Briefing

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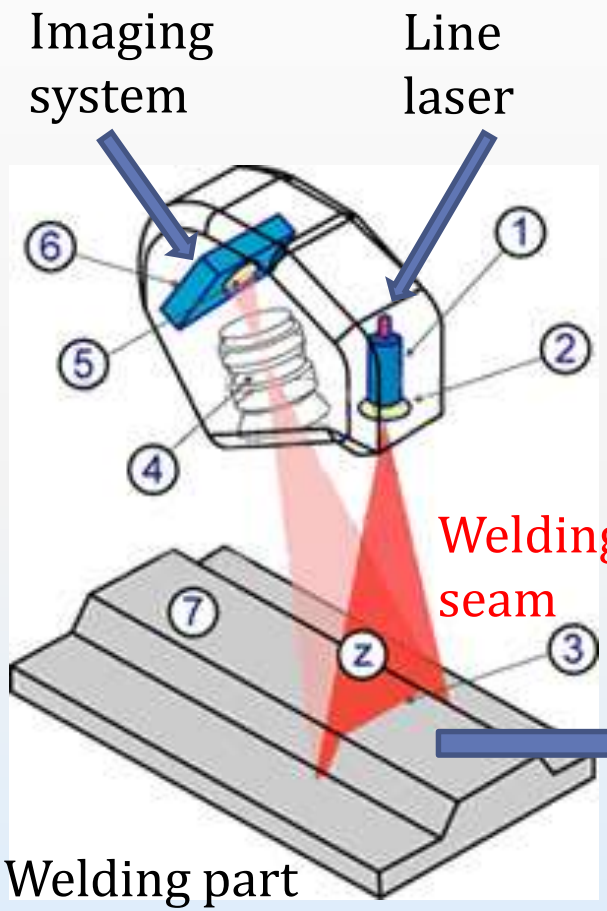
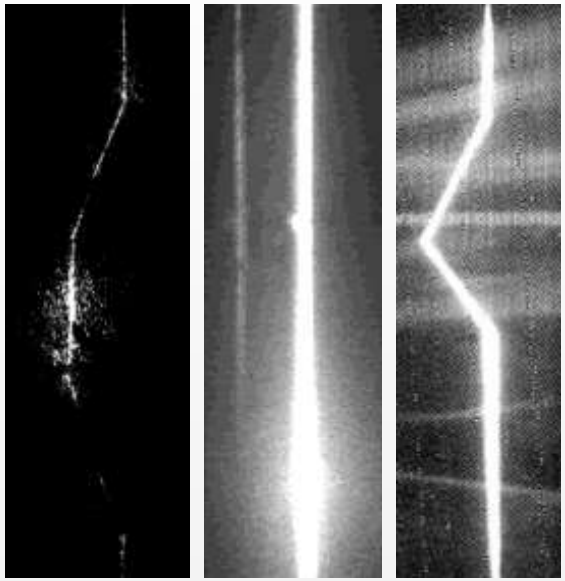
- Research Interests（computer vision）
  - **Low complexity image processing algorithms**
  - **Image based personal authentication**

Low complexity image processing algorithms

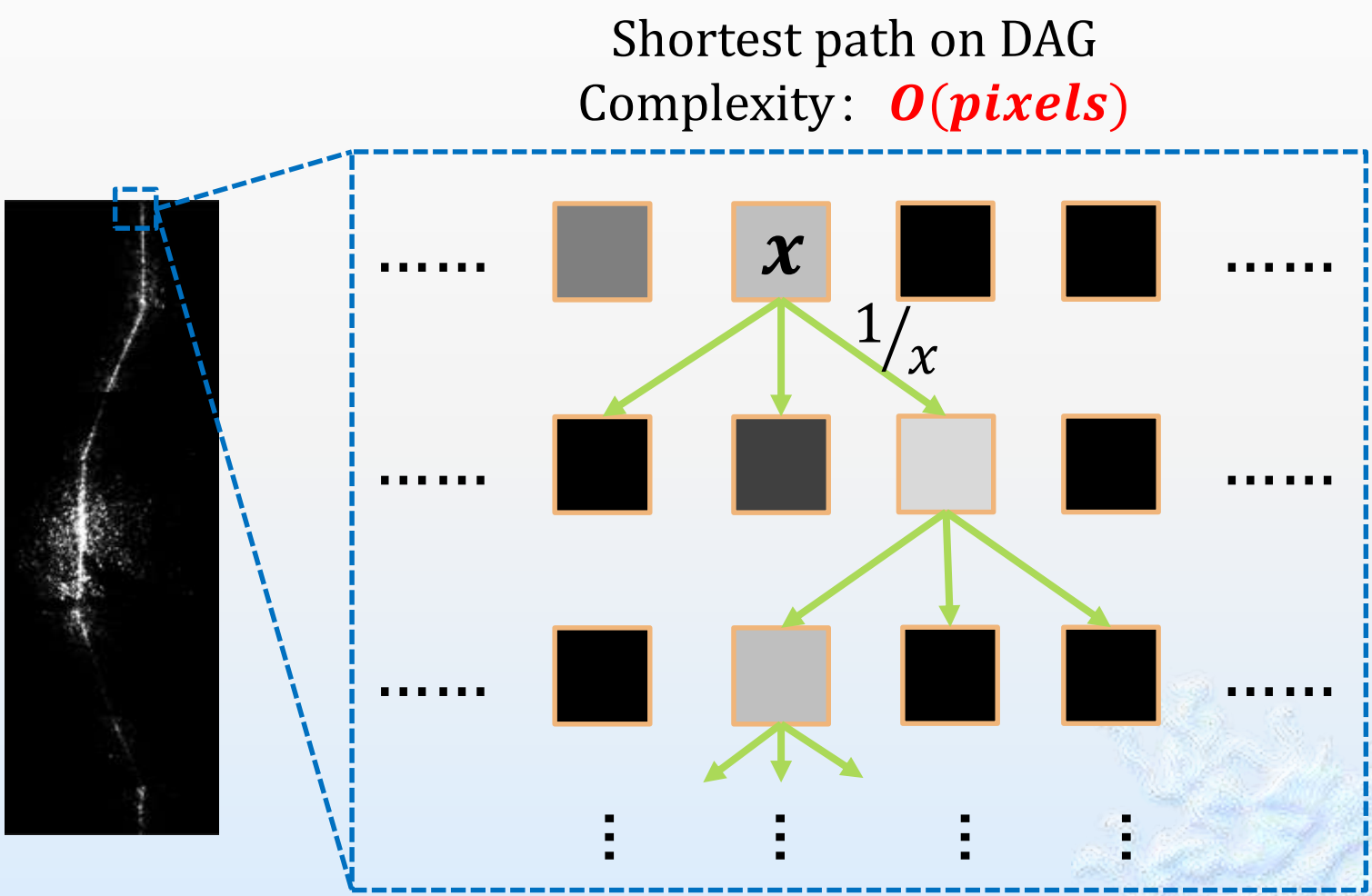
- *Efficient welding seam tracking*





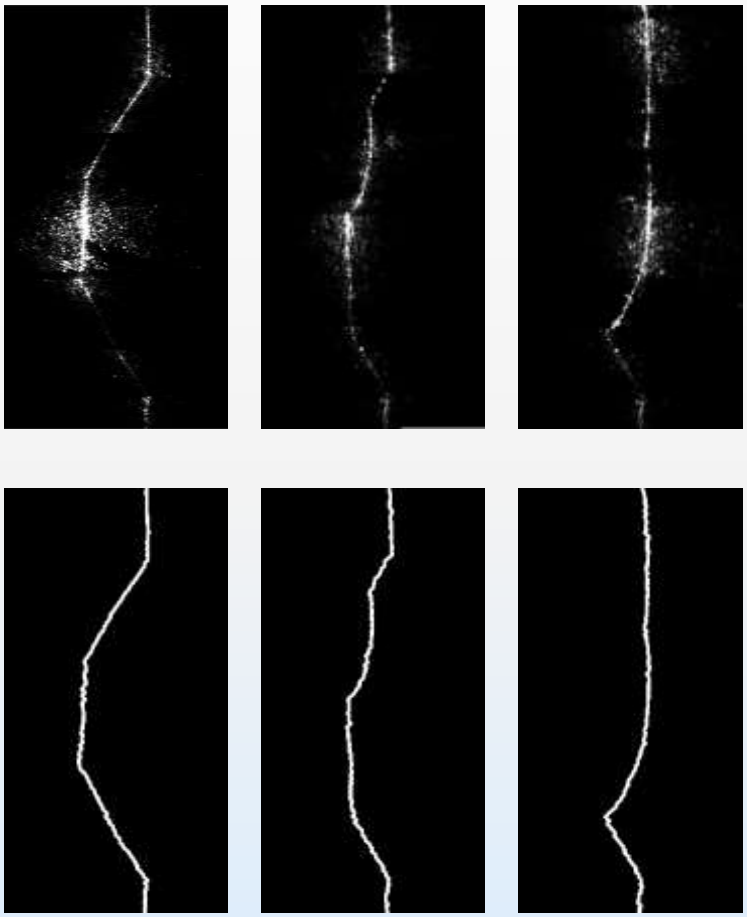
Low complexity image processing algorithms

- *Efficient welding seam tracking*

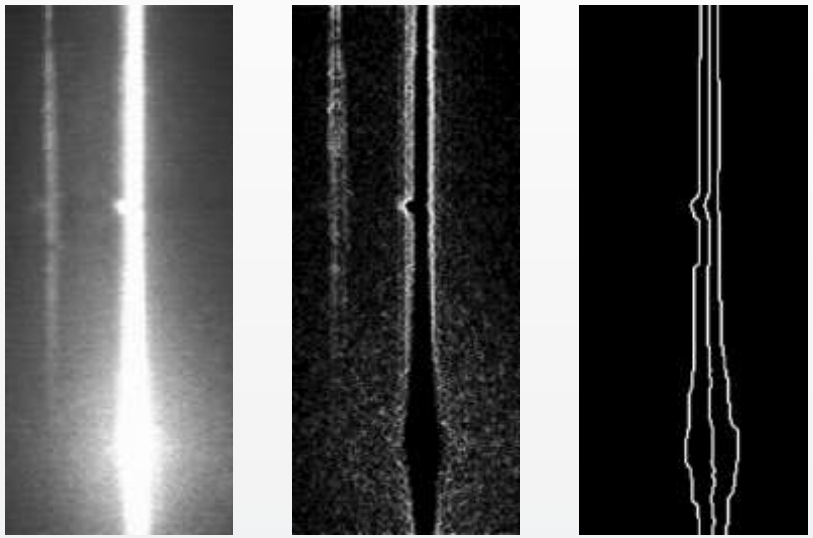


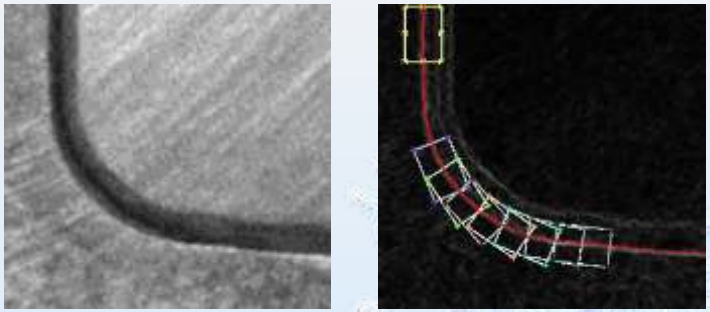
Low complexity image processing algorithms

- *Efficient welding seam tracking*



gradient

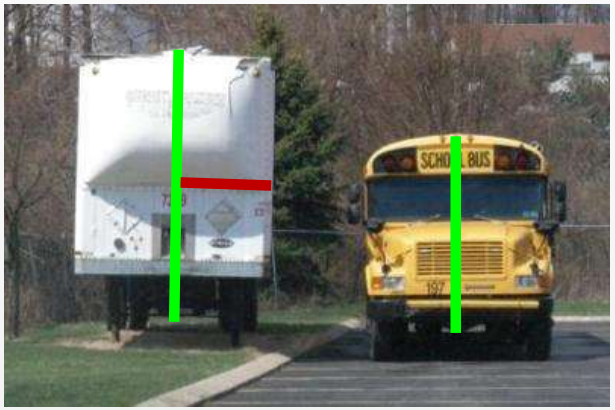




***J.S. Chen**, et. al.,* Robust Welding Seam Tracking using Image Seam Extraction, *Sci. and Tech. of Weld. and Join. 2012*

Low complexity image processing algorithms

- *Image symmetry detection using longest palindromic substring (LPS) detection*



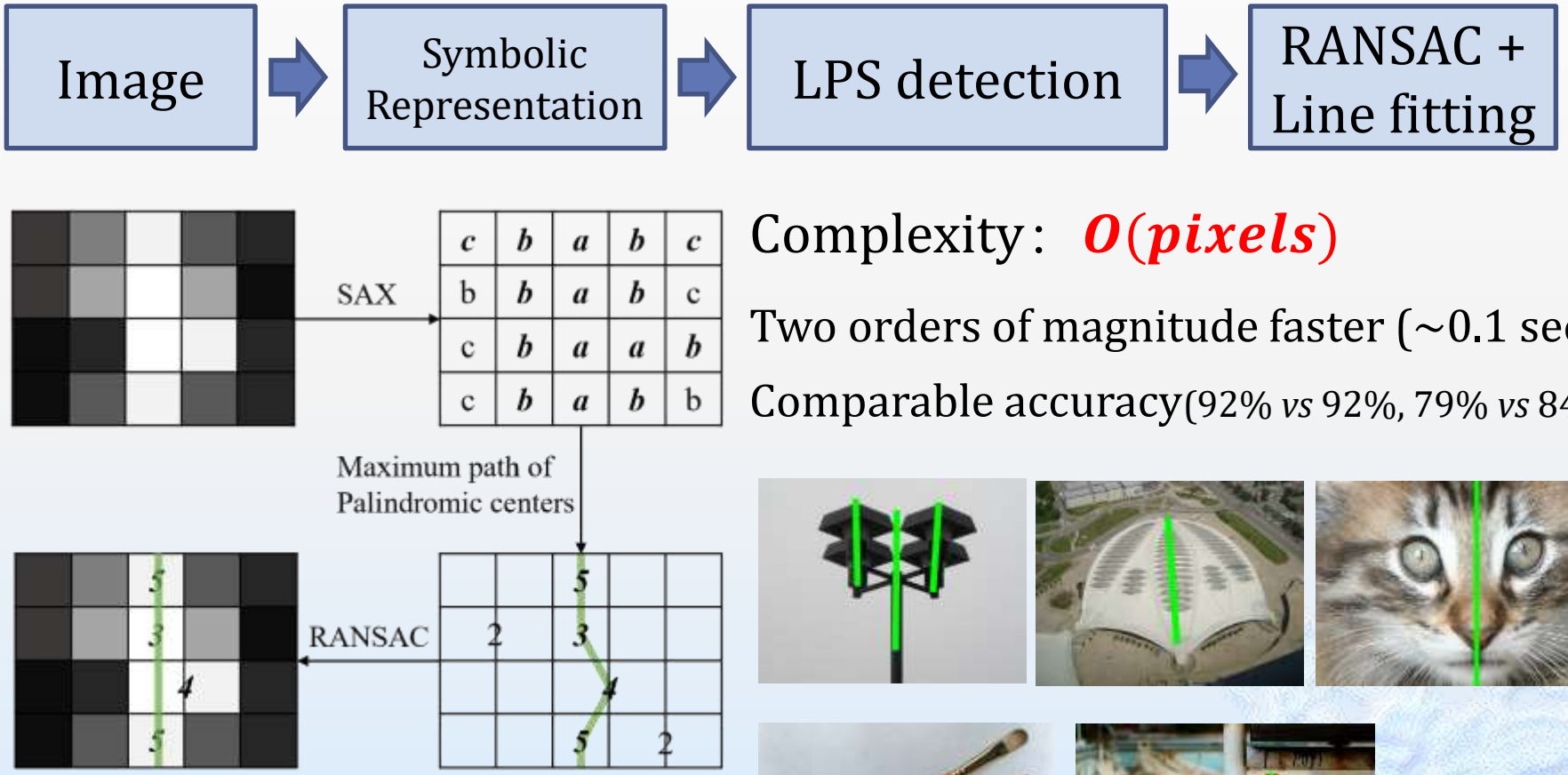
LPS: E F C B D B C A E

SVEUGJVABEQTQLOHTERRETHOLQTQEBAVJGBPQT

Manacher Algorithm('94) : $\boldsymbol{O(n)}$!

Low complexity image processing algorithms

- *Image symmetry detection using LPS detection*



Complexity: $O(pixels)$

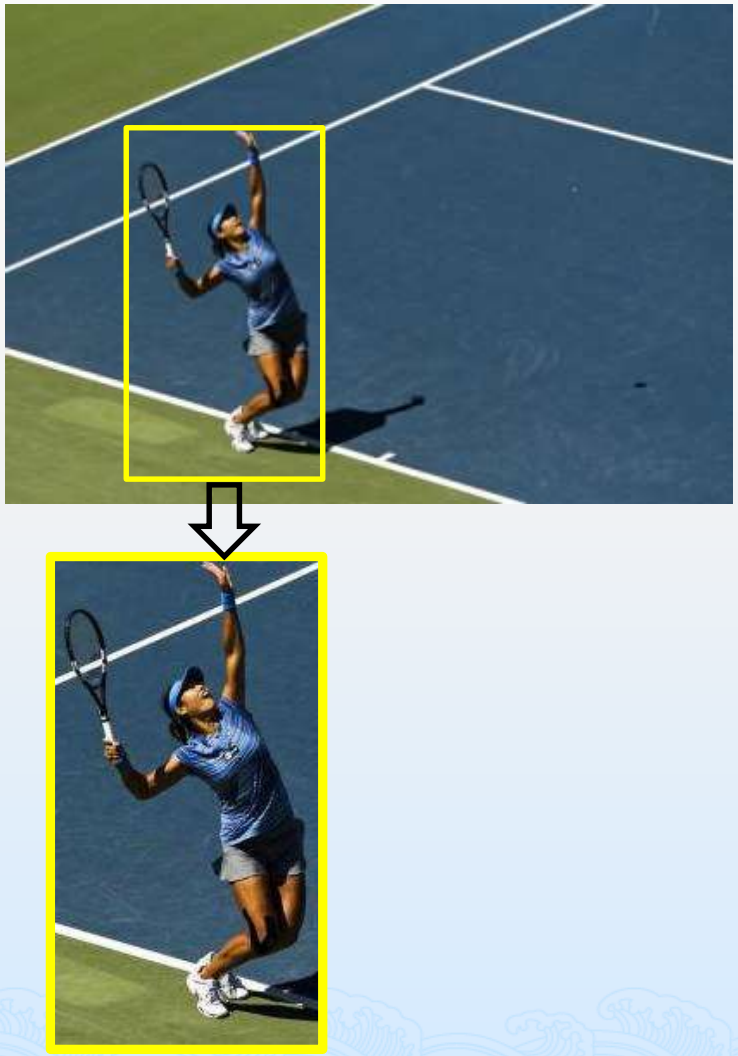
Two orders of magnitude faster (~0.1 sec)

Comparable accuracy(92% *vs* 92%, 79% *vs* 84%)

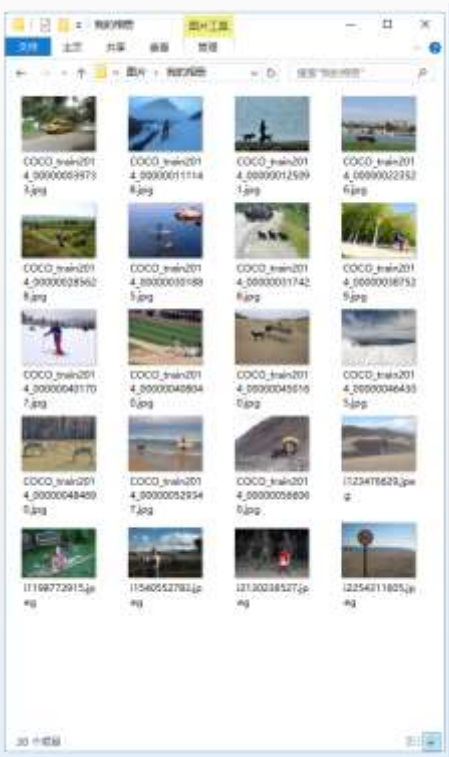
S.H. Liang, ***J.S. Chen***, *et. al.*, Linear Time Symmetric Axis Search Based on Palindrome Detection, *ICIP'16*

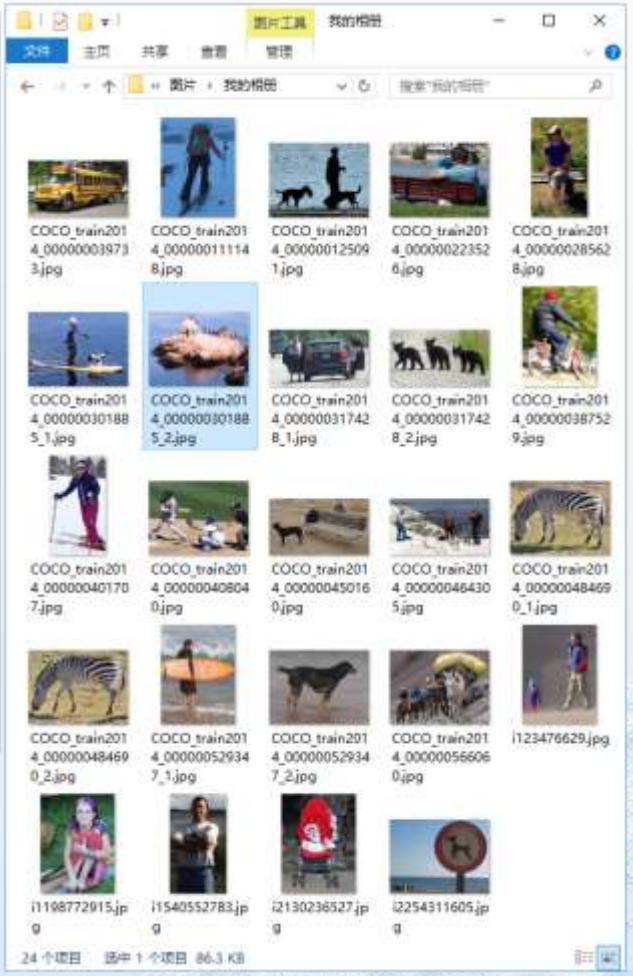
Low complexity image processing algorithms

- *Automatic image cropping/thumbnailing*



Content aware thumbnailing





Low complexity image processing algorithms

- *Automatic image cropping/thumbnailing*

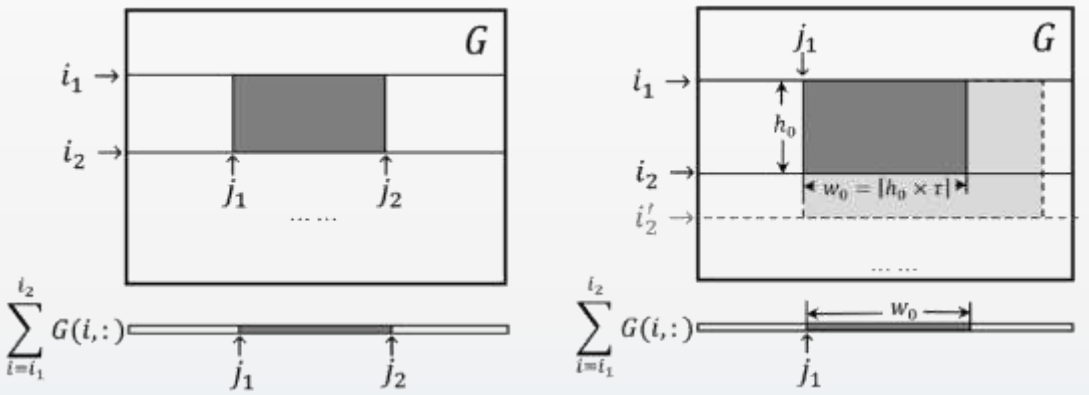
Matrix minimum coverage problem: locating the smallest area rectangle with enough summed value

Algorithm 4 $Fixed\_AspRatio\_Rectangle(G, \tau, r)$

Input: G is a non-negative attention map with size $m \times n$; τ is the percentage of total attention to be preserved; r is the aspect ratio of cropping rectangle; suppose integral maps G^+ and G_c^+ are calculated.

Output: The smallest rectangle $\hat{R}$ with aspect ratio r that satisfies (1); four values to define $\hat{R}$: i and j are the upper left corner coordinates, w and h are the width and height.

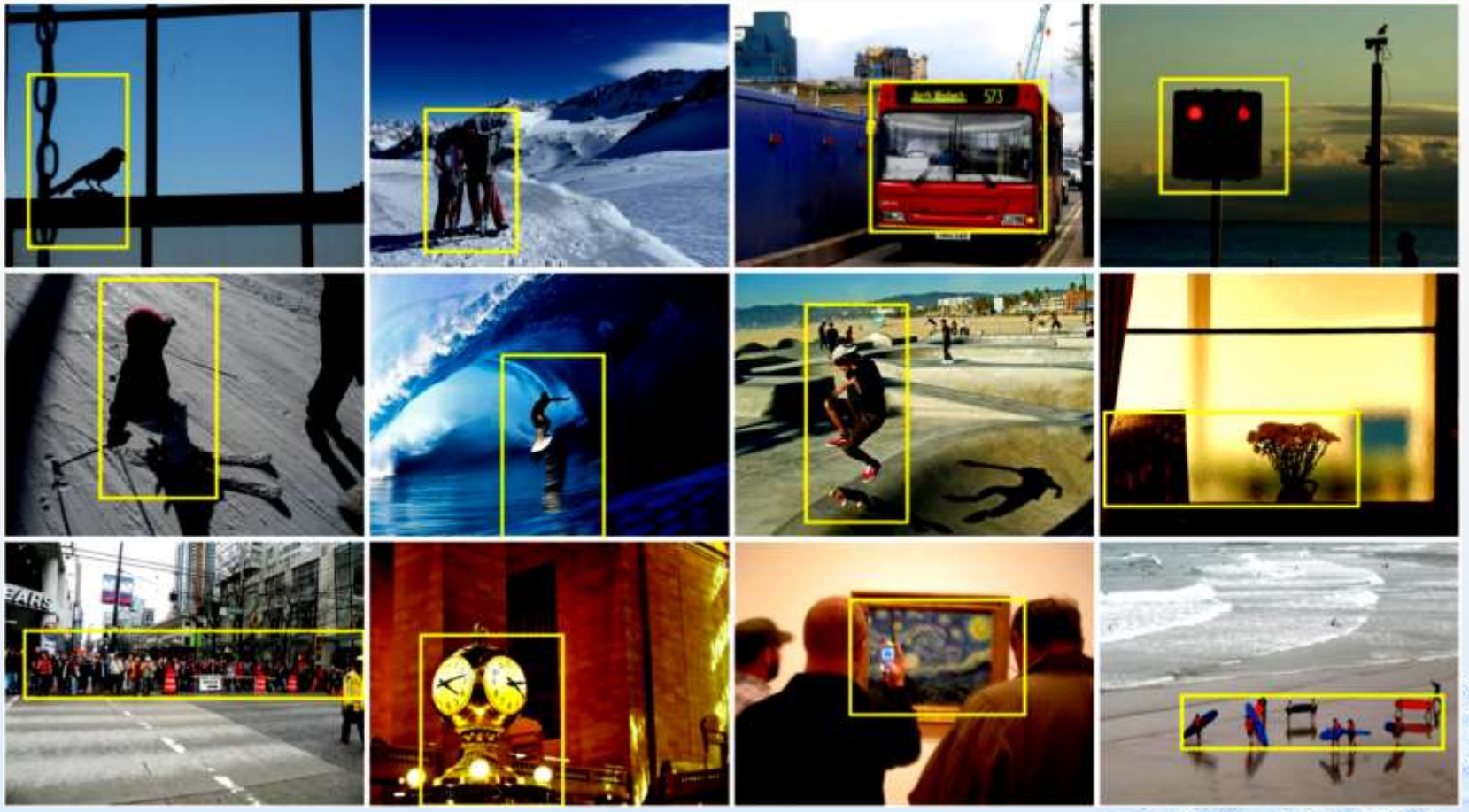
$i \leftarrow 0, j \leftarrow 0, w \leftarrow \infty, h \leftarrow \infty$
$i_1 \leftarrow 1, i_2 \leftarrow 1, T \leftarrow \tau G^+(m,n), S_{min} \leftarrow -1$
repeat
  $h_0 \leftarrow i_2 - i_1 + 1, w_0 \leftarrow \lceil h_0 \times r \rceil$
  if $w_0 > n$ **then**
    $i_1 \leftarrow i_1 + 1$
  else
    $\hat{a} = G_c^+(i_2,:) - G_c^+(i_1 - 1,:)$
    $j_1, S_0 \leftarrow maxSubarrayFL(\hat{a}, w_0, T)$
    if $j_1 > 0$ **then**
      if $w_0 h_0 < wh \vee (w_0 h_0 = wh \wedge S_0 > S_{min})$ **then**
        $i \leftarrow i_1, j \leftarrow j_1, w \leftarrow w_0, h \leftarrow h_0$
        $S_{min} \leftarrow S_0$
      end if
      $i_1 \leftarrow i_1 + 1$
    else
      $i_2 \leftarrow i_2 + 1.$
    end if
  end if
until $i_2 > m \wedge i_1 \geq m$
return i, j, w, h



The computational complexity can be as low as $\boldsymbol{O(pixels)}$ given the target aspect ratio !

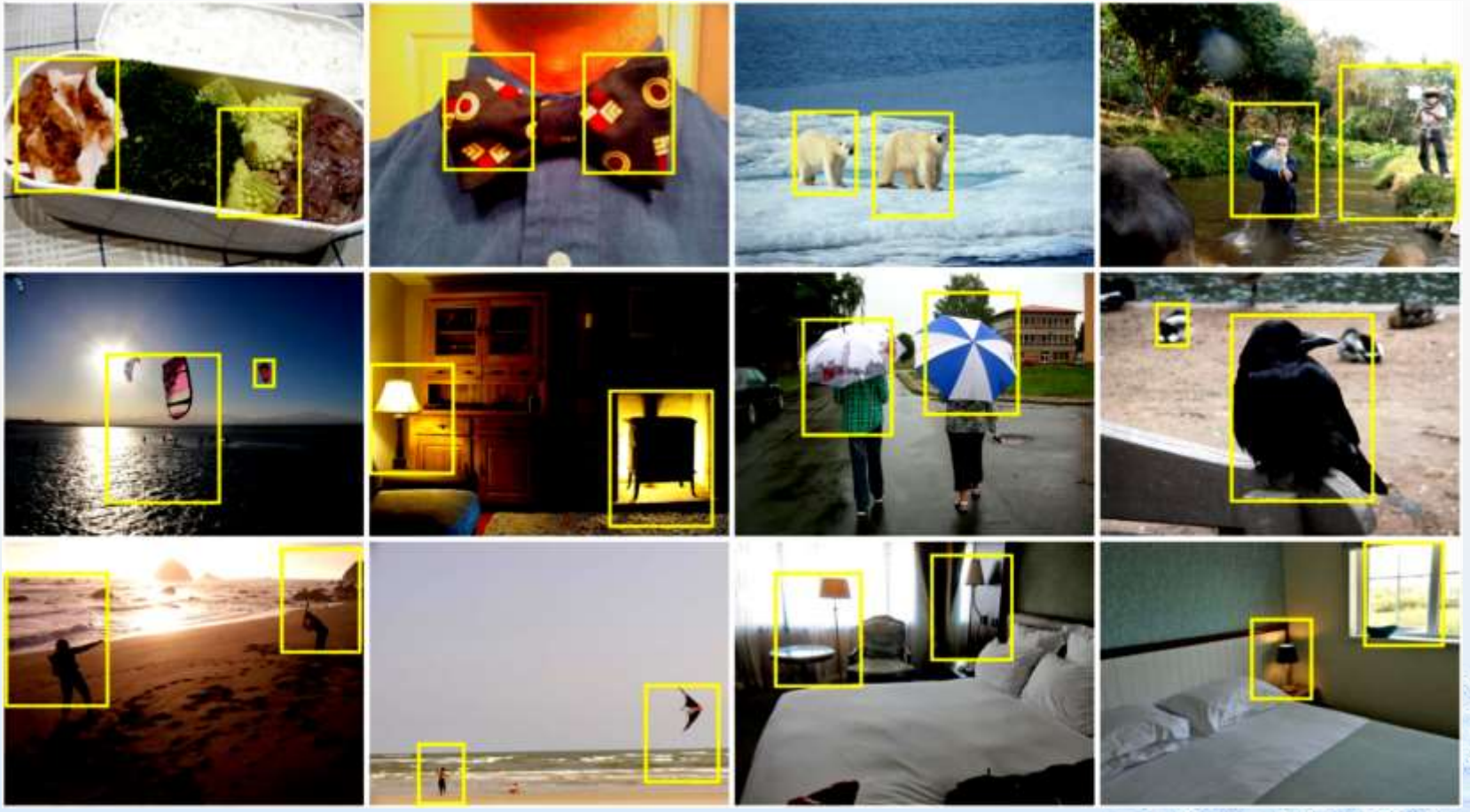
Low complexity image processing algorithms

- *Automatic image cropping/thumbnailing*



Low complexity image processing algorithms

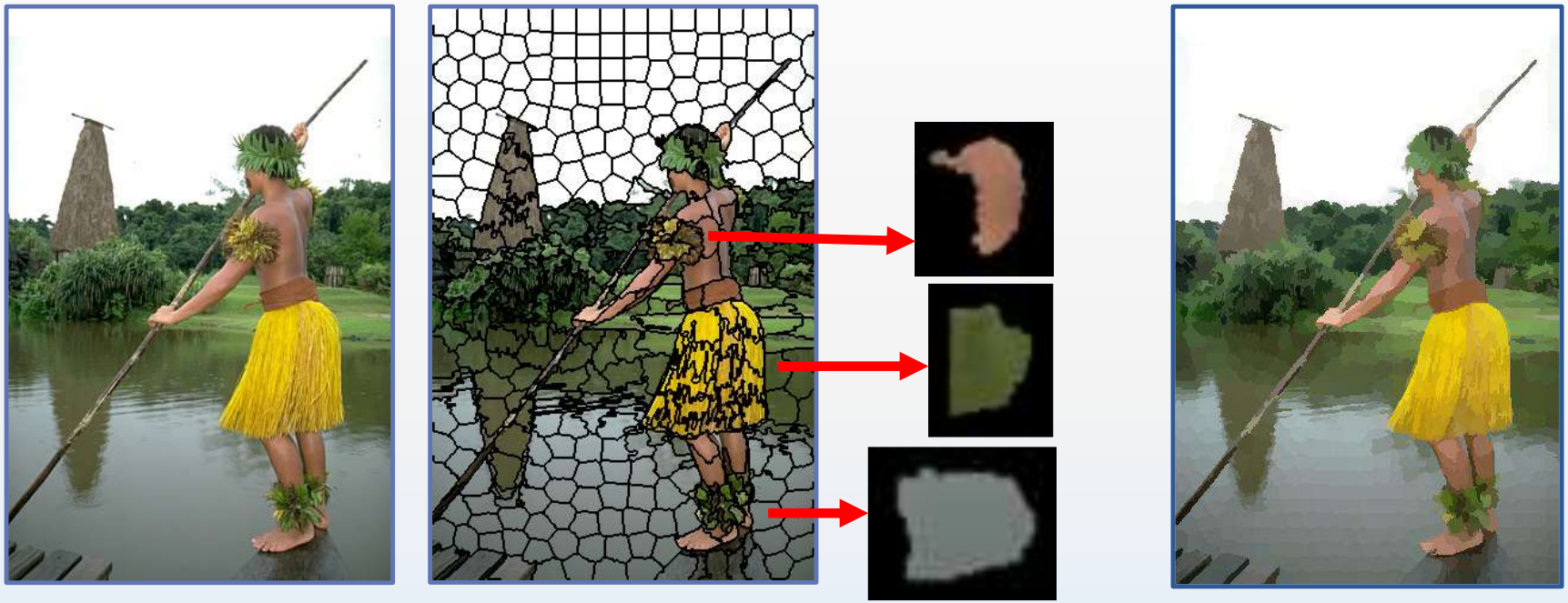
- *Automatic image cropping/thumbnailing*



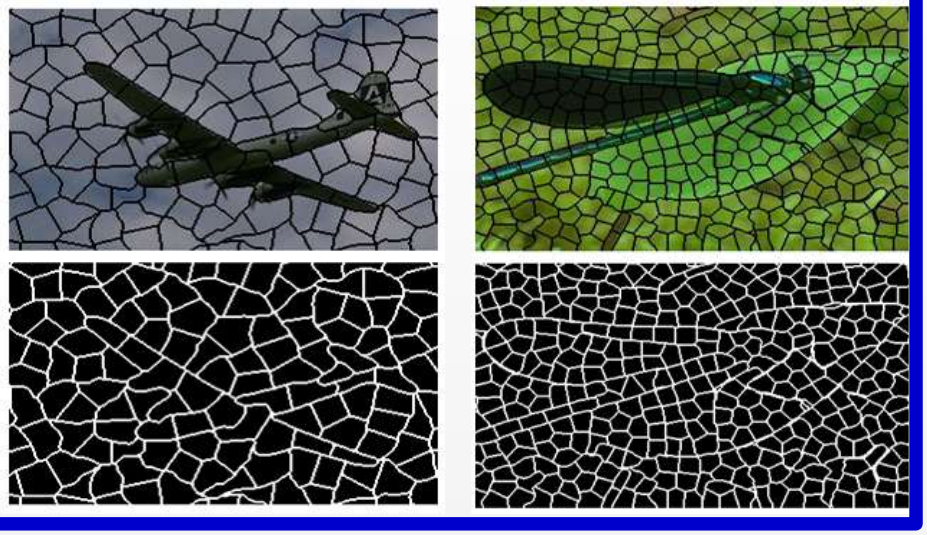
***J.S. Chen**, et. al.,* Automatic Image Cropping: A Computational Complexity Study, *CVPR'16*

Low complexity image processing algorithms

- Linear spectral clustering superpixel



Low complexity image processing algorithms



$$\sum_{k=1}^{K} \frac{\sum_{\boldsymbol{p}\in\pi_k} \sum_{\boldsymbol{q}\in\pi_k} w(\boldsymbol{p})\phi(\boldsymbol{p}) \cdot w(\boldsymbol{q})\phi(\boldsymbol{q})}{\sum_{\boldsymbol{p}\in\pi_k} w(\boldsymbol{p})}$$

Global methods

Preserving global image structure, high superpixel compactness;

high complexity $\boldsymbol{O(pixels^{1.5})}$, low boundary adherence.

Local methods

High boundary adherence, low complexity $\boldsymbol{O(pixels)}$;

Poor global structure, low superpixel compactness

$$\sum_{k=1}^{K} \sum_{\boldsymbol{p}\in\pi_k} w(\boldsymbol{p}) \| \phi(\boldsymbol{p}) - \frac{\sum_{\boldsymbol{q}\in\pi_k} w(\boldsymbol{q})\phi(\boldsymbol{q})}{\sum_{\boldsymbol{q}\in\pi_k} w(\boldsymbol{q})} \|^2$$

Low complexity image processing algorithms

- Linear spectral clustering superpixel

Global methods and **local methods** actually may share the same optimization objection!

$$\sum_{k=1}^{K}\sum_{p\in\pi_k} w(p)\|\phi(p)-\frac{\sum_{q\in\pi_k} w(q)\phi(q)}{\sum_{q\in\pi_k} w(q)}\|^2$$

$$=\sum_{k=1}^{K}\sum_{p\in\pi_k} w(p)\left(\|\phi(p)\|^2-2\phi(p)\cdot\frac{\sum_{q\in\pi_k} w(q)\phi(q)}{\sum_{q\in\pi_k} w(q)}+\|\frac{\sum_{q\in\pi_k} w(q)\phi(q)}{\sum_{q\in\pi_q} w(q)}\|^2\right)$$

$$=\sum_{k=1}^{K}\sum_{p\in\pi_k} w(p)\|\phi(p)\|^2-\sum_{k=1}^{K}\left(2\sum_{p\in\pi_k} w(p)\phi(p)\cdot\frac{\sum_{q\in\pi_k} w(q)\phi(q)}{\sum_{q\in\pi_k} w(q)}-\sum_{p\in\pi_k} w(p)\|\frac{\sum_{q\in\pi_k} w(q)\phi(q)}{\sum_{q\in\pi_k} w(q)}\|^2\right)$$

$$=\sum_{k=1}^{K}\sum_{p\in\pi_k} w(p)\|\phi(p)\|^2-\sum_{k=1}^{K}\left(2\frac{\|\sum_{p\in\pi_k} w(p)\phi(p)\|^p}{\sum_{p\in\pi_k} w(p)}-\frac{\|\sum_{p\in\pi_k} w(p)\phi(p)\|^2}{\sum_{p\in\pi_k} w(p)}\right)$$

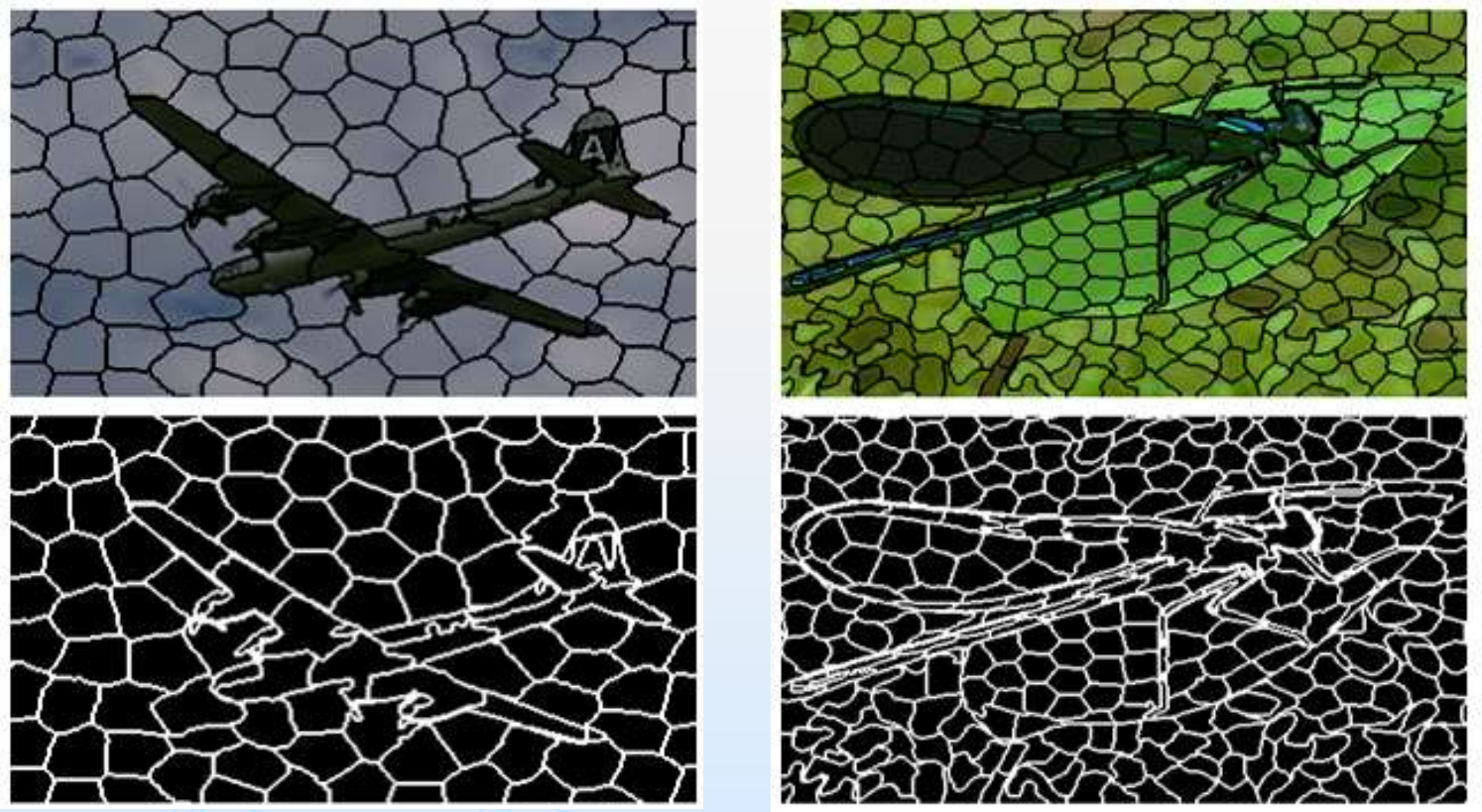
$$=\sum_{k=1}^{K}\sum_{p\in\pi_k} w(p)\|\phi(p)\|^2-\sum_{k=1}^{K}\frac{\|\sum_{p\in\pi_k} w(p)\phi(p)\|^2}{\sum_{p\in\pi_k} w(p)}$$

$$=\sum_{k=1}^{K}\sum_{p\in\pi_k} w(p)\|\phi(p)\|^2-\sum_{k=1}^{K}\frac{\sum_{p\in\pi_k}\sum_{q\in\pi_k} w(p)\phi(p)\cdot w(q)\phi(q)}{\sum_{p\in\pi_k} w(p)}$$

Low complexity image processing algorithms

- Linear spectral clustering superpixel

LSC: an $\boldsymbol{O(pixels)}$ algorithm capable of generating superpixels with both high boundary adherence and satisfactory global structure preservance.



Low complexity image processing algorithms

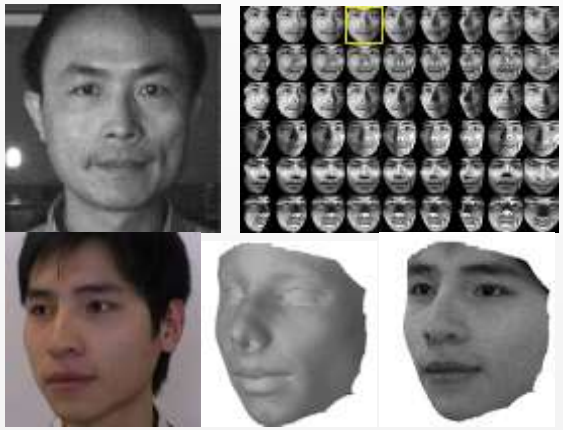
- Linear spectral clustering superpixel

Z.Q. Li & J.S. Chen, Superpixel Segmentation using Linear Spectral Clustering, *CVPR'15*

Image based personal authentication

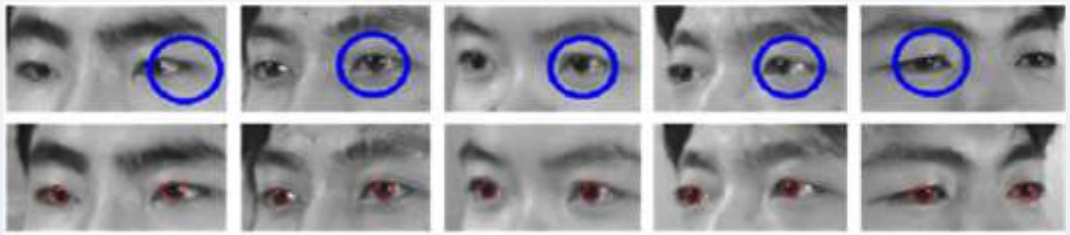
- Face recognition for open environments

Illumination (ECCV'10)

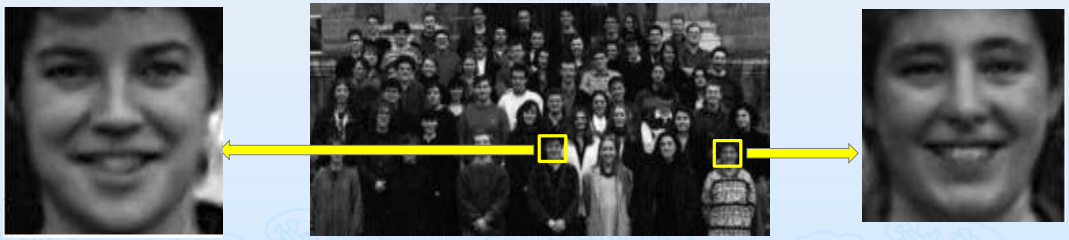


3D Modeling (ICIP'13,CVPRW'14)

Face quality (SPL'15)



Eye tracking (PR'13)



Super-resolution (ACCV'12)

Facial symmetry (SPL'14)

Image based personal authentication

- Face illumination transformation

Locally constrained global optimization

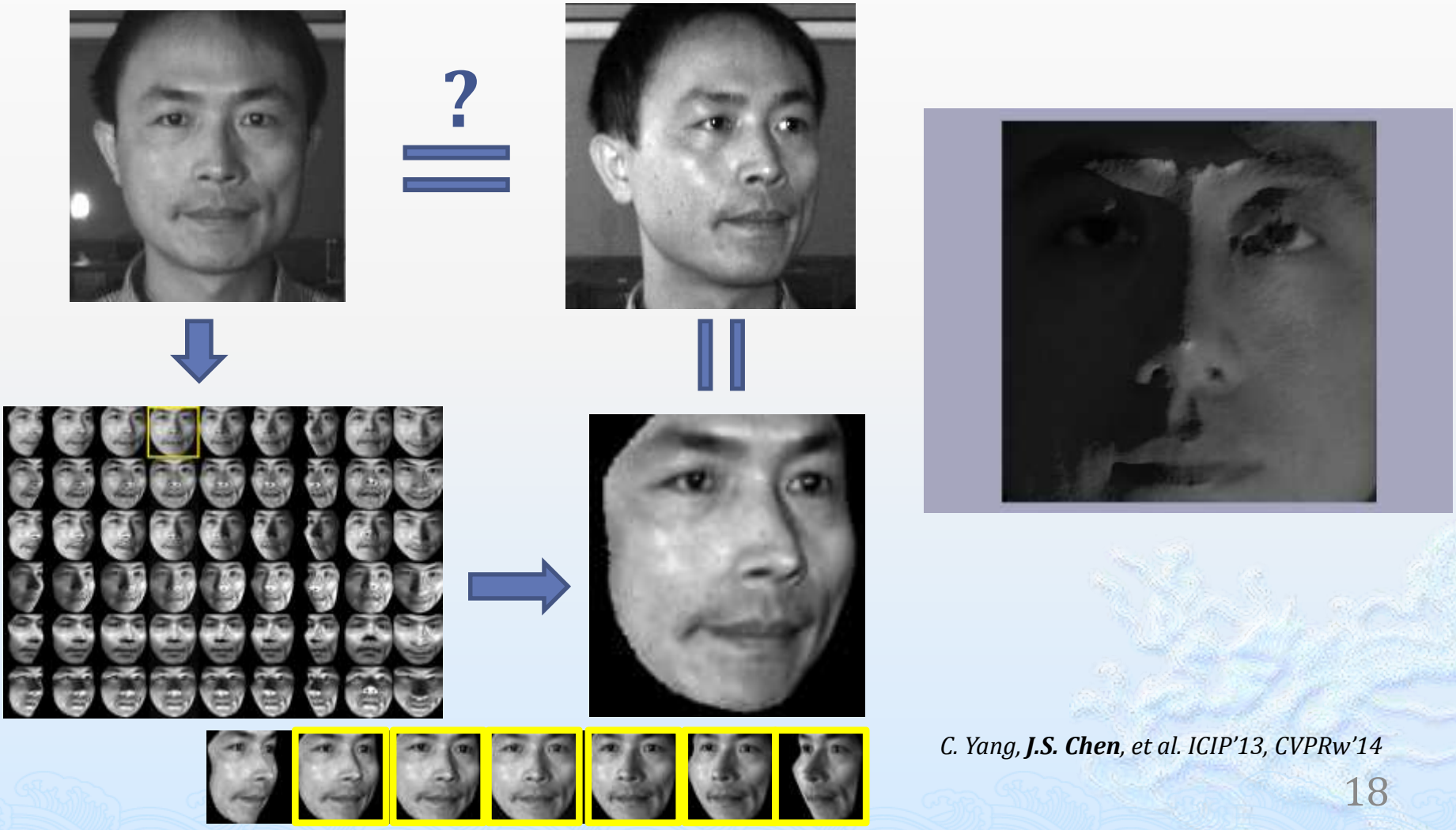
$$\arg\min_{\alpha, I_t^B} \sum_i \left(\sum_{j \in \omega_i} \left(I_t^B(j) - \alpha_i I_t^A(j) \right)^2 + \lambda(\alpha_i - \tau_i)^2 \right)$$

local global

***J.S. Chen**, et. al.*, Face Image Relighting using Locally Constrained Global Optimization, *ECCV 2010*

Image based personal authentication

- Face 3D modeling



*C. Yang, **J.S. Chen**, et al. ICIP'13, CVPRw'14*

Image based personal authentication

- Face super-resolution based on manifold learning

LR Recont. HR

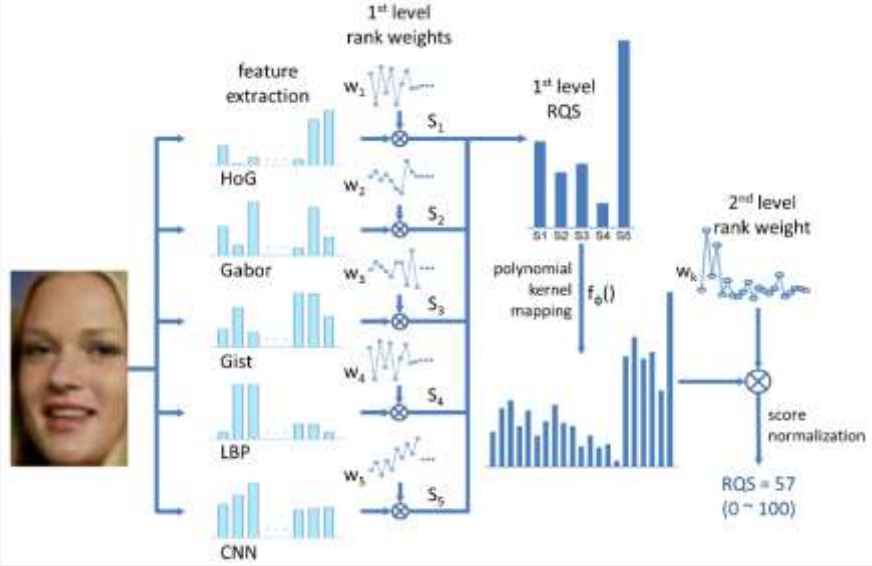
Frequency domain manifold learning

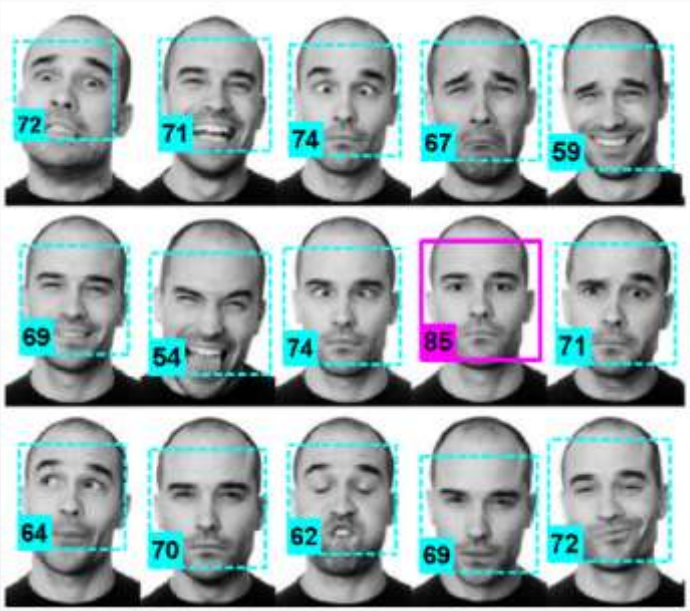
SSIM 93.9% → 95.4%
PSNR 31.9dB → 33.7dB

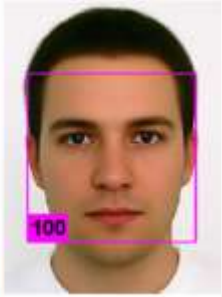
IEICE Trans 2012
Science China 2012
ACCV 2012

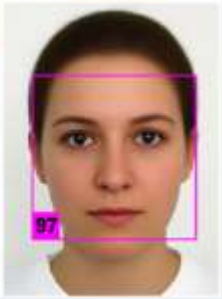
Image based personal authentication

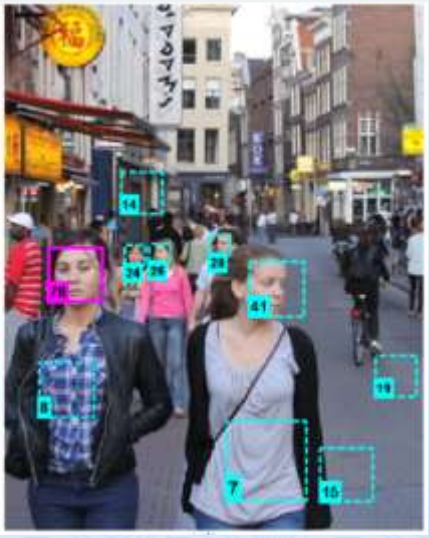
- Face quality assessment based on rank learning











- A framework for face quality assessment
- Using rank learning to expand training set space
- Improving video based face recognition robustness in real life

***J.S. Chen**, et al.,* Face Image Quality Assessment Based on Learning to Rank, *SPL'15*

Thanks !