Microsoft Research Asia Update

Hsiao-Wuen Hon

Managing Director, Microsoft Research Asia

Microsoft Research

MSRA Overview

- People & Organization
- Research
- Products & Technology Transfer
- External Collaboration

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- Research lab locations
  - Redmond, Washington (Sep, 1991)
  - Cambridge, UK (July, 1997)
  - **Beijing, China** **(Nov, 1998)**
  - Silicon Valley, California (July, 2001)
  - Bangalore, India (Jan, 2005)
  - Boston, MA (Sep, 2008)
  - New York City (May, 2012)

Cambridge

Asia

India

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People

- New Hires
  - Jiang BIAN, Yahoo Research
  - Karlsson BORJE, Nokia
  - Xun GUO, MediaTek
  - Kwantaek KIM, LG
  - Zhuang LI, MSR SVC
  - Xin LIU, UC Davis
  - Tim PAN, GEMFOR Tech
  - Takaaki SHIRATORI, CMU/Disney
  - Hong TAN, Purdue – Haptics & HCI
  - Yingcai WU, UC Davis
  - Oversea Ph.D's
    - Liang CHEN (UC San Diego), Koji YATANI(Univ. of Toronto),
  - 15 domestic Ph.D's & Masters

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People and Research Areas

Hsiao-Wuen HON

HCI
Hong TAN

Speech
Frank SOONG

Innovation Engineering
Jonathan TIEN

Technology Strategy
Eric CHANG

Baining GUO

Visual Computing - **Yi MA**

Graphics - **Baining GUO**

Multimedia - **Shipeng LI, Feng WU**

Theory - **Baining GUO**

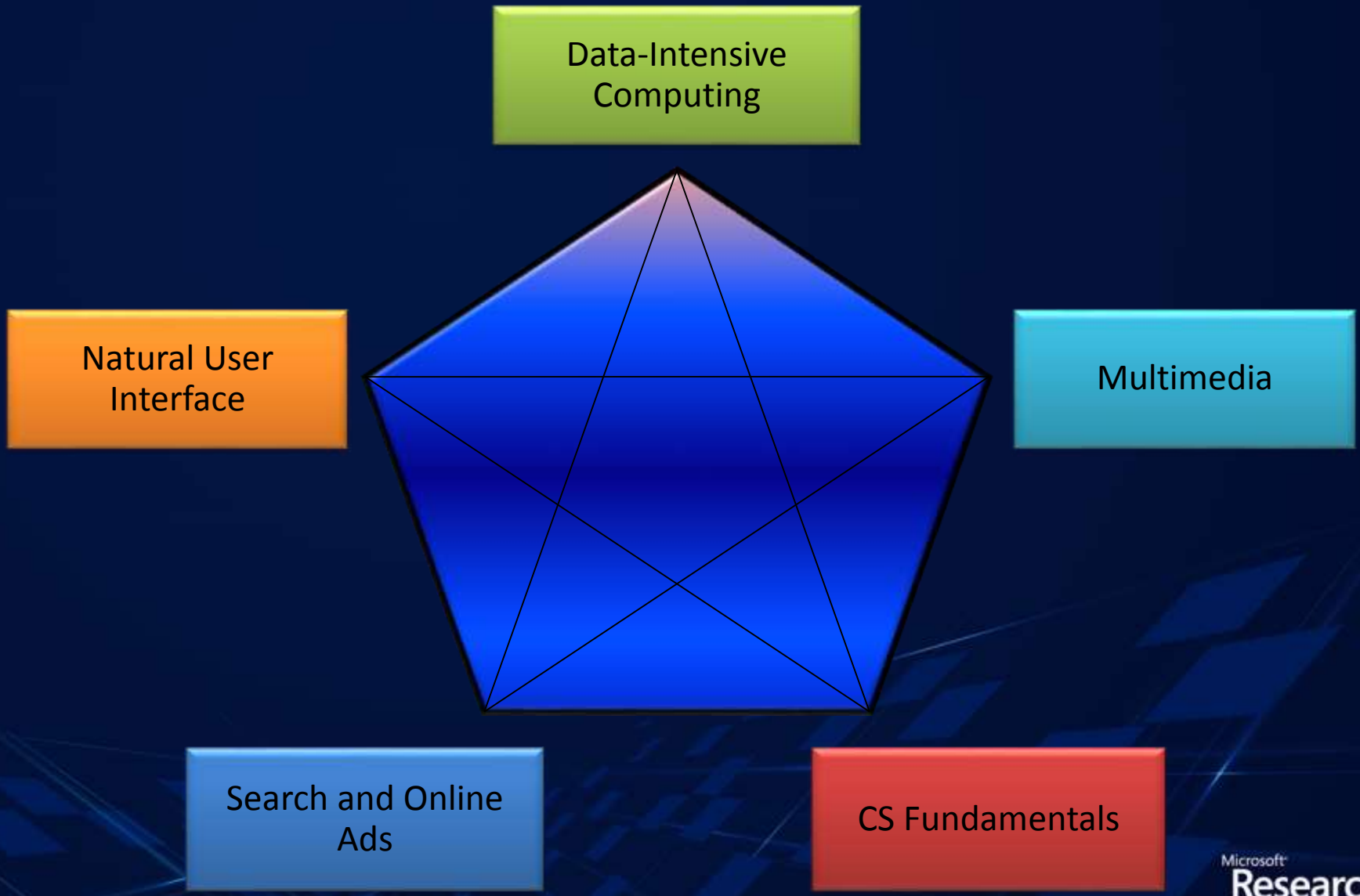
Wei-Ying MA

Web/Data Search & Mining – **Jirong WEN, Haixun WANG**
Natural Language Processing – **Ming ZHOU**
Multimedia Search & Mining – **Lei ZHANG**
Knowledge Mining – **Yong RUI, Chin-Yew LIN**
Internet Economics – **Tie-Yan LIU**
Machine Learning – **Zheng CHEN**

Feng ZHAO

System - **Zheng ZHANG, Lidong ZHOU**
Network & Wireless - **Yongguang ZHANG**
Hardware - **Feng-Hsiung HSU**
Software Analytics - **Dongmei ZHANG**
Mobile & Sensing – **Feng ZHAO**

MSRA Focus Areas



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Research Groups

Hardware Computing	Multimedia Search and Mining
Human Computer Interaction	Nature Language Computing
Internet Graphics	Software Analytics
Internet Media	Speech
Knowledge Mining	System
Machine Learning	Theory
Media Computing	Visual Computing
Mobile and Sensing Systems	Web Search and Mining
Innovation Engineering Group	Wireless and Networking
Data Management, Analytics and Services	Internet Economics and Computational Advertising

Academic Impact

Publications:

CVPR 2012/11/10/09/08/07	26/13/18/8/15/16 papers
SIGIR 2012/11/10/09/08/07	6/8/5/8/8/7 papers
SIGGRAPH 2012/11/10/09/08/07	9/4/7/6/8/7 papers
WWW 2012/11/10/09/08/07	3/3/6/9/8/6 papers
ACL 2012/11/10/09/08/07	7/5/4/6/5/4 papers
SIGKDD 2012/10/09	8/3/7 papers
ACM Multimedia 2011/10/09/08/07	15/7/6/8/8 papers
SIGMOD 2012/11/10	3/2/5 papers
UbiComp 2012/11	2/4 papers
CHI 2012/11	7/5 papers
SODA 2013/12/11	2/3/3 papers
AAAI 2012/11	3/4 papers
VLDB 2012/11	4/3 papers
OSDI 2012/SOSP 2011	1/1 paper
NSDI 201/11	2/1 papers
ICSE 2012	2 papers
FSE 2012	1 paper

- Best papers - Ubicomp 2012, ICIMCS 2012, Pervasive 2012, Eurosys 2012, MobileHCI 2012, PhoneSense 2011, NSDI 2011, *IEEE CSVT 2011,* CoNEXT 2010, ISSAC 2010, AIRS 2010, UIC 2010,
- Best student Paper Awards – PODC 2012, ECML PKDD 2010
- Best demos – Sensys 2011, ACM-MM 2010, SIGCOMM 2010, MMM 2010

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Research Updates

Natural User Interface

- Kinect User Identity
- Kinect Object Digitalization
- Avatar Kinect
  - Kinect Head Pose & Face tracking
- Kinect Body Gesture Recognition

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Kinect based Object Digitization

Play with your own gadgets in games

Share your buddy with others

Natural UI Interaction w/ Virtual Objects

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Kinect based Object Digitization

Simple inputs

- Front and back snapshots of objects

Smooth 3D reconstruction

- Poisson surface reconstruction to fill holes and generate watertight smooth surface

Fast speed

- Parallel octree construction using both CPU and GPU

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Comparisons

35,862 Triangles
36MB Mem
20 Seconds

33,263 Triangles
28MB Mem
5.6 Seconds

7,662 Triangles
20MB Mem
1.4 Seconds

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Comparisons

35,862 Triangles
36MB Mem
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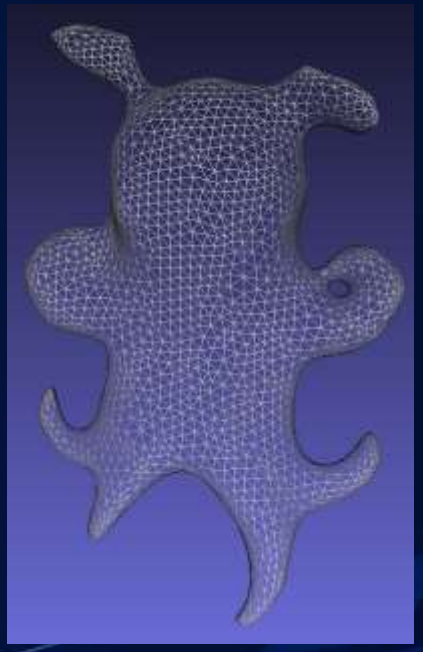

7,662 Triangles
20MB Mem
1.4 Seconds

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Avatar Kinect

Facial expression tracking

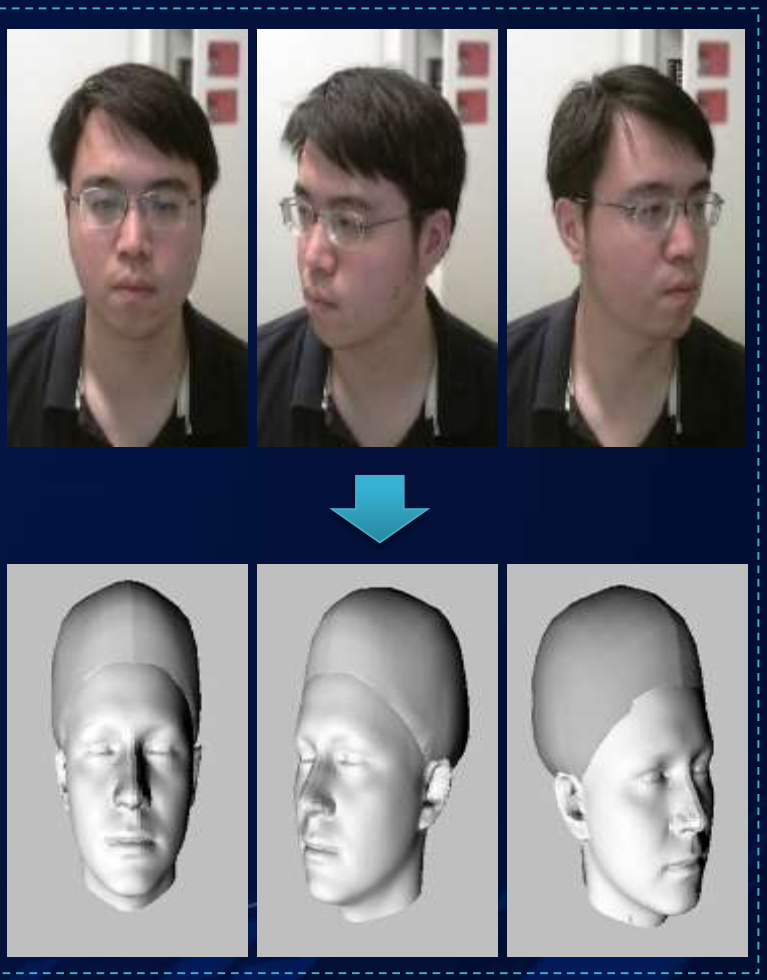
- 3D head pose tracking
- 3D expression tracking

Capture subtle expression

- Brow frown, mouth movement, …

Super Fast

- RGB + Depth sensing



Track 3D Pose

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Avatar Kinect

Facial expression tracking

- 3D head pose tracking
- 3D expression tracking

Capture subtle expression

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Super Fast

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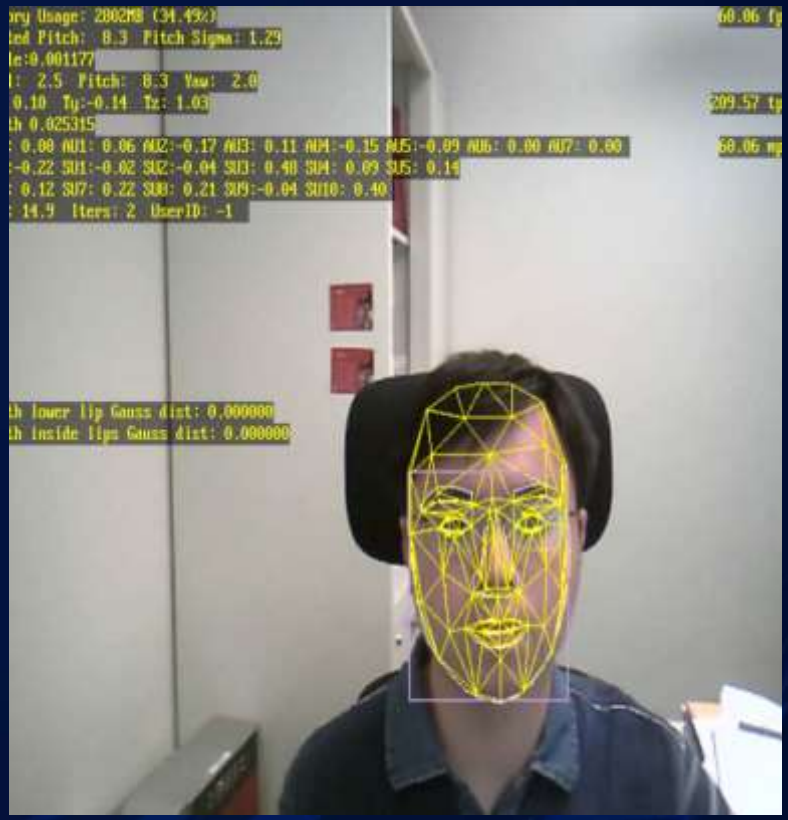

Track 3D Expression

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Gesture Recognition

- A lot of applications require accurate understanding of human gestures
  - Sign language reading and dancing
- Some tasks may require the detailed sequence of the gesture action
  - Kinect Sports
- We tackle the problem of gesture recognition + alignment

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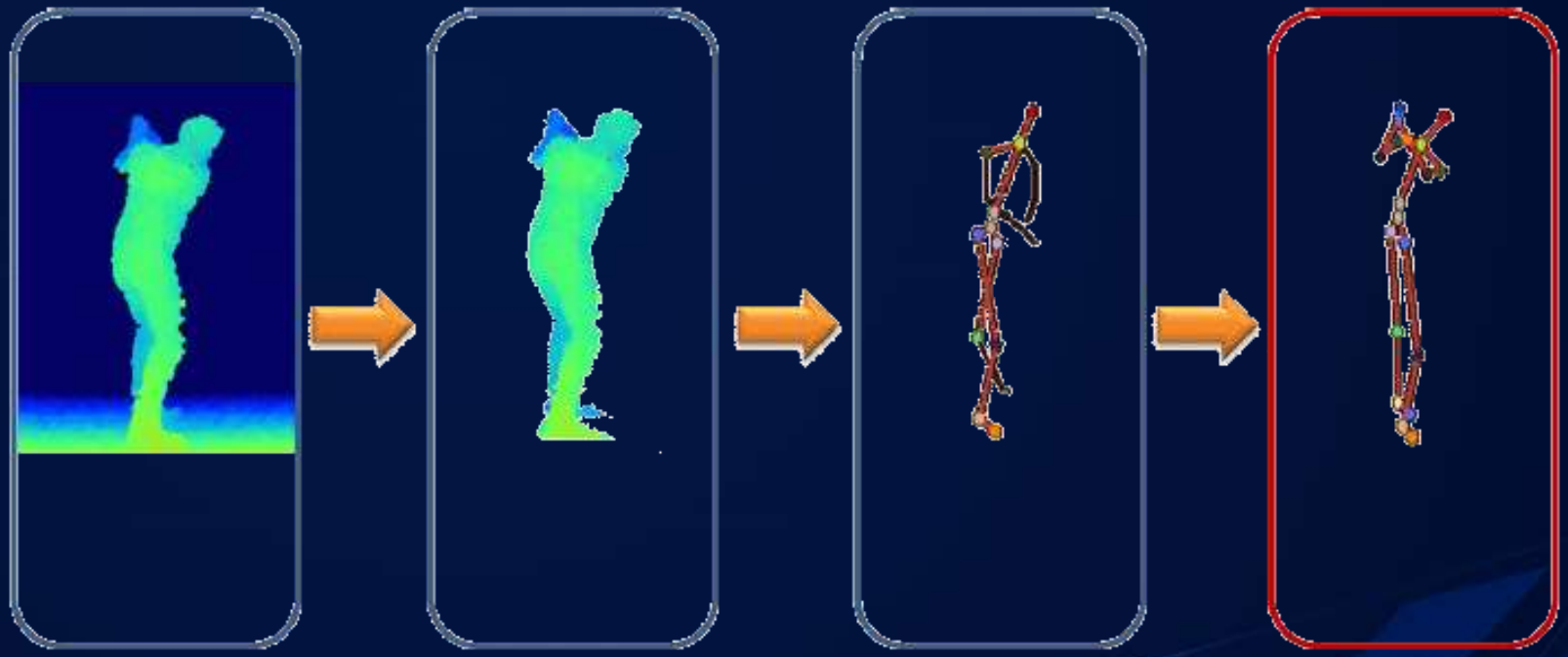
Xbox Kinect Pipeline: Skeleton Correction & Alignment



Depth Image

Background Removal

Skeleton Extraction

Skeleton Correction & Alignment

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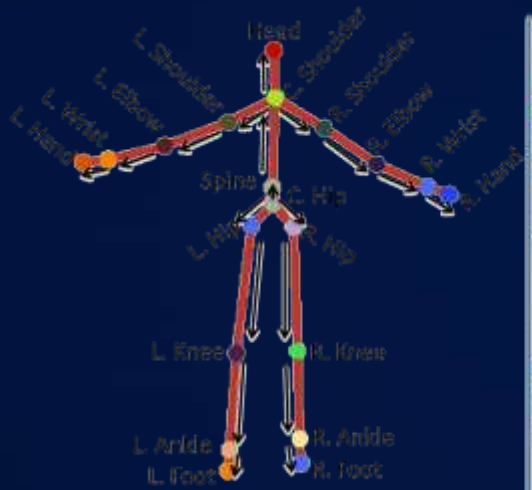
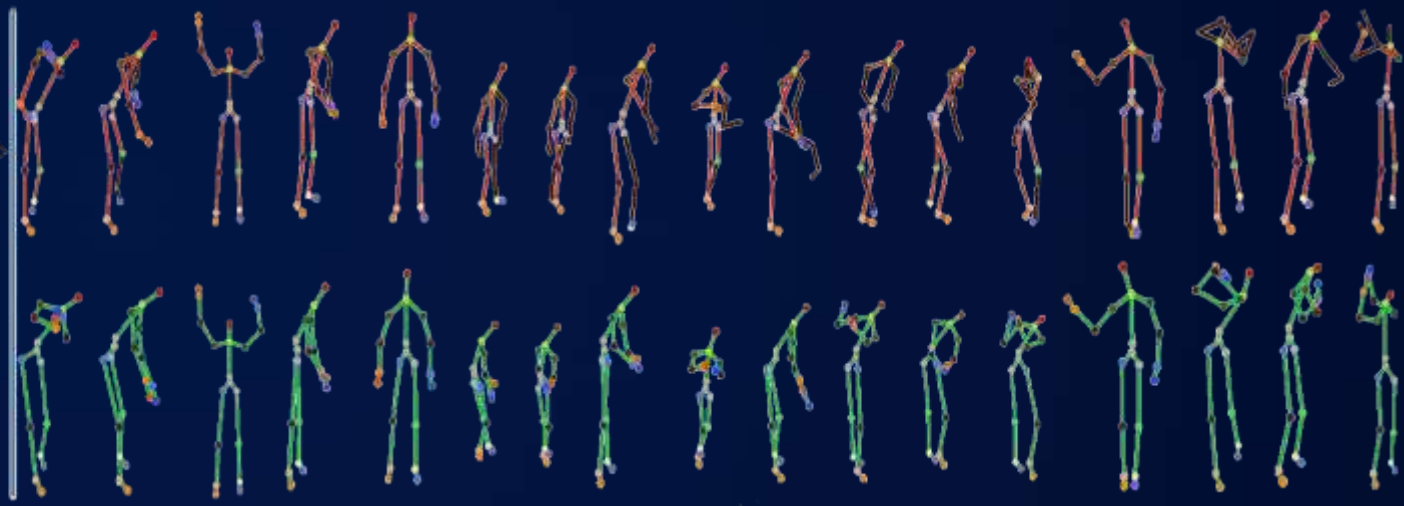
Skeleton/Gesture Recognition





Two key observations:

(1) There are systematic errors which enable us to learn alignment function for the correction.
(2) The alignments are nonlinear and non-deterministic.

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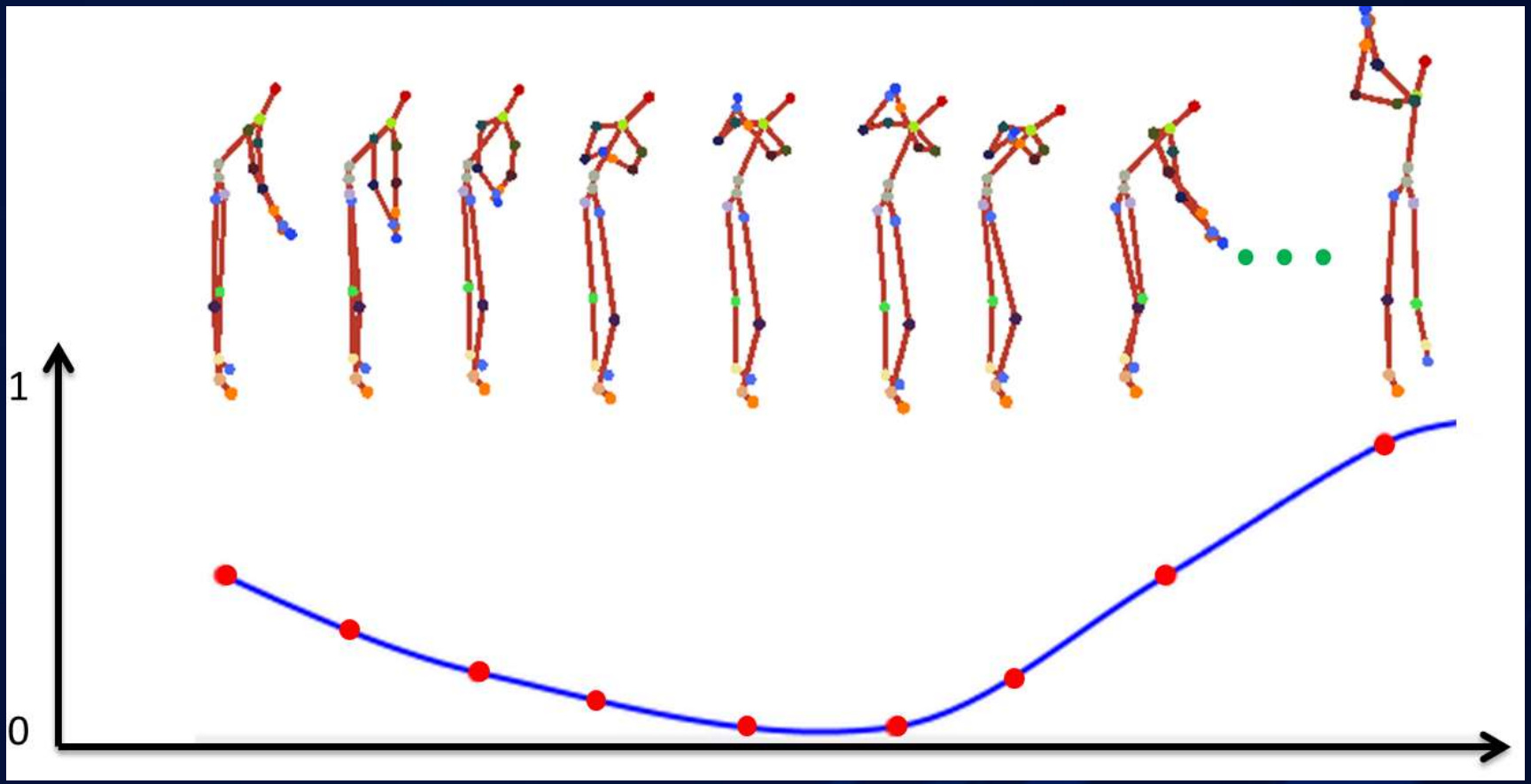
Skeleton/Gesture Alignment



- The skeletons are aligned w/ numerical values
- The numerical values are used to drive the avatar

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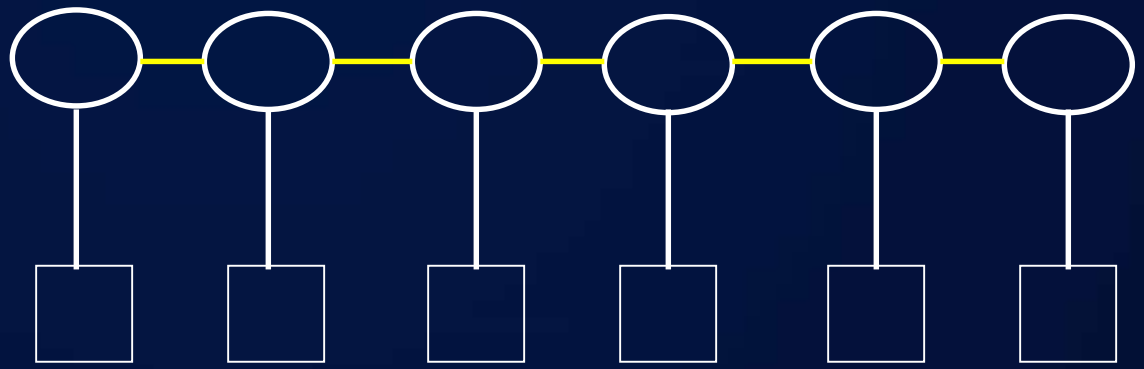
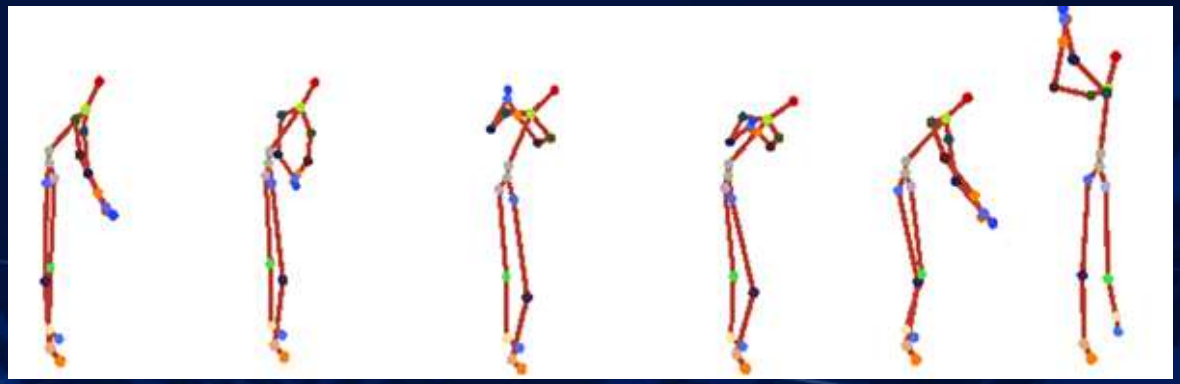
A Hidden Markov Model

Aligned Values



Input Skeletons



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Output Distribution Model

- Random forests
  - A collection of decision trees
  - Like mixture distribution to model player variation
  - Ensemble learning (voting) for robustness
- Decision tree
  - Leaf nodes model different poses

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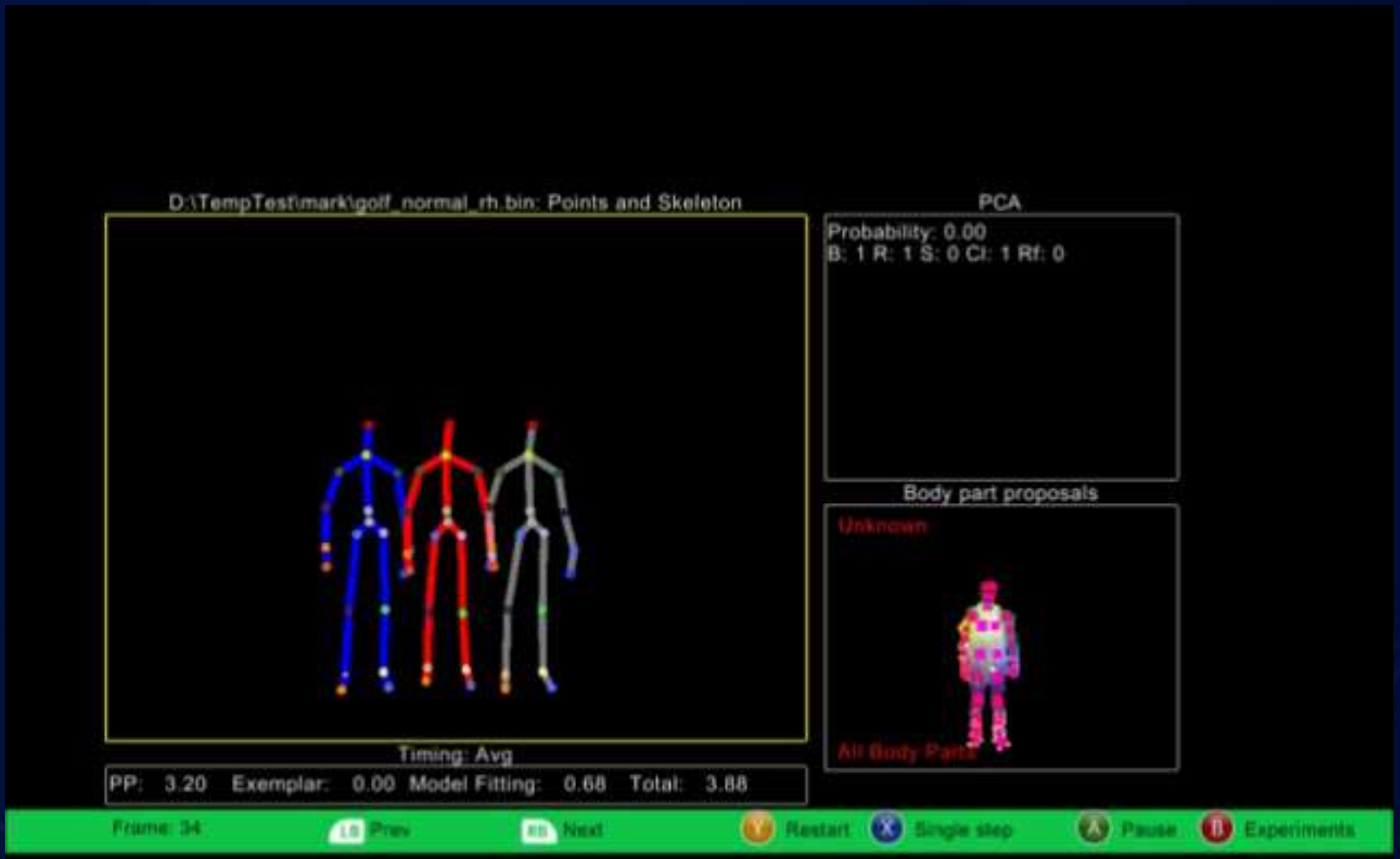
Demo



Ground-truth (blue), Input estimation (red), Corrected skeleton (grey)

Qualitative Results

Test type	Parameters	Avg RMS	Std RMS	Worst RMS	Best RMS	Avg Size	Std Size	AvgRMS improved %
PCA	0.99 nobucket	0.063947	0.007199	0.0810688	0.046536	2117.9KB	108.2KB	27.58003035
PCA	0.99, 70/95	0.069329	0.008458	0.0979424	0.051021	1770.5KB	24.73KB	27.42888109
PCA	0.99, 40/60	0.077407	0.009294	0.1018474	0.05586	658.9KB	8.9KB	22.17762486
RFR	50 trees	0.045592	0.009073	0.0748388	0.027429	3778.8KB	13.2KB	42.40323838
RFR	25 trees	0.046848	0.008629	0.0673977	0.032307	1692.4KB	7.51KB	41.99635189
RFR	10 trees	0.053246	0.008121	0.0702379	0.033958	676.3KB	3.46KB	39.17118753

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Research Updates

Multimedia

- Head Scanning
- Hair Modeling

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Kinect Based 3D Face Avatar

3D face avatar based on Kinect input

- Simple capture – 3 shots
- Good results & robust for different people
- Depth – provide 3D shape of face, but noisy
  - modeling overall shape and nose
  - robust alignment and pose estimation against face model
- RGB
  - For texture details (skin color)
  - For modeling feature regions (mouth, eye)
  - Could use high-resolution RGB face shot from cameras

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Kinect Based 3D Avatar

3D Face Priors

Dense Correspondence

Morphable Model

Laplacian Deformation

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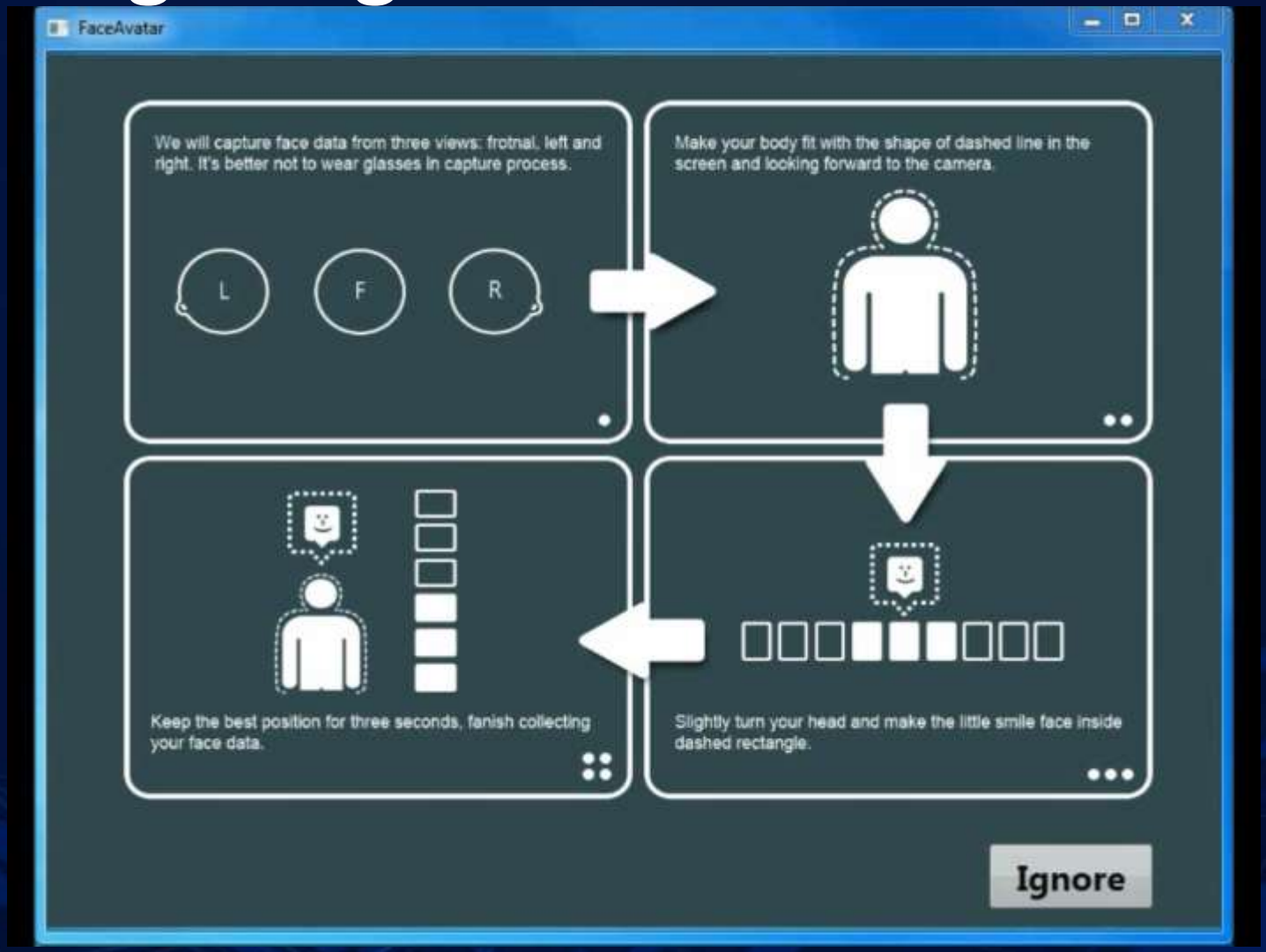
Kinect Based 3D Face Avatar (Fang Yang will give me new one on Sat.)



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Hair in Real World

- Important appearance feature
- A lot of (~100k) thin fibers
- Diverse hairstyles
- Complex interaction and dynamics

Hair in Graphics

- Important applications
- Manual modeling is difficult
- Capturing is difficult too
- Impractical for normal users

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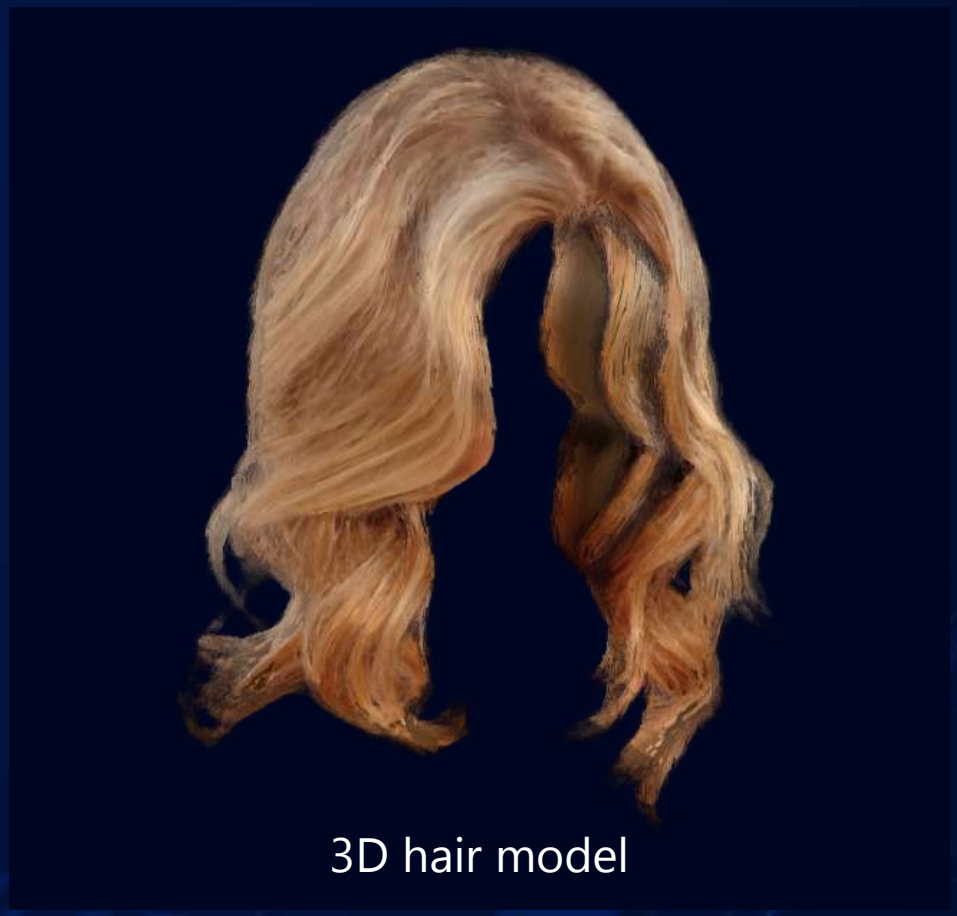
Goal: 3D Hair from Single Image

Single portrait image



3D hair model

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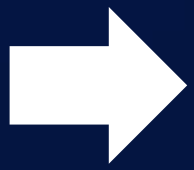
Goal: 3D Hair from Single Image

Single portrait image



- Detailed 3D geometry
- Visually plausible
- Simple user interaction
- Enable interesting apps

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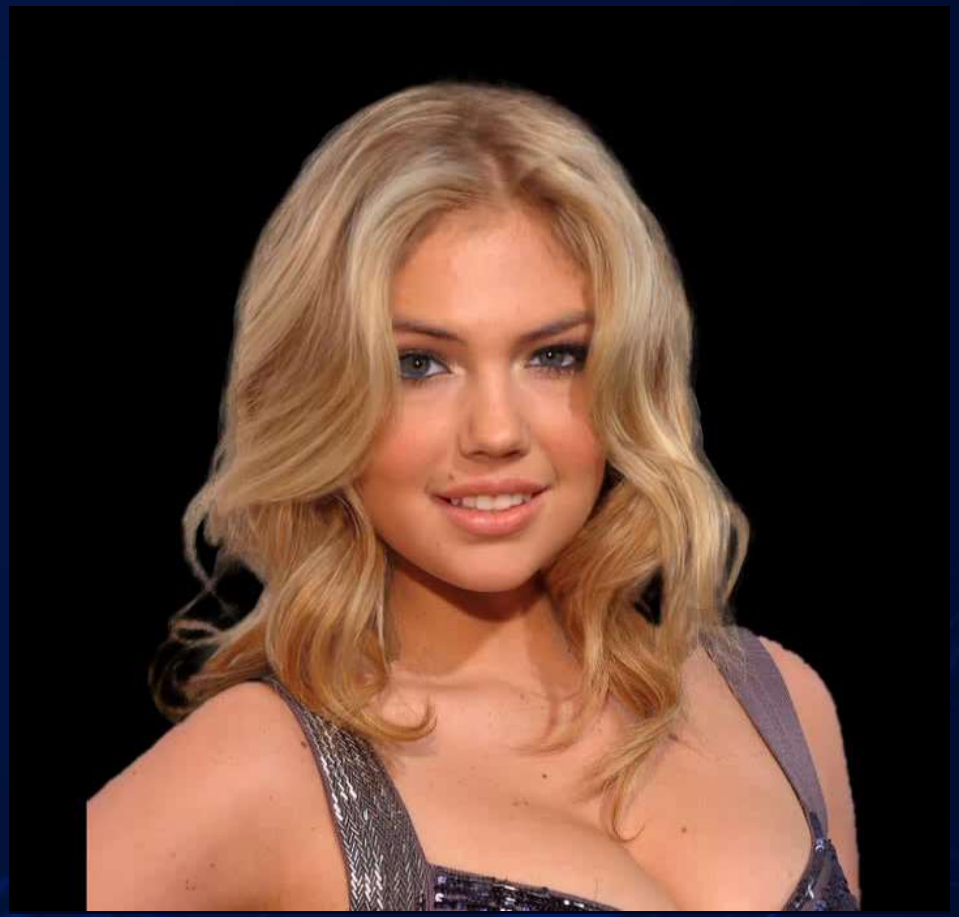
Result

Single portrait image
+ user strokes



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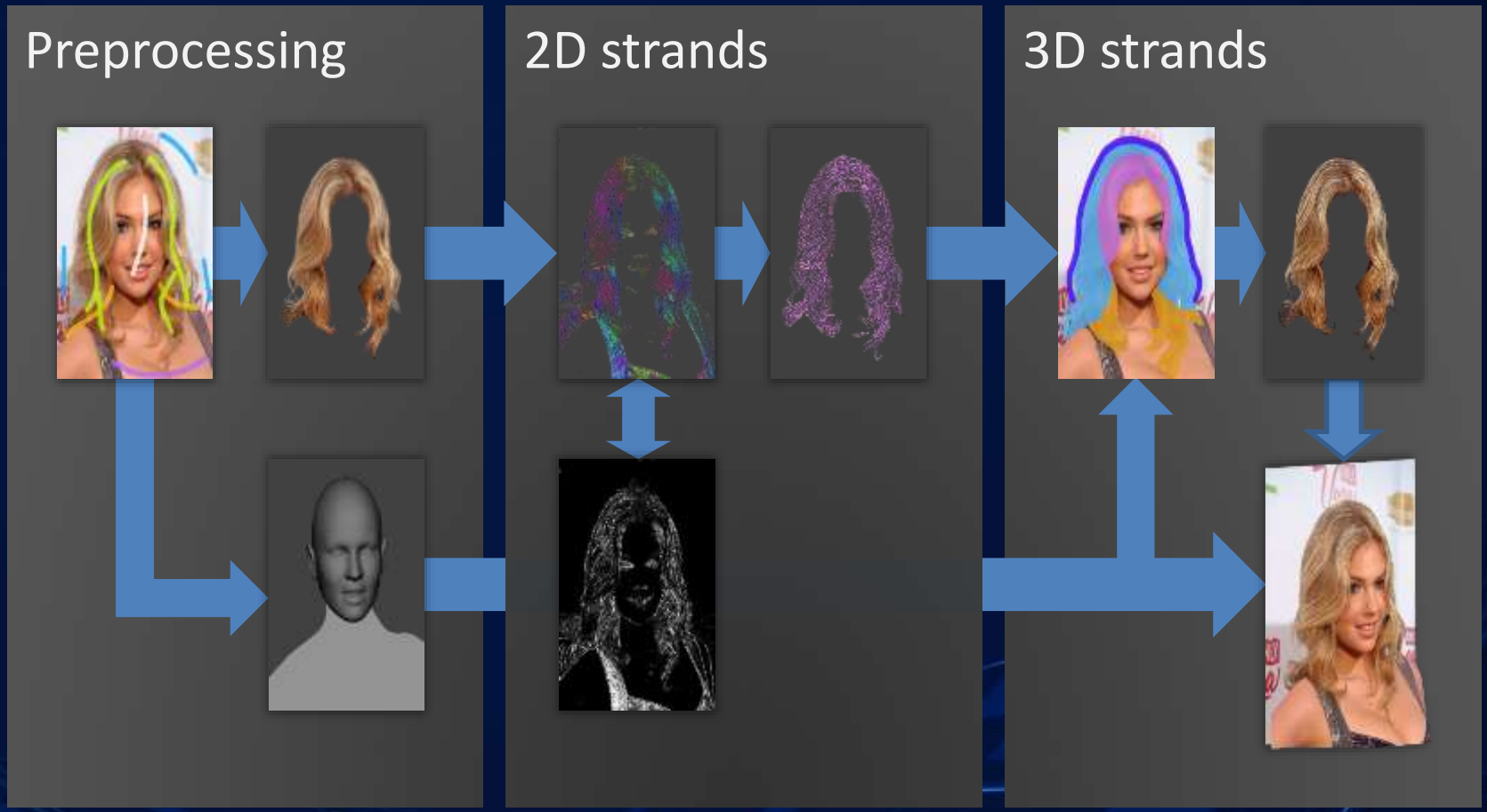
Algorithm



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Strand Tracing

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3D Strands: depth estimation

Initial depth

w/o region structure

w/ region structure

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3D Strands: hair volume

- Additional strands in the hair volume

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Applications

- Portrait pop-up
- Hairstyle replacement
- Hairstyle editing

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Portrait Pop-ups: layers completion

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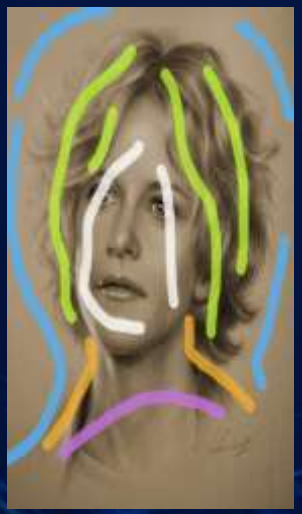
Portrait Pop-ups: more results



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Hairstyle Replacement

- Build pop-up for source & target.
- Compensate for head's shape/pose

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Hairstyle Replacement: more results

Original

Replaced

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Hairstyle Replacement: more results

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Hairstyle Editing

Original image

Adjust smoothness

Add geometric noise

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Limitations

- Not a complete 3D model of the real hair
- Extension to video would be ha
- Lighting condition is ignored

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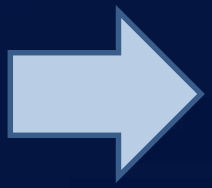
Single Image 3D Hair Modeling



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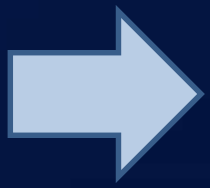
3D Hair Replacement



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3D Hair Replacement

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Research Updates

Search and online Advertisement

- Large Scale Image Search through Query by Image
- Building Image Knowledge Base through Mining Billions of Web Images
- Keyword auction: Probabilistic Broad Match, Optimal Auction Learning, Bandit Algorithm for Bid Optimization
- Attribute based Image Search
- Lights!

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Attribute based Image Search

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What Are Attributes?

Clipart

Linedrawing

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What Are Attributes?

Screen Shot

Tiled Images

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What Are Attributes?

Simple Background

Portrait

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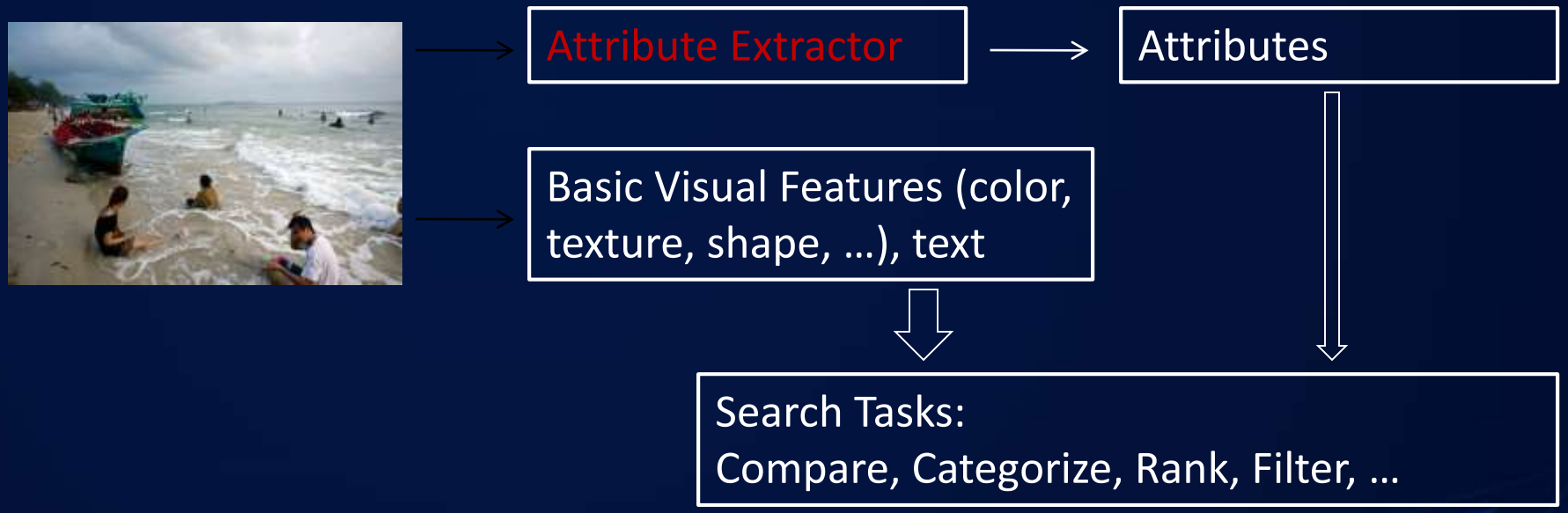
Attribute-based Search Framework



- Advantages
  - Scalable
  - High precision
  - Used explicitly or implicitly

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Color/Clipart/Linedrawing Filter

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Color Filter Examples

dog

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Color Filter Examples

dog + red

Red is not a word in the query, but means a color filter Red

Color Filter Examples

sunset

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Color Filter Examples

sunset + blue

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Intention Analysis (w/ Query Object)

Flower + Orange

>

T-shirt + Yellow

>

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Intention Analysis (w/o Query Object)

Sunset + Blue

Forest + Yellow

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Our Solution

- Salient object detection
  - Check if an image contains a salient object
  - Discover the position of the object

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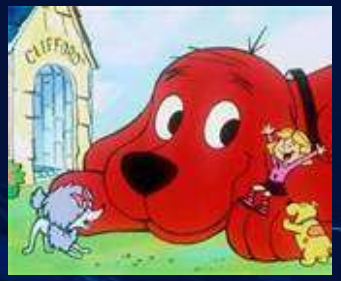
Original Images



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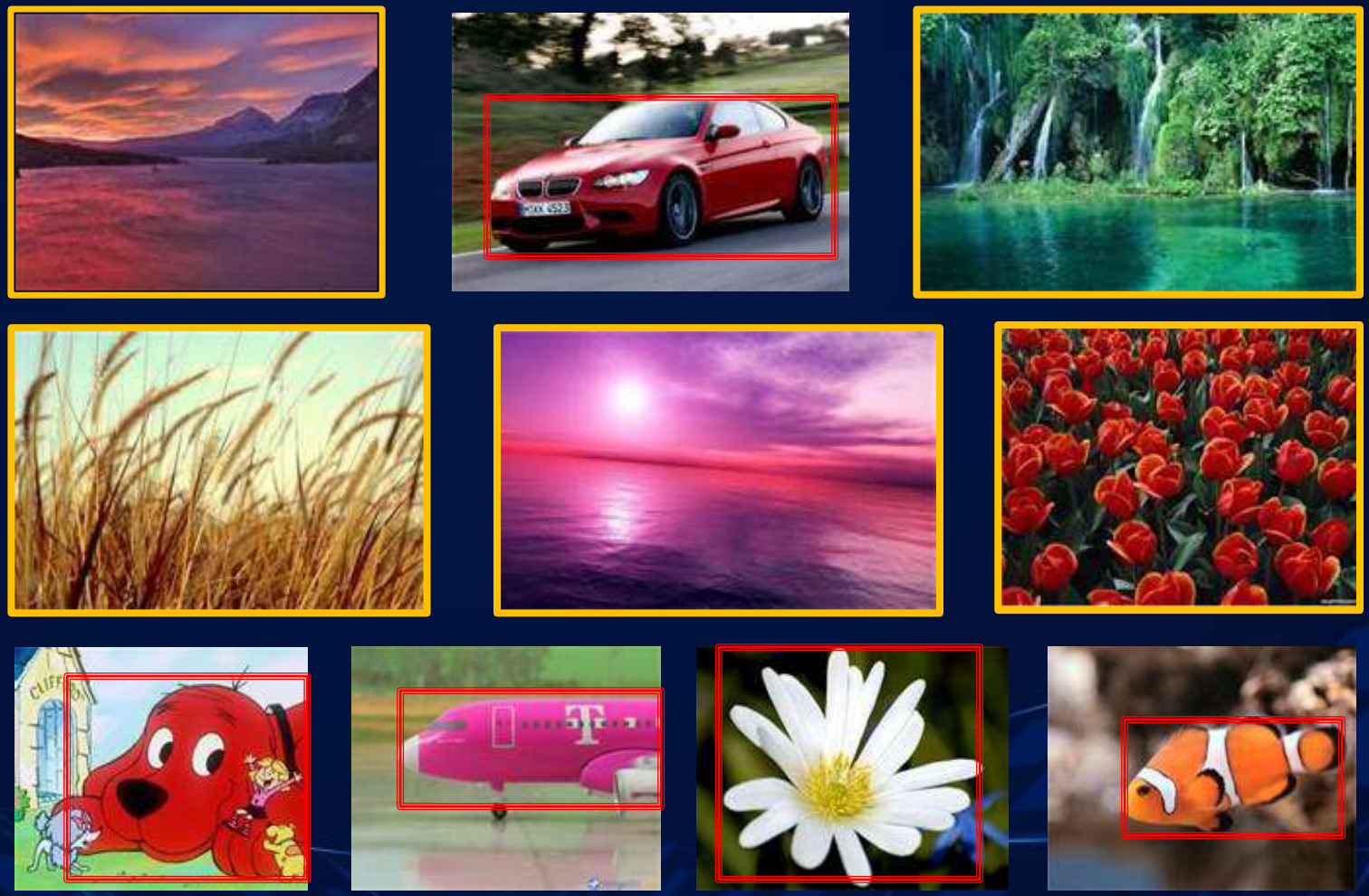
Salient Object Detection



Non-object

bounding box of salient object

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Our Solution

- Salient object detection
  - Check if an image contains object
  - Discover the position of the object
- Learn to naming colors + context-aware color naming

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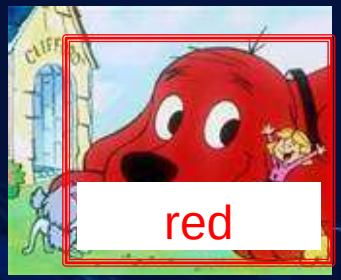
Dominant Color Naming



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Our Solution

- Salient object detection
  - Check if an image contains object
  - Discover the position of the object
- Learn to naming colors + context-aware color naming
- Textual adjustment
  - Promote images whose surrounding texts contain the color name (e.g., red,…)

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BMW

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BMW + blue

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BMW + pink

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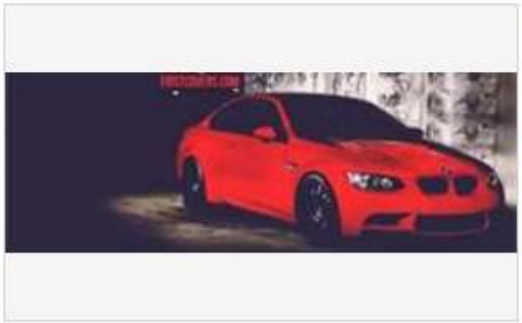

BMW+ red

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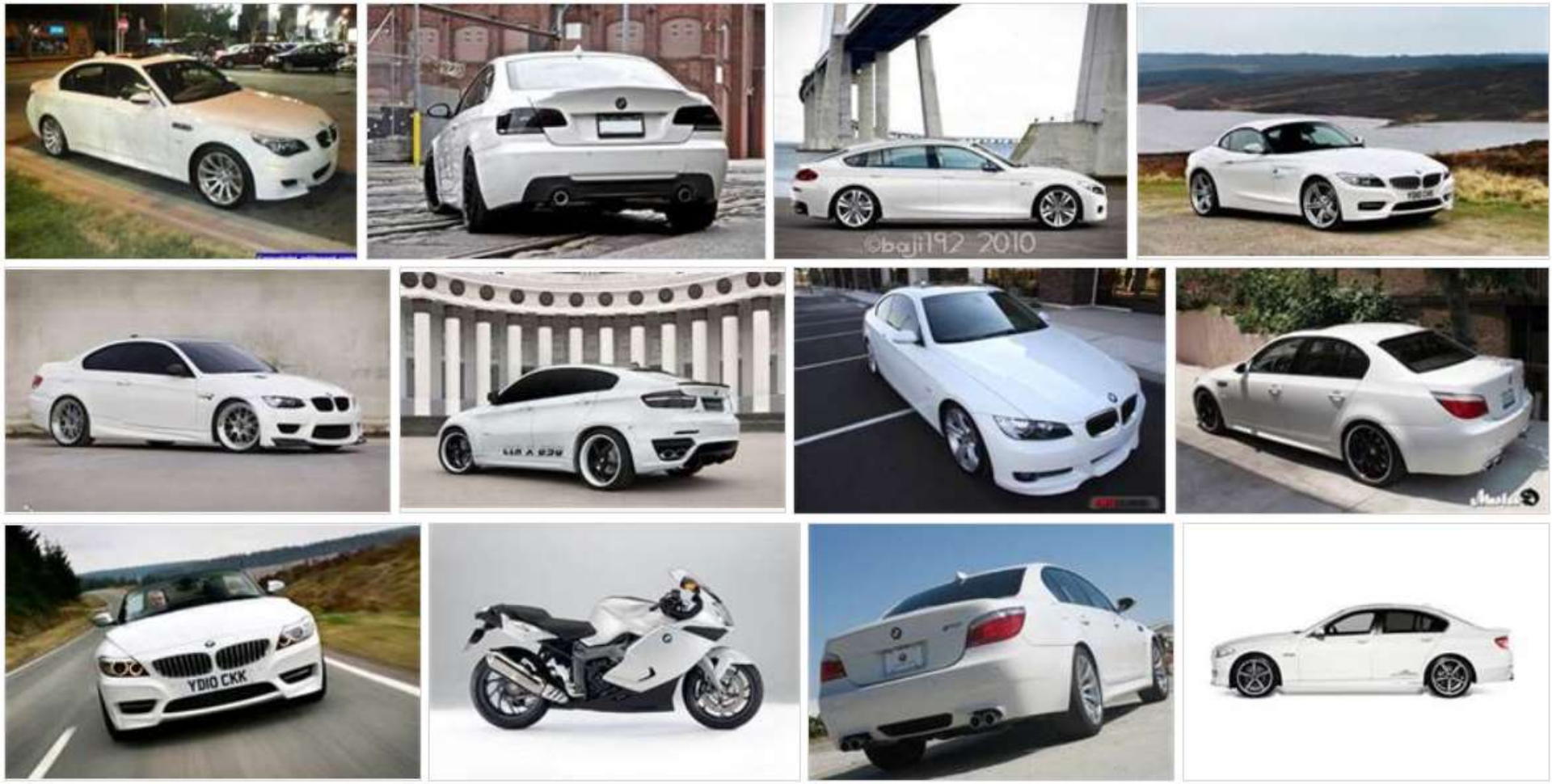

BMW+ white

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dog

Microsoft Research

dog + red

Microsoft Research

dog + blue

Microsoft Research

dog + brown

Microsoft Research

dog + black

Microsoft Research

dog + white

Microsoft Research

forest

Microsoft Research

forest + green

Microsoft Research

forest + red

Microsoft Research

forest + yellow

Microsoft Research

sunset

Microsoft Research

sunset + blue

Microsoft Research

sunset + green

Microsoft Research

sunset + orange

Microsoft Research

tulips

Microsoft Research

tulips + pink

Microsoft Research

tulips + purple

Microsoft Research

tulips + red

Microsoft Research

Taylor Swift

Microsoft Research

Taylor Swift + purple

Microsoft Research

Taylor Swift + red

Microsoft Research

Examples of Cliparts

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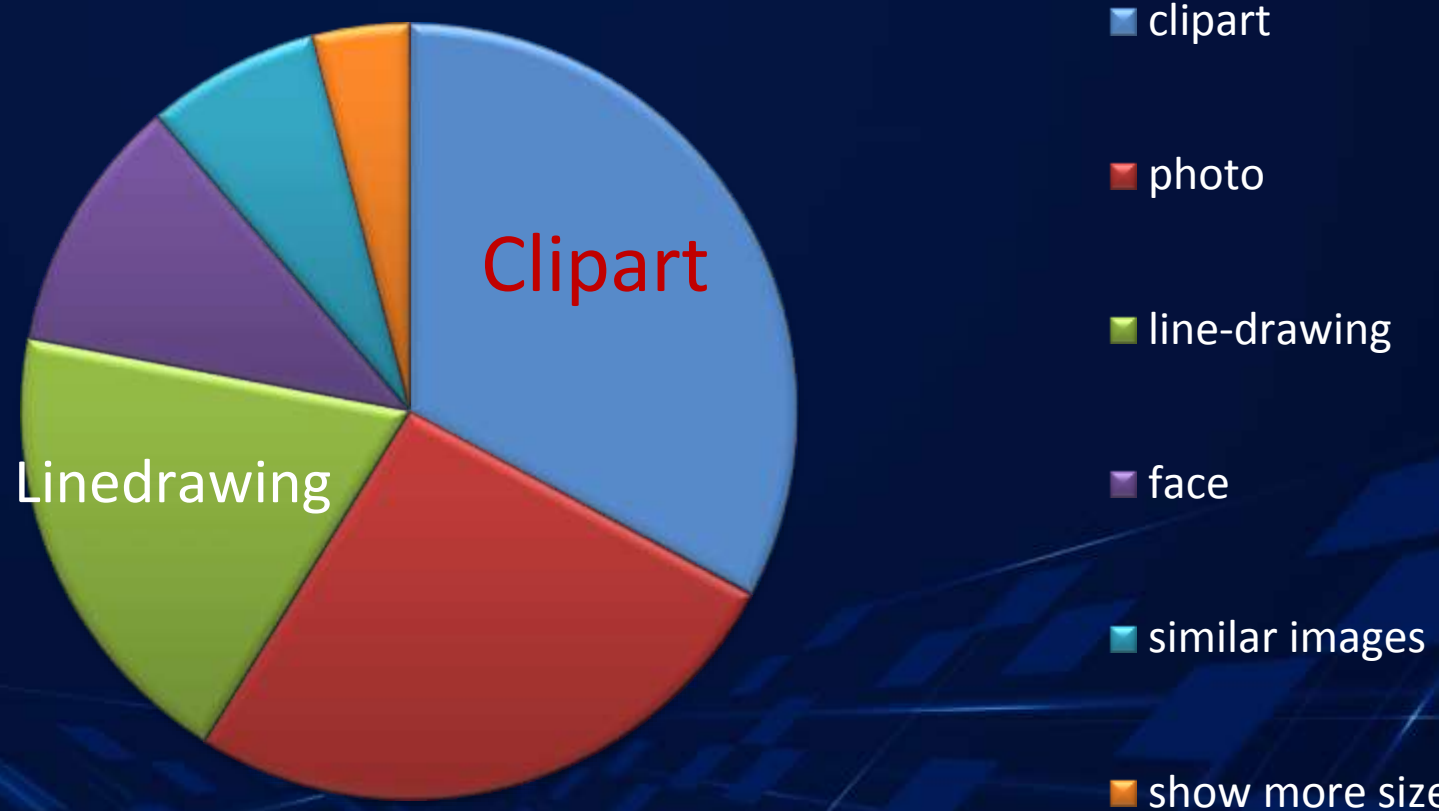
Important Filters

- Usage on image search



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Cascaded Filtering

Web Images

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Cascaded Filtering

Web Images

Background Filter

# of colors in the image border and corners

rule based classifier

Simple Background Filter:
Filter out complex background image and generate foreground mask

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Cascaded Filtering

Web Images

Background Filter

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rule based classifier

Simple Background Filter:
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Cascaded Filtering

Web Images

Background Filter

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Cascaded Filtering

Web Images

Background Filter

Shape Filter

foreground mask
shape features, like perimeter, area…

rule-based classifier

Shape Filter:
Prefer images with simple shape

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Cascaded Filtering

Web Images

Background Filter

Shape Filter

foreground mask shape features, like perimeter, area…

rule-based classifier

Shape Filter:
Prefer images with simple shape

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Cascaded Filtering

Web Images

Background Filter

Shape Filter

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Cascaded Filtering

Web Images

Background Filter

Shape Filter

Texture Filter

normalized edge pixel numbers

rule-based classifier

Texture Filter:
Prefer images without complex texture

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Cascaded Filtering

Web Images

Background Filter

Shape Filter

Texture Filter

normalized edge pixel numbers

rule-based classifier

Texture Filter:
Prefer images without complex texture

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Cascaded Filtering

Web Images

Background Filter

Shape Filter

Texture Filter

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Cascaded Filtering

Web Images

Background Filter

Shape Filter

Texture Filter

Photo Filter

Photo Filter:
Classify photo and cartoon style

- gradient strength histogram
- saturation histogram
- lighting histogram

random forest classifier

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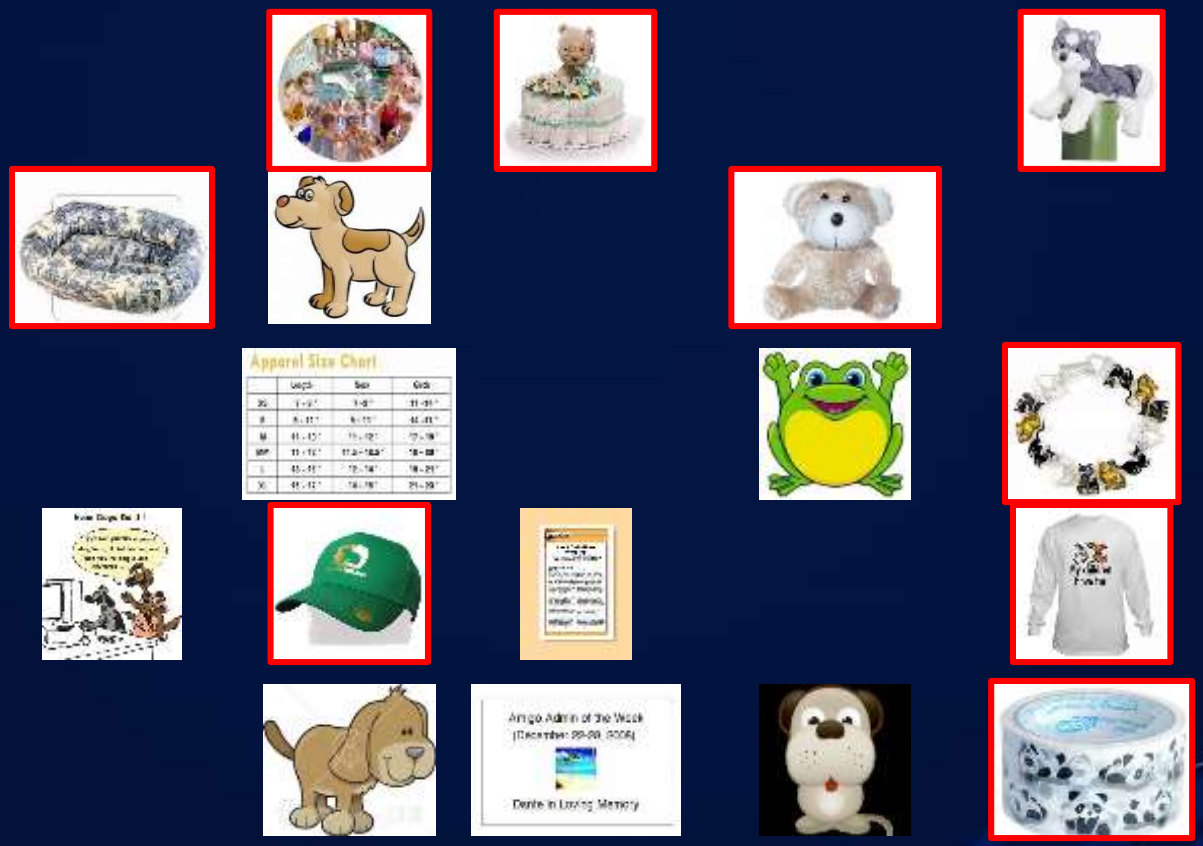
Cascaded Filtering



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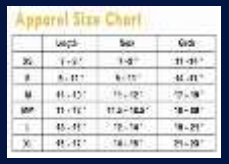
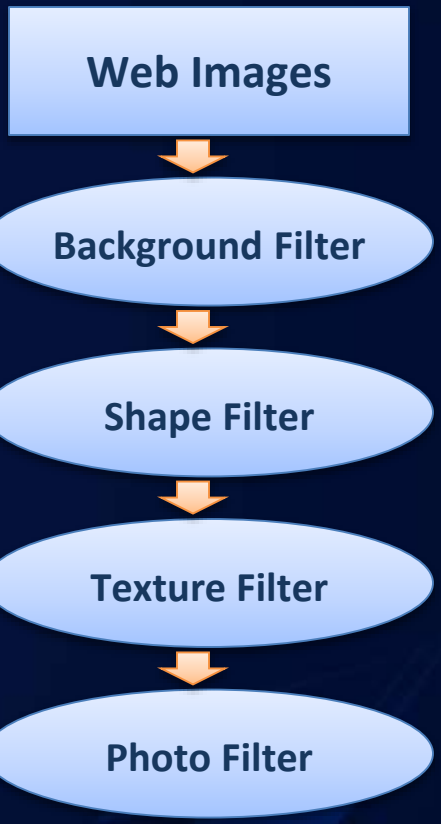
Microsoft Research

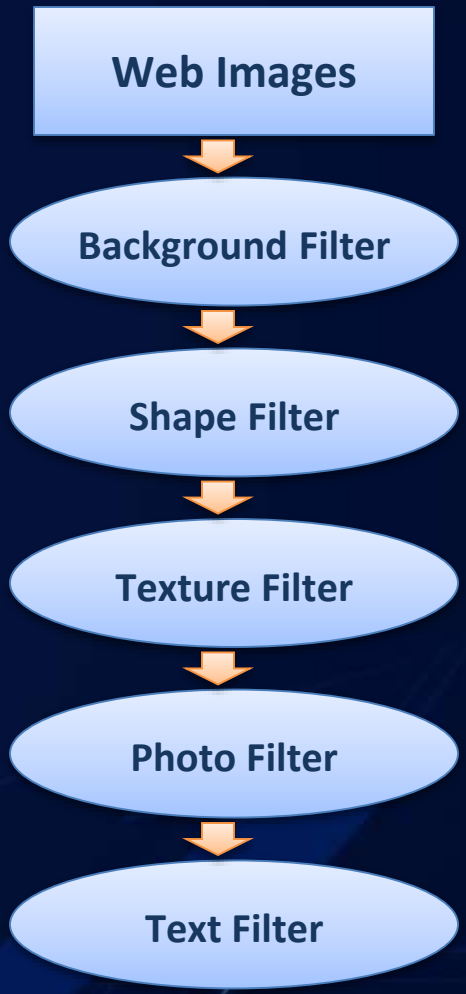
Cascaded Filtering





Microsoft Research

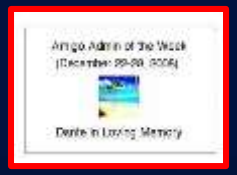
Cascaded Filtering

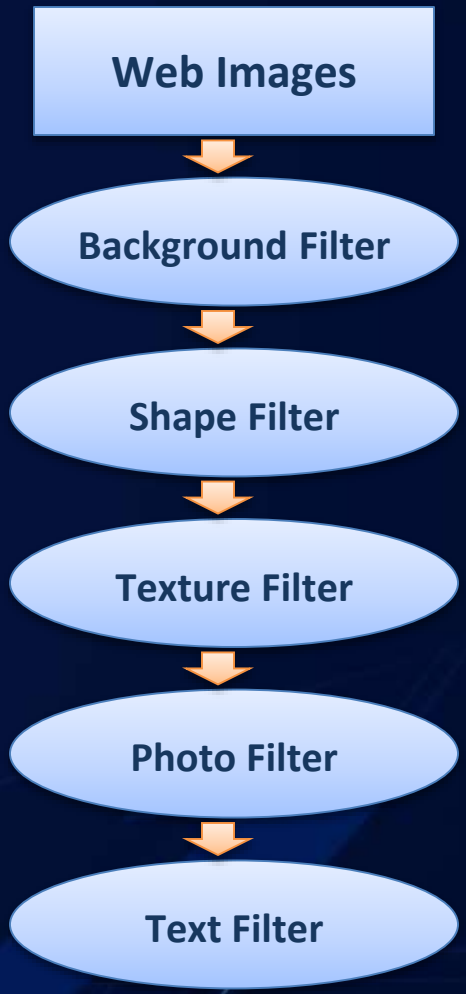


Text Filter:
Text detection using gradient feature

Microsoft Research

Cascaded Filtering

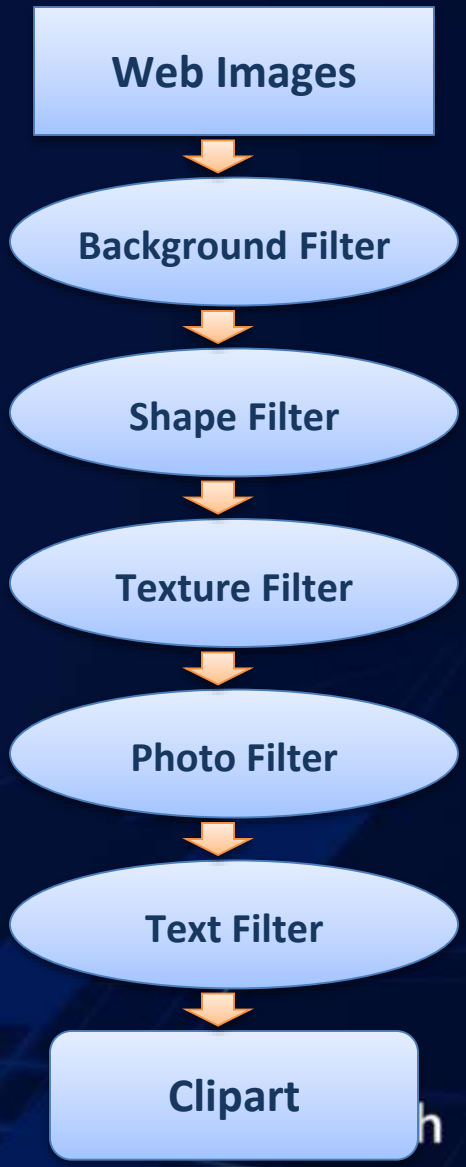




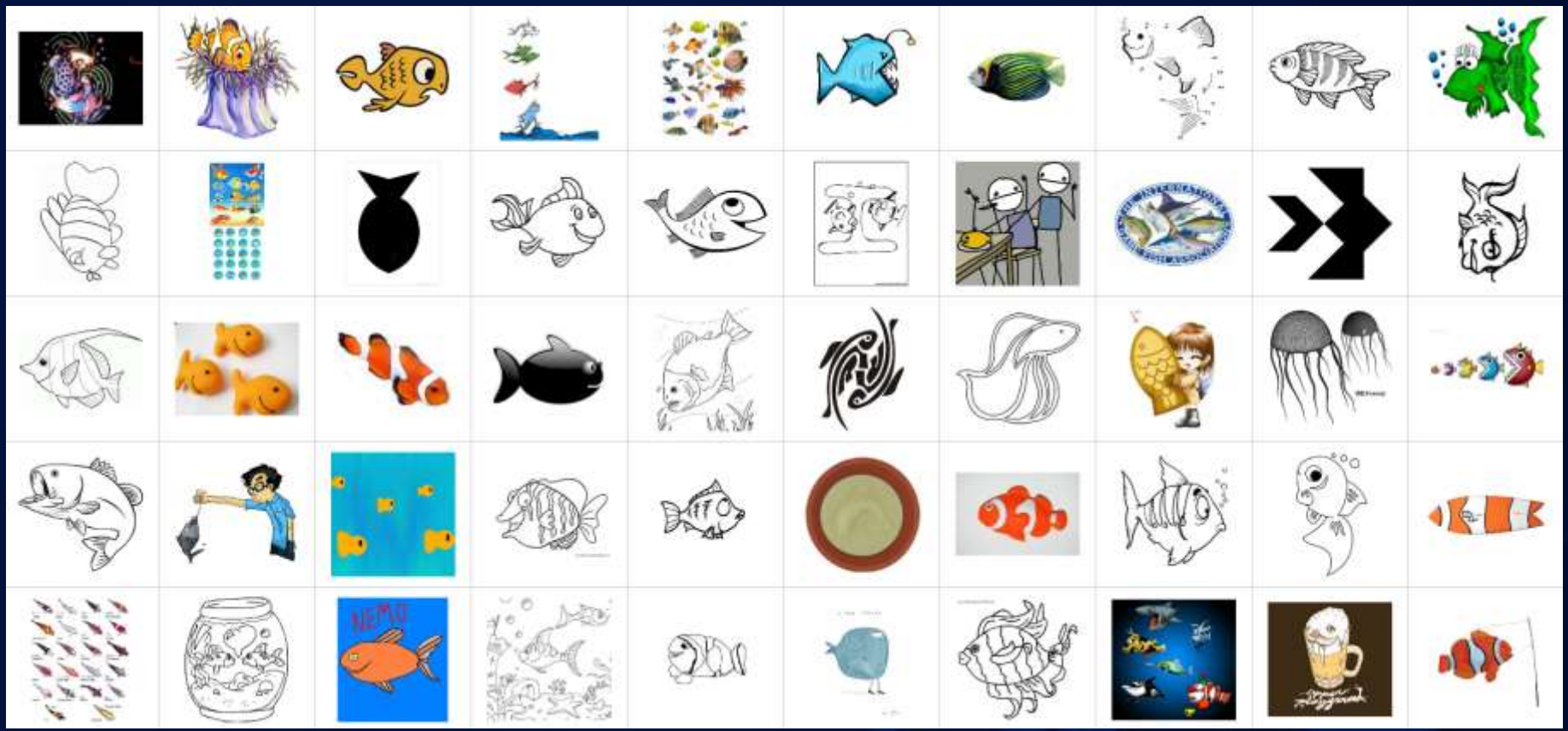
Text Filter:
Text detection using gradient feature

Microsoft Research

Cascaded Filtering



A problem with filtered results



The results are not always attractive!

Microsoft Research

Relevance ≠ Clipart Relevance

- Ranking should be based on the relevance to ***query and clipart style***, not only the query
- Observation - Good clipart images often contain “clipart” or “cartoon” keywords
- Solution: visual filter + clipart specific text ranker

Microsoft Research

Example

crab

keyword: crab
Visual attribute: clipart

keyword: crab

keyword: crab, clipart
Visual attribute : clipart

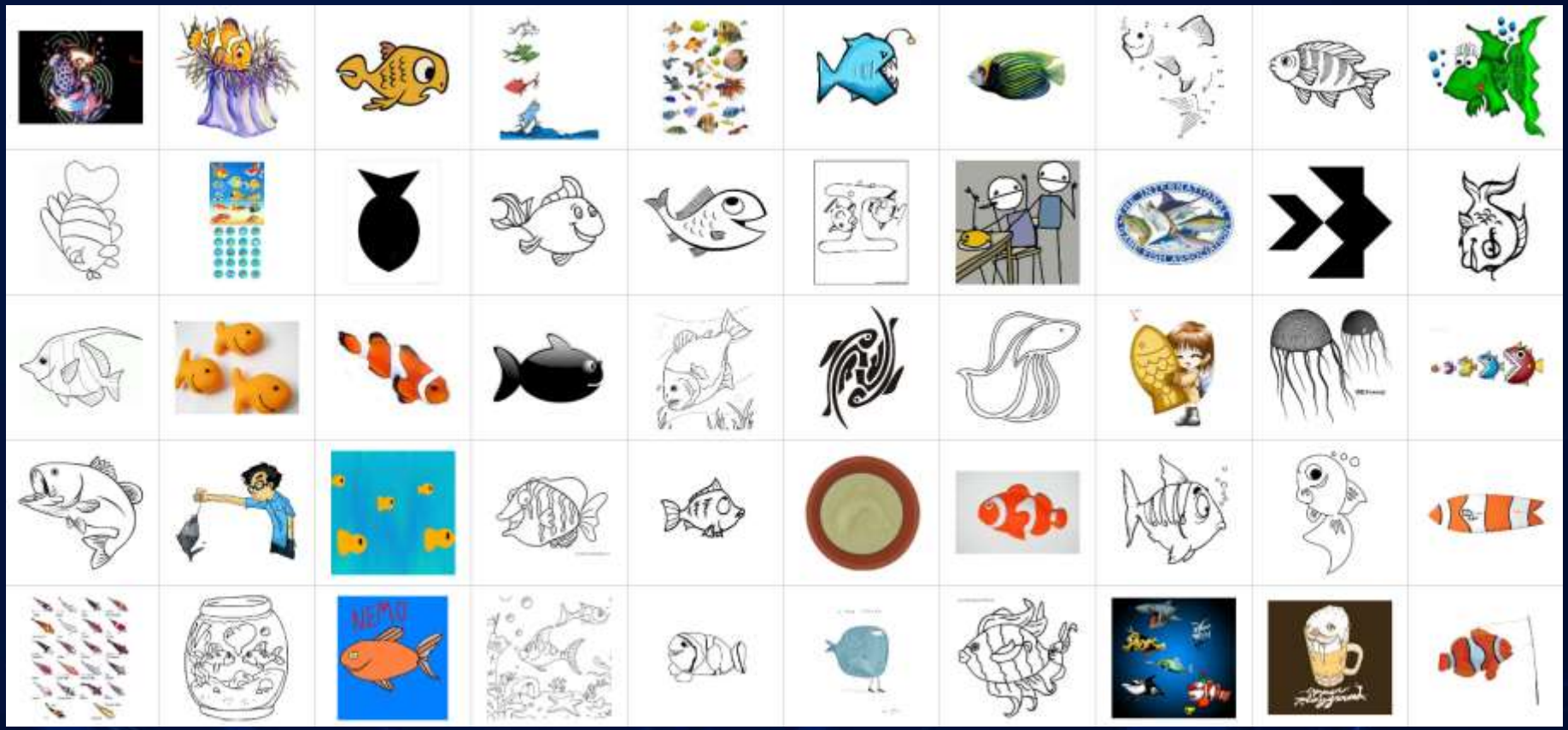
Visual filter only

Visual + Text

Microsoft Research

Results without Clipart Specific Text Ranker

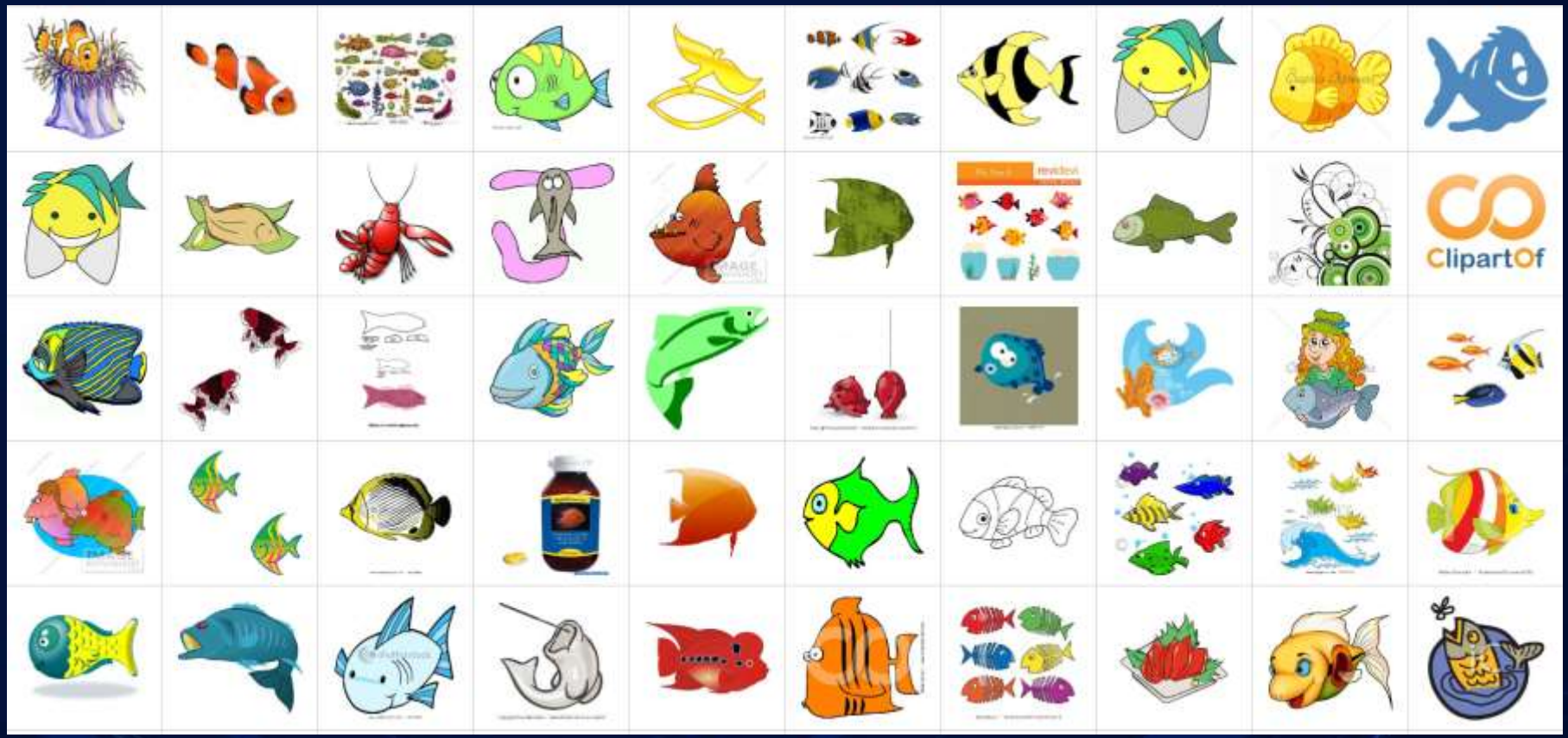
fish



Microsoft Research

Results with Clipart Specific Text Ranker

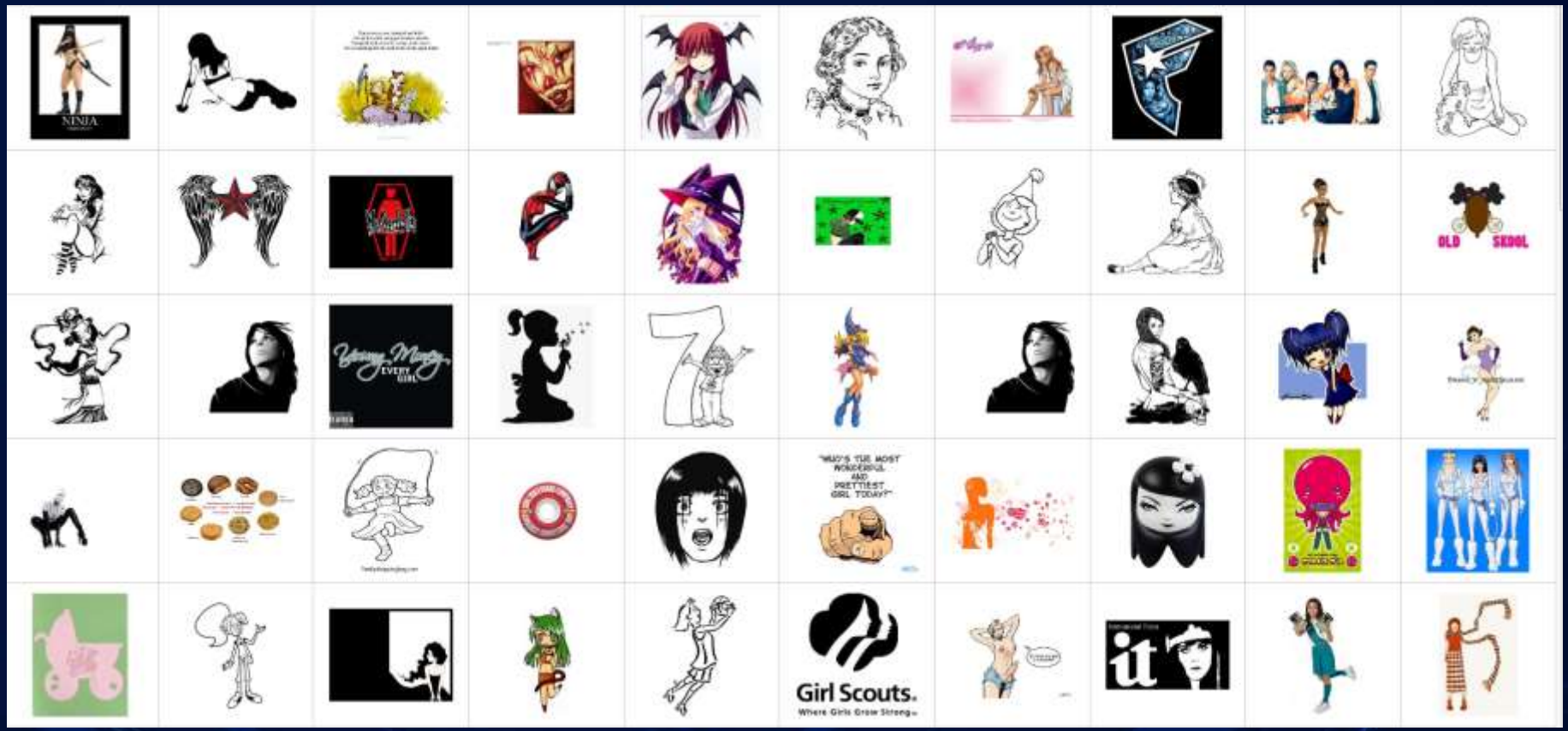
fish



Microsoft Research

Results without Clipart Specific Text Ranker

girl



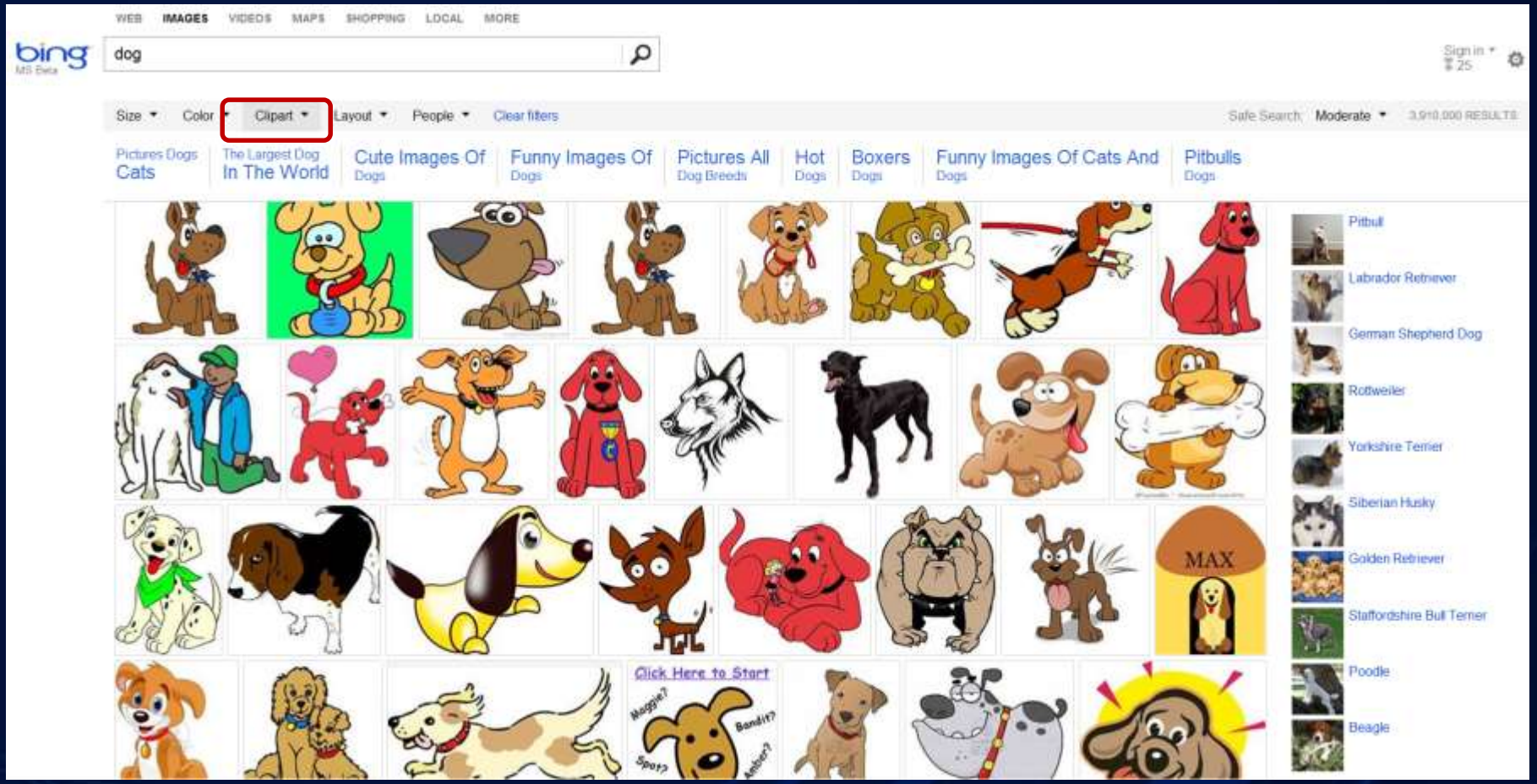
Microsoft Research

Results with Clipart Specific Text Ranker

girl

Microsoft Research

Bing Clipart Filter



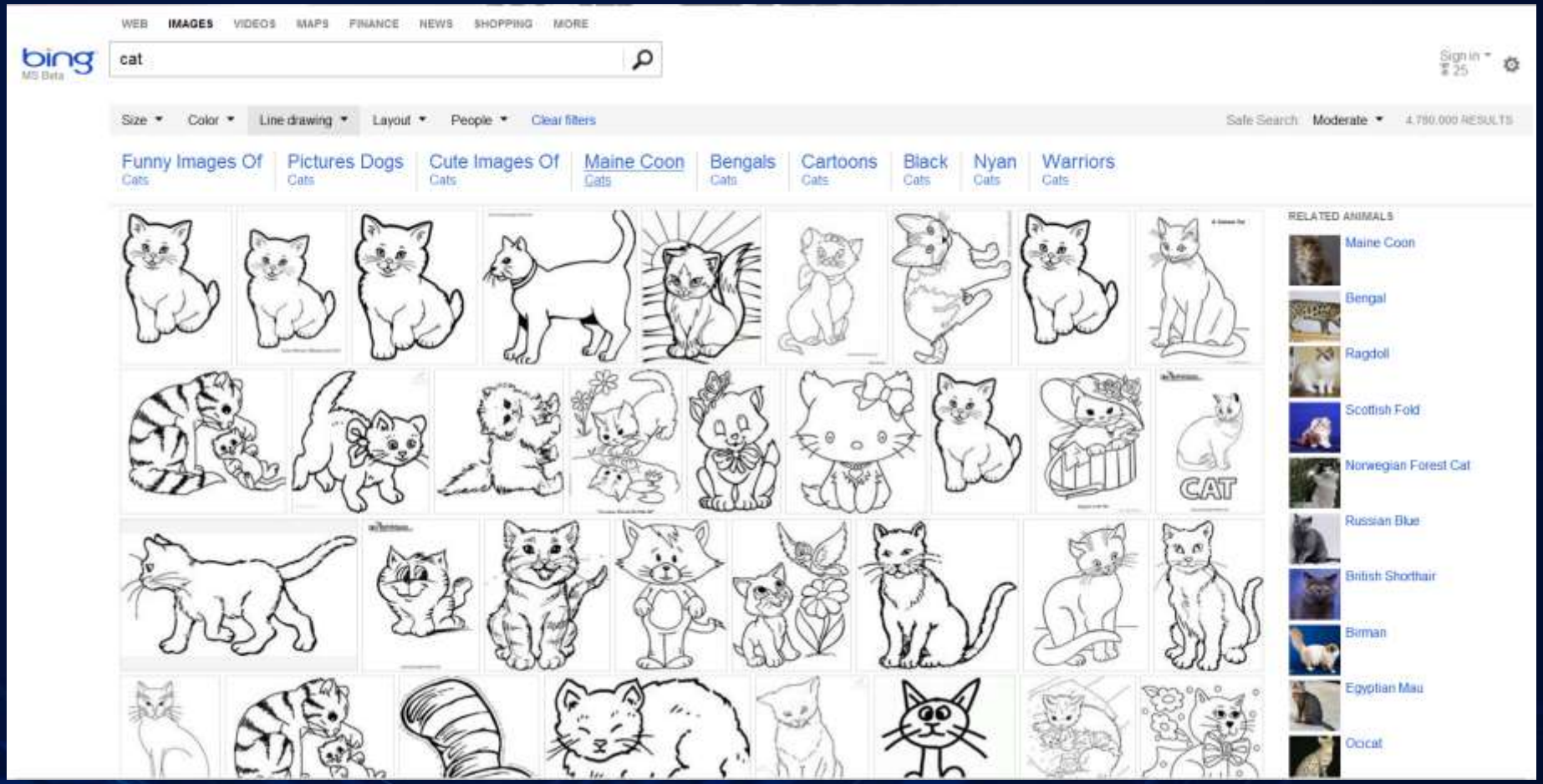
- Visual filter + clipart specific text ranker

Microsoft Research

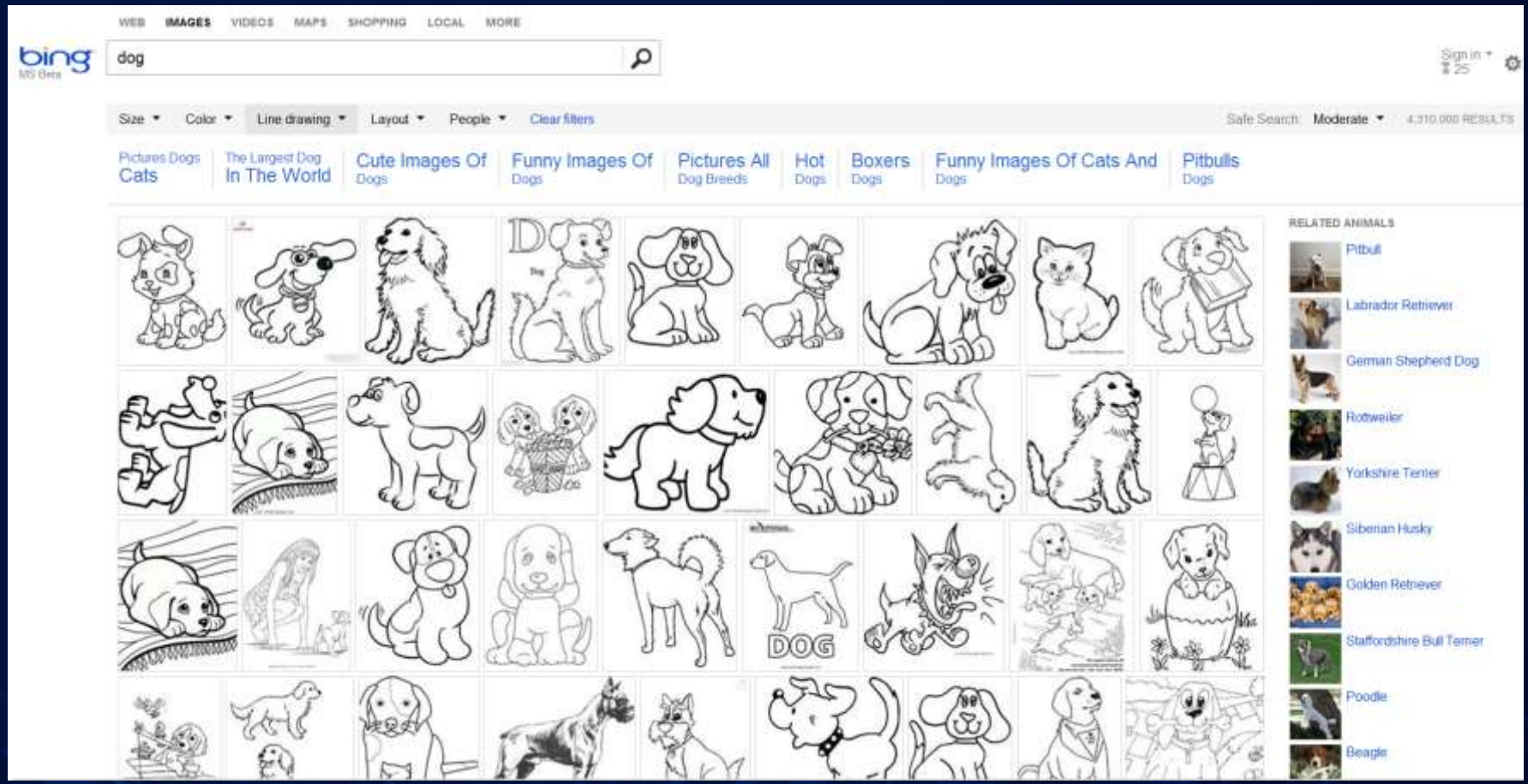
Linedrawing Filter

Microsoft Research

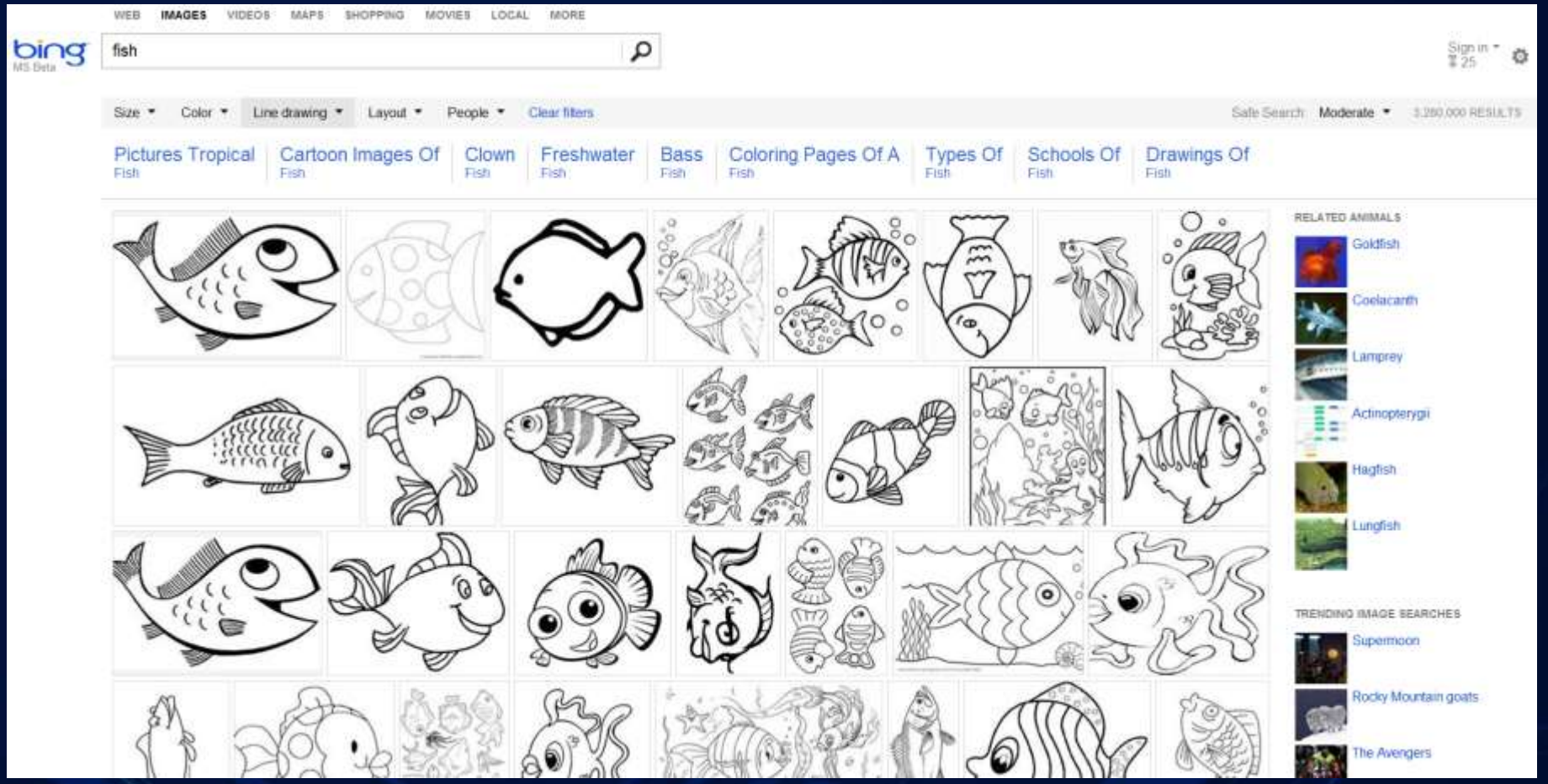
Results



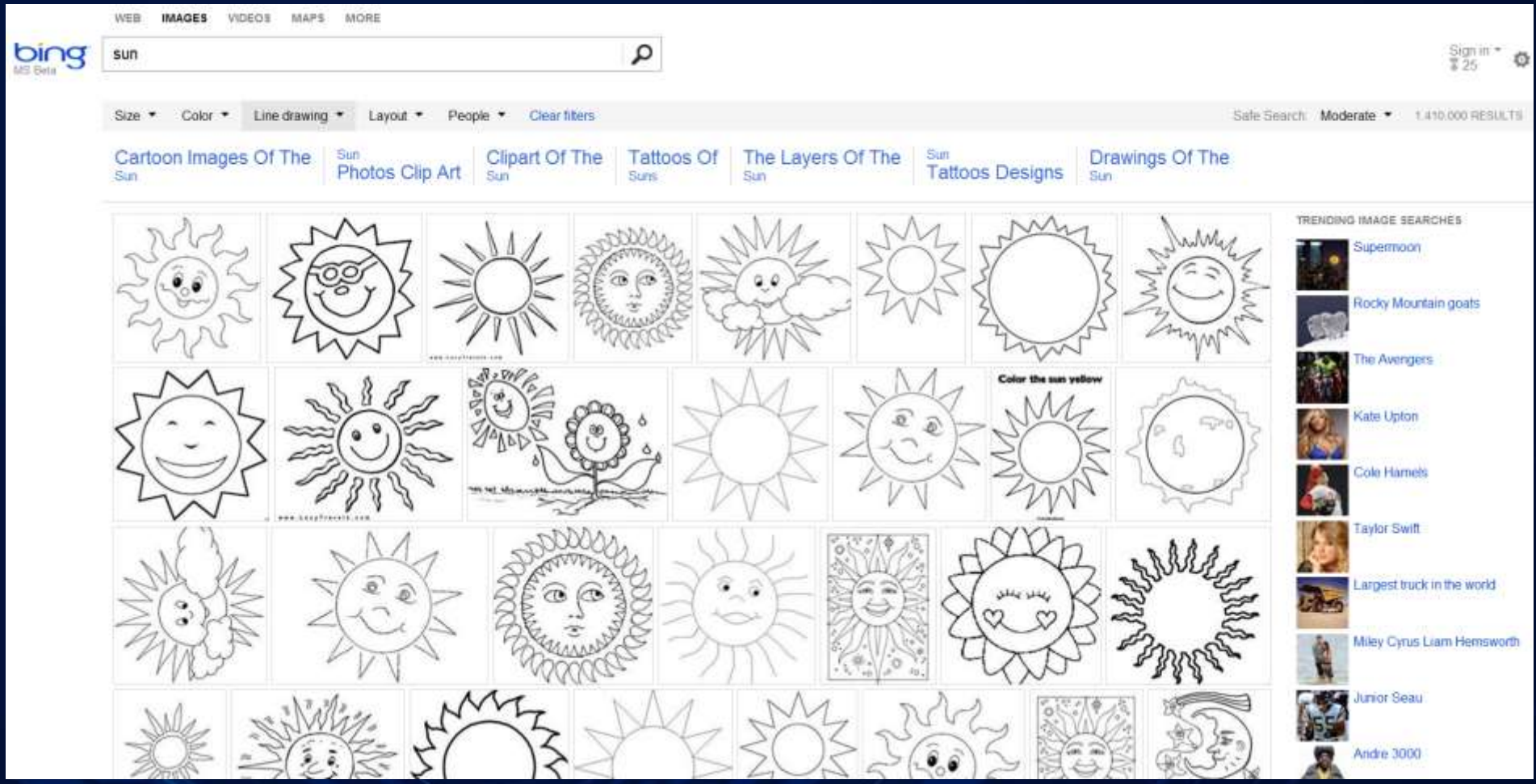
Microsoft Research



Microsoft Research

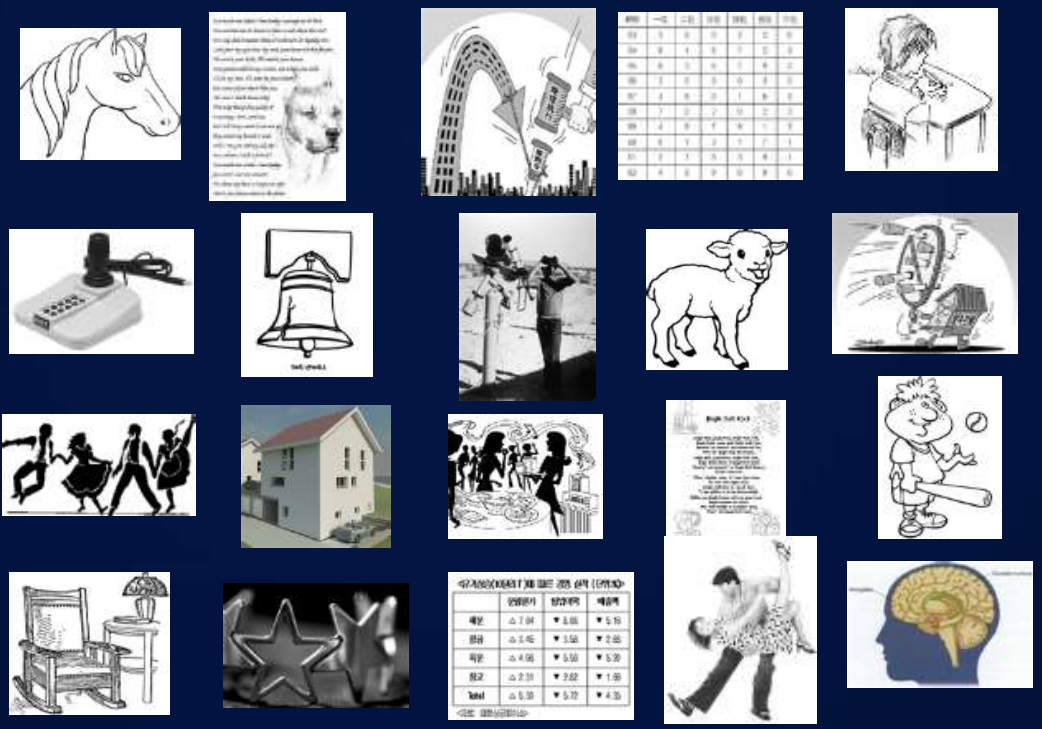


Microsoft Research



Microsoft Research

Cascaded Filtering



Web Images

Color Image Filter

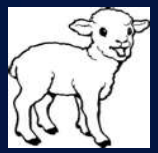
# of non black-white pixels in the image

rule based classifier

Color Image Filter:
Filter out non black-white images

Microsoft Research

Cascaded Filtering



Web Images

Color Image Filter

Foreground Shape Filter 1

Foreground Shape Filter 2

Texture Filter

Text Filter

Linedrawing

Text Filter:
Filter out images with big text regions (share with clipart filter)

Attribute based Visual Quality Improvement

Microsoft Research

Motivation

- Visual quality is important for user experience

Microsoft Research

Existing System

Text based information (text metawords):

- Word hit number
- Phrase exactly match number
- Static rank
- BM25
- …

Problem:

Only used text information, can not consider visual quality

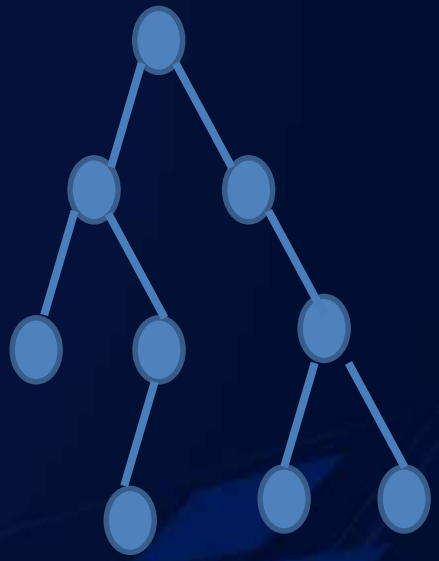
Microsoft Research

Integrate Visual Features

Low-level visual features

Hardly directly combine with text metawords

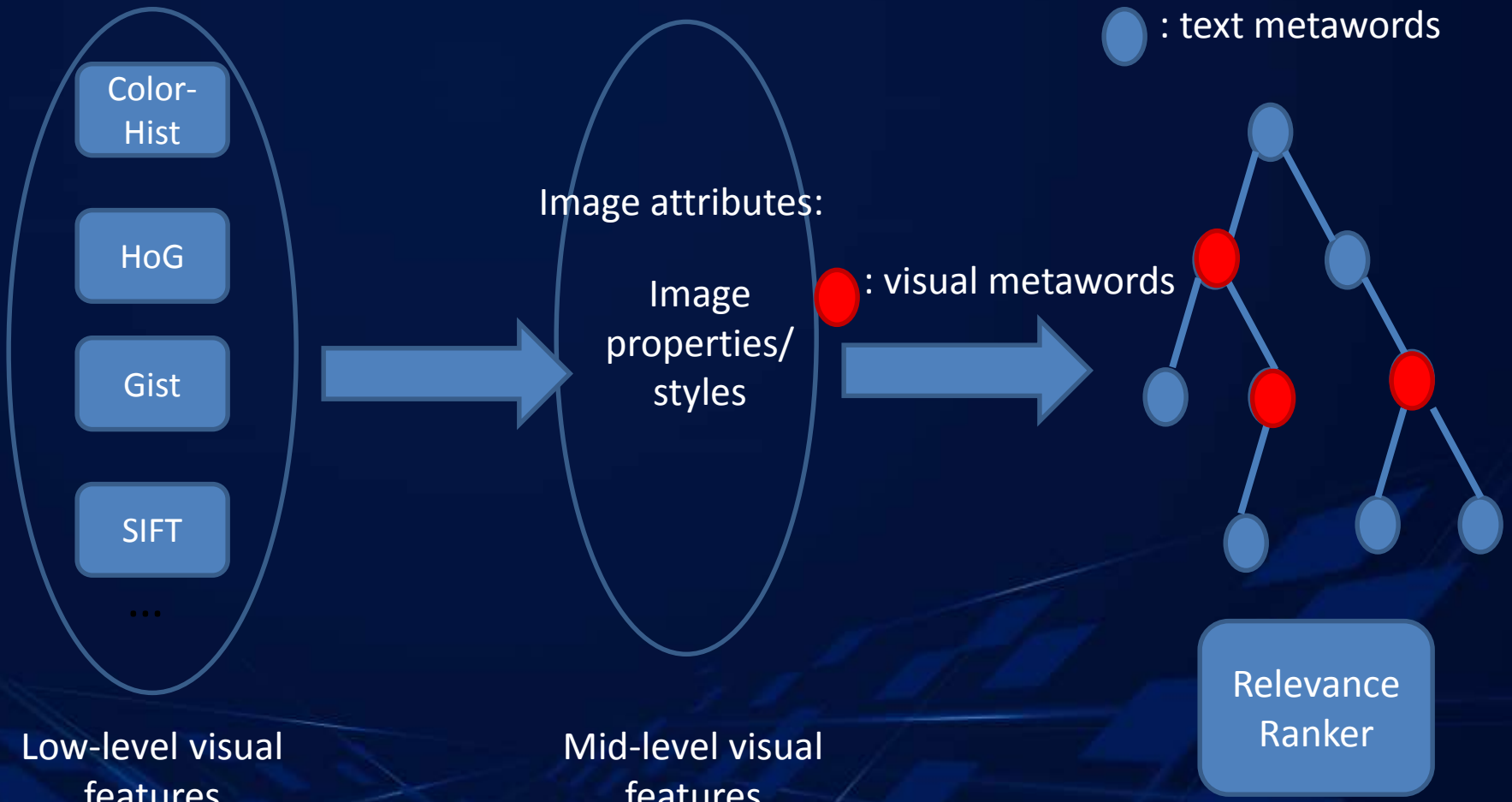
: text metawords



Relevance Ranker

Microsoft Research

Integrate Visual Features



Microsoft Research

Image Quality Related Attributes

- People images

Prefer

Not prefer

Microsoft Research

Image Quality Related Attributes

- People related attributes (metawords)

just face

head and shoulder

human body

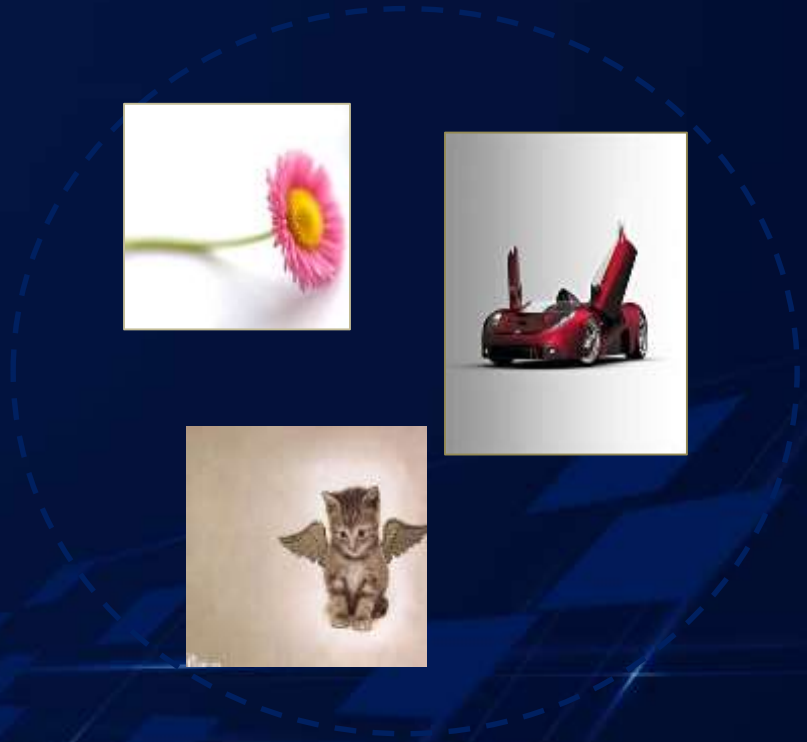
others

Microsoft Research

Image Quality Related Attributes

- Object images

Prefer

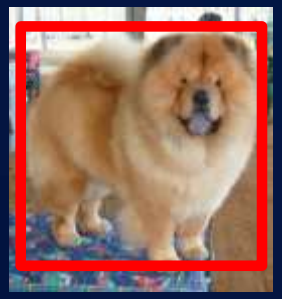


Not prefer

Microsoft Research

Image Quality Related Attributes

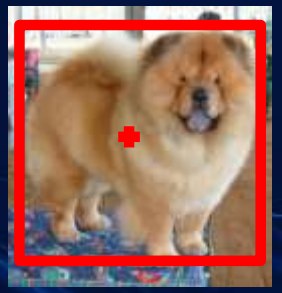
- Object related attributes (metawords)



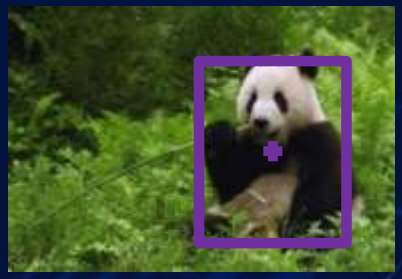
size: large

size: medium

size: small



position: center



position: off-center

position: edge

Microsoft Research

Image Quality Related Attributes

- Image styles

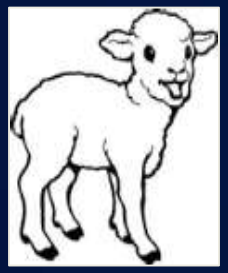
Prefer

Not prefer

Microsoft Research

Image Quality Related Attributes

- Image style related attributes (metawords)



linedrawing

clipart

black-white

tiled image - scatter

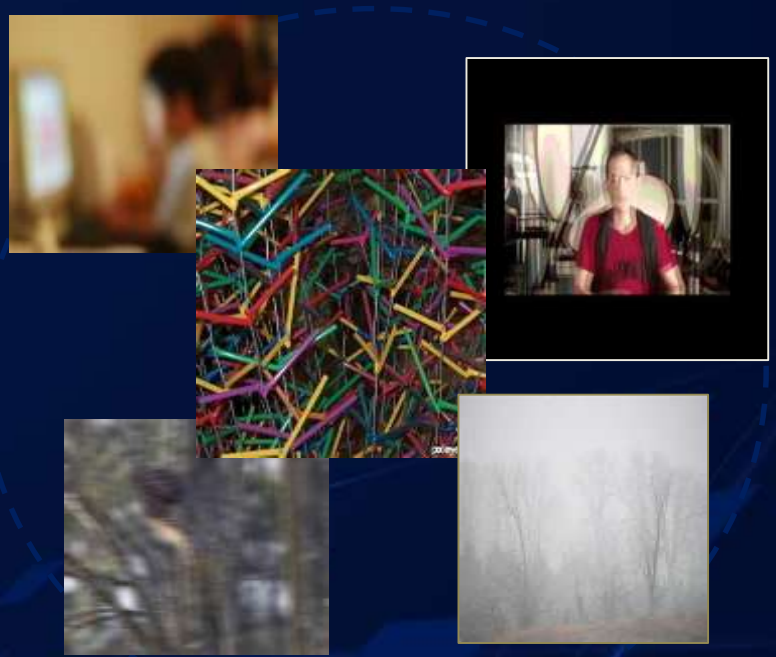
tiled image - grid

Microsoft Research

Image Quality Related Attributes

- General Photos

Prefer



Not prefer

Microsoft Research

Image Quality Related Attributes

- Attributes (metawords) for general photos
  - Photo quality

high quality

fair quality

low quality

  - Image color entropy

Microsoft Research

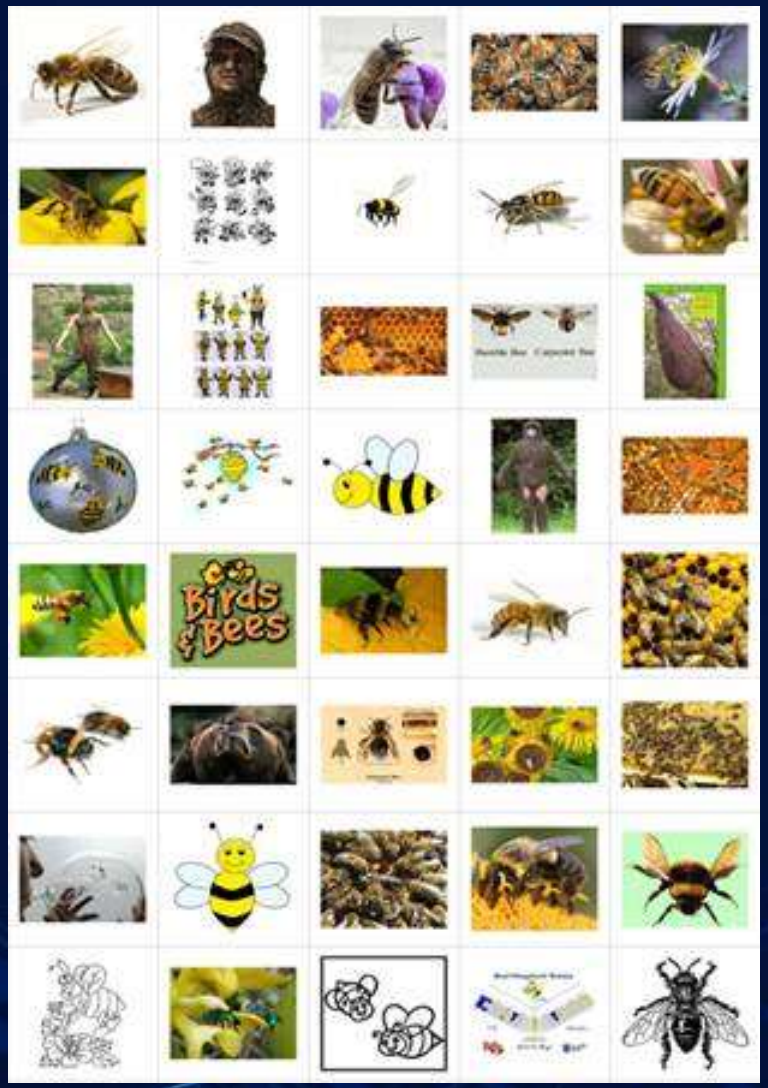
Comparison Results

Old results (query = dog)

Current results (query = dog)

Microsoft Research

Comparison Results



Old results (query = bees)

Current results (query = bees)

Research

Comparison Results

Old results (query = Royal Wedding)

Current results (query = Royal Wedding)

Research

Comparison Results

Old results (query = Blueberries)

Current results (query = Blueberries)

Microsoft Research

Research Updates

Data Intensive Computing

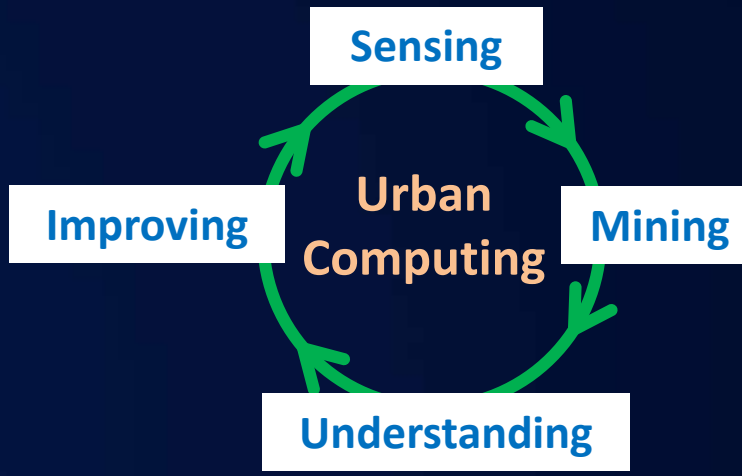
- Server (Software) Switch in DataCenter
  - NSDI 2011 best paper
- Real-time matrix computation & StreamInsight
  - Eurosys 2012 best paper
- Urban Computing
- Engkoo Pinyin IME – Next generation cloud-based IME
  - Beta release: http://pinyin.engkoo.com/

Microsoft Research

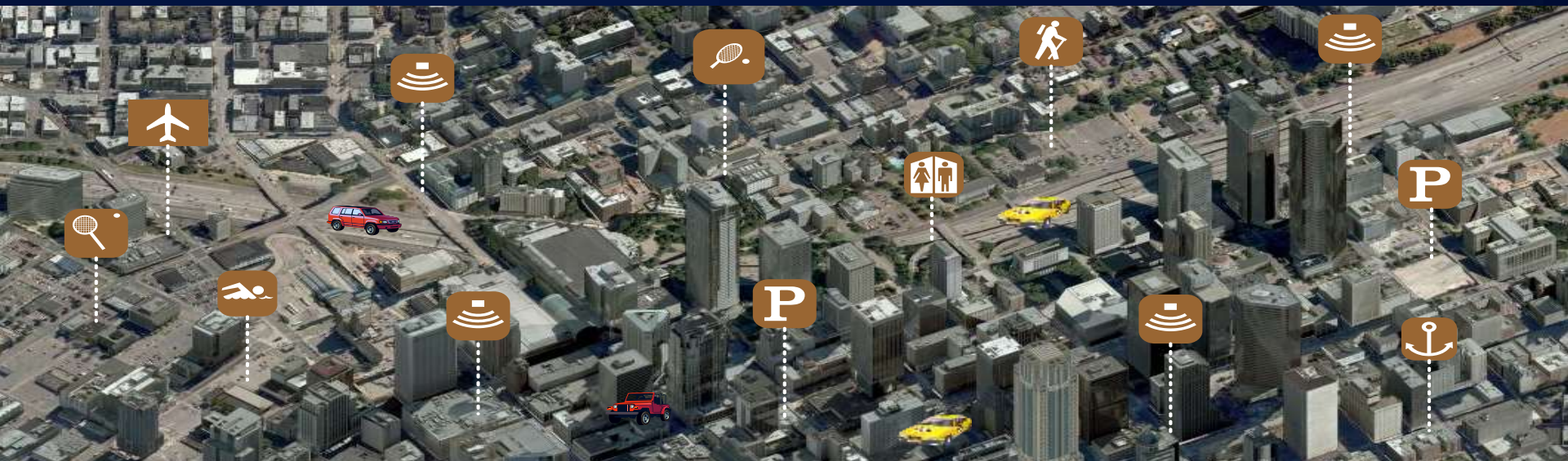
URBAN COMPUTING

Microsoft Research

Urban Computing



Urban computing is emerging as a concept where every sensor, device, person, vehicle, building, and street in the urban areas can be used to sense city dynamics to enable technologies to serve people in urban environment .



City Dynamics

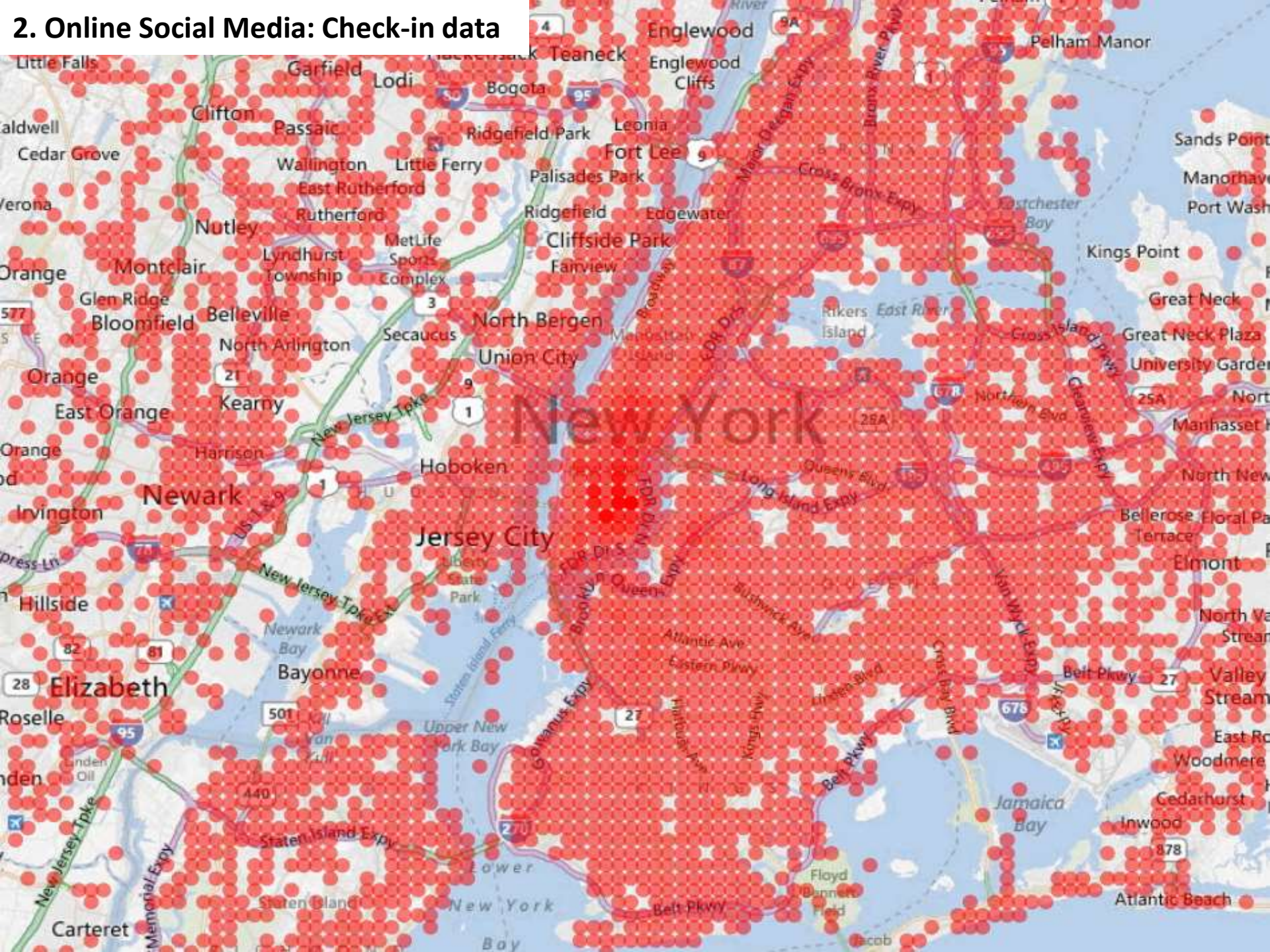
- Scope
  - Traffic flow
  - Human mobility
  - Energy consumption
  - Environment
  - Economics
  - Population
  - ……

- Data available
  - Mobile phone signal
  - GPS traces of vehicles and people
  - Ticketing data in public transportation systems
  - User-generated content (Tweeter, Yelp)
  - Map & POI data
  - Transportation sensor networks
    - Camera and loop sensors
    - Parking lots
  - Environmental sensor network
    - Air quality
    - Temperature
    - Radiation
  - Real estate listings
  - ….

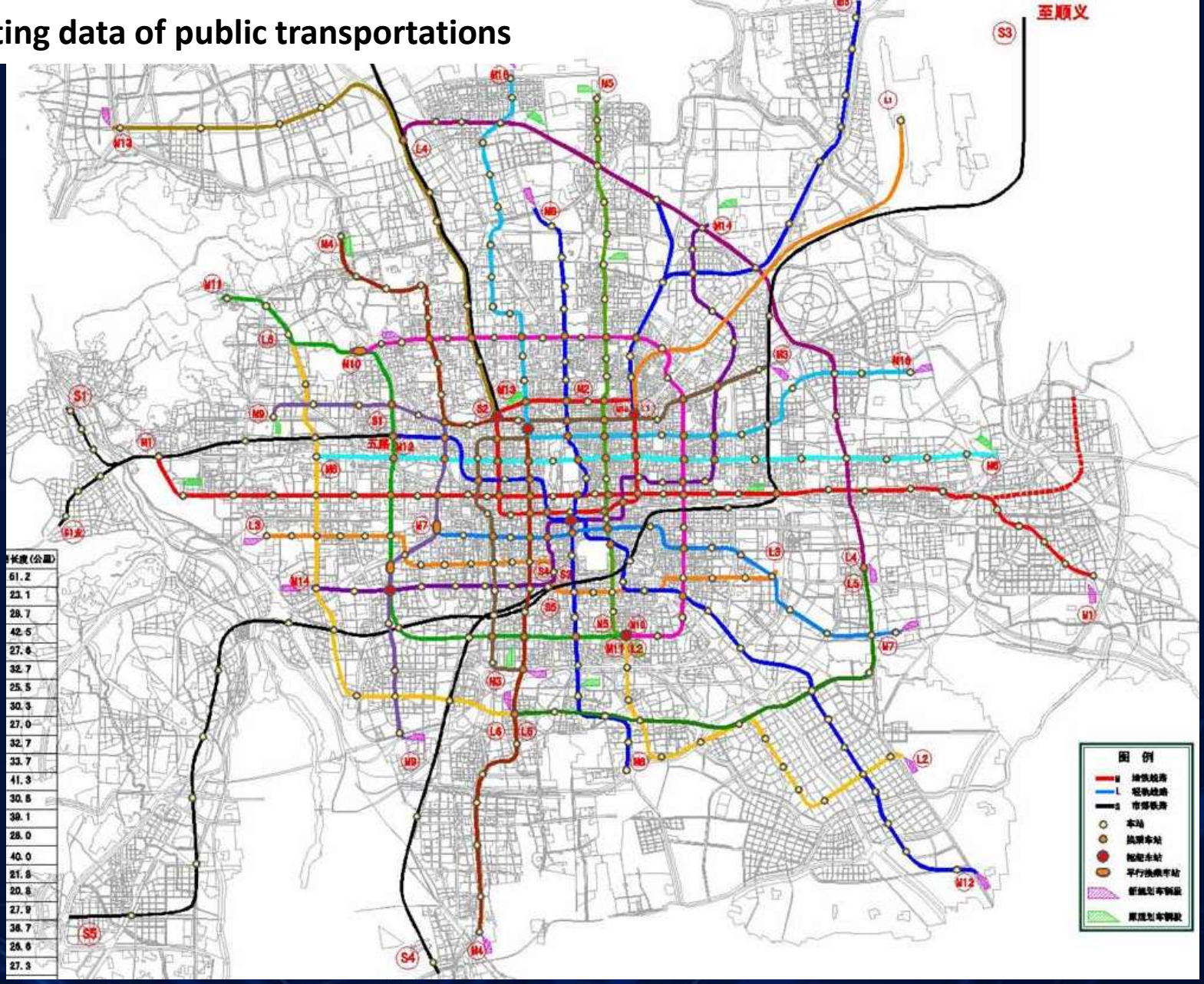
Microsoft Research

1. GPS trajectories of 33,000 taxis in 2009, 2010, and 2011

2. Online Social Media: Check-in data



3. Ticketing data of public transportations



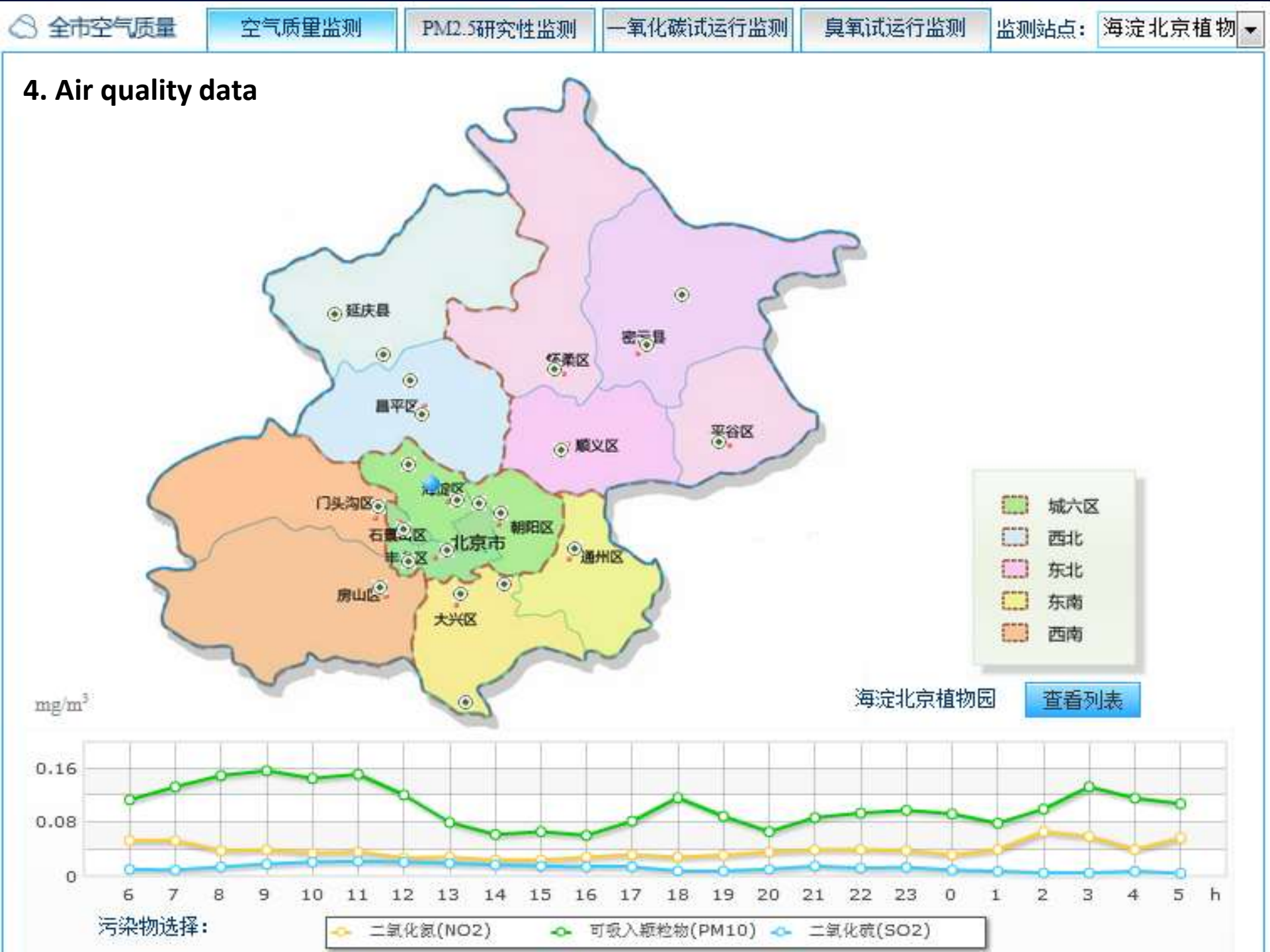
长度(公里)
61.2
23.1
28.7
42.6
27.6
32.7
25.5
30.3
27.0
32.7
33.7
41.3
30.8
39.1
28.0
40.0
21.8
20.8
27.9
38.7
26.6
27.3

Beijing Subway by 2015: The city with the longest distance of subway (561KM)

Two times longer than that of Paris(221.6KM)

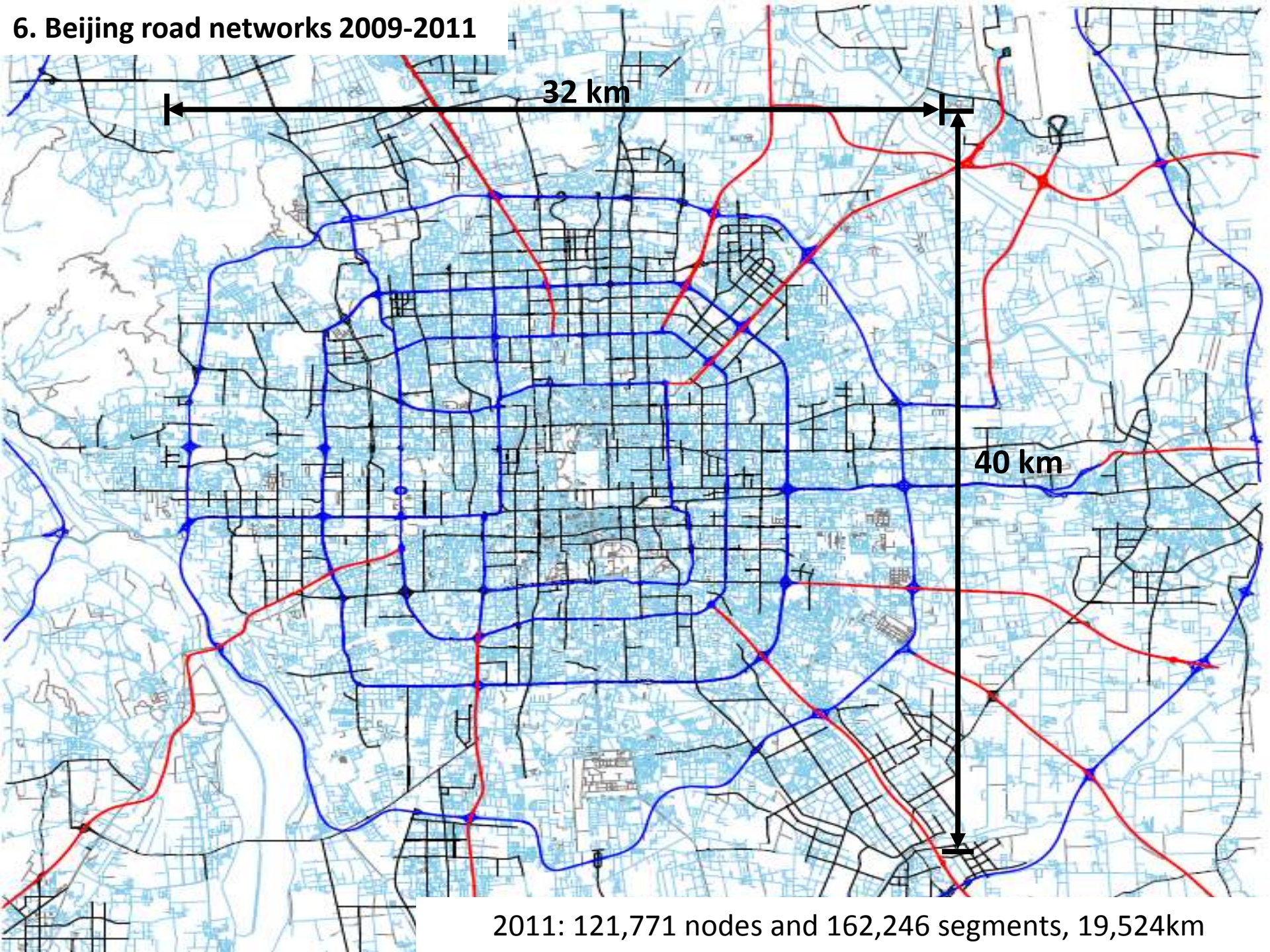
Research

4. Air quality data



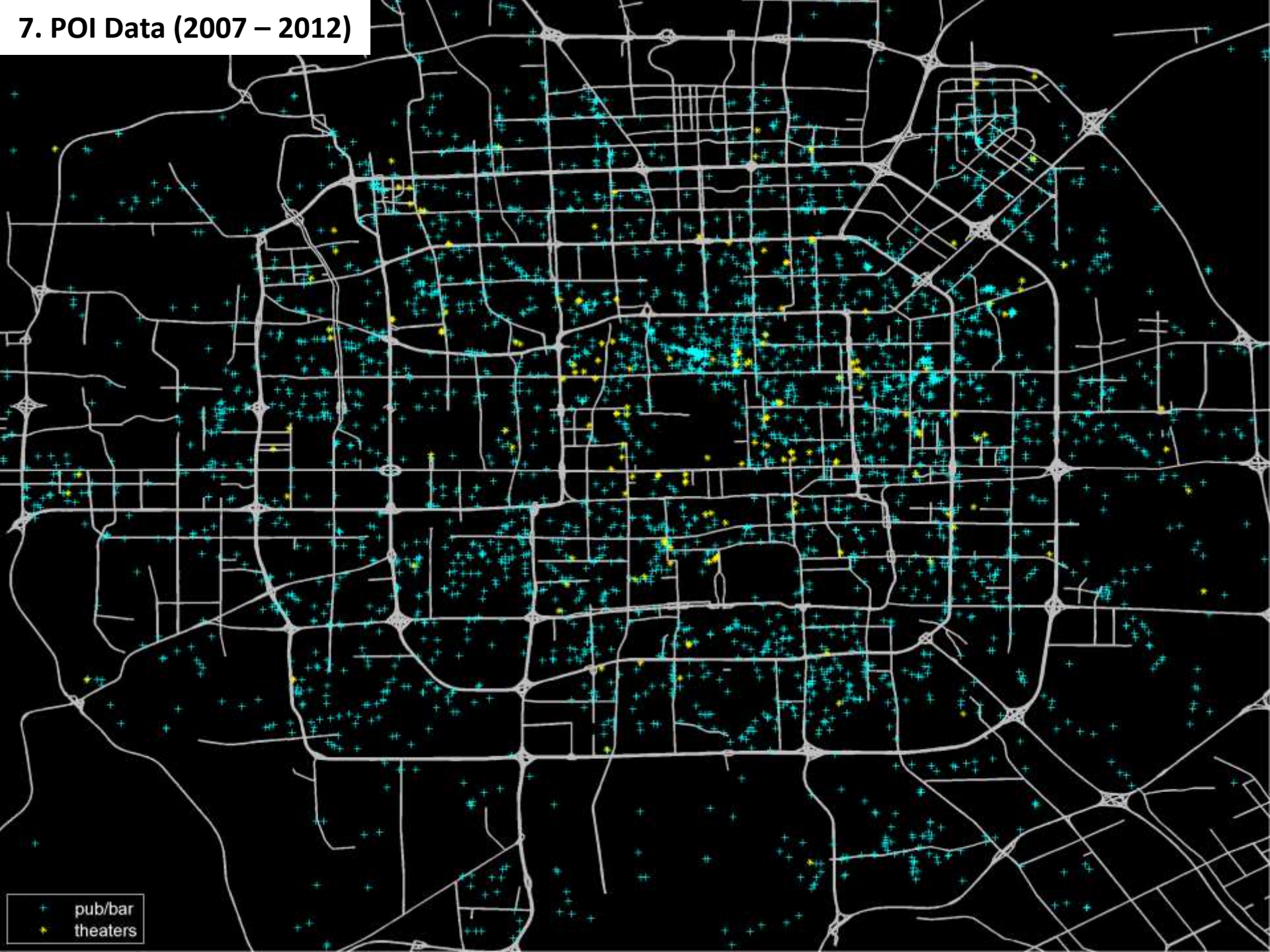
5. Real estate market

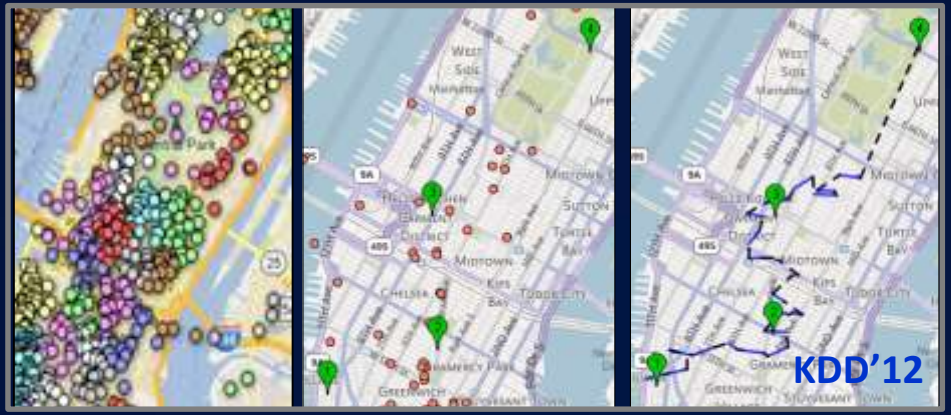
6. Beijing road networks 2009-2011



2011: 121,771 nodes and 162,246 segments, 19,524km

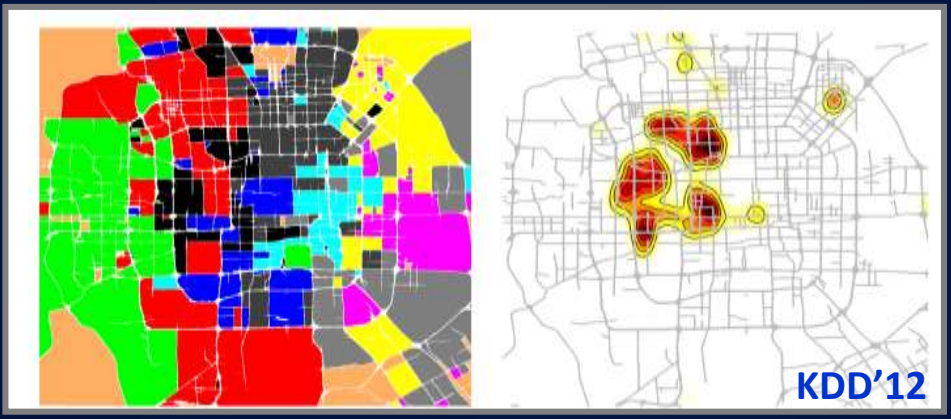
7. POI Data (2007 – 2012)



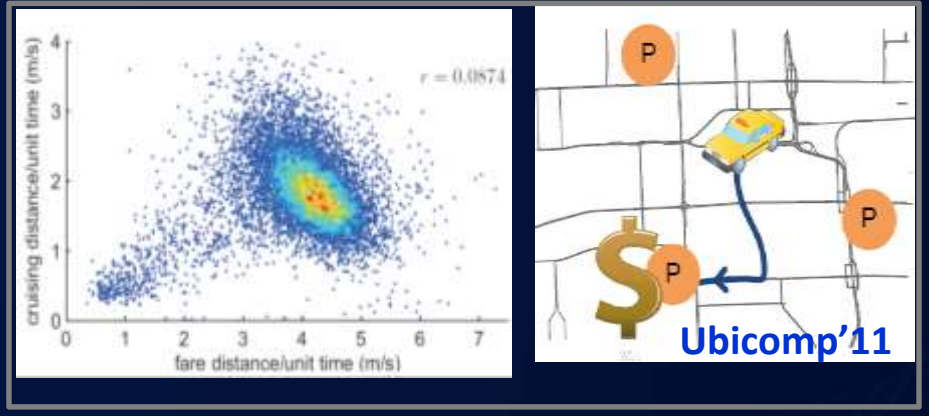


Route Construction from Uncertain Trajectories

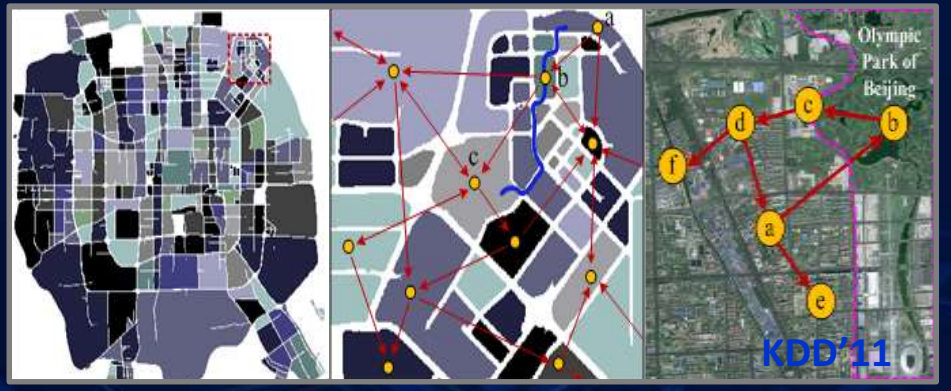
Finding Smart Driving Directions



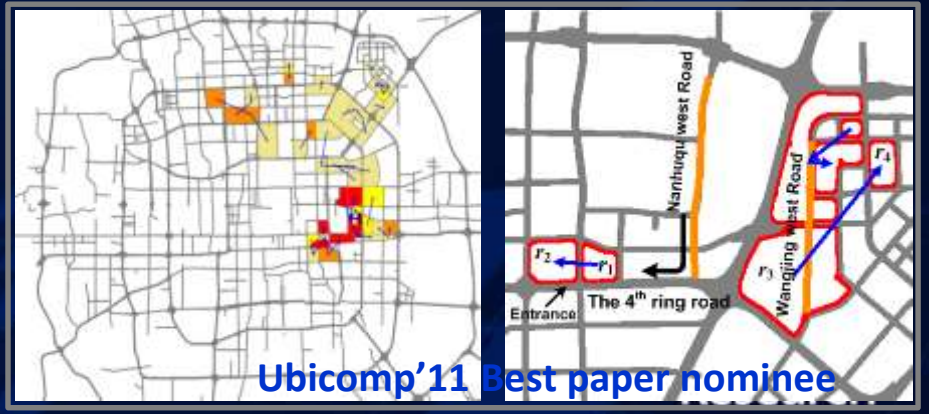
Discovery of Functional Regions



Passengers-Cabbie Recommender system

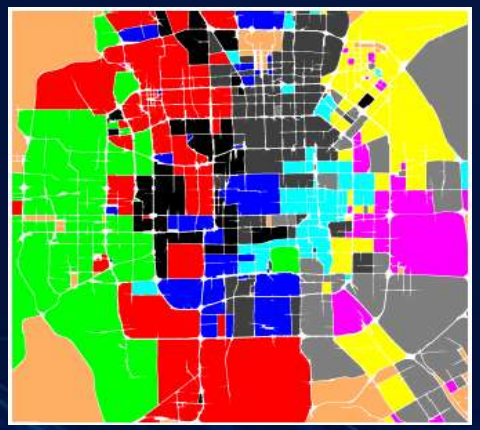


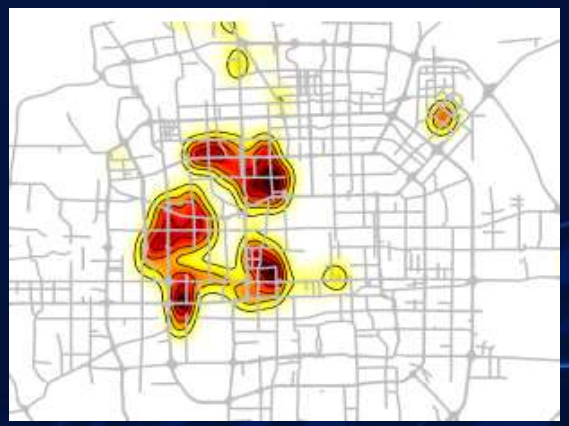
Anomalous Events Detection



Urban Computing for Urban Planning

Discover Regions of Different Functions using Human Mobility and POIs

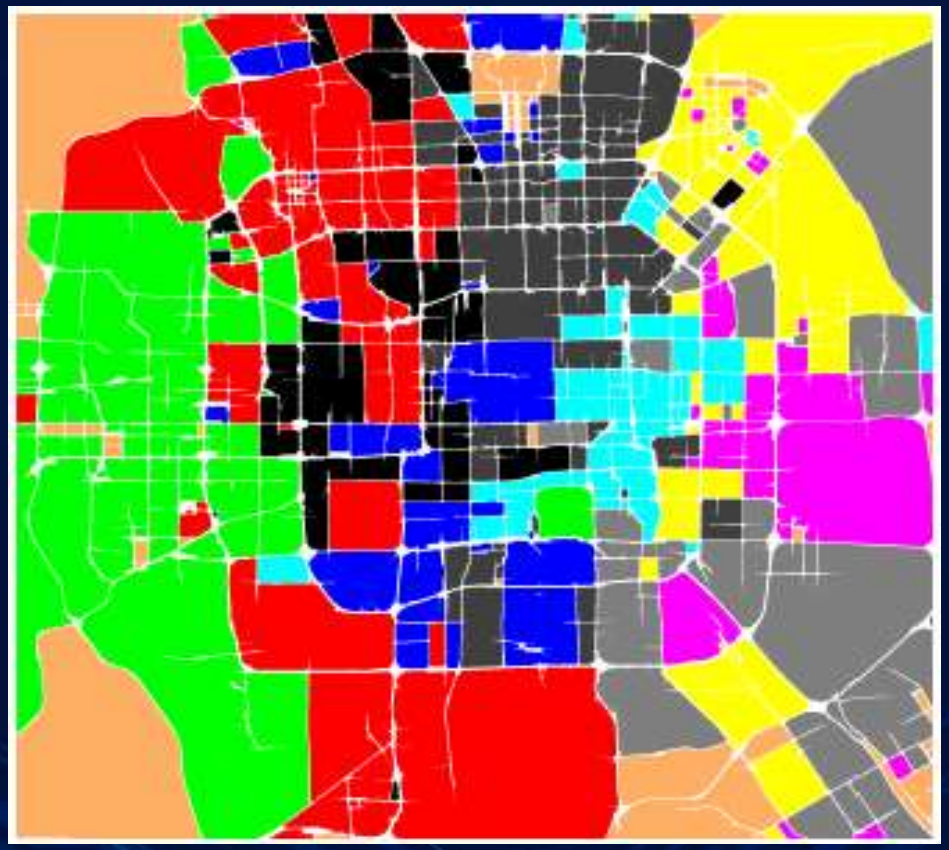




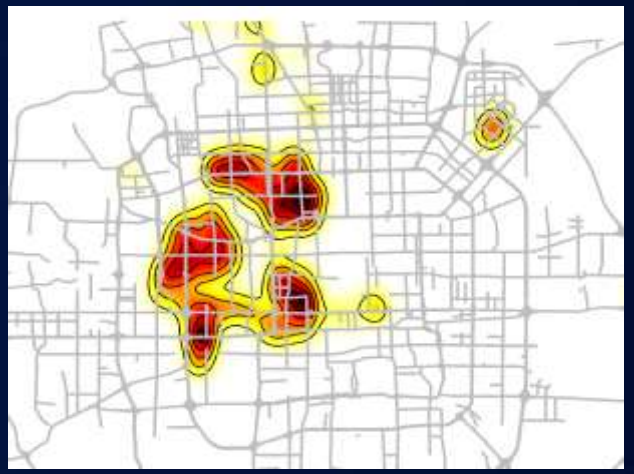
Microsoft Research

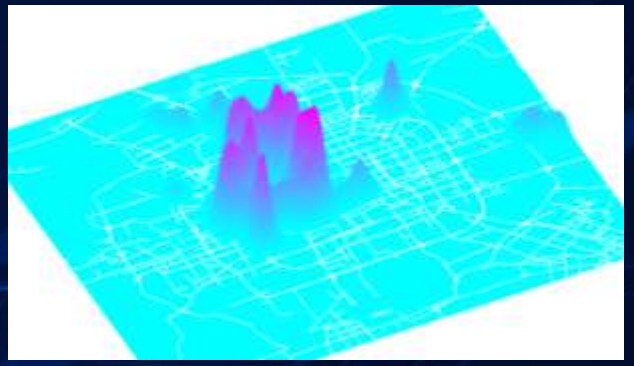
Goals

- Discover regions of different functions in urban areas
- Identify the kernel density of a functionality



Functional Regions



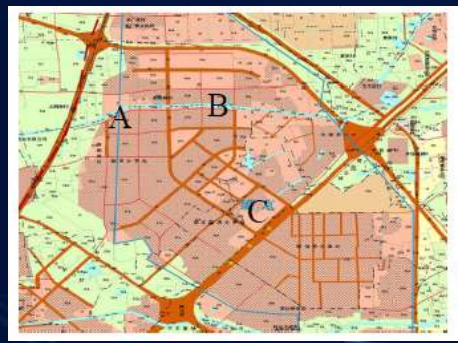


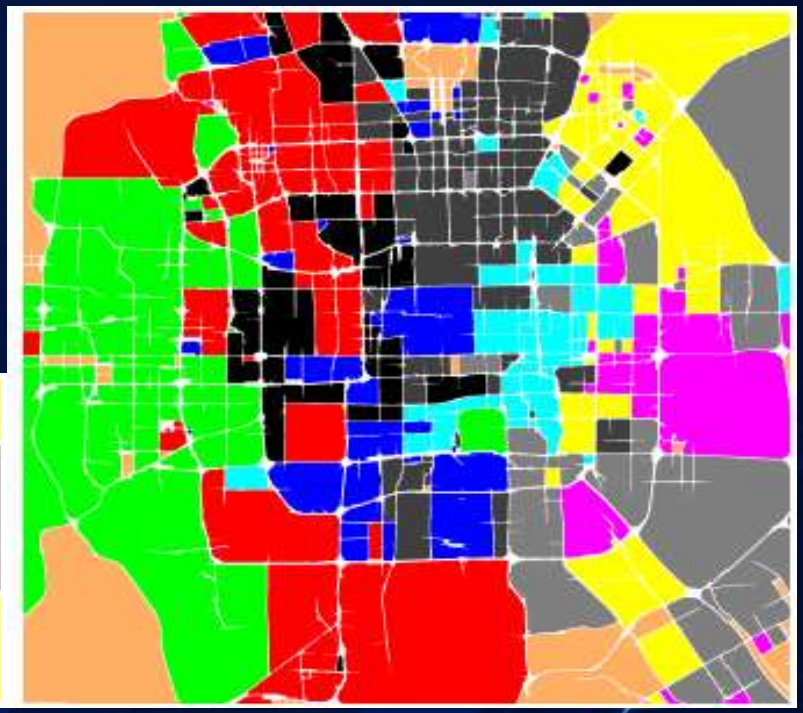
Functionality Density

Microsoft Research

Applications

- Calibrating urban planning
- Business planning
- Advertising





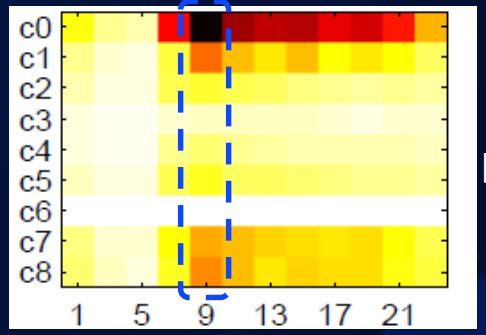
Microsoft Research

Motivation and Challenges

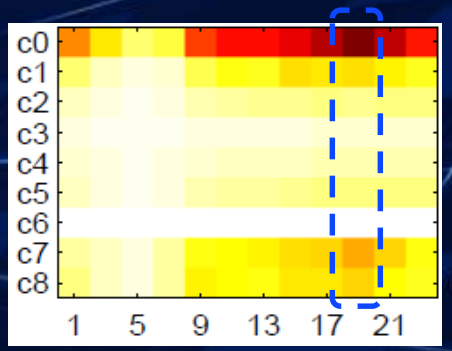
- POIs indicate the function

- But not enough
  - Compound
  - Quality

- Human mobility
  - Differentiate between POIs of the same category
  - Indicates the function of a region



Leaving



Arrival

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Methodology Overview

- Mapping from regions to documents
  - Regions → Documents (*R*)
  - Functions → Topics (*K*)
  - Mobility patterns → Words (*N*)
  - POIs → meta data like keywords and authors
- LDA(Latent Dirichlet Allocation)-variant topic model

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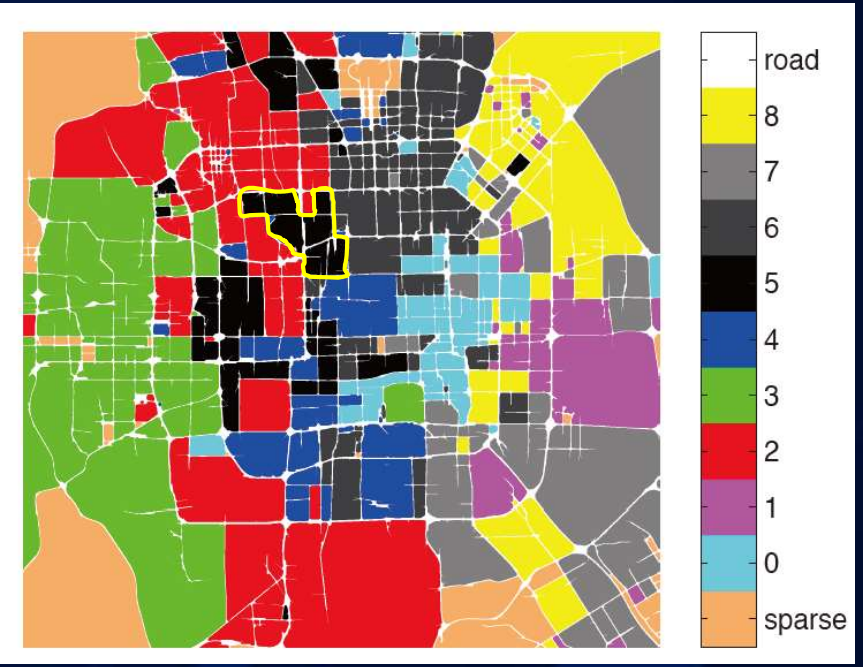
Territory Identification

- Region aggregation
  - Cluster regions according to topic distributions
  - Aggregate individual regions into big territories



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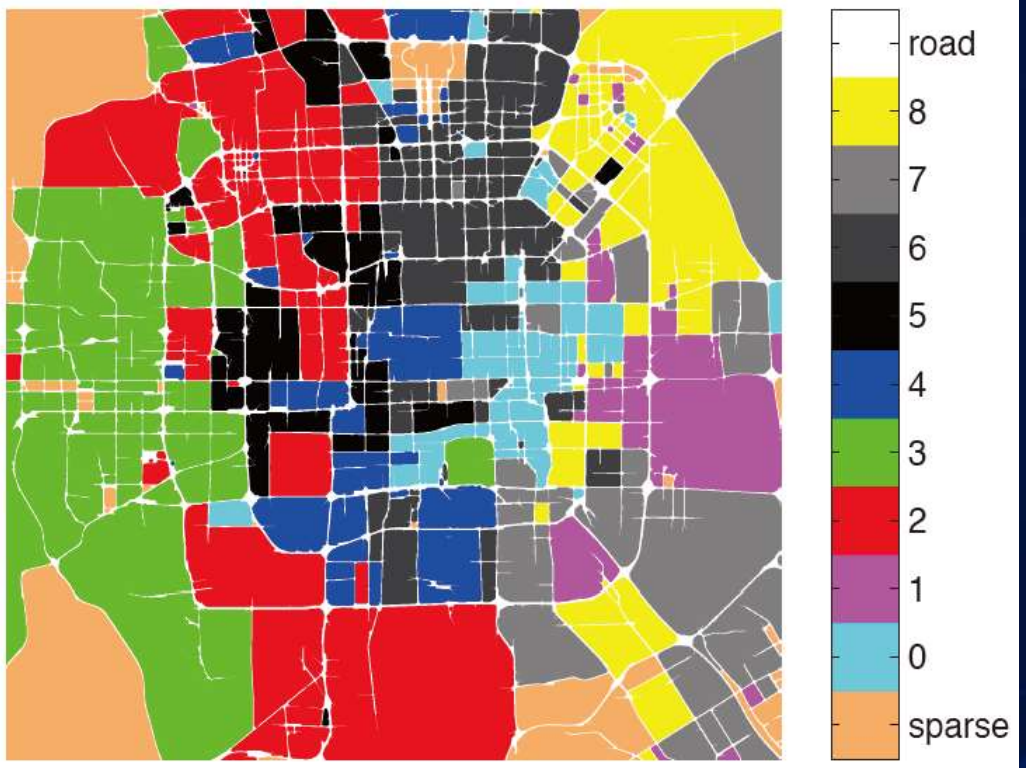
Annotation of Territories



Emerging residential areas

Regions under construction

Developed residential areas

Developed commercial areas

Areas of historic interests

Nature and parks

Education and science areas

Developing commercial areas

Diplomatic and embassy areas

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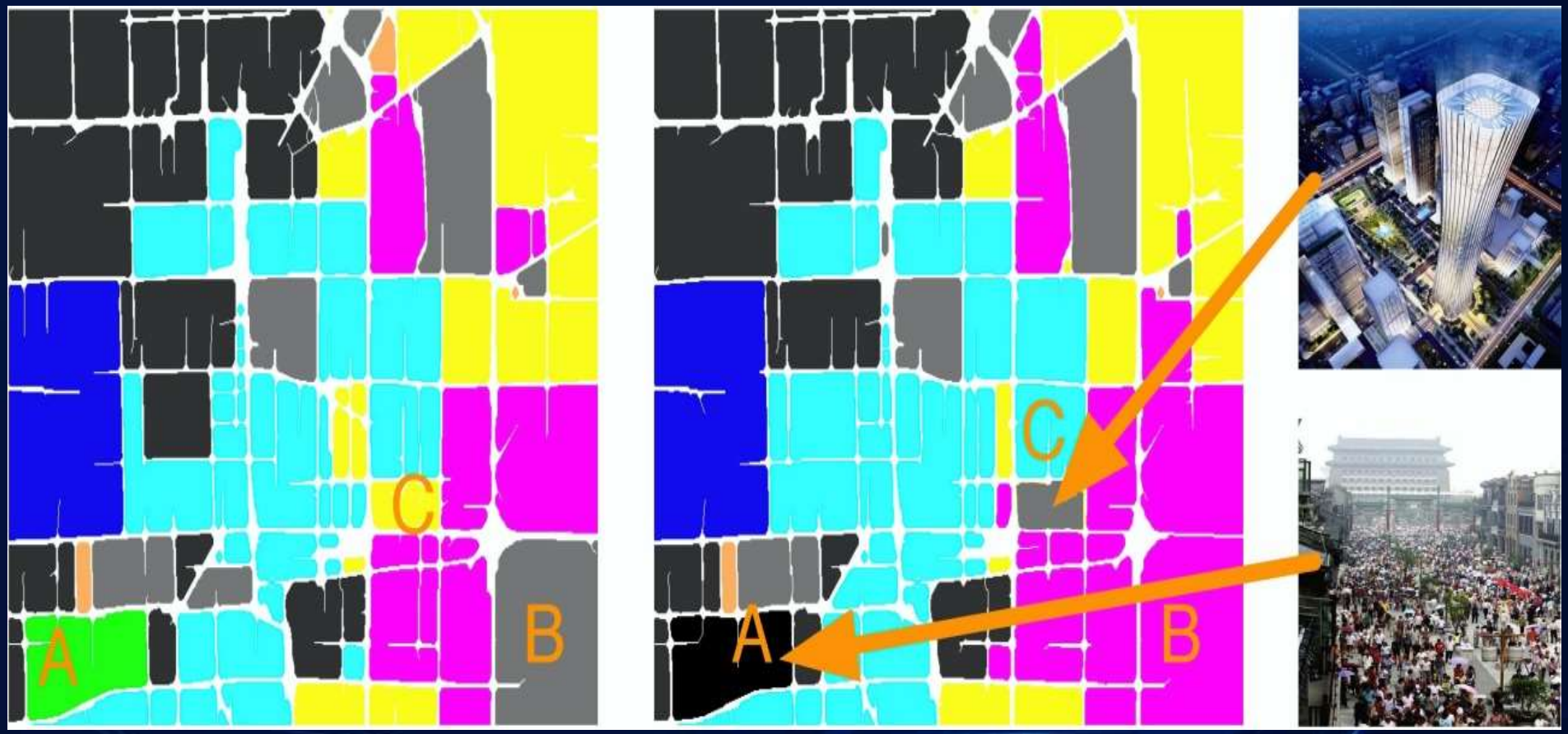
Evaluation

2010

2011



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Research Updates

CS Fundamentals

- Theory papers in SODA, STOC, FOCS, WINE, …
- System & Networking paper in SOSP, SIGCOMM, NSDI, ICSE, Eurosys, Mobicom, Mobisys, Sensys, …
- BSGP – High-level GPU programming language
- Indoor Navigation

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BSGP: Bulk-Synchronous GPU Programming

- High-level programming language
  - Hardware independent
  - Easy to write and maintain
  - Well optimized
- Easy to debug

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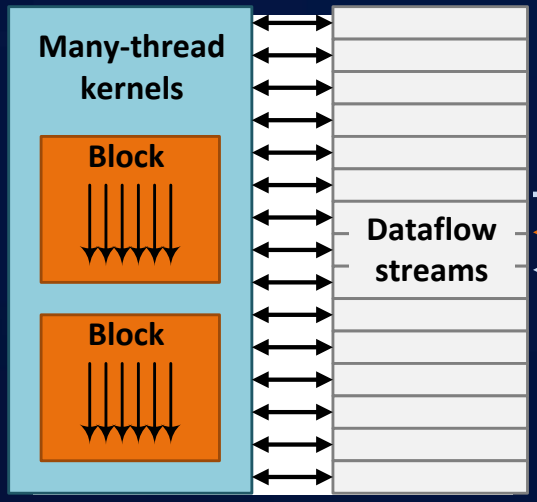
GPUs vs. Programmers

GPU architecture:
stream/kernel

Programmer:
data structure/algorithm

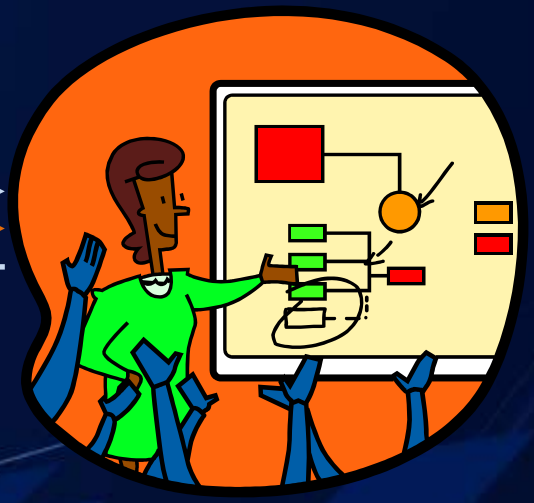


Low level programming:
Direct-compute, CUDA, OpenCL, AMP …

?

High level programming:

BSGP !



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Bulk Synchronous Parallel (BSP)

- First proposed by Leslie G. Valiant (1990)
  - A bridging model for parallel computation
- First CPU implementation by Bill McColl (1997)
  - BSPlib: The BSP Programming Library
- Challenges on GPUs
  - Many-thread computational model on GPUs because of the stream-kernel architecture

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Research on BSGP (2007~now)

- Compiler (ACM TOG 2008)
  - BSGP: Bulk-Synchronous GPU Programming
- Debugger (ACM TOG 2009)
  - Debugging GPU Stream Programs Through Automatic Dataflow Recording and Visualization
- Applications on GPUs (ACM TOG 2008~2012)
  - KD-tree construction
  - Micropolygon ray tracing
  - Hair modeling and rendering
  - …

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Eating Our Own Dog Food (2007~now)

- 20+ new GPU algorithms
  - First KD-tree/Octree construction on GPUs
  - Neural network training
  - Optimization
- System
  - RenderAnts
  - About 50,000 lines of BSGP code, and compiled into about 2,000 CUDA kernels.

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Contribution to Community

- BSGP download
  - Research.microsoft.com download site
  - http://research.microsoft.com/en-us/downloads/283bb827-8669-4a9f-9b8c-e5777f48f77b/default.aspx

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Fast Bootstrapping of Indoor Localization Services

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Motivation

- Growing demand for fine-grained indoor localization
  - Indoor navigation
  - Mobile advertising
  - Mobile social network
  - …

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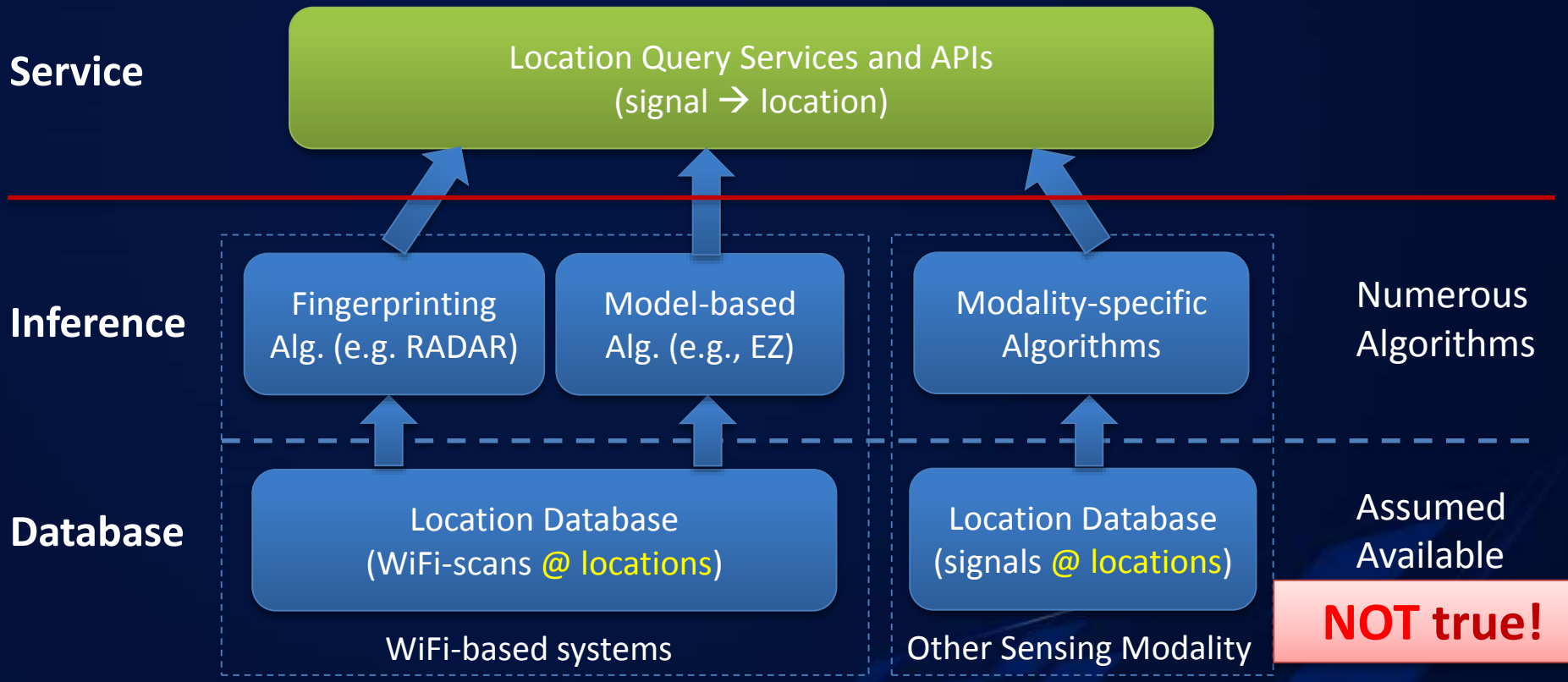
Overall System Architecture



Few indoor localization systems actually deployed!

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Key Problem

- How to efficiently build and maintain the location database?

- Challenges:
  - Data collection: high user involvement
  - Offline processing: noisy or bad data
  - Database maintenance: frequent environment change

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Taxonomy of Data Collection Methods

- Supervised: Tap&Hold
  - Manually locate oneself on map and collect WiFi fingerprint for that spot
- Unsupervised: Walking-based
  - Walking with a survey plan
    - For vendors, may tapping at landmarks (e.g., turns)
    - Good for initial data collection
  - Freestyle walking
    - For ordinary users in their normal use
    - Good for database maintenance, via crowdsourcing

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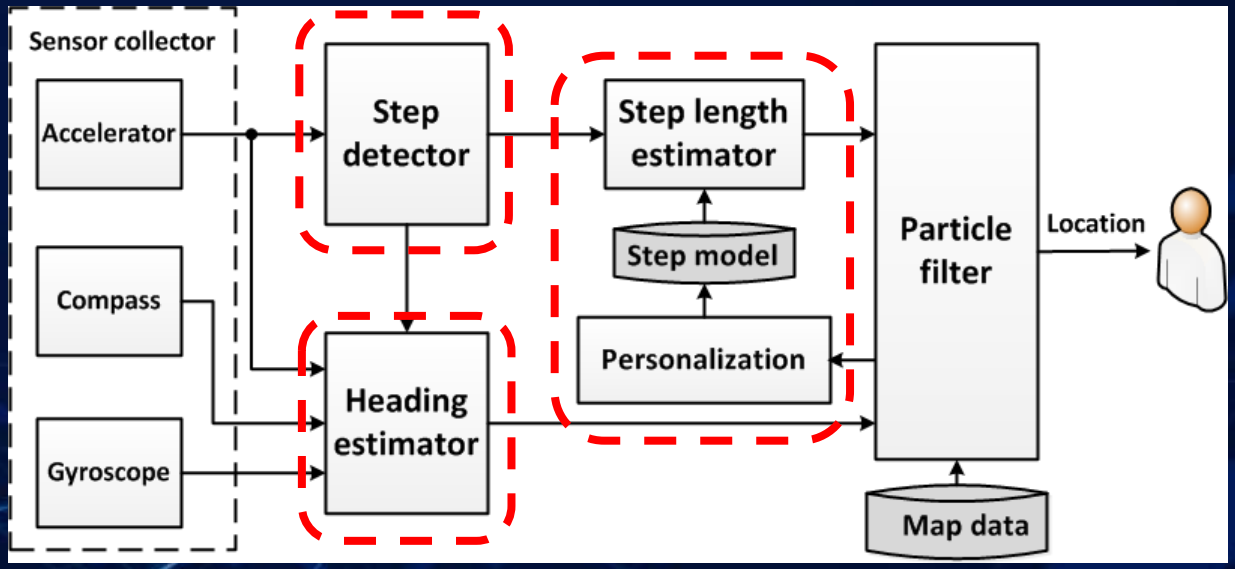
Enabling Walking-based Collection

- Inertial sensor based Dead-Reckoning
  - Robust step detector
  - Robust heading estimator
  - Accurate, personalized step length model



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Walking with a Survey Plan

- Problem: Noisy sensor data
- Solution: Robust turn detection algorithm

Survey plan

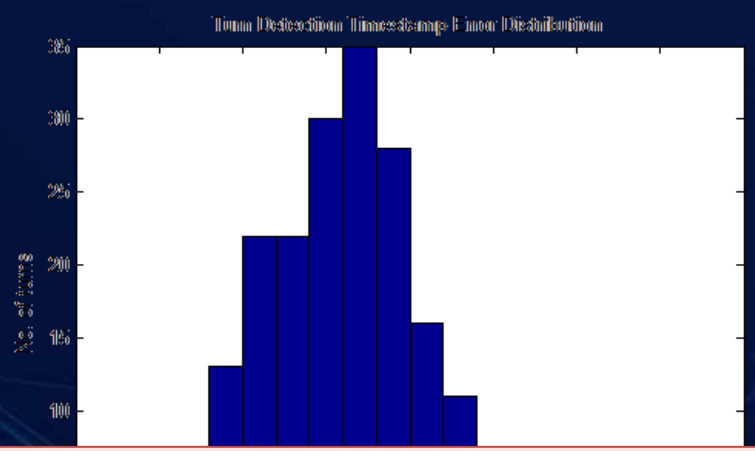
Raw sensor data

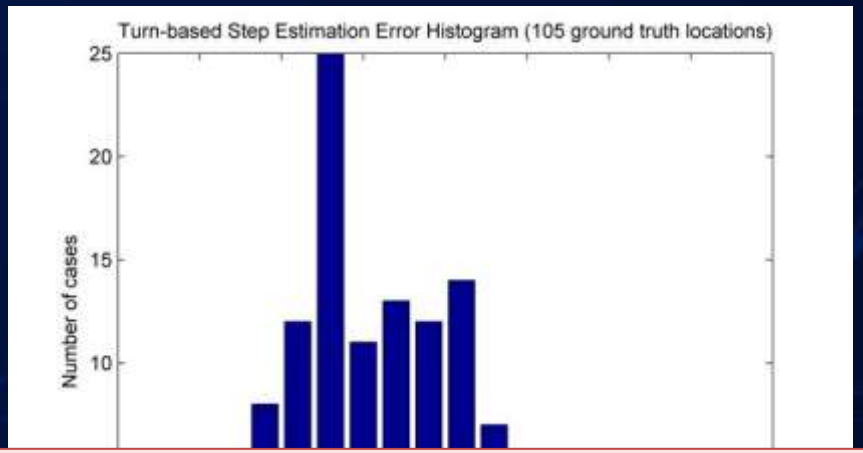
Rectified results

Research

Accuracy of Turn Detection

Path/Trace list	# of Effective turns	# of Detected turns	Detected Turn Position Error (mean / min / max)
1st	18	18	**1.07**, 0.25, 2.24 (seconds)
2nd	9	9	**1.17**, 0.22, 2.38 (seconds)
3rd	9	9	**1.23**, 0.41, 2.50 (seconds)
4th	4	4	**0.91**, 0.58, 2.40 (seconds)

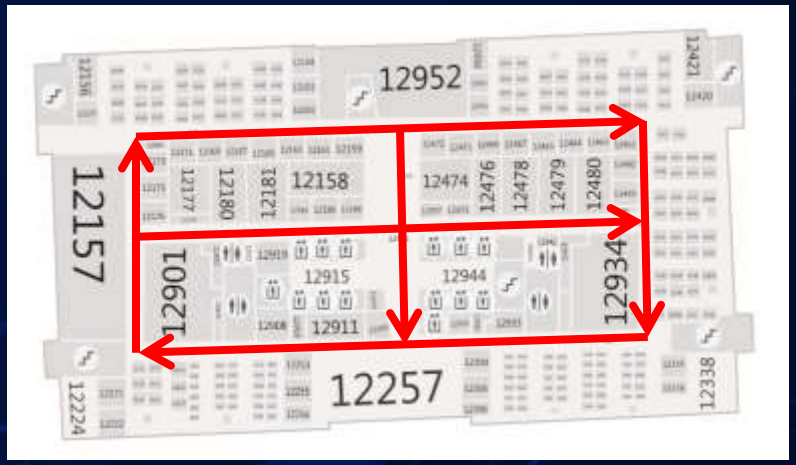




Average step position error: 1.1 m

Comparing Data Collection Methods: End-to-End Evaluation

- Training datasets
  - Tap & hold
    - 45 points in 35 minutes
  - Walking
    - 1809 points in 35 minutes
- Test data set
  - 3288 points



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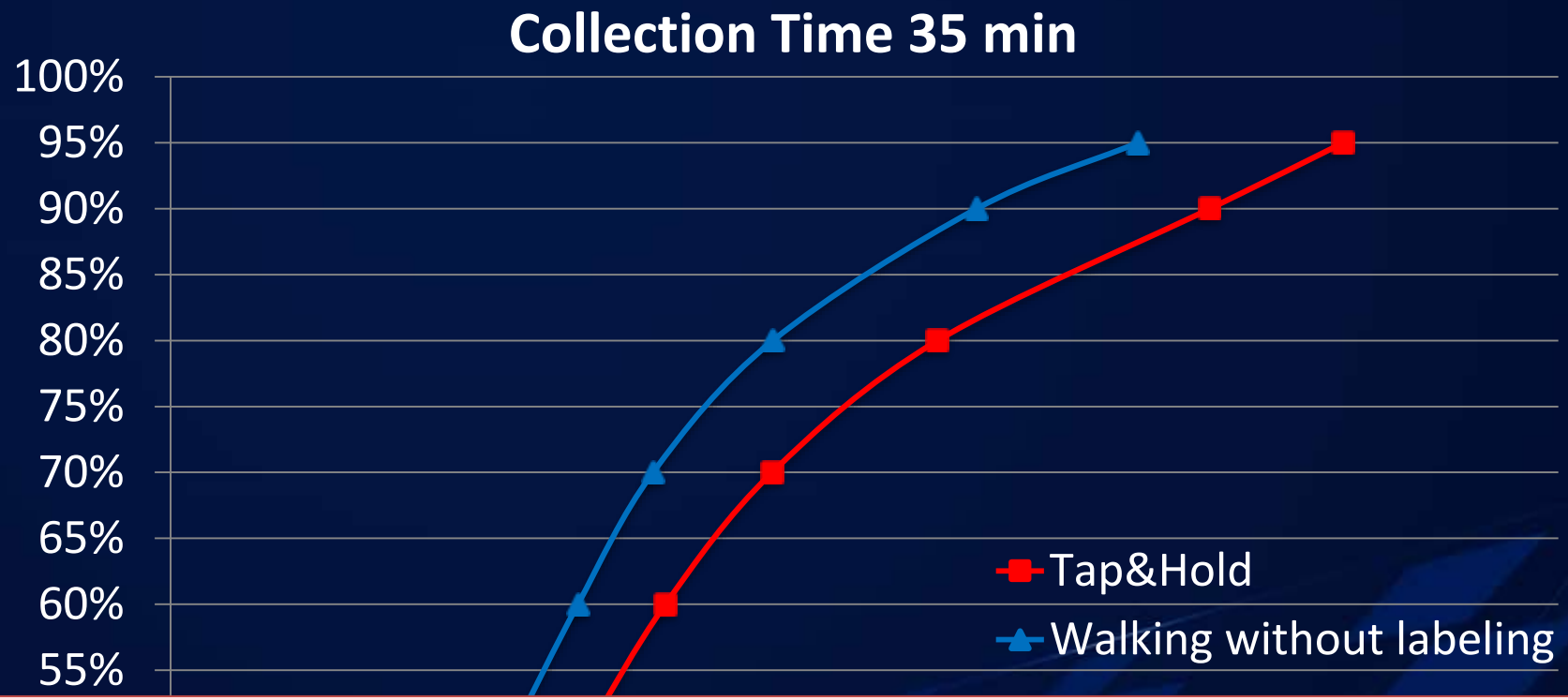
End-to-end Evaluation*



Plain walking outperforms Tap&Hold,
with much less user effort and much higher data yield.

Data Collection with Freestyle Walking

- Challenges
  - Unplanned paths: requiring path detection
  - Phone usage diversity: error-prone DR results
- Solutions:
  - Trace-back via backward propagation in PF
  - Location refinement via overall trace rectification
    - Match traces to map, by landmarks (e.g., turns)

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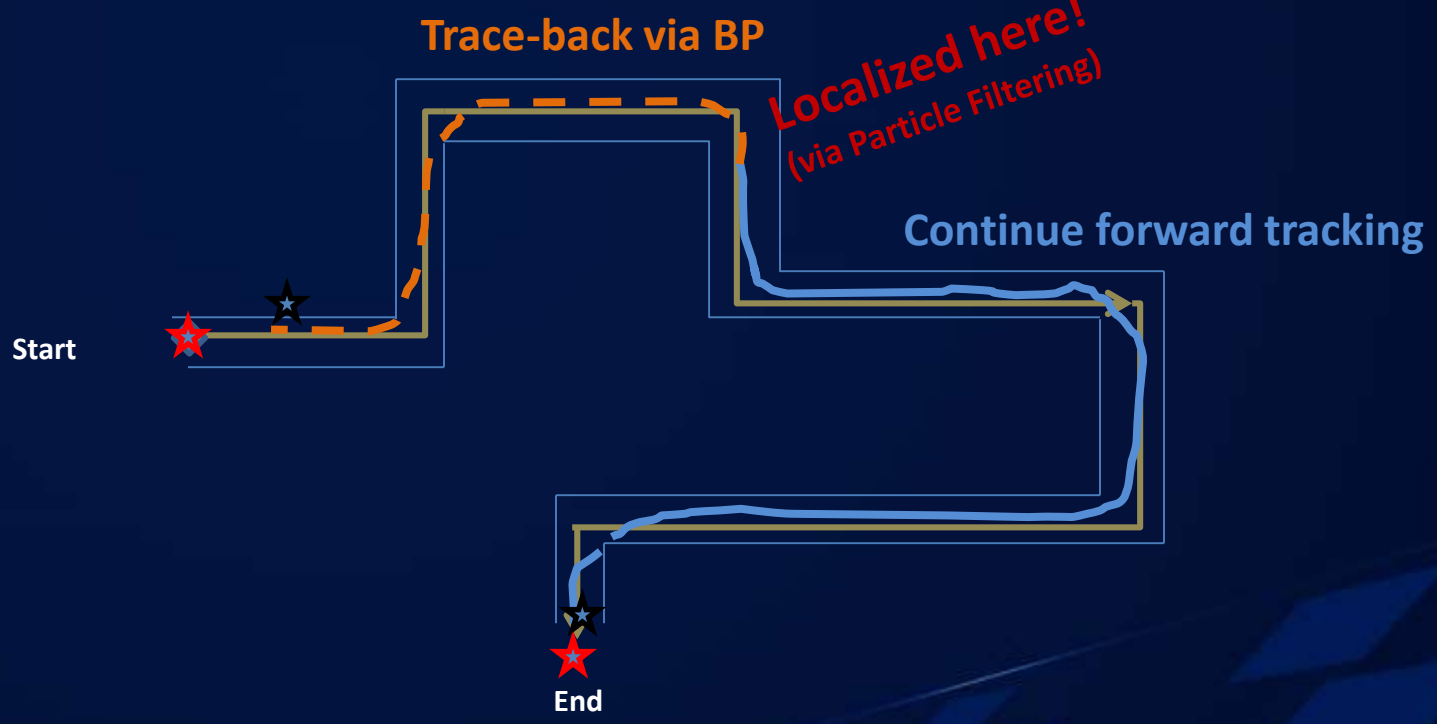
An Illustrative Example



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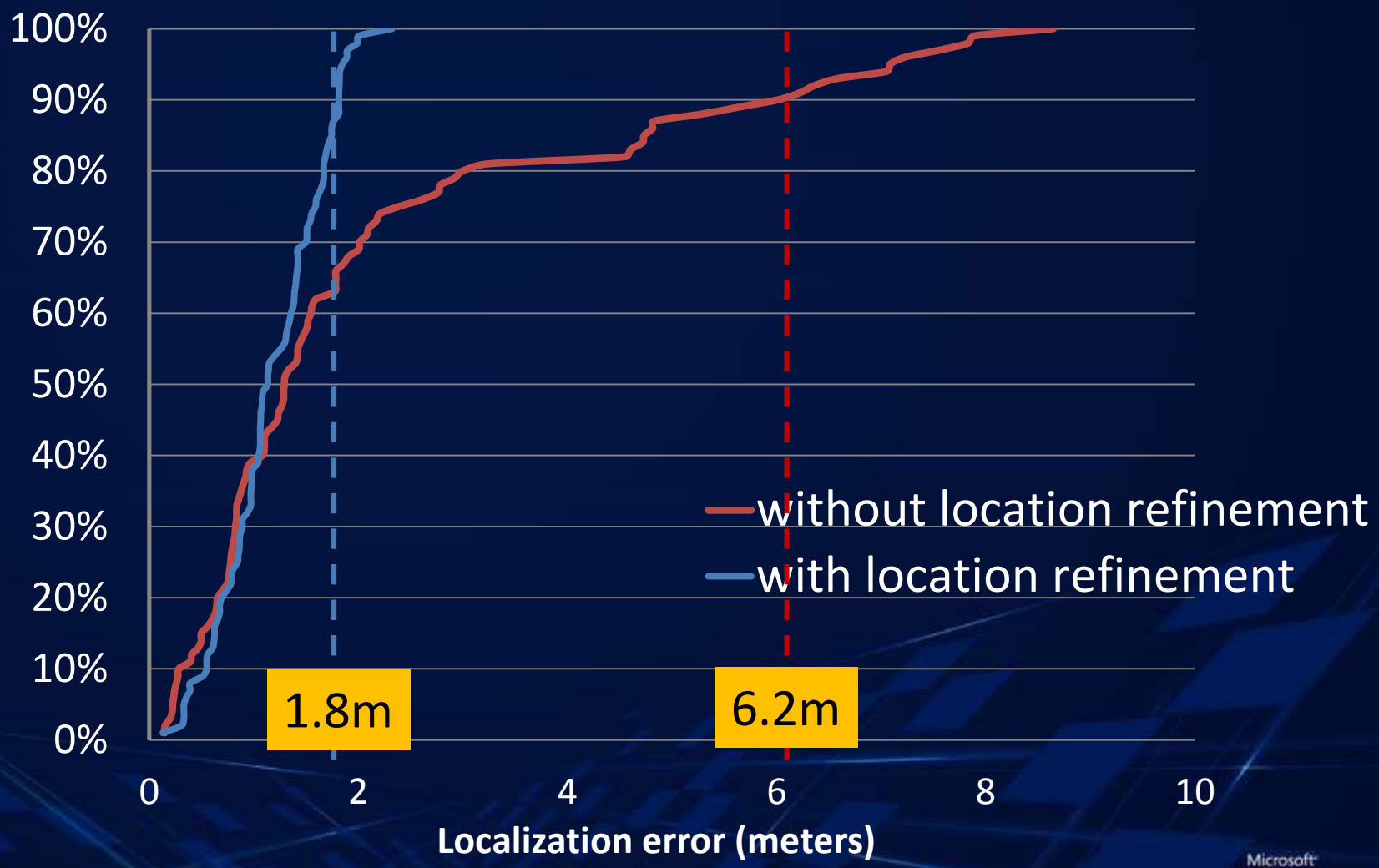
Accuracy under Freestyle Walking



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Conclusion

- MSRA follows the same missions after 14 yrs
  - Advance the state of the art
- We are expanding our research areas
  - Systems & networking, HCI, Haptics,…
- We love to collaborate with you as usual
  - Please visit us often & give us feedback
- Let’s work together

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THANK YOU

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