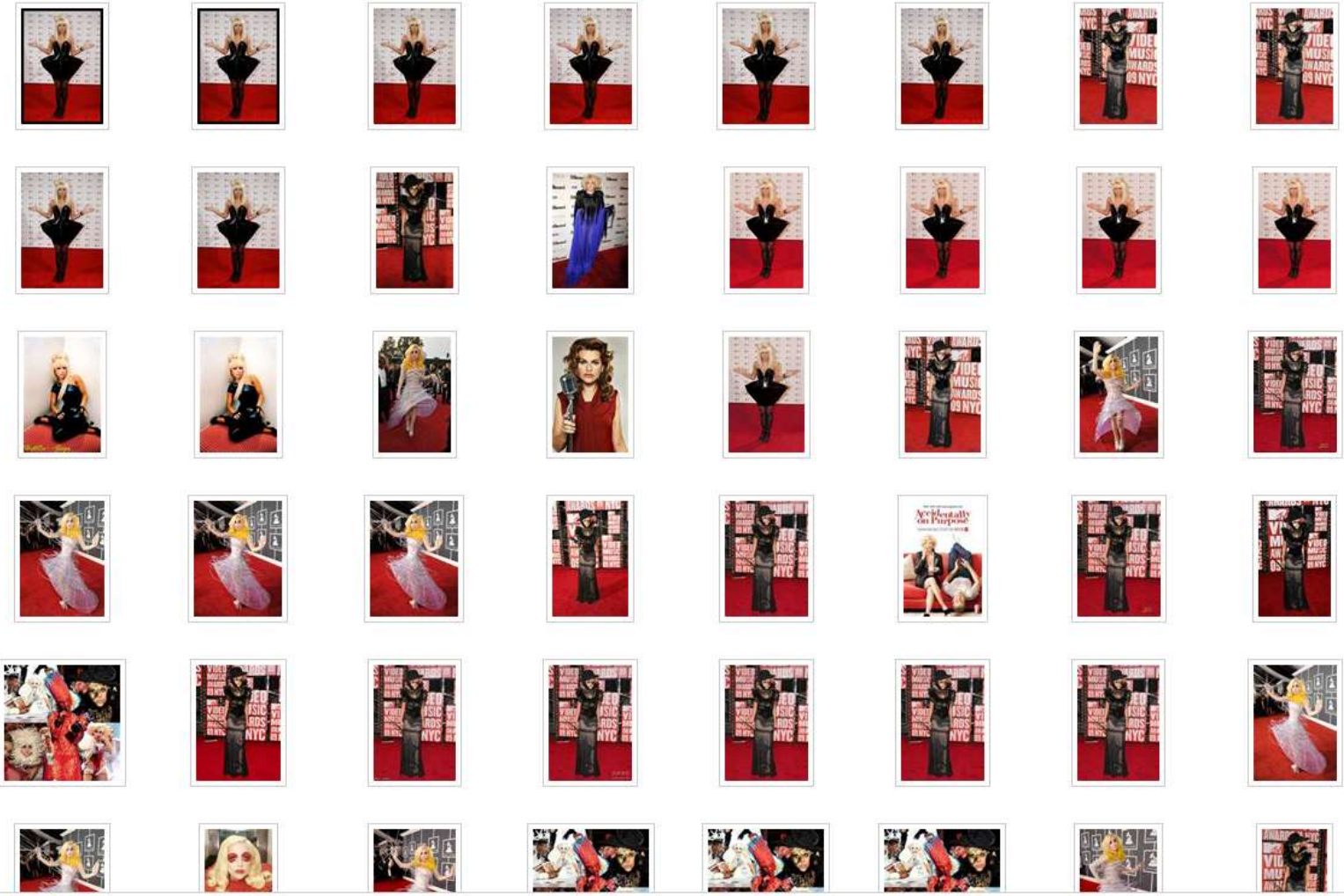

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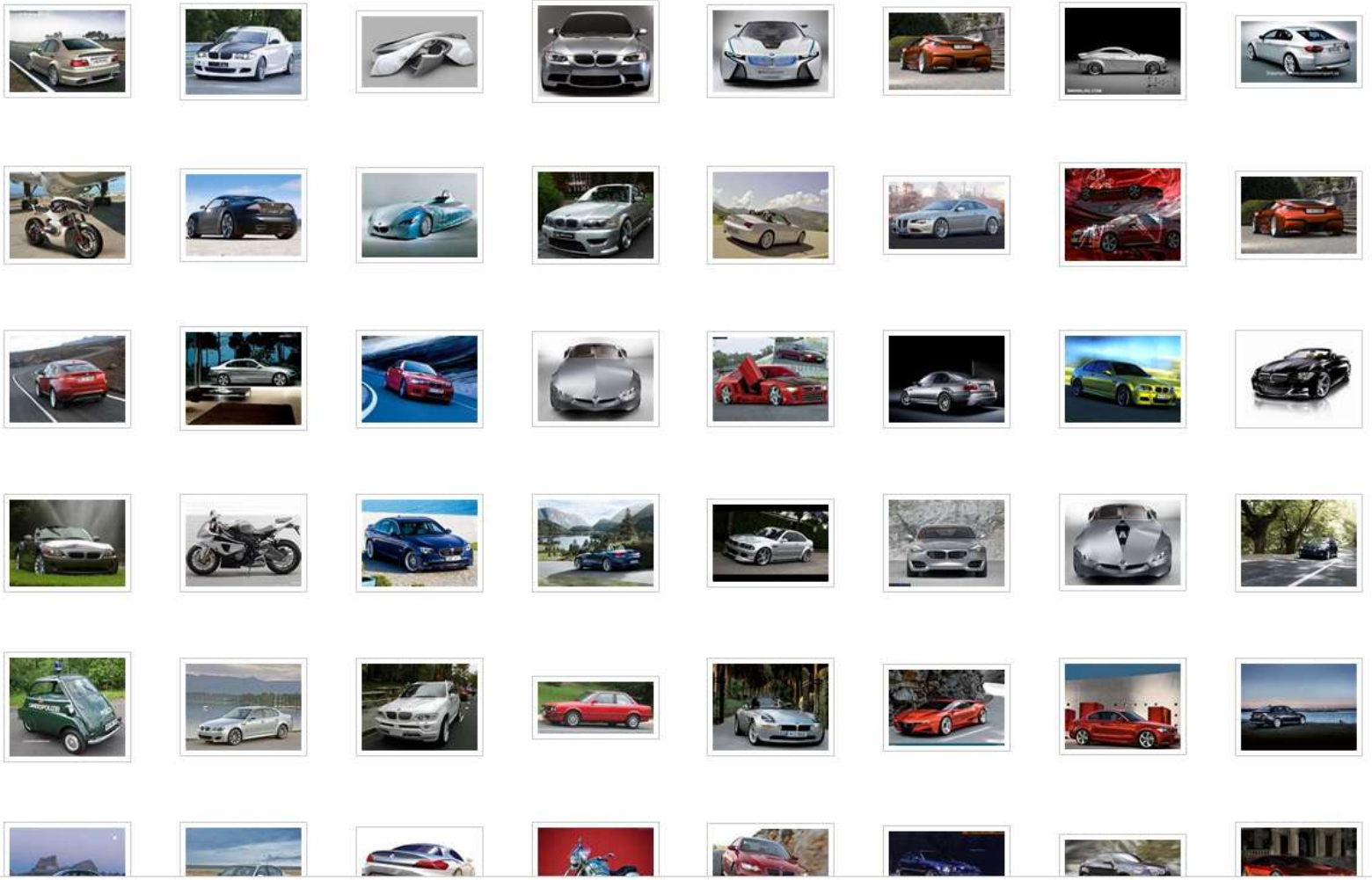

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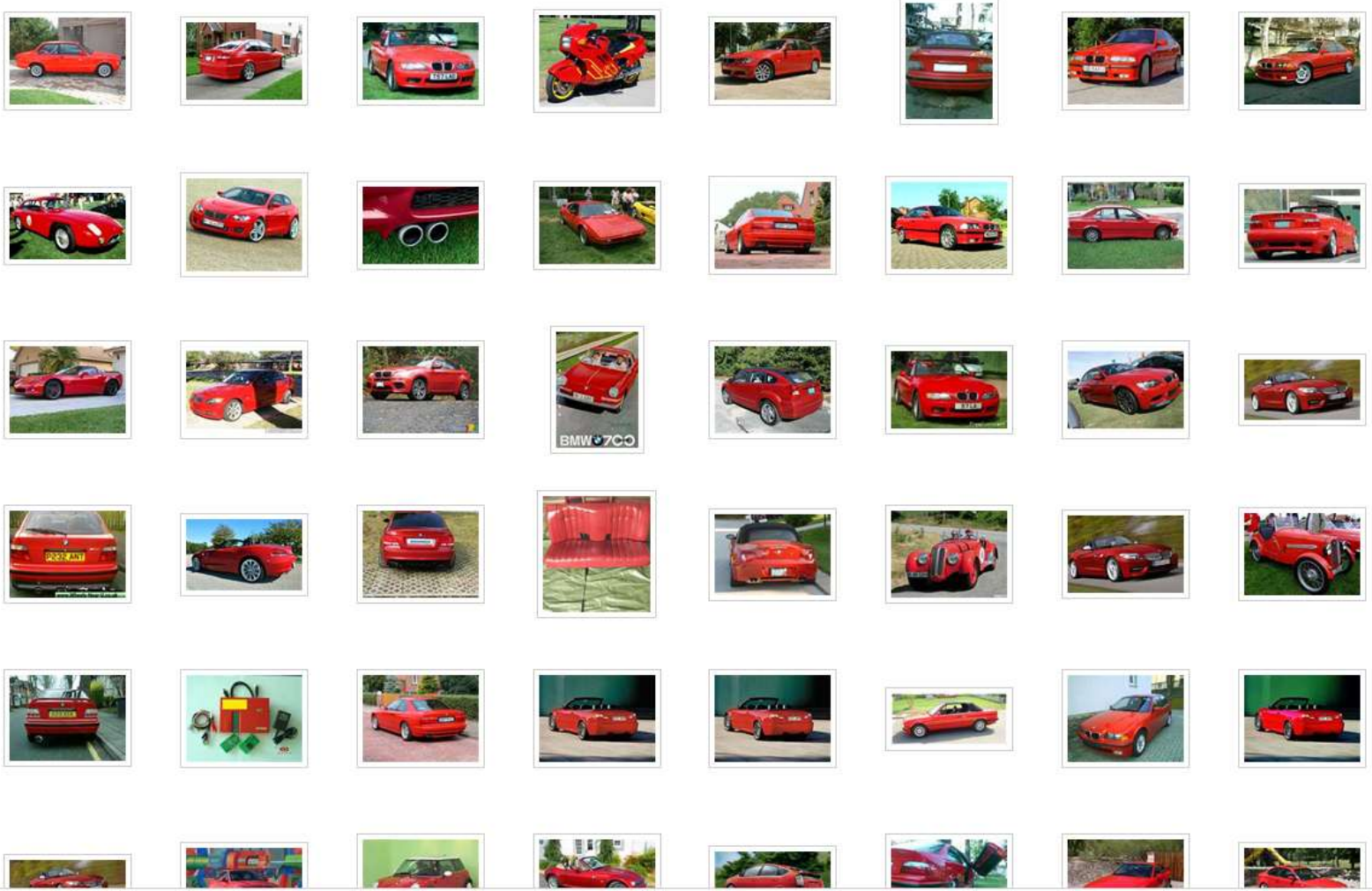

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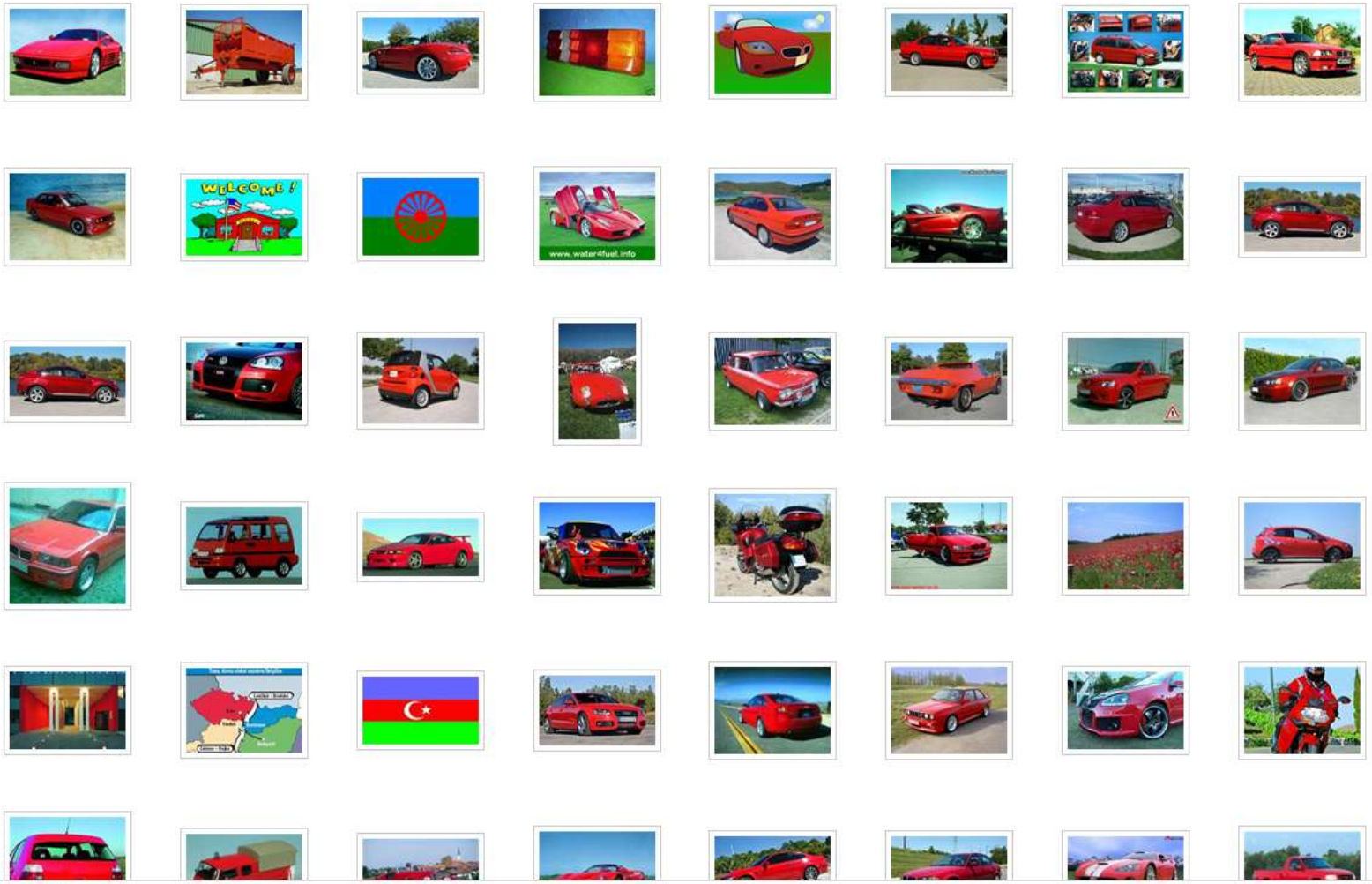

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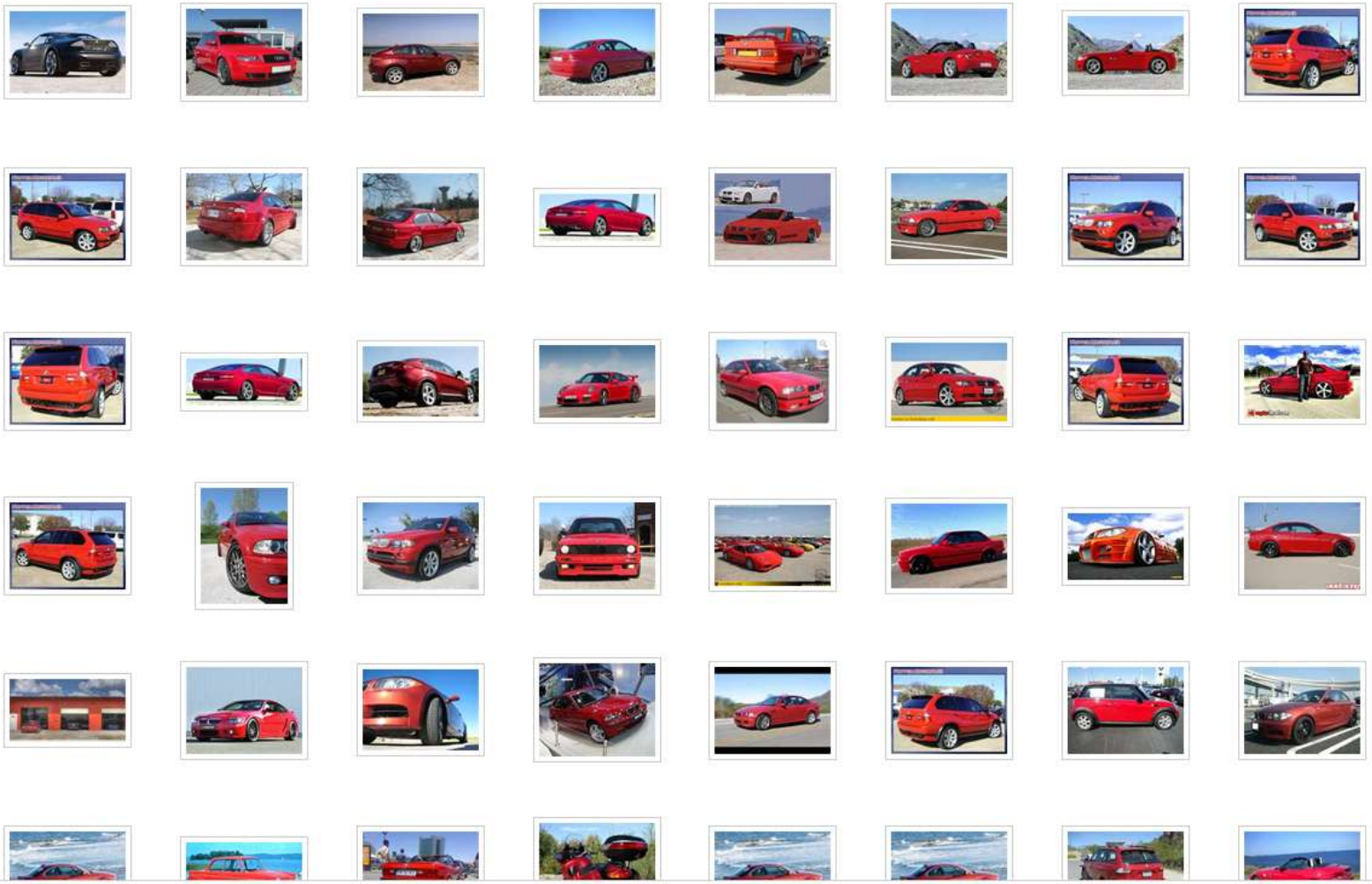

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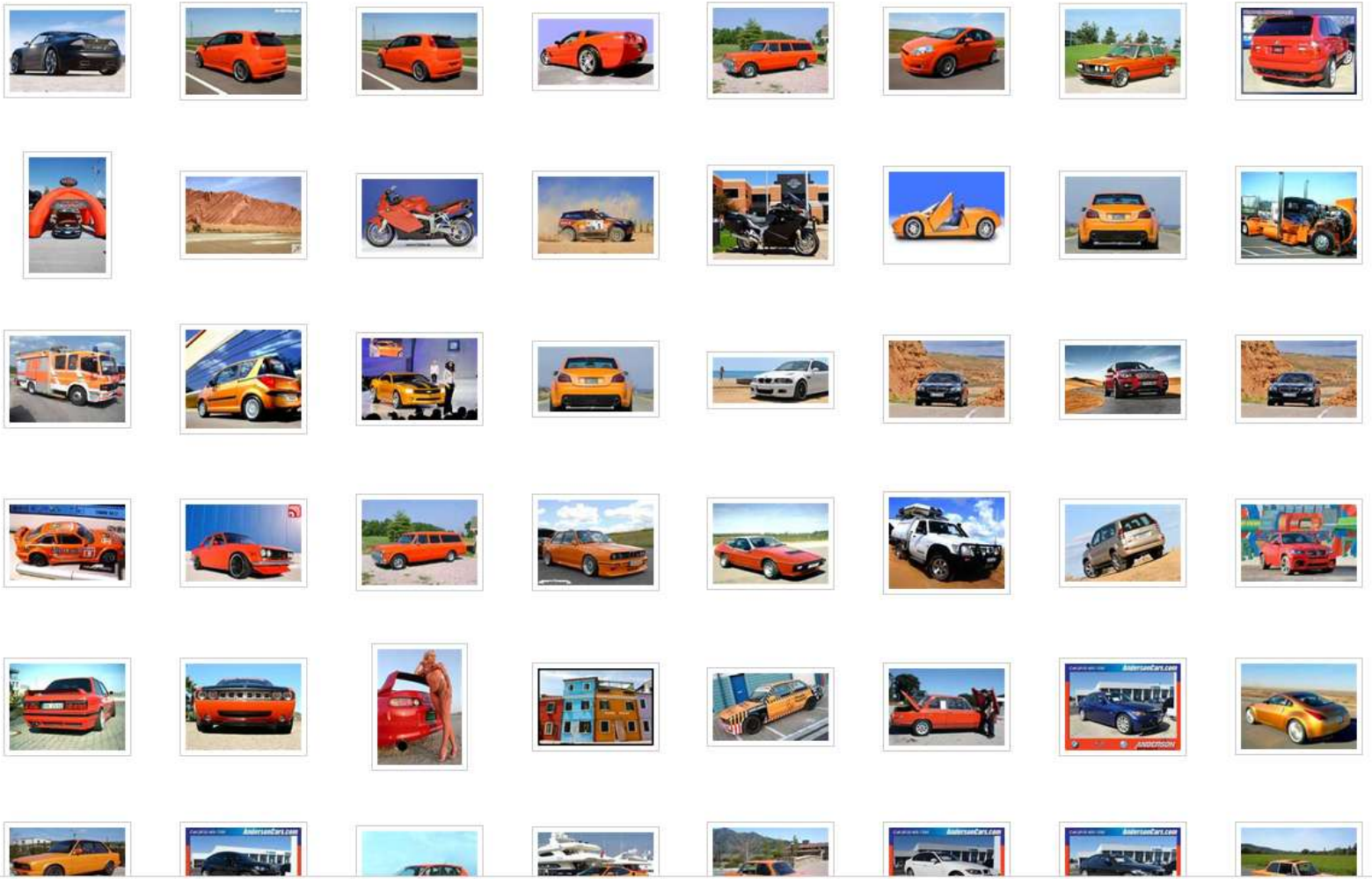

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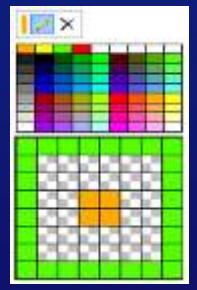
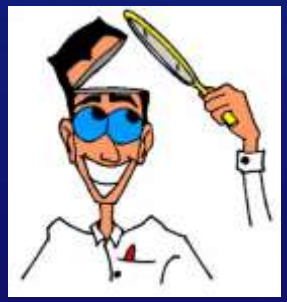
Why Color-Sketch Works

- What are difficult
  - Semantics is difficult
  - Intent prediction is difficult
- What are easier
  - Using color sketch to describe images' content
  - Using color sketch to describe users' intent

content → color sketch ← intent





Color sketch is an intermediate representation to connect images' content and users' intent.

Image Search by Color Sketch

A good example of internet image searching approach combining text, content and interface, which works on web-scale data.

Limitation of Color Sketch

- Only works well for those semantics that can be described by color distribution
- Only works well when people are able to transfer their desire into color distribution

A more complex example:

A flying butterfly on the top-left of a flower.

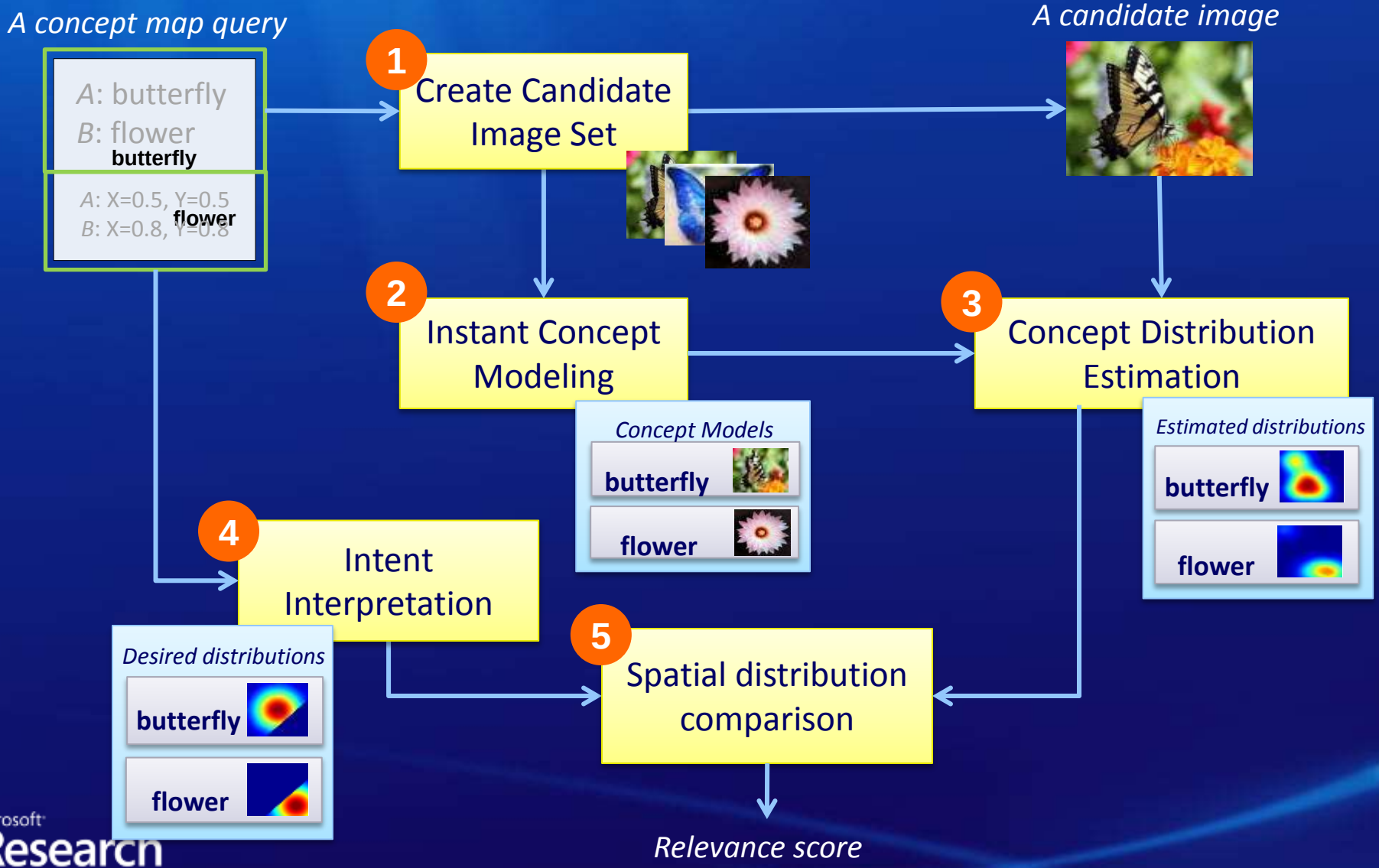
Ex5: Search By Concept Sketch

- Not shipped yet ☺
  - But preliminary result will be published as a SIGIR 2010 paper

A *concept map* query

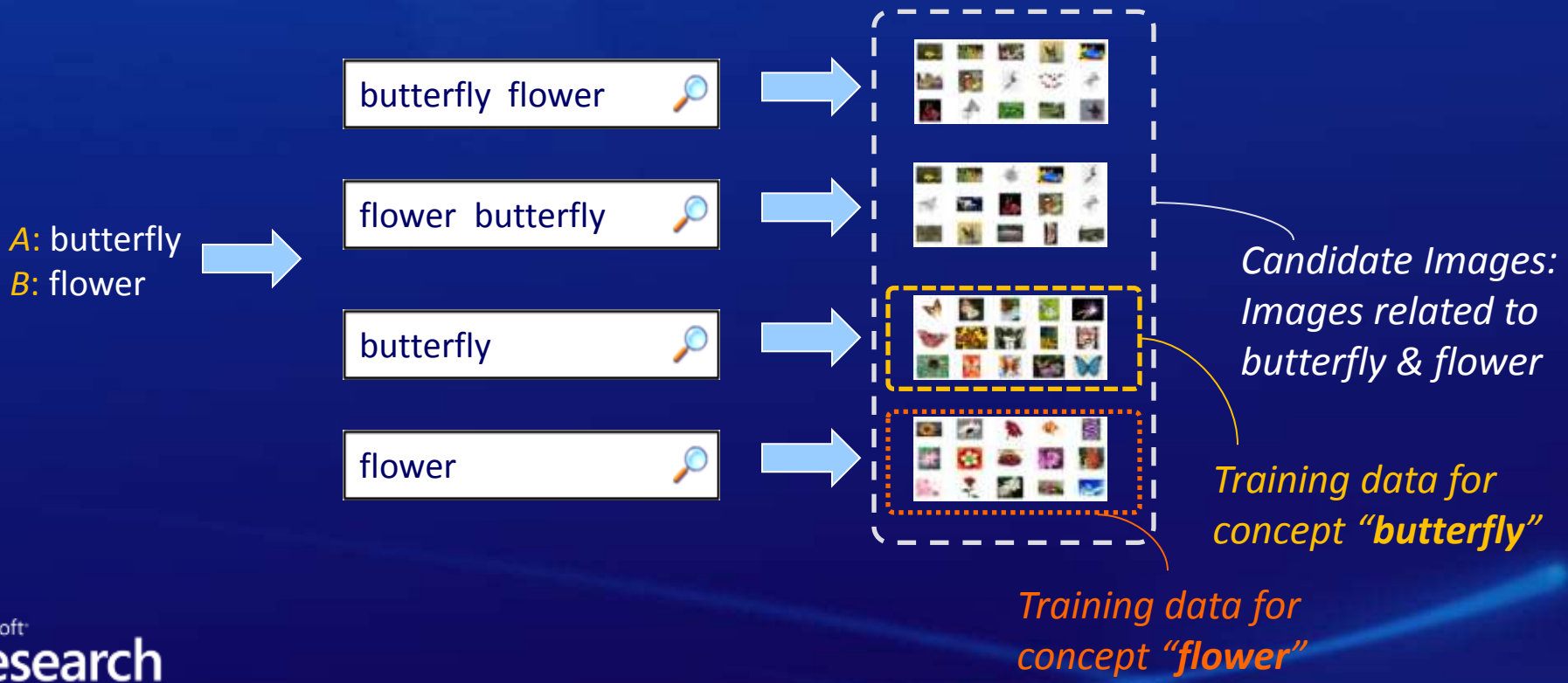
Image search results of our system

Framework


A concept map query
A: butterfly
B: flower
butterfly
A: X=0.5, Y=0.5
B: X=0.8, Y=0.8
flower
1
Create Candidate Image Set
A candidate image
2
Instant Concept Modeling
3
Concept Distribution Estimation
Concept Models
butterfly
flower
Estimated distributions
butterfly
flower
4
Intent Interpretation
Desired distributions
butterfly
flower
5
Spatial distribution comparison
Relevance score

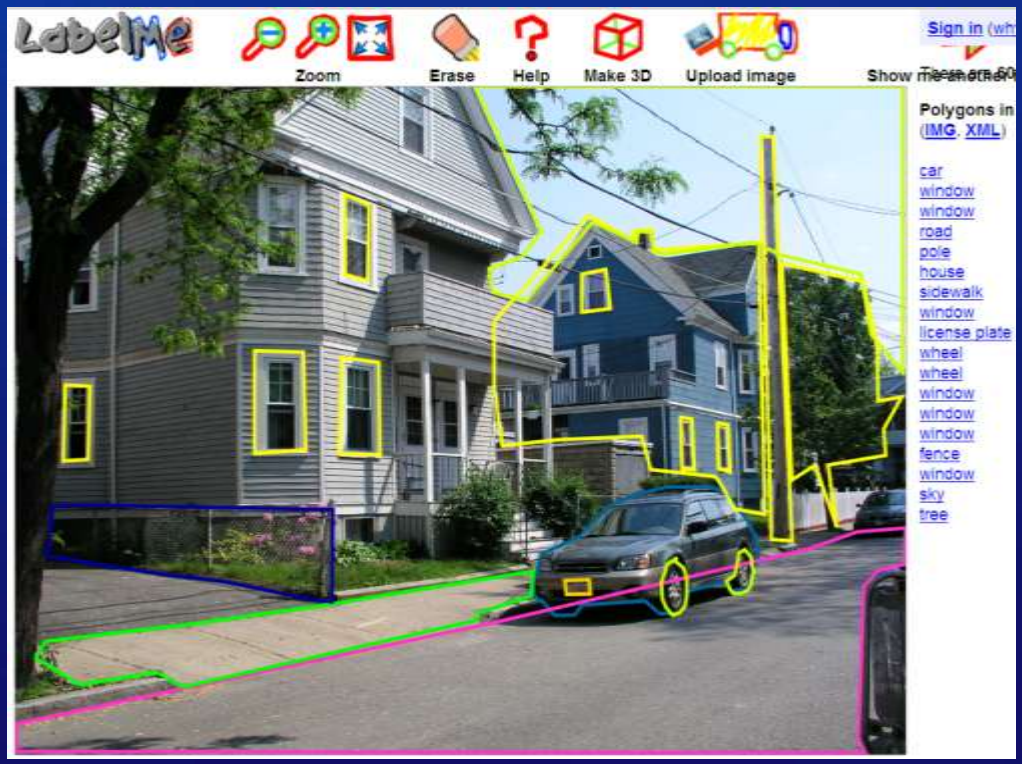
Creating Candidate Image Set

- Goal: get a group of candidate images from Web
  - Ensure the presences of the concepts
  - Reduce computational cost



Instant Concept Modeling

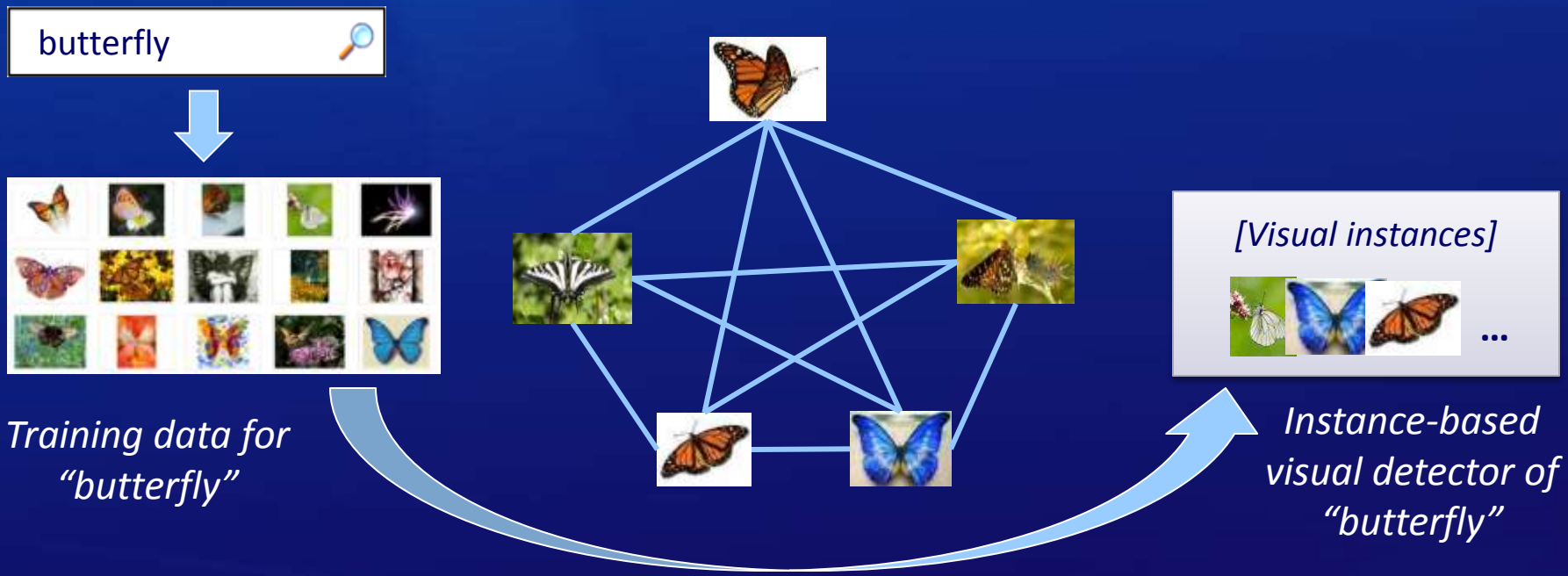
- A possible solution – manual tag-to-region



Manual tagging is expensive

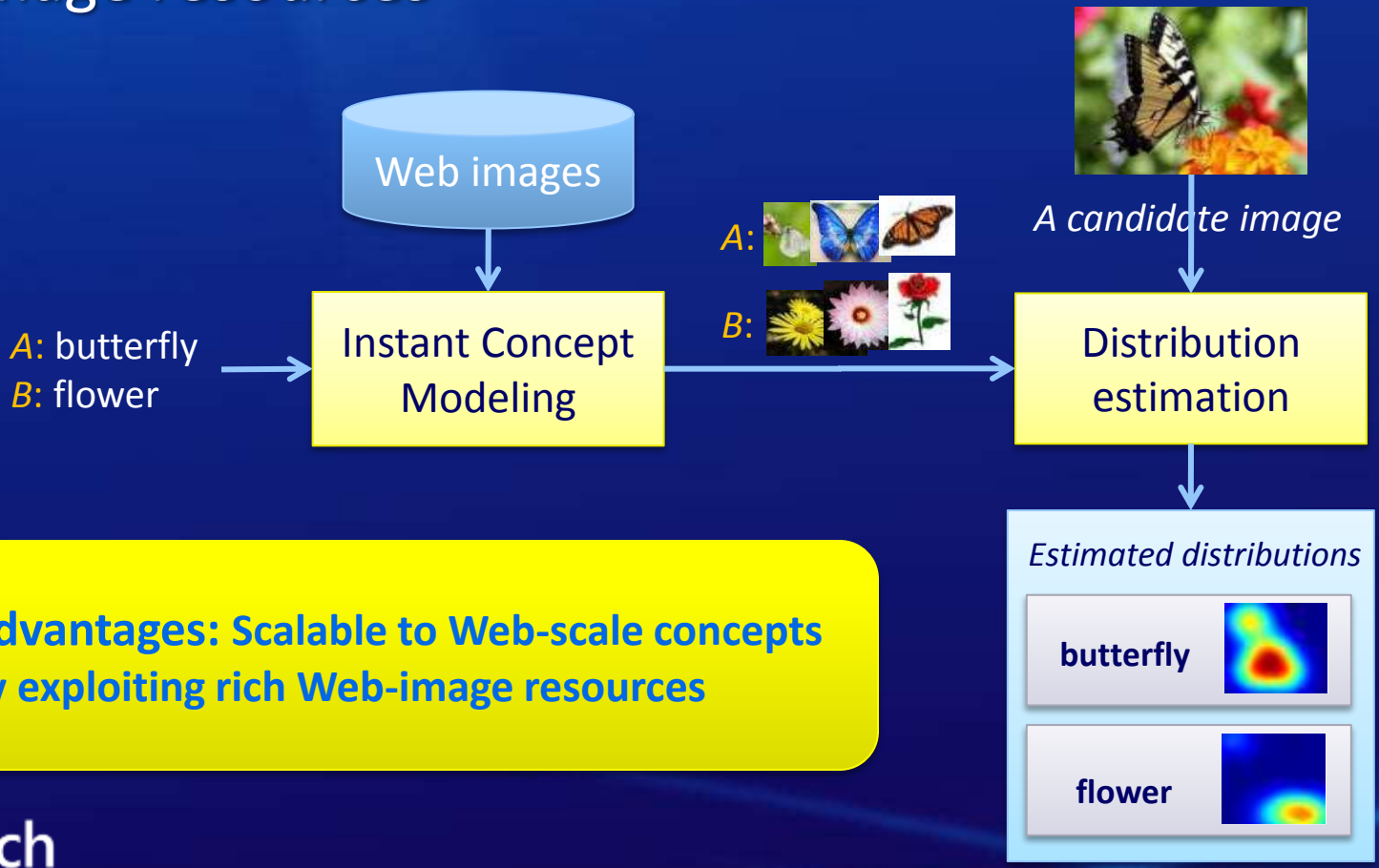
Instant Concept Modeling

- Goal: To learn a simple (but works well on the candidate image set) visual detector for each concept



Concept Distribution Estimation

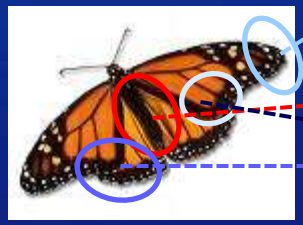
- Goal: Automatic concept localization leveraging Web-image resources



Advantages: Scalable to Web-scale concepts by exploiting rich Web-image resources

Concept Distribution Estimation

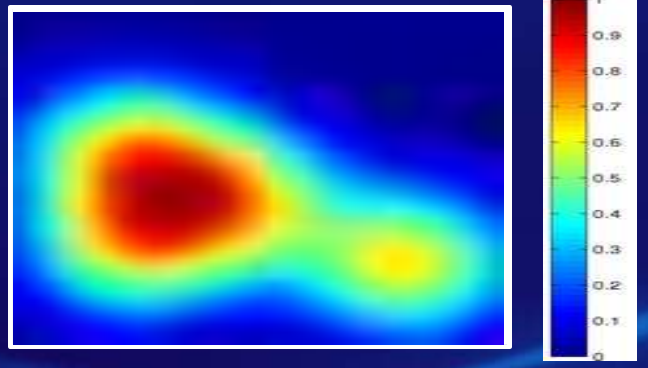
- Goal: estimate the distribution of a concept in an image



A visual instance

A candidate image

Estimated distributions of representative butterflies in the candidate image



Estimated distribution

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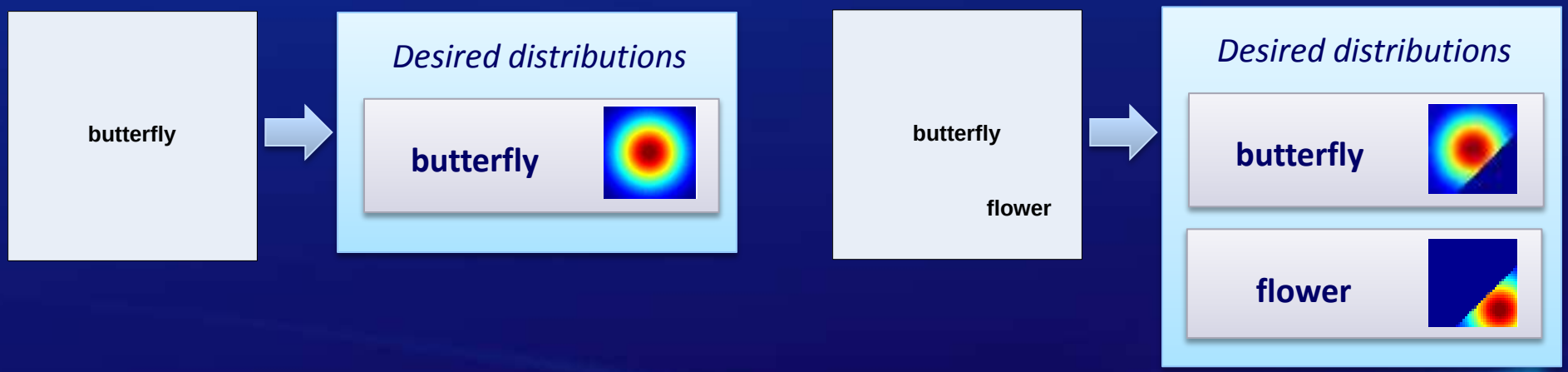
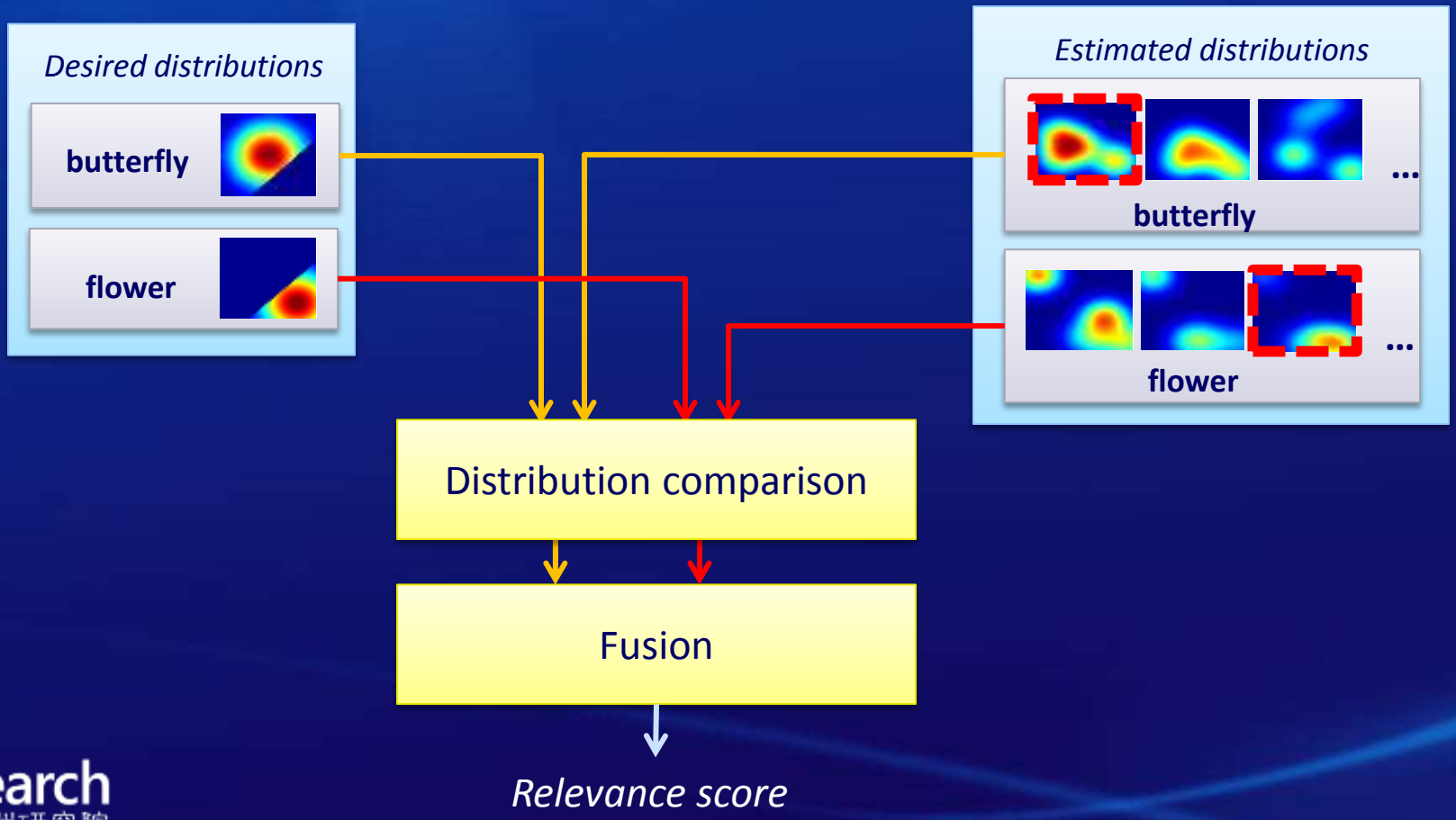
Intention Interpretation

- Goal: represent user's spatial intention as 2D distributions
- Principles
  - A concept should appear near the specified position
  - A concept should not appear at the positions of the other concepts



Spatial Distribution Comparison

- Goal: compute the similarity of the desired distributions and the estimated distributions



Search Results Comparison

Task: searching for the images with “snoopy appear at right”

Text-based image search

“show similar image”

Image search by concept map

Search Results

Task: searching for the images with “snoopy appear at top” / “snoopy appear at left”

snoopy

snoopy

Search Results Comparison

Task: searching for the images with “a jeep shown above a piece of grass”

jeep grass

jeep

grass

Search Results Comparison

Task: searching for the images with “a car parked in front of a house”

house car

house

car

Search Results Comparison

Task: searching for the images with “a keyboard and a mouse being side by side”

keyboard mouse

keyboard mouse

Search Results Comparison

Task: searching for the images with “sky/Colosseum/grass appear from top to bottom”

sky Colosseum grass

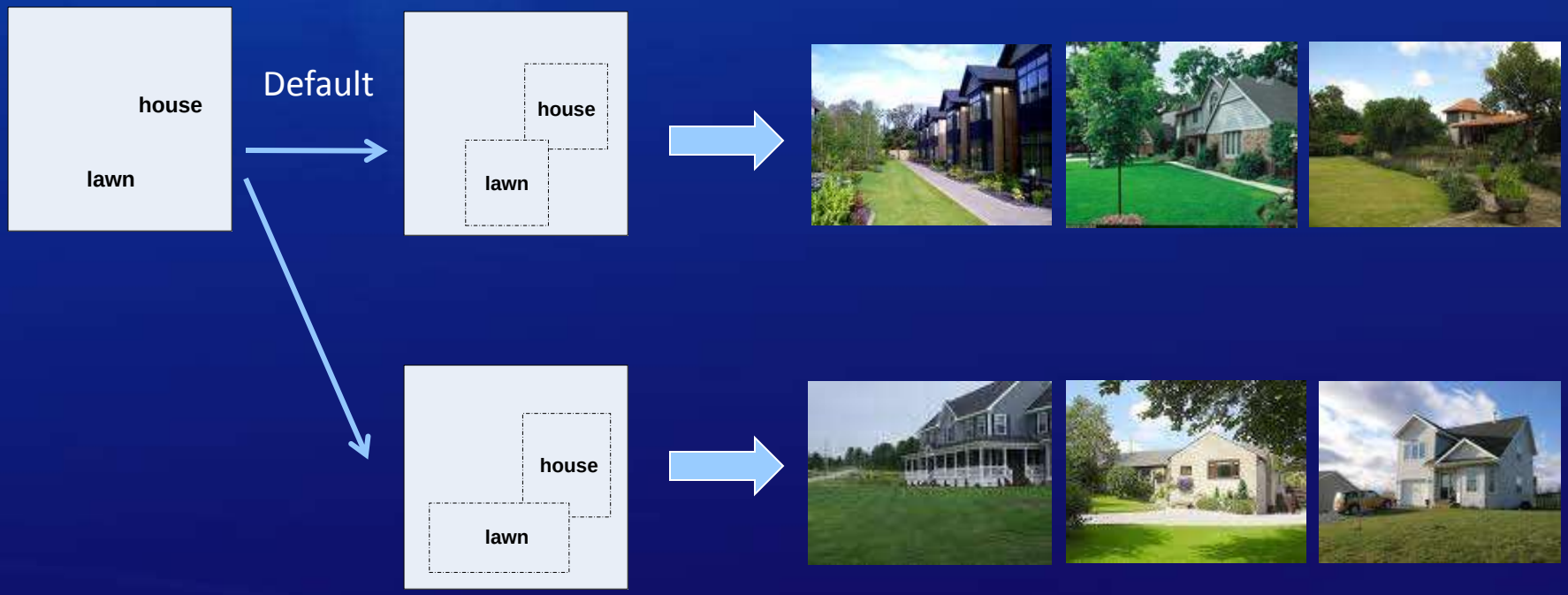
sky

Colosseum

grass

Advanced Function:
Influence Scope Adjustment

- Allow users to explicitly specify the occupied region of a concept



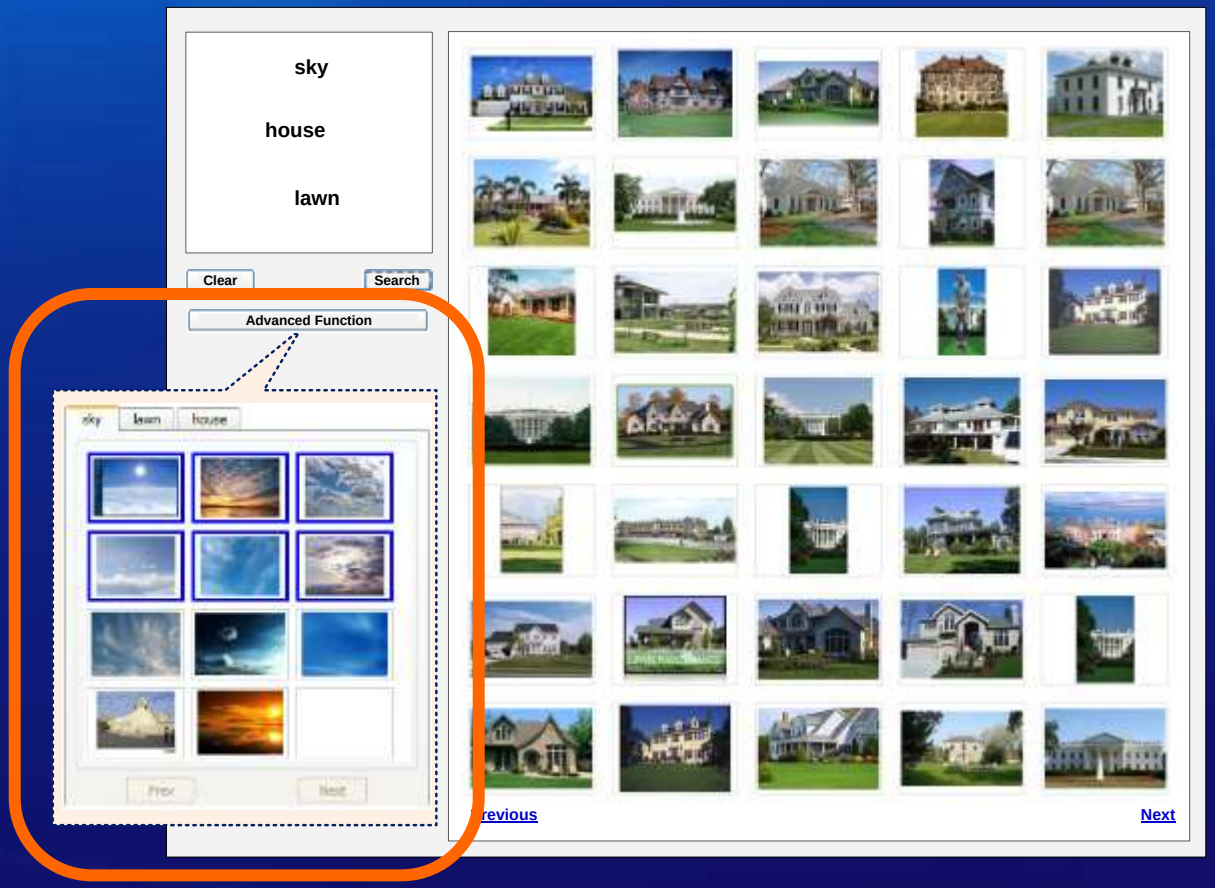
Search for the long narrow lawn at the bottom of the image

Advanced Function:
Influence Scope Adjustment

Searching for small windmill

Searching for large windmill

Advanced Function:
Visual Modeling Adjustment



Allow users to indicate or narrow down what a desired concept looks like (*visual constraints*)

Advanced Function:
Visual Modeling Adjustment

Searching for front-view jeeps

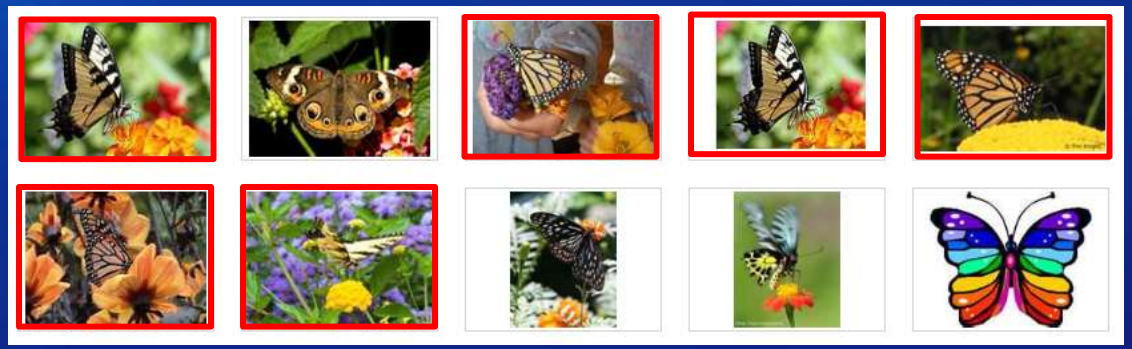
jeep

Searching for side-view jeeps

Visual instances

Advanced Function:
Visual Modeling Adjustment

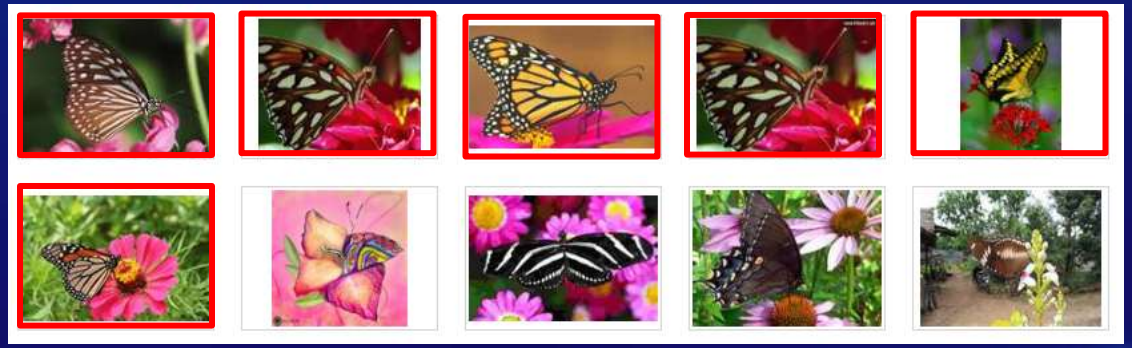
Searching for butterfly with yellow flower



butterfly

flower

Searching for butterfly with red flower



Visual instances

Image Search by Concept Sketch

A promising approach to enable content-aware web-scale image search based on mining semantics from web data.

Summary

- The practical approaches of realizing web-scale content-aware multimedia search
  - Combing text and content
  - Providing interactive interface to express search intent
  - Indexing and searching efficiently
- Five exemplary approaches introduced
  - Smart video thumbnail
  - Show similar images
  - More sizes
  - Search by color sketch
  - Search by concept sketch

Thank You