Mobile Image Retargeting

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Image Retargeting
Image Retargeting

crop center
Image Retargeting

crop center

scaling
Image Retargeting

crop center  scaling  letterbox
Image Retargeting

retargeting
Image Retargeting

- content-aware
- objectives
  - preserve important structure and content
  - no artifacts
Image Retargeting

- content-aware
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  - preserve important structure and content
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saliency map
Image Retargeting

- content-aware
- objectives
  - preserve important structure and content
  - no artifacts

artifacts
Goals

• bring image retargeting to a mobile device
  ‣ limited CPU, GPU and screen size
• intuitive user interface for small displays
• combine cropping and warping techniques
Related Work
Seam Carving

- Seam Carving

repeatedly remove the least salient path

„Seam carving for content-aware image resizing.“ Avidan and Shamir, SIGGRAPH 2007
Warping Techniques

- Look for a continuous mapping $F : I \rightarrow I'$
Warping Techniques

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- look for a continuous mapping $F : I \rightarrow I'$
- modeled as energy minimization

\[ S(x, y) \parallel J_F(x, y) - \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \parallel^2 \]

saliency map

Jacobian of the mapping
Warping Techniques

- look for a continuous mapping \( F : I \rightarrow I' \)
- modeled as energy minimization

\[
E(F) = \int_{x=0}^{H} \int_{y=0}^{W} S(x, y) \parallel J_F(x, y) - \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \parallel^2 \, dx \, dy
\]

saliency map

Jacobian of the mapping
Warping Techniques

- discretization on regular grid

Original grid $G$ with $M$ rows and $N$ columns maps to deformed grid $G'$ through a function $F$. The diagram illustrates the transformation process.
Possible Discontinuities

• impose hard constraints
• leads to a convex optimization problem
• optimization is expensive and only feasible on coarse grids
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Our Retargeting Operator
Axis-Aligned Image Deformations

- linear number of variables \( s = (s^{\text{rows}}, s^{\text{cols}})^T \)
- complexity \( \mathcal{O}(M + N) \) instead of \( \mathcal{O}(M \cdot N) \)
- fast optimization
ASAP Energy

- locally correspond to a similarity transform

important cells should not change their aspect ratio
ASAP Energy

- locally correspond to a similarity transform

- we use a grid of 25 x 25 cells
• locally correspond to a similarity transform

$$E(F) = \int_{x=0}^{H} \int_{y=0}^{W} S(x, y) \parallel J_F(x, y) - \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \parallel^2 \, dx \, dy$$

• we use a grid of 25 x 25 cells
ASAP Energy

- locally correspond to a similarity transform

\[
\left( \Omega_{i,j} \left( \frac{M}{H} s_i^{\text{rows}} - \frac{N}{W} s_j^{\text{cols}} \right) \right)^2
\]

- we use a grid of 25 x 25 cells
ASAP Energy

• locally correspond to a similarity transform

\[
\Omega_{i,j} \left( \frac{M}{H} s^\text{rows}_i - \frac{N}{W} s^\text{cols}_j \right)^2
\]

average saliency per grid cell

• we use a grid of 25 x 25 cells
ASAP Energy

• locally correspond to a similarity transform

\[
(\Omega_{i,j} \left( \frac{M}{H} s_i^{\text{rows}} - \frac{N}{W} s_j^{\text{cols}} \right))^2
\]

average saliency per grid cell  
change in aspect ratio

• we use a grid of 25 x 25 cells
ASAP Energy

- locally correspond to a similarity transform

\[
E_{ASAP} = \sum_{i=1}^{M} \sum_{j=1}^{N} \left( \Omega_{i,j} \left( \frac{M}{H} s_{i}^{\text{rows}} - \frac{N}{W} s_{j}^{\text{cols}} \right) \right)^2
\]

- average saliency per grid cell
- change in aspect ratio

- we use a grid of 25 x 25 cells
Constraints

- row and column sums are target image size

\[
\begin{align*}
    s_{1}^{\text{row}} + s_{2}^{\text{row}} + \cdots + s_{M}^{\text{row}} &= H' \\
    s_{1}^{\text{cols}} + s_{2}^{\text{cols}} + \cdots + s_{N}^{\text{cols}} &= W'
\end{align*}
\]
Constraints

- no grid cell disappears: minimum cell size

\[ s_i^{\text{rows}} \geq \bar{H}_i^{\text{min}}, \quad i = 1, \ldots, M \]

\[ s_j^{\text{cols}} \geq \bar{W}_j^{\text{min}}, \quad j = 1, \ldots, N \]
Constraints

- no grid cell disappears: minimum cell size

\[ s^\text{rows}_i \geq H_i^\text{min}, \quad i = 1, \ldots, M \]

\[ s^\text{cols}_j \geq W_j^\text{min}, \quad j = 1, \ldots, N \]
Optimization Problem

- quadratic convex optimization problem (QP)
- solved with a customized solver generated with CVXGEN
- optimization takes 6 milliseconds on a recent iPhone or iPad for a grid of 25 x 25 cells
DEMO
Automatic Saliency Detection
Automatic Saliency Detection

- What is important?
- Low-level stimuli driven approaches
  - regions of high contrast
  - we use gradient magnitude with dilation
Automatic Saliency Detection

• What is important?
• Low-level stimuli driven approaches
  - regions of high contrast
  - we use gradient magnitude with dilation
• High-level object based saliency
  - we use the iOS face detector
User Interface
Problem
Problem

• small screen does not allow split view
Problem

- small screen does not allow split view
- combine saliency map and retargeted image
Problem

- small screen does not allow split view
- combine saliency map and retargeted image
- updated warp moves image under the finger
Fixed-point stabilization

- move the image to fix the point at the finger
Fixed-point stabilization
Cropping
Threshold-based Cropping

1. optimize
Threshold-based Cropping

1. optimize  
2. crop

crop threshold
Threshold-based Cropping

1. optimize  2. crop

crop threshold
Threshold-based Cropping

1. optimize  2. crop  3. optimize

crop threshold
Results
RetargetMe Benchmark

original  CR  SV  MULTIOP  AAIR  our operator
Benefit of Cropping

original image

without cropping

with cropping
Results

- interactive performance of 60 fps
- cropping operator
  - greediness of threshold approach
- application
  - picture gallery
Summary

• incorporated cropping into the Axis Aligned Retargeting framework
• interactive touch-screen implementation
• easy to use interface
• picture gallery application
Future Work

- more sophisticated cropping approaches
- application in a (mobile) web browser
- video retargeting
Conclusion

- fast, fluid, fun to use application
- cropping operator is simple yet effective
- source code is publicly available
- app is a free download in the iOS App Store

www.refooorm.at
Questions

Mobile Image Retargeting

› www.refoooorm.at
Thank you for your attention.