中国科学技术大学
University of Science and Technology of China

计算机图形学
Computer Graphics

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名企大咖面对面(第五季第2期)

- 2023年3月29日(周三)20:00-21:30
- 中国计算机学会, 计算机辅助设计与图形学专委会
- 主题： AR/VR
  - 歌尔： 虚拟现实与数字人行业现状
  - ALVA System： AR赋能的智慧工业
  - Rokid： AR技术在汽车行业的应用和发展

CAD&CG直播间

我们是计算机图形学，我们的方向包括：

- 下一代人机交互范式：增强现实
- 支撑吃鸡王者的背后硬核算法
- 解决工业设计领域“卡脖子”问题的计算机辅助设计技术
- 国产自研的数字孪生城市大脑
- 颠覆传统家居设计行业的云平台
- 服务亿万用户的抖音内容创作工具
- 搭载在亿台手机上的图形图像技术
- 工业4.0：智能制造的核心技术3D打印
- 制作精良业内标杆的3A大作
- 国产自主可控的实时渲染引擎

内容感知的图像缩放

内容感知的图像缩放

- **概念**
  - 图像在不同终端显示时，面临画面尺寸变化
  - 通过缩放减少或者扩展图像的大小去适应不同的显示屏幕

图像缩放

Content Aware

Uniform Scaling

内容感知的图像缩放

- **图像处理**
  - （不）等比例缩放、裁剪
- **图形处理**
  - 内容感知的画面增删或变形

不等比例缩放

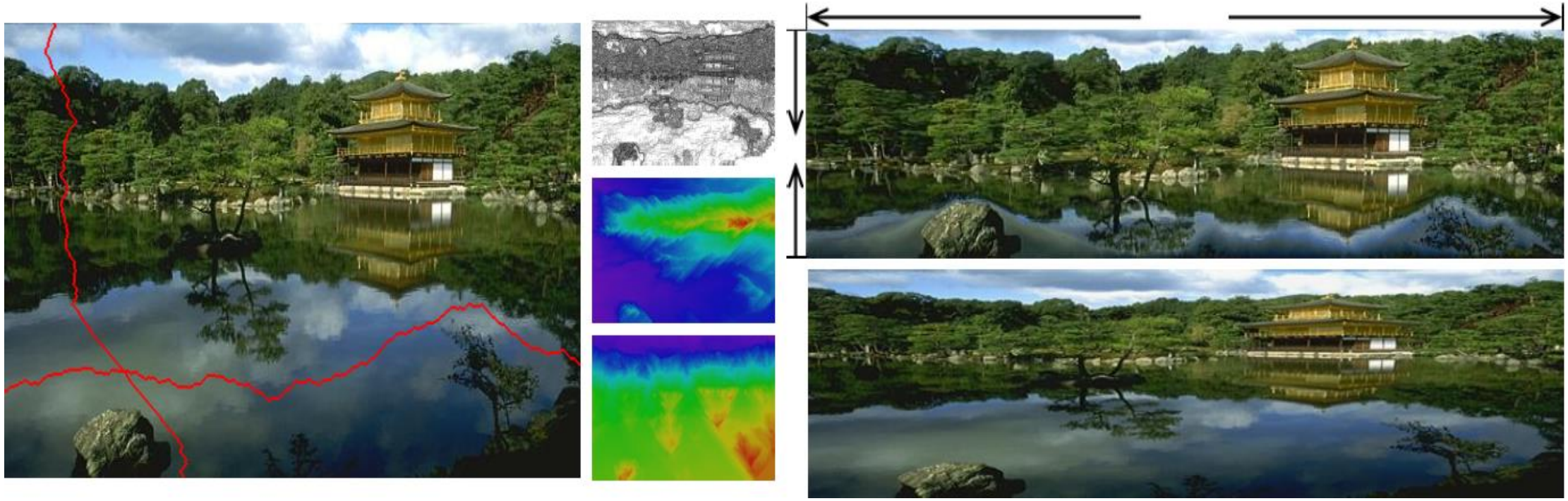
等比例缩放

裁剪

Seam Carving

图像缩放方法

- **Seam Carving**
  - **思想：**通过在图像中增加水平和竖直方向连续的缝隙进行扩大或缩小图像
  - seam：图像中连通的低能量像素通路，并且每行或者每列只包含一个像素

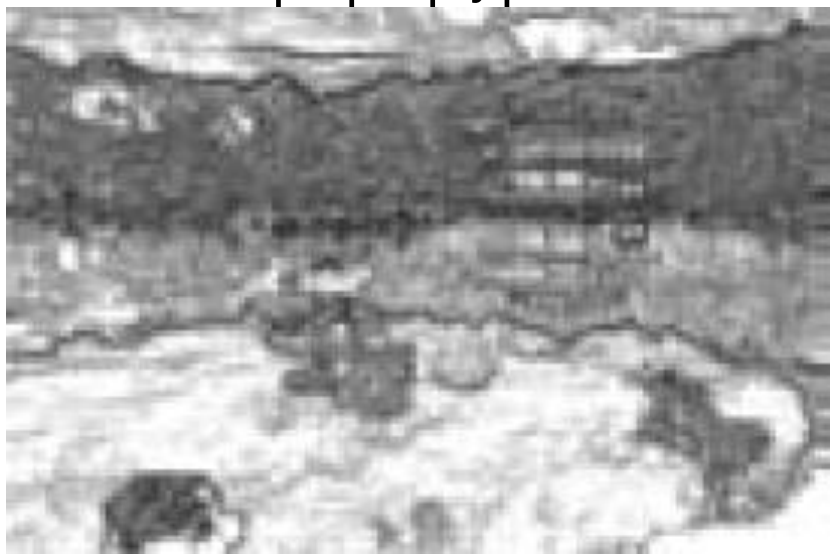


Seam Carving

- **方法**
  - 定义Seam(缝隙)为图像中穿过较低视觉显著性区域的连线

视觉显著性 $e(I) = \left|\frac{\partial I}{\partial x}\right| + \left|\frac{\partial I}{\partial y}\right|$

缝隙



梯度图

Seam Carving

- **方法**
  - 定义Seam(缝隙)为图像中穿过较低视觉显著性区域的连线
  - 动态规划寻找符合条件的缝隙

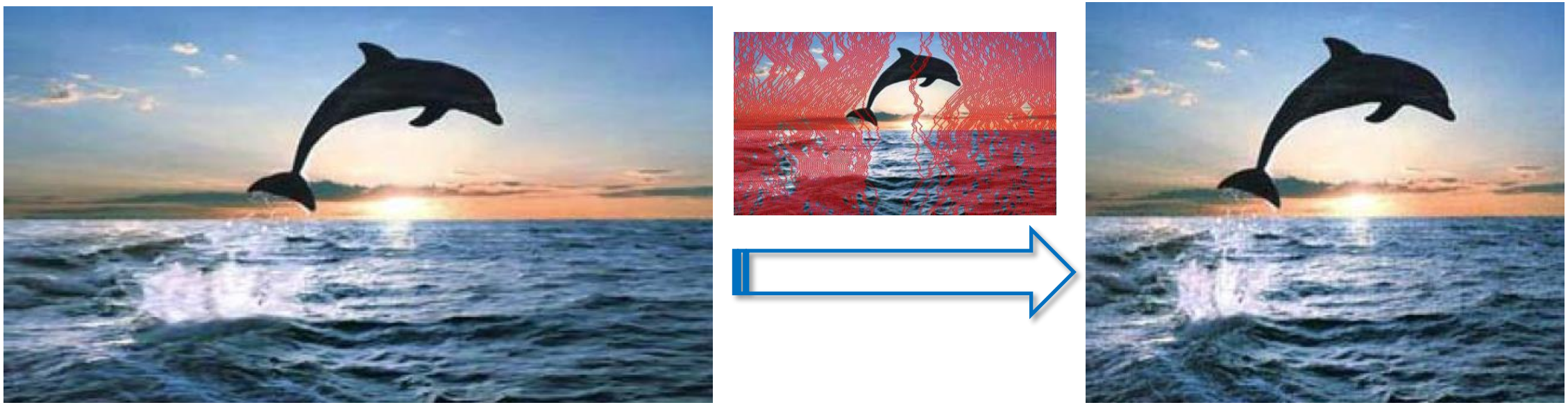
竖直缝隙 $s^{\mathrm{x}} = \{s_i^x\}_{i=1}^n = \{x(i)\}_{i=1}^n$ $\quad \forall i,\ |x(i) - x(i-1)| \leq 1$

最优缝隙 $s^* = \min_s E(s) = \min_s \sum_{i=1}^{n} \mathrm{e}(\mathrm{I}(s_i))$

$$M(i,j) = \mathrm{e}(i,j) + \min(M(i-1,j-1), M(i-1,j), M(i-1,j+1))$$

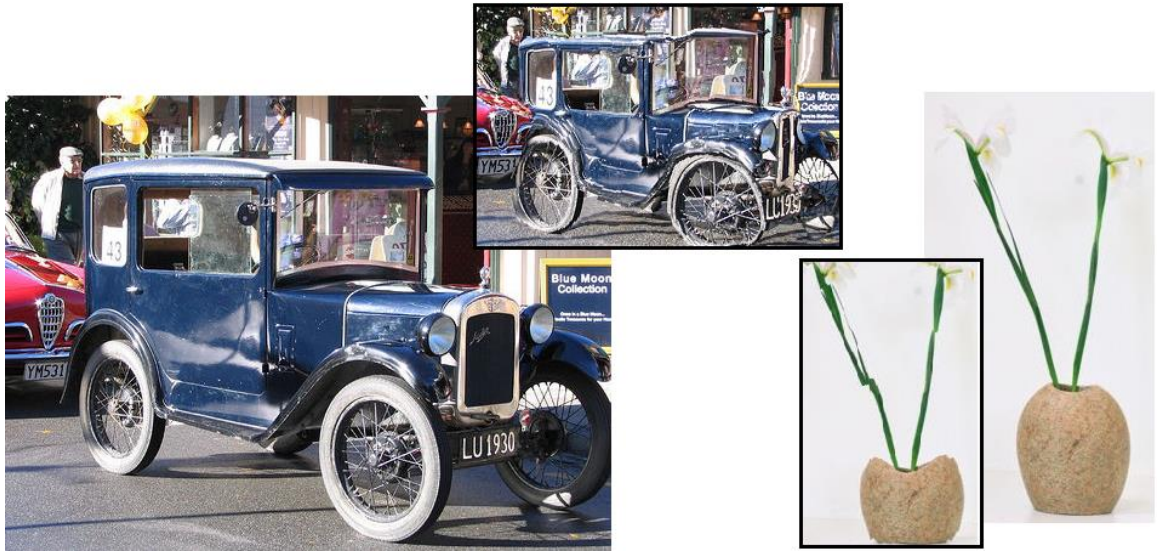
Seam Carving

- **方法**
  - 定义Seam(缝隙)为图像中穿过较低视觉显著性区域的连线
  - 动态规划寻找符合条件的缝隙
  - 删除缝隙，调整图像尺寸



Seam Carving

- **结果**

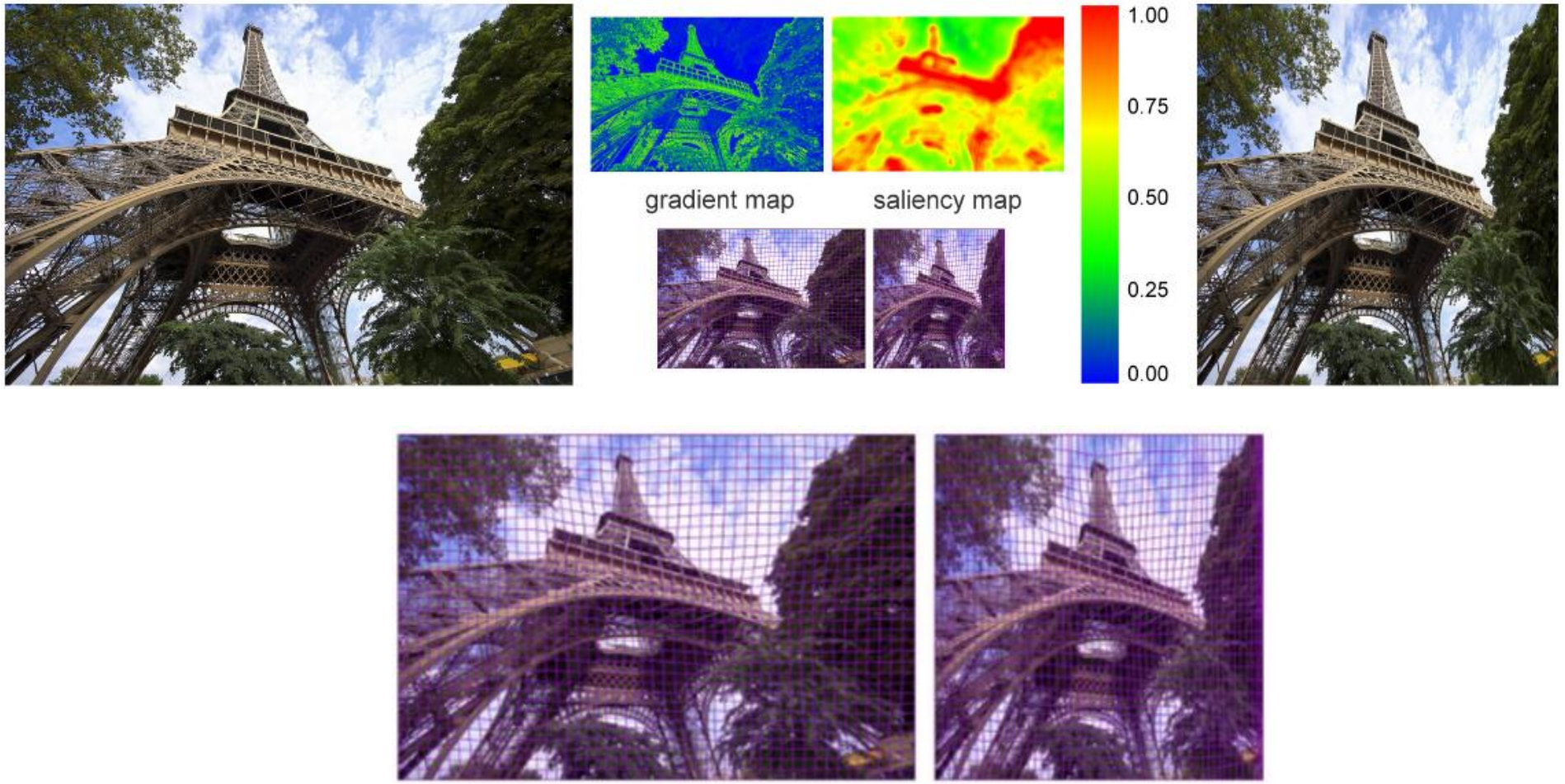


局限性

1. 效率低
2. 难以保持图像结构

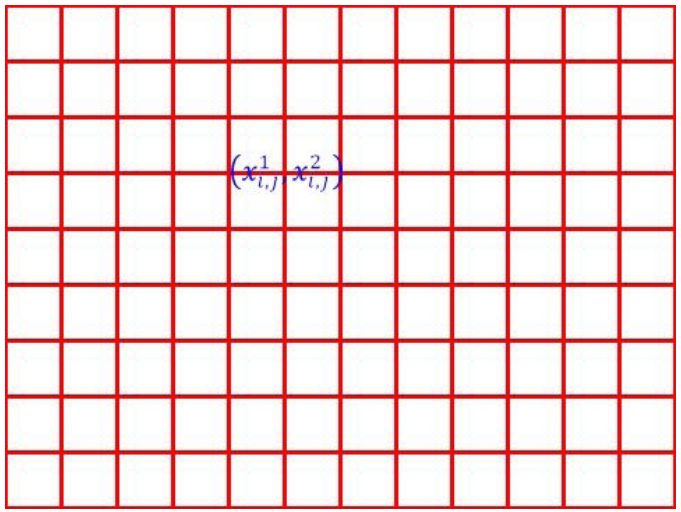
网格变形驱动的图像缩放

- **思想：**以目标尺寸为约束，对原始图像进行结构保持的变形



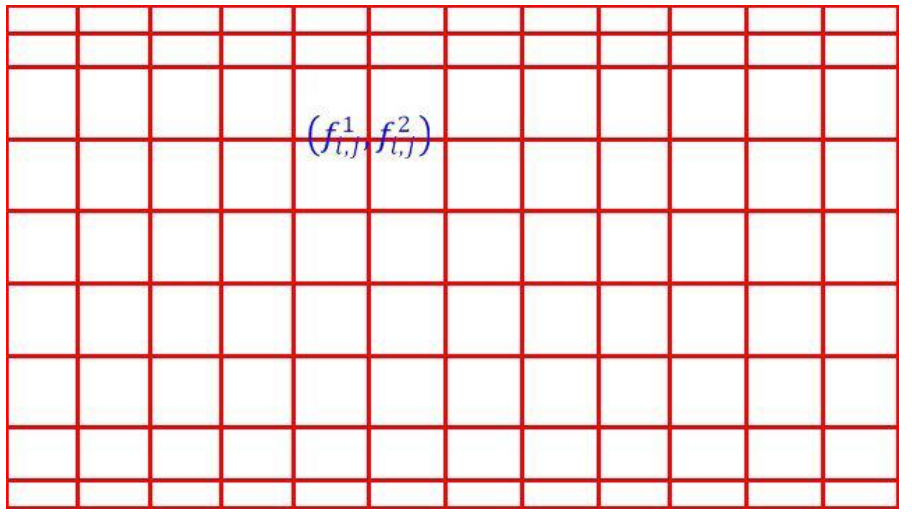
网格变形驱动的图像缩放

Embedding



Low-distortion Deformation

$$\min \sum_q D_q$$



Texture Mapping

Distortions/dissimilarity

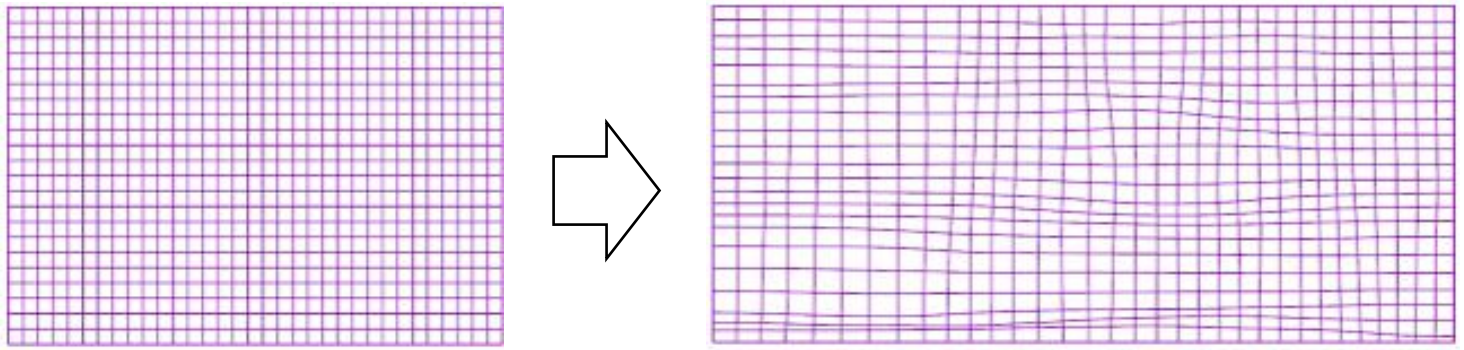
Conformal distortion
(stretch)

Isometric distortion
(Stretch + Scaling)

网格变形驱动的图像缩放

- **方法：**网格变形驱动图像缩放

$$D = D_u(f) + D_l(f)$$

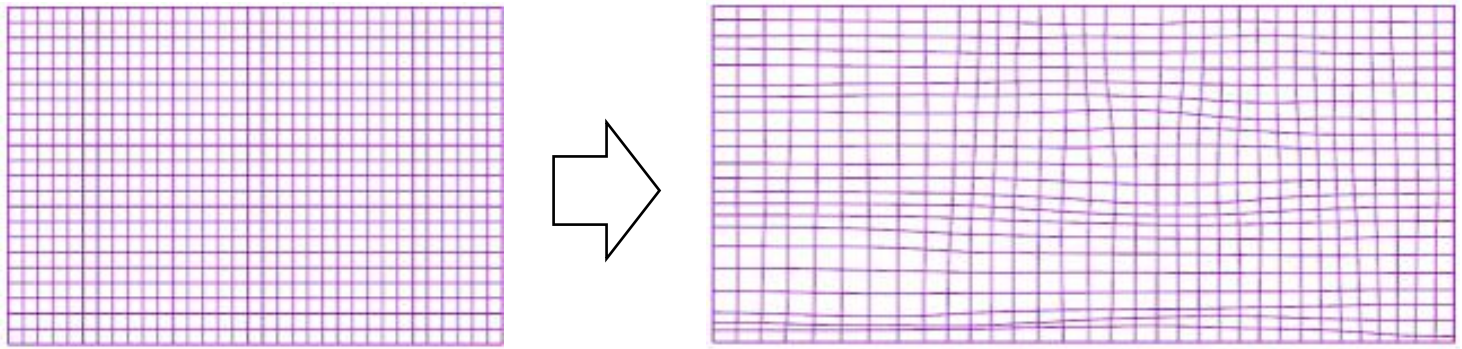


$f: \mathrm{v}_i \rightarrow \mathrm{v}_i'$ $\mathrm{v}'=s_f\mathrm{v}+\mathrm{t}$

网格变形驱动的图像缩放

- **方法：**网格变形驱动图像缩放

$$D = D_u(f) + D_l(f)$$



均匀缩放 $D_u(f) = \sum_{\{i,j\}\in \mathrm{E}} \left\| \left(\mathrm{v}_i' - \mathrm{v}_j'\right) - s_f\left(\mathrm{v}_i - \mathrm{v}_j\right) \right\|^2$

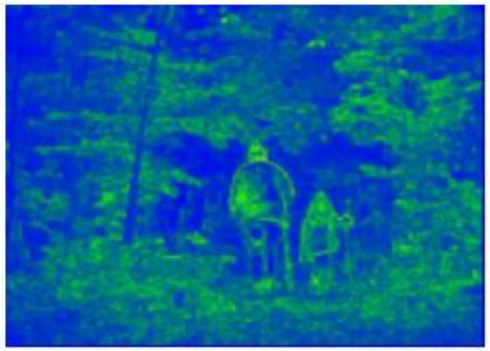
比例缩放 $D_l(f) = \sum_{\{i,j\}\in \mathrm{E}} \left\| \left(\mathrm{v}_i' - \mathrm{v}_j'\right) - l_{ij}\left(\mathrm{v}_i - \mathrm{v}_j\right) \right\|^2$

边界条件 $\mathrm{v}_0' = (0,0)^T \qquad \mathrm{v}_{\mathrm{end}}' = (n', m')^T \qquad \mathrm{v}_{i,y(x)}' = i/m'(n')$

网格变形驱动的图像缩放

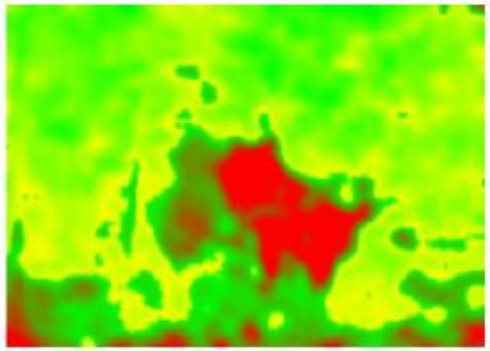
- **结构**
  - 图像梯度+图像显著度
    - 梯度：图像局部结构分部
    - 显著度：视觉注意区域
  - 变形时保持结构变化尽可能少

原始图



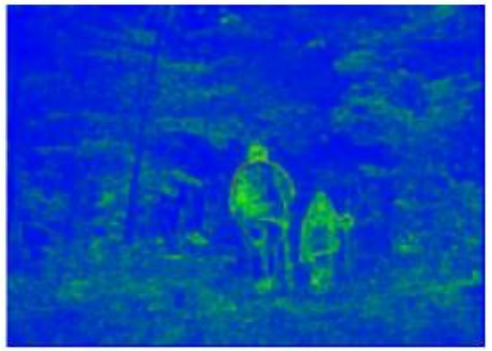
梯度图

X



显著图

=

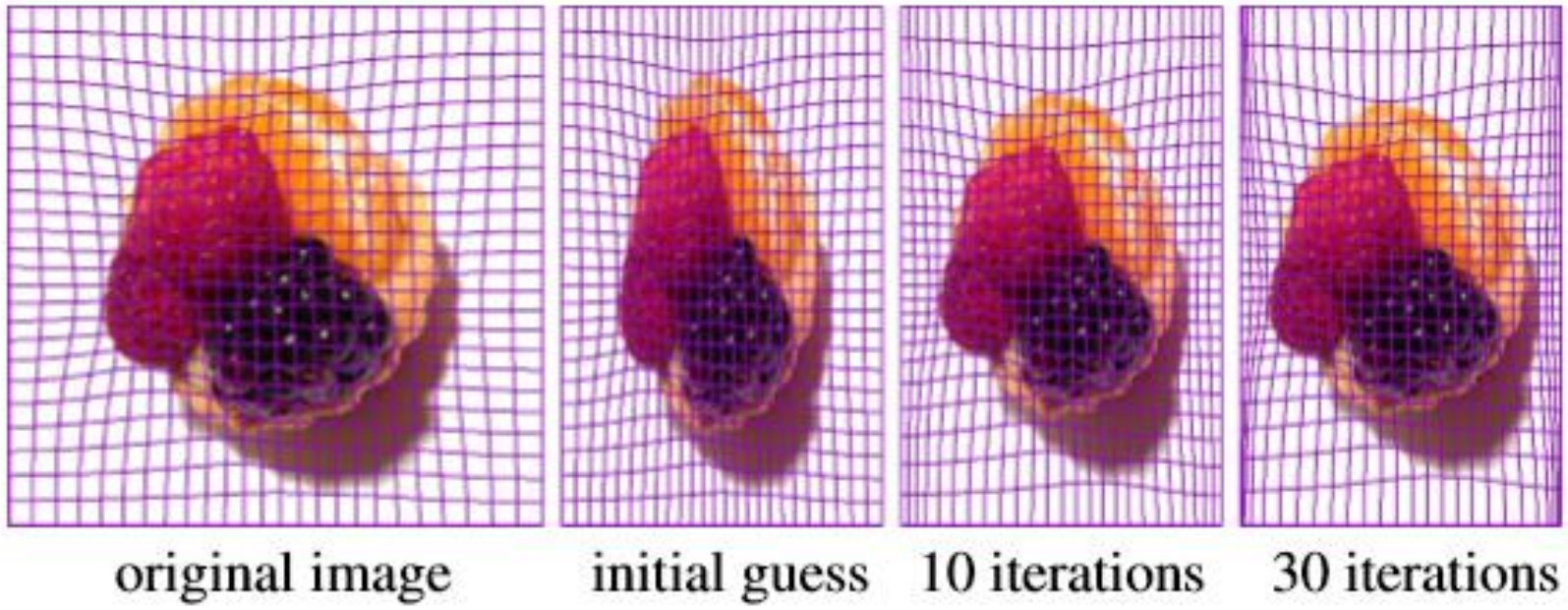


结构图

网格变形驱动的图像缩放

- **求解**
  - 自适应网格设置：更具结构重要性图放置网格顶点
  - 简单缩放作为初值：

$$\mathrm{v}' = s_f \mathrm{v} + \mathrm{t}$$



网格变形驱动的图像缩放

- 结果

原始图　　缝隙增删　　网格变形

局部线结构扭曲

网格变形驱动的图像缩放

- 结果







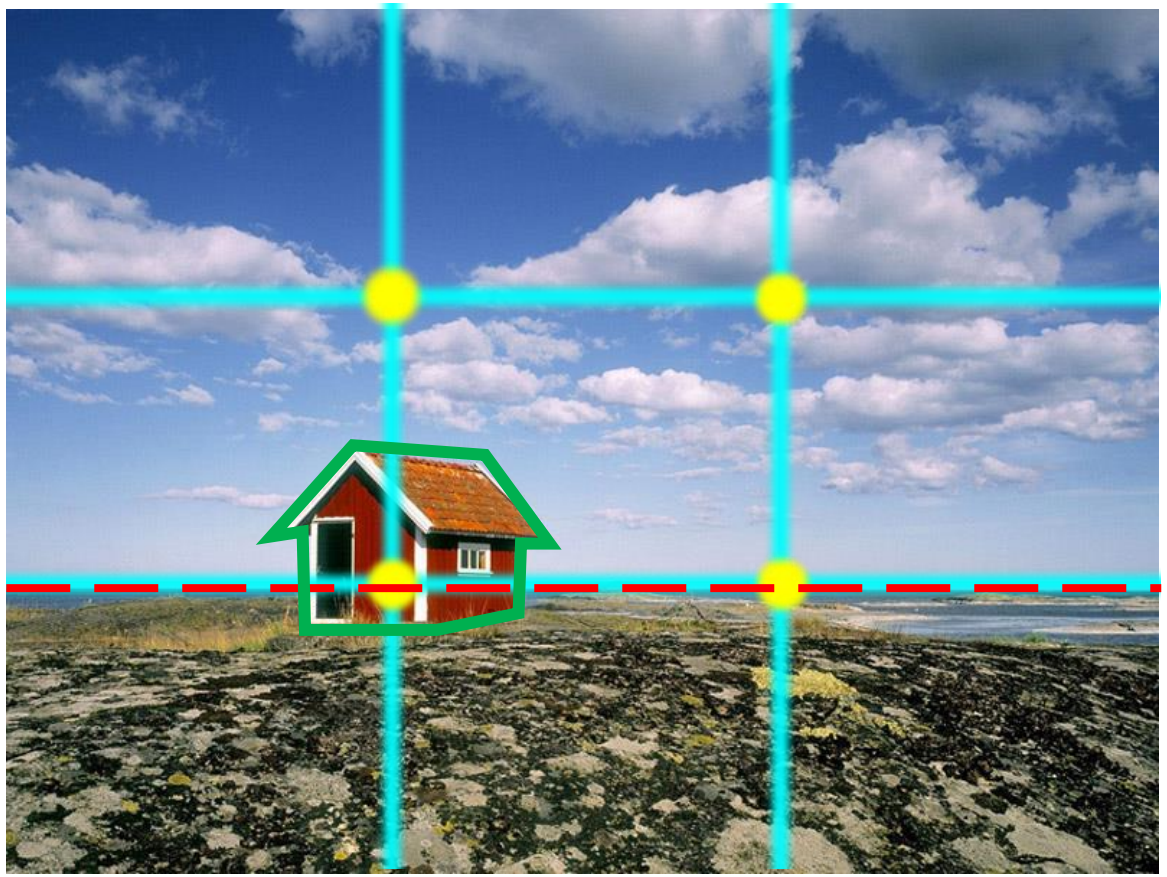

基于retargeting的美学构图优化

美学构图优化

- Considering aesthetics (photo composition)
  - The pleasing selection and arrangement of visual elements within the picture frame
- Cropping-retargeting operator

Basic Composition Guidelines (1)

- Rule of thirds

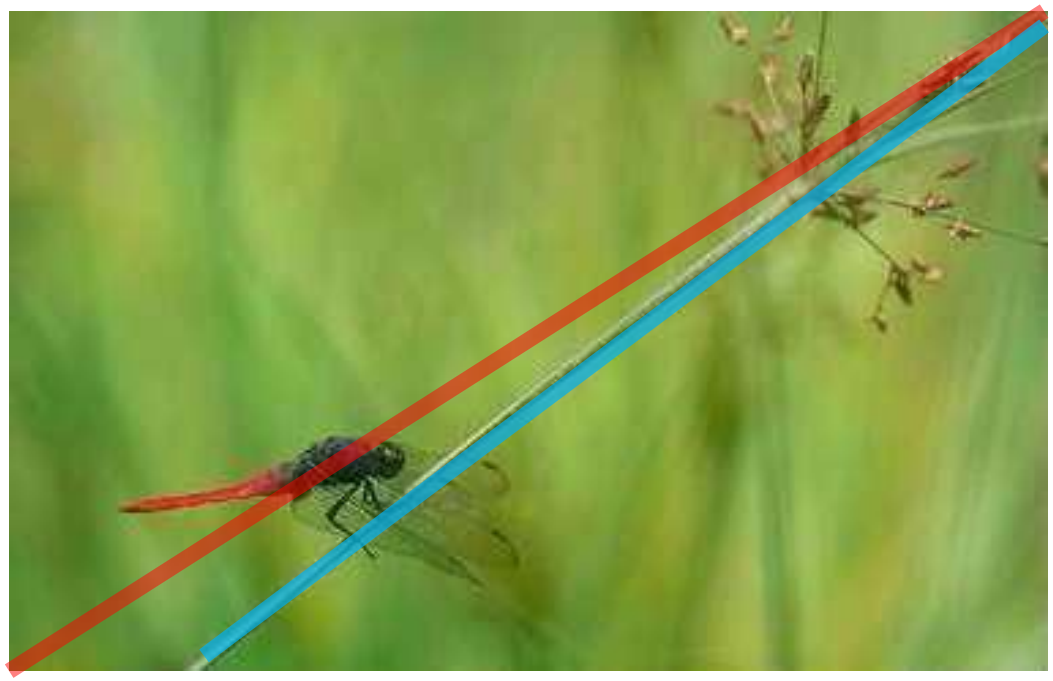


Power lines

Power points

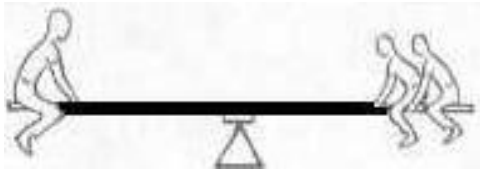
Basic Composition Guidelines (2)

- Diagonal dominance



Basic Composition Guidelines (3)

- Visual balance



Basic Composition Guidelines (4)

- Sizes of visual elements



Cropping+Retargeing

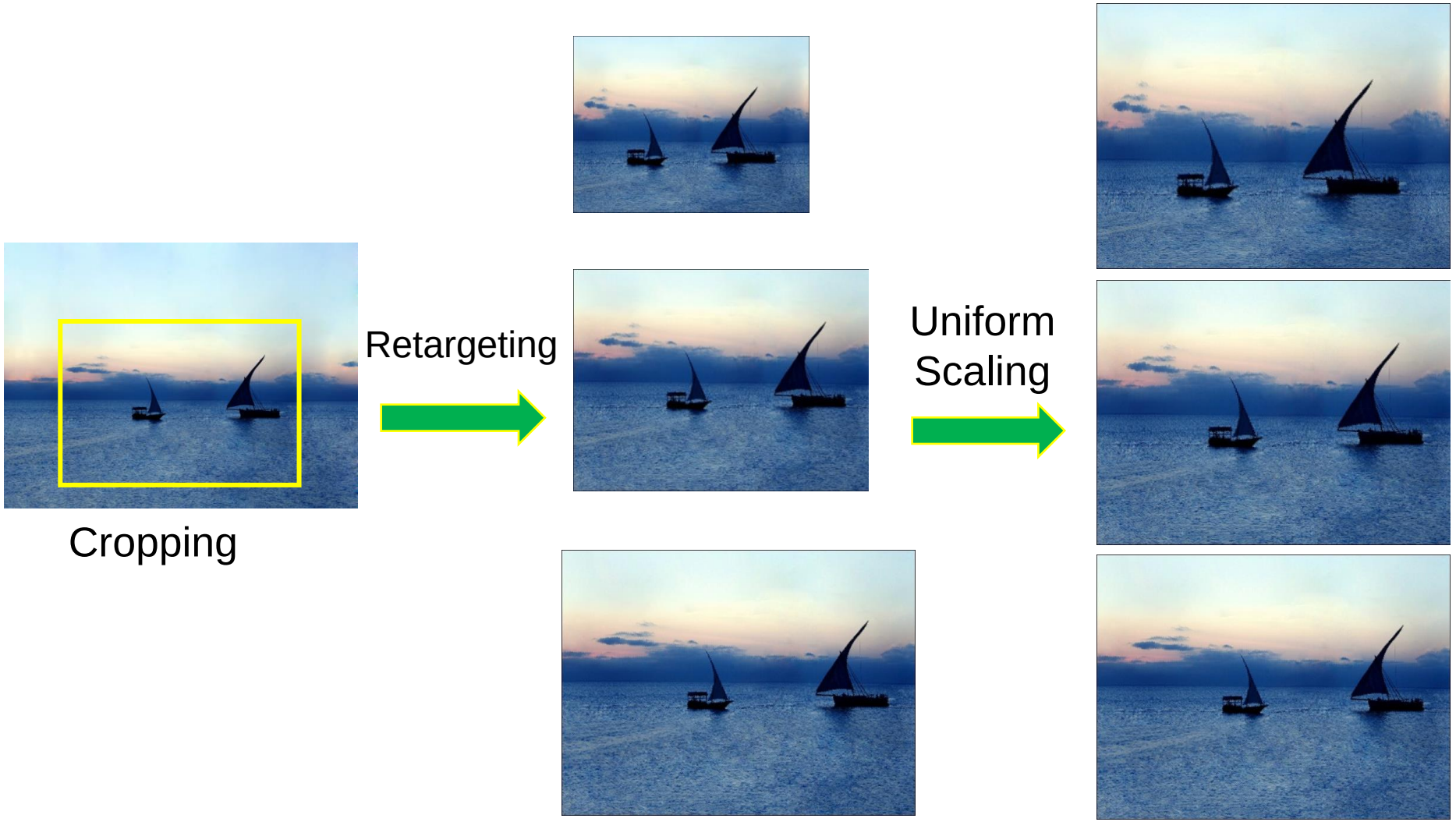
Cropping

Retargeting

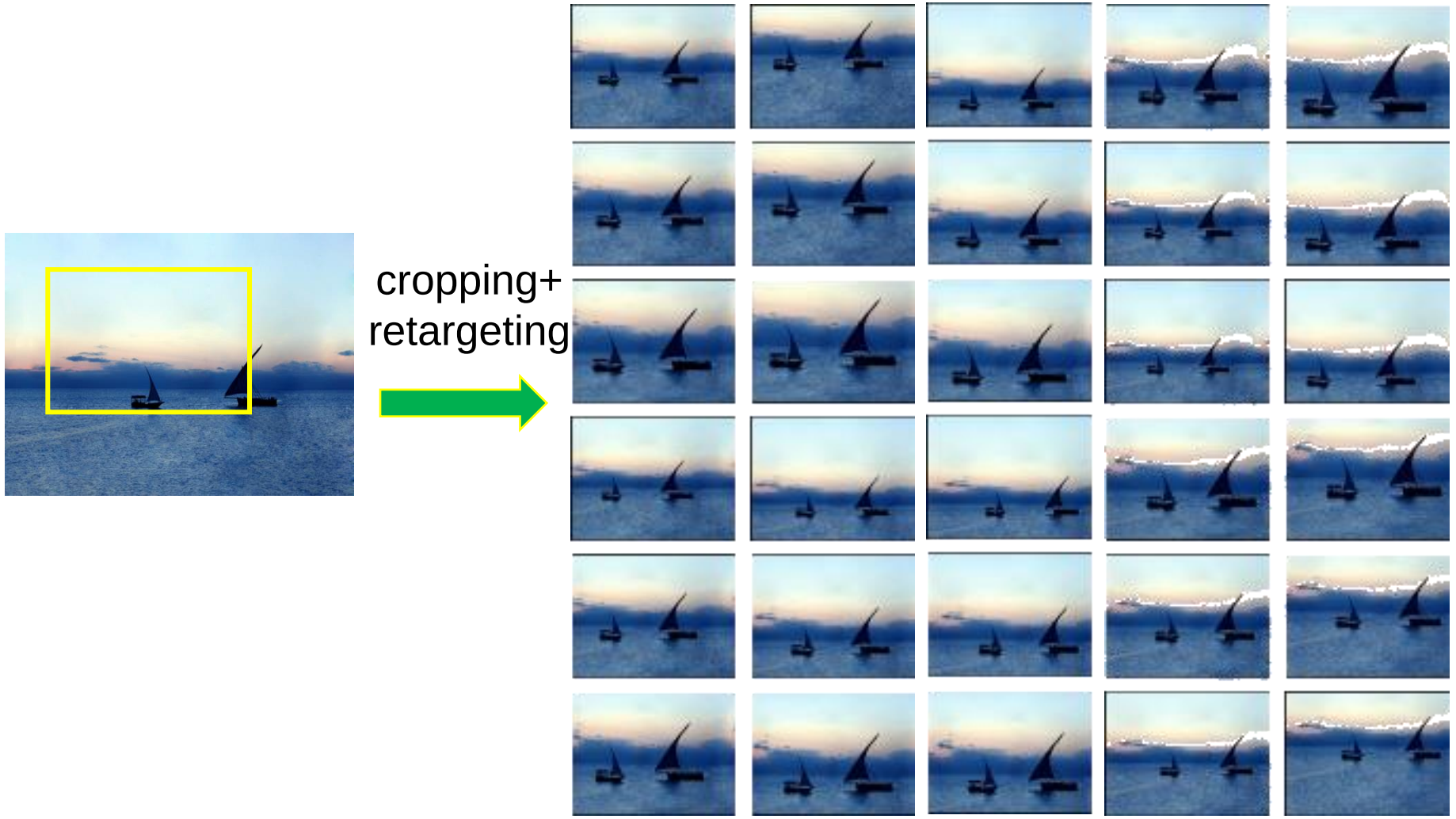
Removing superfluous regions

Changing distances and sizes

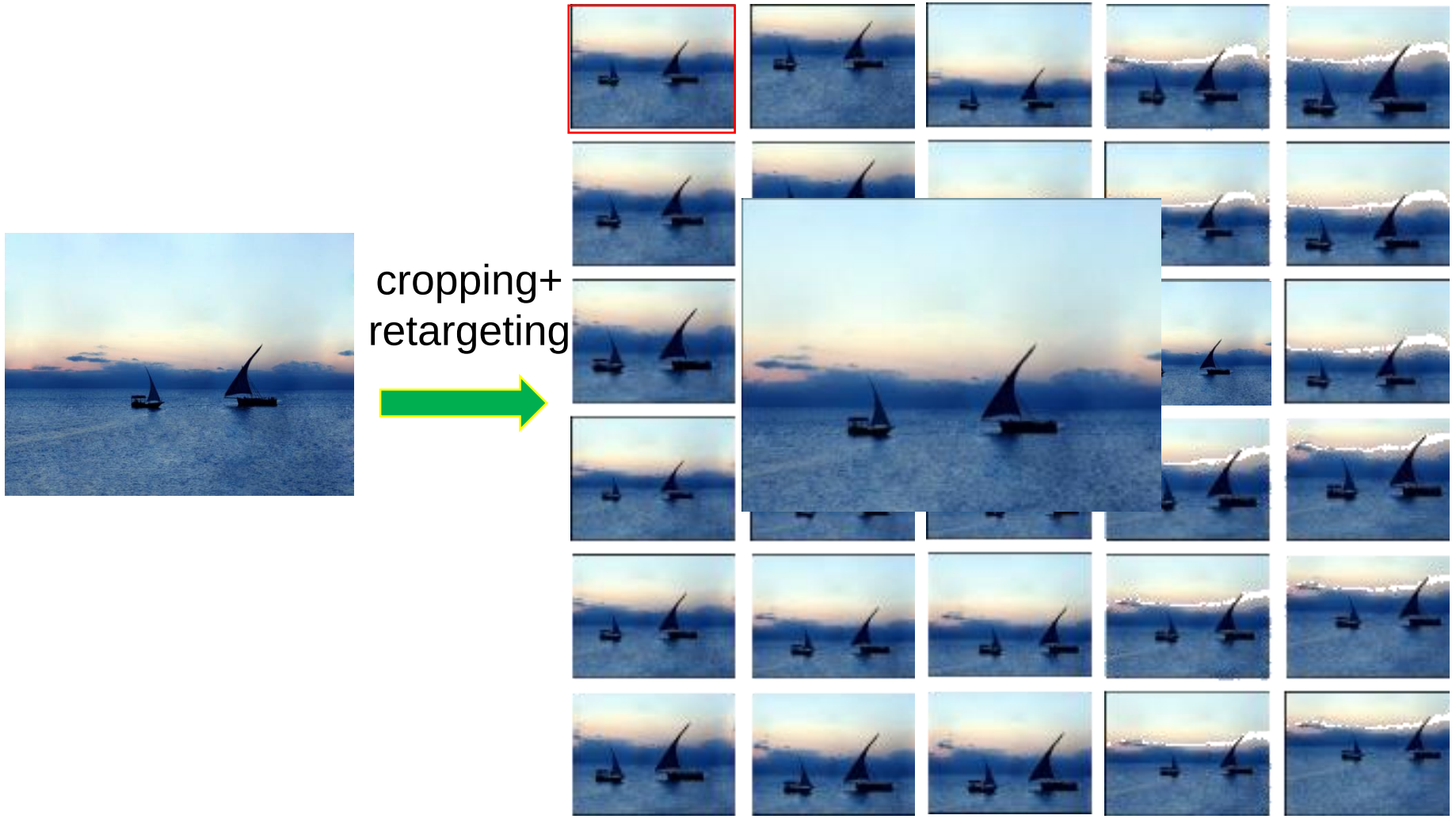
Cropping+Retargeting Operator



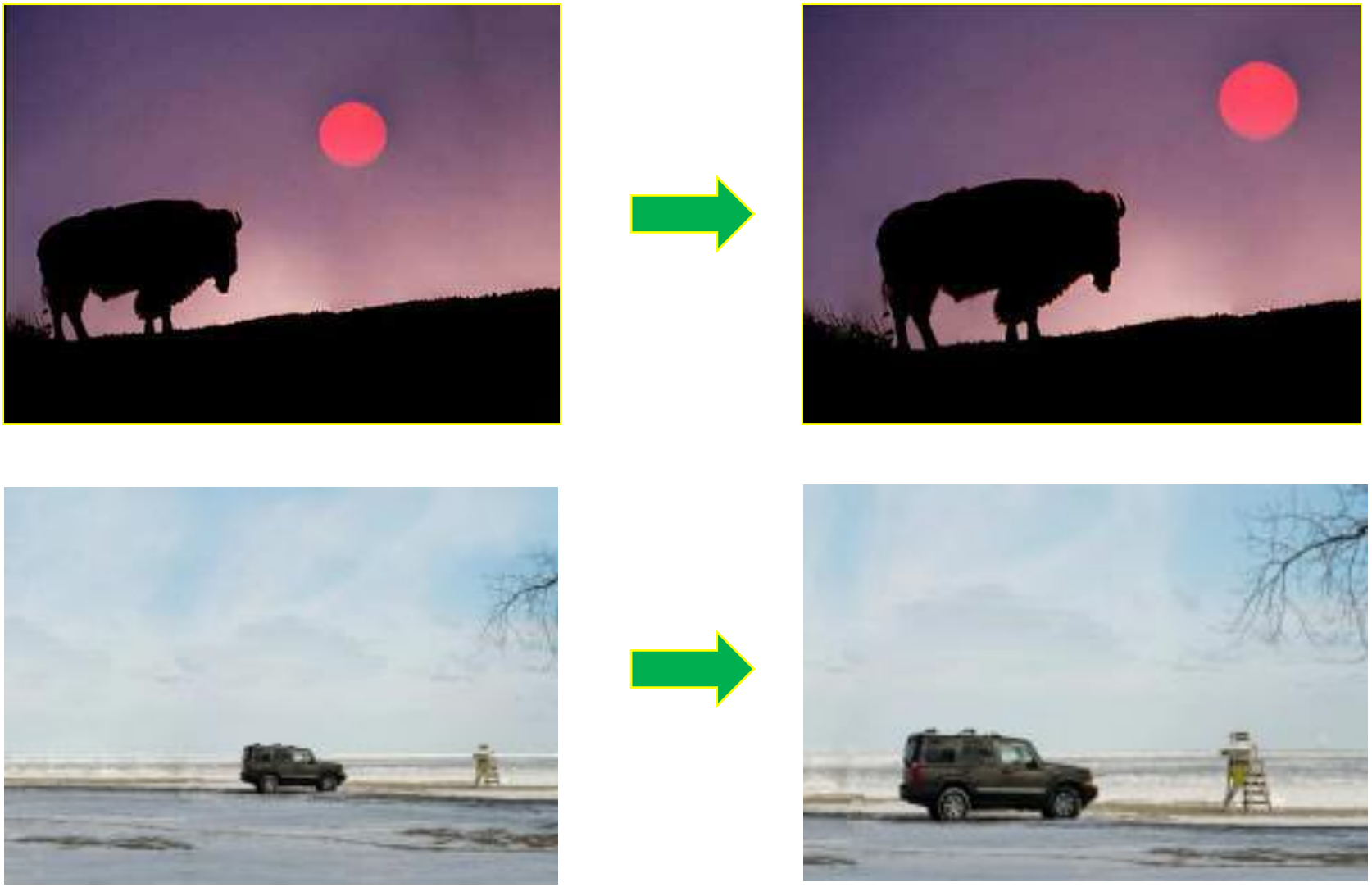
All Possible Cropping+Retargeting



Searching the Optimal Result



Results



More Results

More Results






More Results

基于网格变形的重摄影

重摄影Re-photography

Broadway to the battery, Manhattan, 1938 & 1997

Custom house status and New York Produce exchange

Native American museum statues and MTA headquarters

Bowling Green, Foot of Broadway, 1936 & 1997

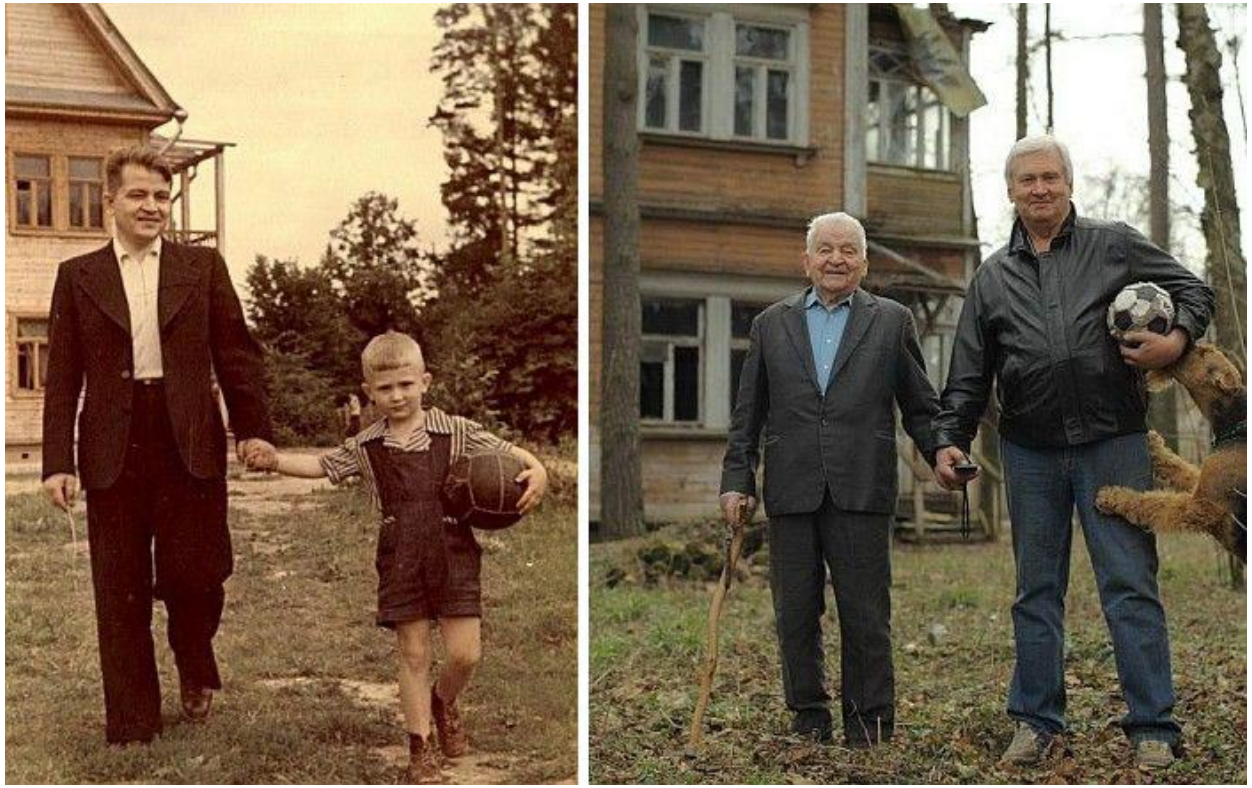
Back to the future - Irina Werning

Johanes 1994 & 2011 Hamburg

Mechi 1990 & 2010 Buenos Aires

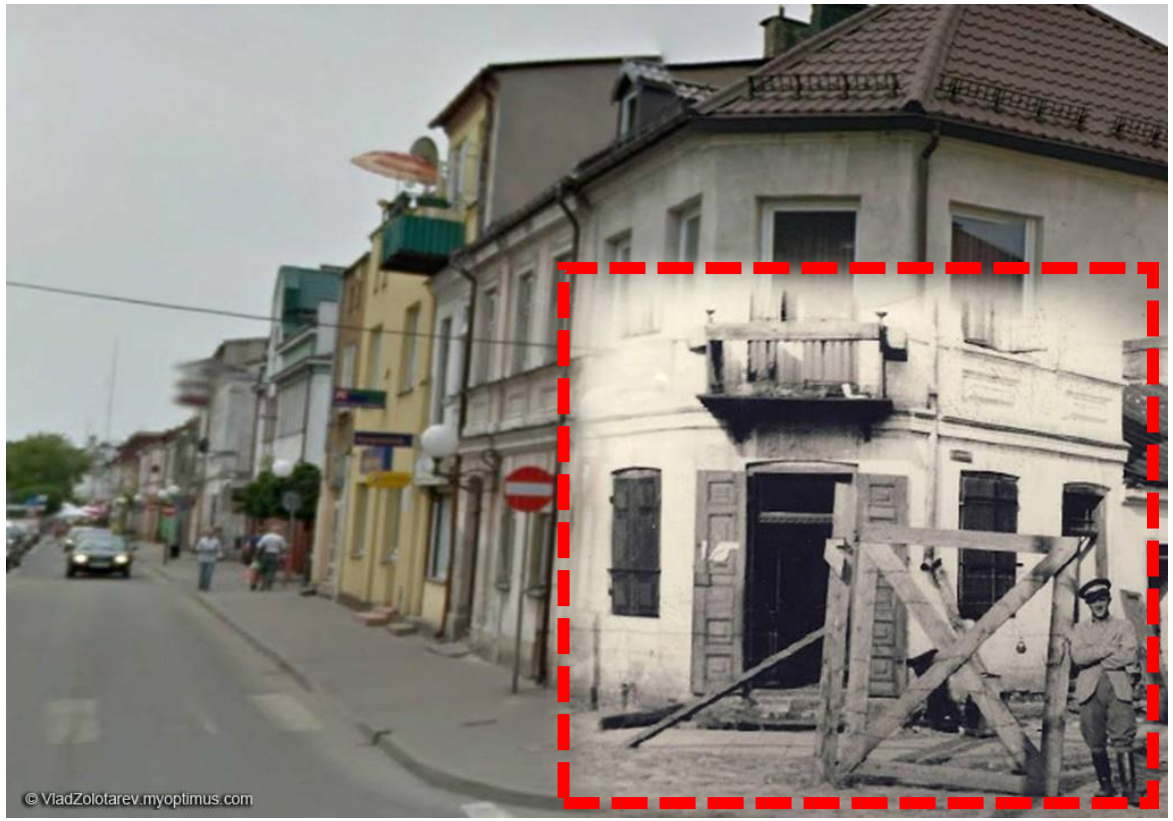
重摄影

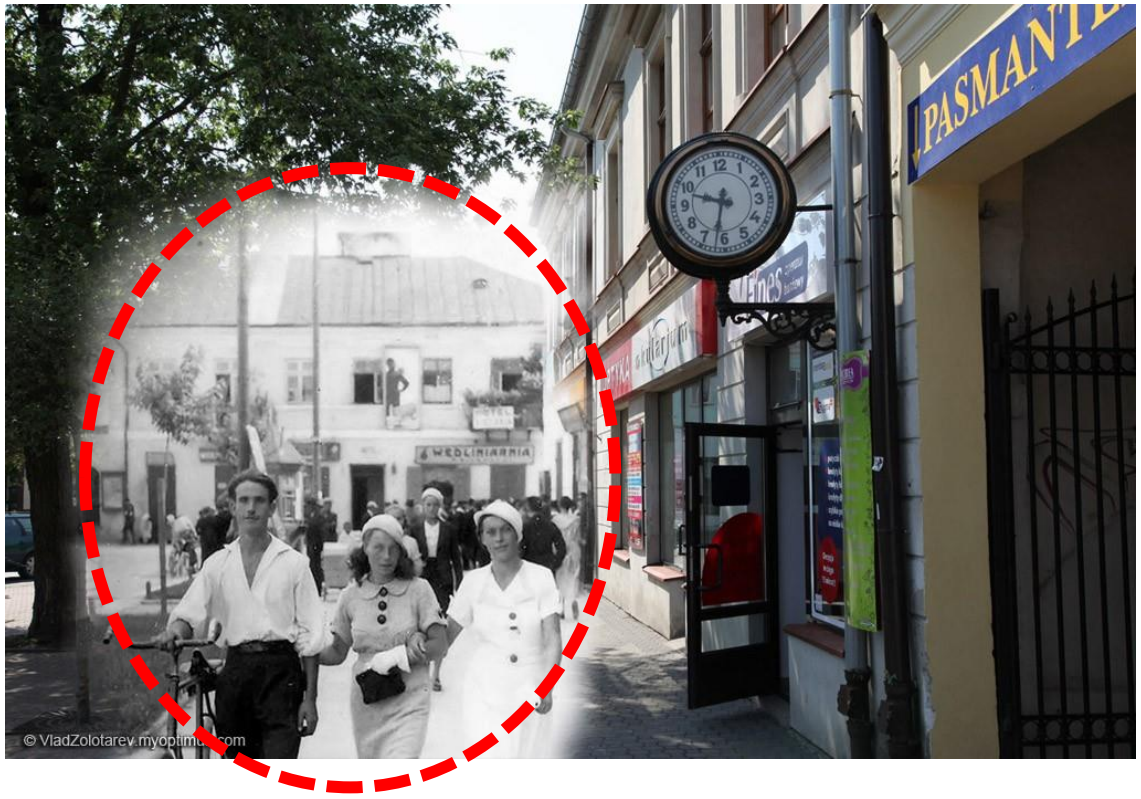
Christoph 21 years apart (1990 & 2011, Berlin Wall)



Father and son 60 years apart (1949 – 2009)

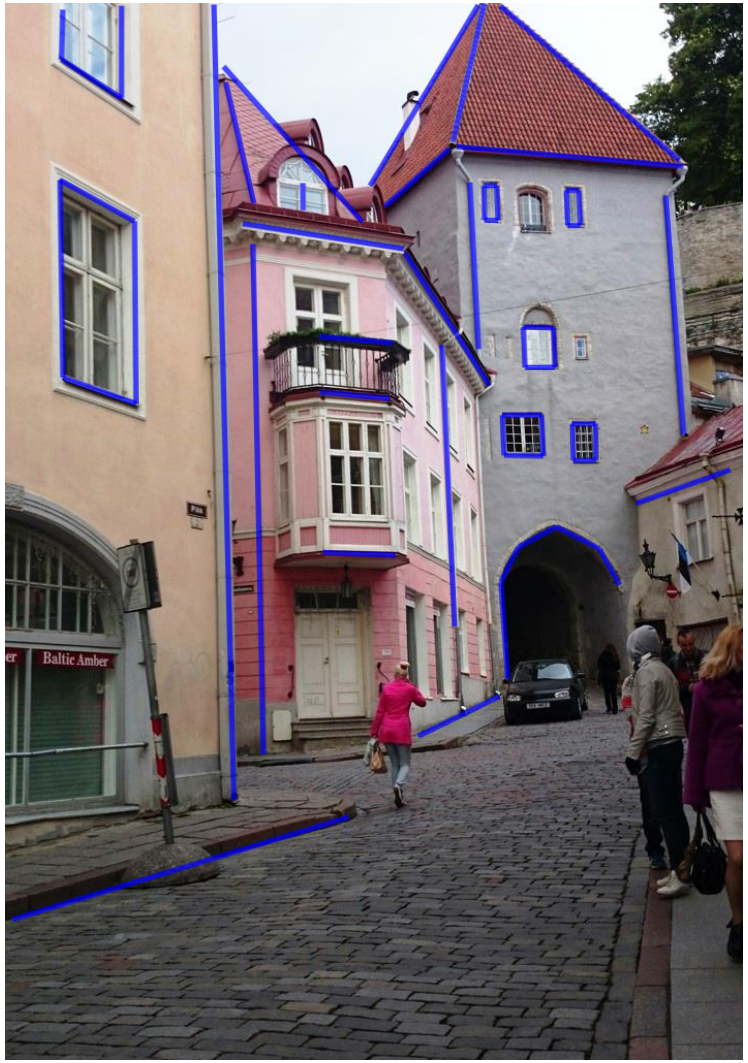
计算重摄影





Perspective-matching Photography

重摄影

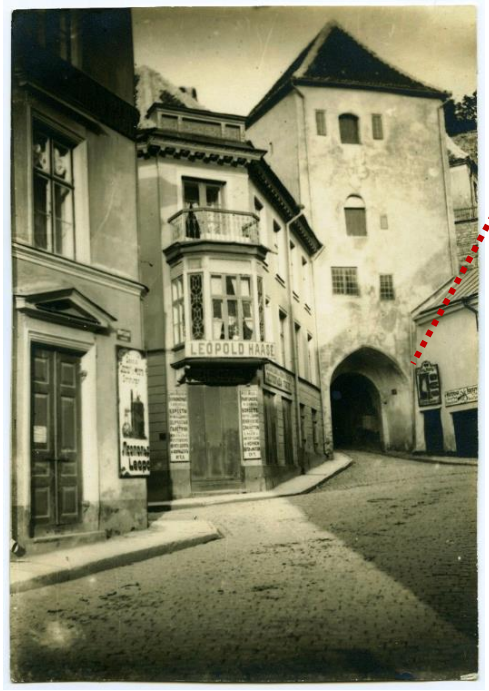


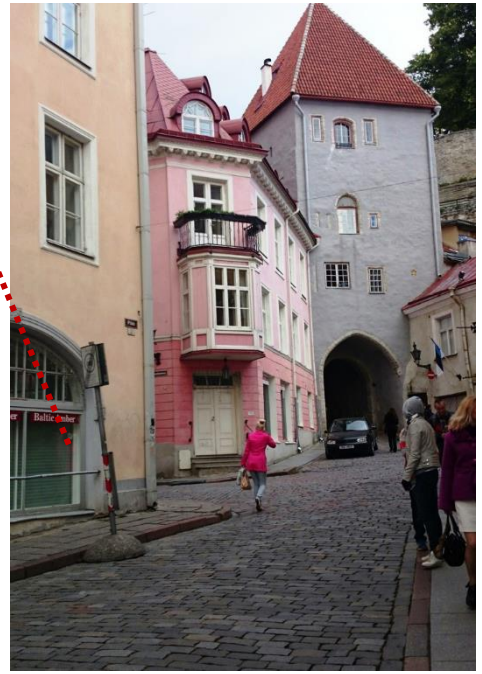
重摄影 – 挑战

- View positions
- Camera parameters
- Scene change

[Bae *et al.* 2010]

Reference



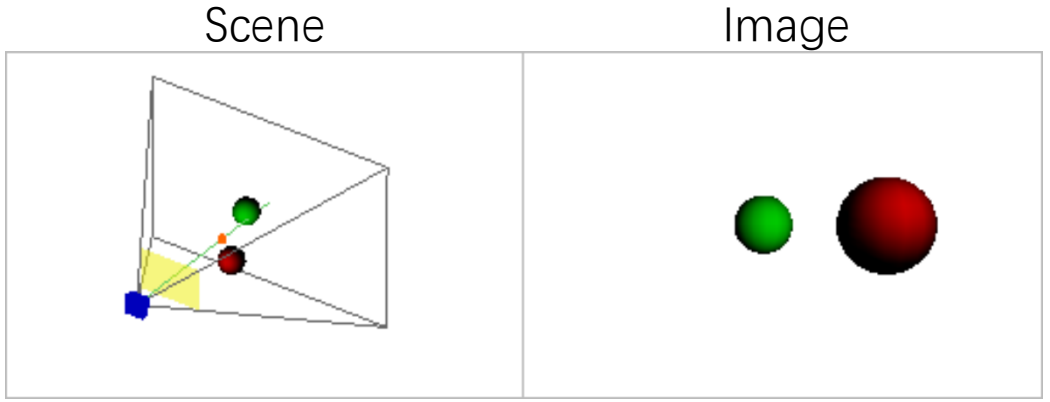


Simplified pinhole camera model

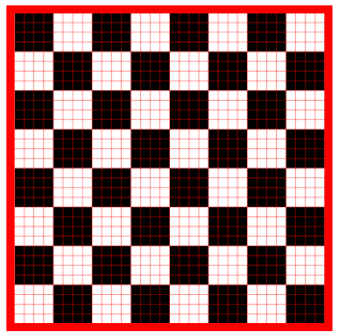
$$s\begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = \begin{pmatrix} f & 0 & 0 \\ 0 & f & 0 \\ 0 & 0 & 1 \end{pmatrix} \underbrace{(R|t)}_{E} \underbrace{\begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}}_{p} = \begin{pmatrix} f & 0 & 0 \\ 0 & f & 0 \\ 0 & 0 & 1 \end{pmatrix} Ep = \begin{pmatrix} fE_1p \\ fE_2p \\ E_3p \end{pmatrix}$$

$$u = \frac{E_1p}{E_3p} f, \qquad v = \frac{E_2p}{E_3p} f$$

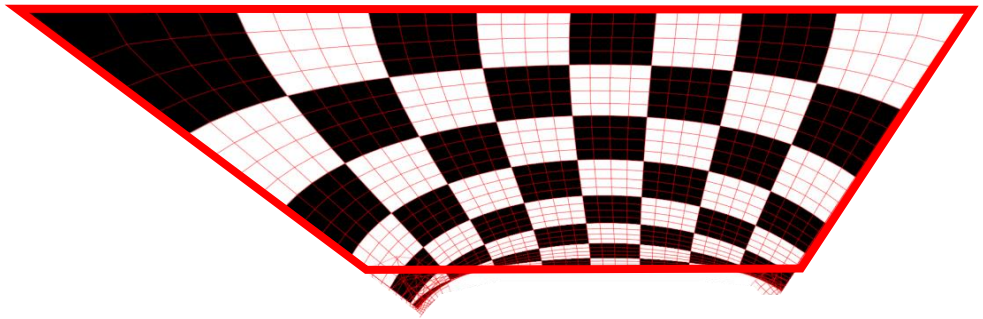
Nonlinear



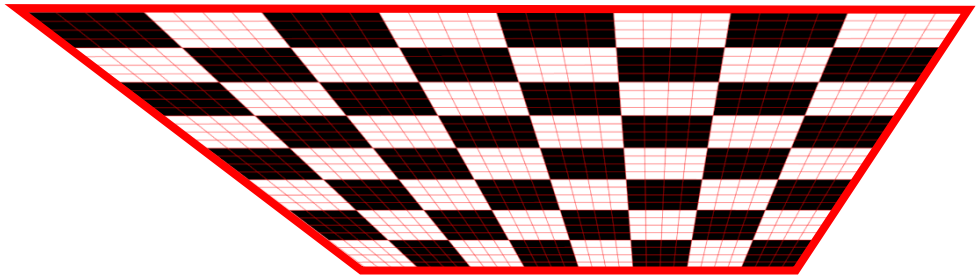
仿射变换近似透视投影



32 × 32 grid



As-Similar-As-Possible

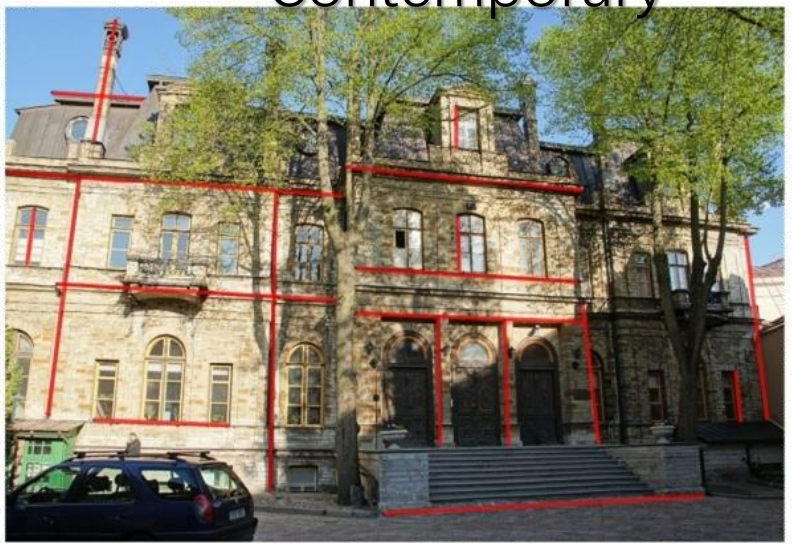


As-Affine-As-Possible

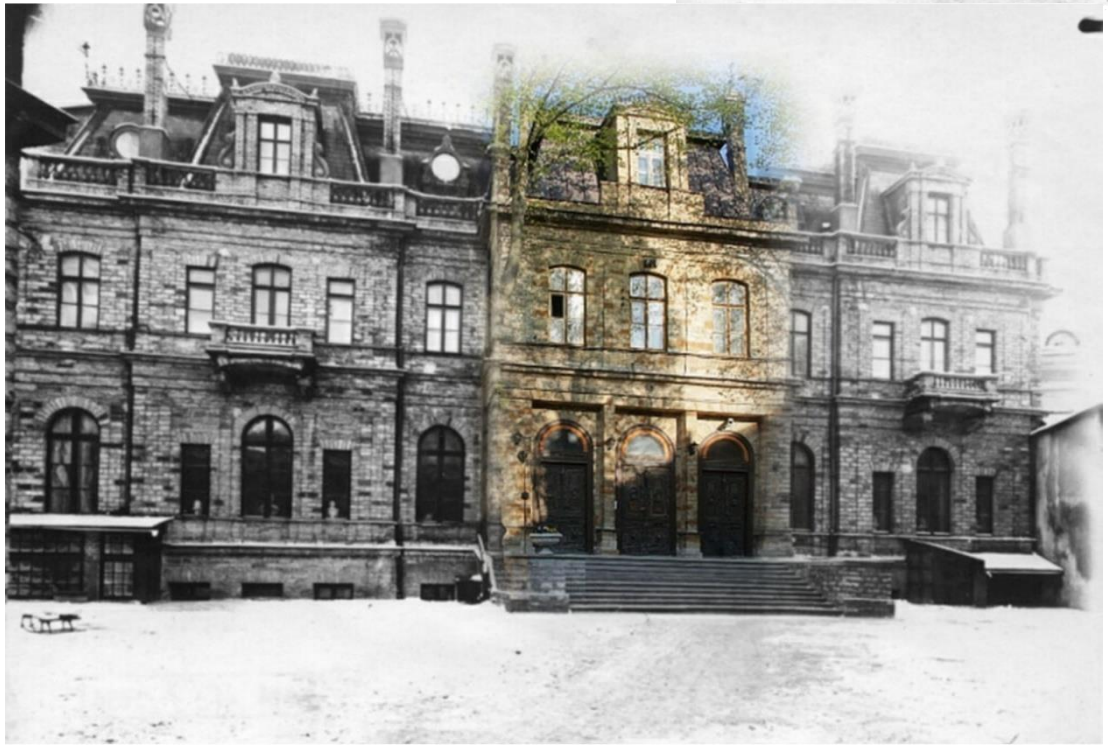
结果

Vintage

Contemporary



Blended



Quad AAAP

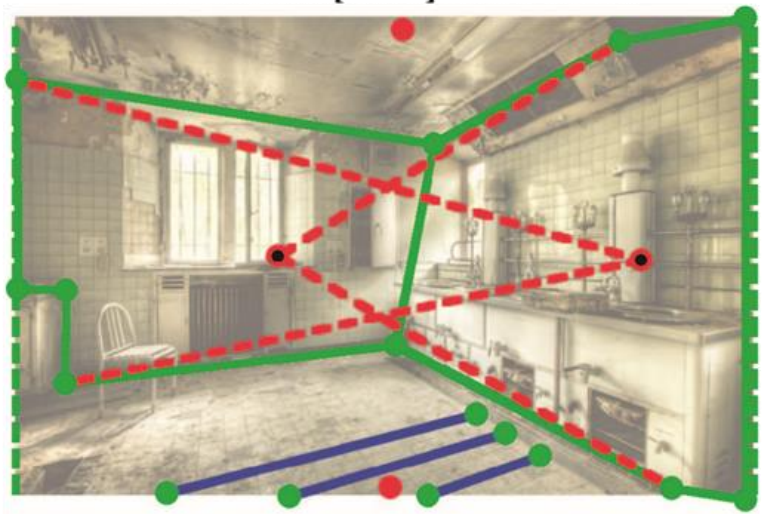
Interactive re-photography

An interactive rephotography session

Perspective editing

- Source

Carrol et al. [2010] constraints



Our AAAP constraints

Carrol et al. [2010] warp

Our AAAP warp

Thank you!

Questions?