PROJECT REPORT

IMPROVED SEAM CARVING THROUGH OBJECT PROTECTION USING SALPROP

Submitted By

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ABSTRACT

This project focuses on Content aware image resizing through object protection. The main purpose of Content-aware Image resizing is to resize an image to different sizes while retaining the integrity of objects in the image. We propose a methodology to effectively resize a given image to desirable dimensions without affecting the objects in the image. Seam Carving proposed by Shai Avidan et al [1] exists as one of the main *modus-operandi* for content aware image resizing. A 'seam' is a connected path of the lowest energy pixels in the image (N4 neighbors). By the N4 neighbors of a pixel we mean the pixels lying on its immediate top, bottom, right & left. The method aims at removing the lowest energy pixels in the image as these blend effectively with the surroundings. Removing these pixels shall not affect the image to a conspicuous extent. It is however seen that even this method of seam carving fails to protect the objects in the image to a great extent, so there remains a need to further improve seam carving. Our method is aimed at improving the results of seam carving by employing the concept of object protection.

INTRODUCTION

Our method improves seam carving by a remarkable extent by protecting the objects in the image from distortion produced by carving, making use of object proposals of Salprop [3]. We take the object proposals of salprop for the image and enhance the energy of the pixels lying in these windows, so that these pixels belonging to the objects in the image are not carved, in order to minimize object distortion. We evaluated our results on the MSRA1000 dataset, and the results prove the effectiveness of our approach.

MOTIVATION

Content aware image resizing finds numerous applications in real life. While designing web pages, a web designer has to pay heed to situations where it may be needed to display the web page designed for displaying on a traditional computer screen, on big screens instead, or on smaller screens like smartphones or tablets. The content must effectively and elegantly fit the display area, which is a main necessity. Using Bootstrap and other web designing technologies it is possible to wrap text depending on the target display size, but an image may be totally distorted in the process. Cropping and/or scaling may be used to handle the issue, but they result in significant information loss in the image, and also disturbing its quality (in case of scaling). To handle this, the web designers can use seam carving and other content-aware image resizing techniques to prevent image distortion while image resizing. Face Recognition systems work on images and are quite sensitive to image distortions. In case of a need for image resizing prior to the process of face detection in an image, the algorithm may not identify the face at all. It seems that even the traditional method of seam carving fails to prevent image distortion in certain cases. We hence felt a need to improve the existing techniques for image retargeting by object protection concept, so that even if the images are resized to new dimensions yet the objects in the image are not distorted.

LITERATURE REVIEW

Matt Nichols et al. [5] aim at improving traditional seam carving method by focusing primarily on preserving straight edges in the image, or at least favor curved over jagged edges. They try to avoid the heavy warping of hard edges in images, so that images after retargeting do not look unrealistic, by adding the gradient difference created by removal of a pixel to the cost of each seam going through that pixel, which favors seams which do not create sharp corners out of previously linear portions of the image. They however, do not focus on preserving the importance-wise prior image features (pixels that lie on the objects, for instance) which, though preserving the straight edges to good extent, work almost negligibly on preserving the objects as a whole in the image foreground.

Prerana Mukherjee et al. [3] in their work have focused on proposing a novel object proposal generation scheme by formulating a graph-based salient edge classification framework that utilizes the edge context. They construct a Bayesian probabilistic edge map to assign a saliency value to the edgelets by exploiting low level edge features. A Conditional Random Field is then learned to effectively combine these features for edge classification with object/non-object label. An objectness score is proposed for the windows generated, by analyzing the salient edge density inside the bounding boxes. We found the method effective for identifying the importance-wise prior Regions of Interest (ROI) in the image corresponding to the objects in the image; incorporating this technique in ours helps to identify the pixels which must be preserved.

APPROACH

Object Protection using SALPROP

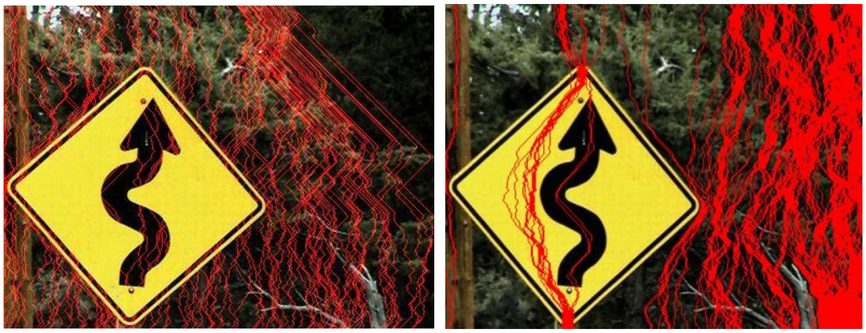
Before proceeding to perform seam carving on the image, we take object proposals of an object detection technique, SALPROP, by our mentor Ms Prerana Mukherjee et al [3], and these object proposals tightly enclose the objects in the input image. We then apply Region-Of-Interest (ROI) based filtering: fspecial (Unsharp Mode), a function available already in MATLAB, to enhance the energy of the pixels lying in these object proposals, so that while seam carving proceeds, the seams will first pass through that portion of image, where lower energy pixels lie. This effectively prevents the low energy pixels lying on the objects to be included in the seams, hence the pixels of the object are protected, while the not-so-important low energy pixels of the background will be removed instead. Fig. 1 shows seams which would be carved (for 25% Seam Carving) by our method, most of which do not pass through the object as a result of object protection we have used. Note here that the seams seem to clearly ‘avoid’ the object boundary.

However, the phenomenon of seams entering the object in case of too much shrinking of image is definitely unstoppable even by an algorithm 100% accurate because if we have had to shrink the image beyond the boundaries of the bounding box, there would be no option left but the seams will pass through the object.

Seam Carving

Seam carving aims at resizing given image to new desirable dimensions, while preserving the image objects, and without affecting the image quality. For serving this purpose, the method seeks to remove the pixels which effectively blend with their surroundings, & removing which would not affect adversely, the image quality, and also such that the objects in the image are not distorted. But simply removing the pixels would distort the image dimensions, the image would no longer remain rectangular. So instead of removing pixels individually, certain ‘paths of least importance’, known as ‘seams’, which are constituted by these low energy pixels only, are taken in the image and these are removed, preserving the rectangularity of the image. **Expansion**

The existing seam-carving techniques support expansion also, apart from image shrinking. The modifications required in our approach for image expansion, are simply constructing the seams of lowest energy pixels again following the same method, and instead of removing them, placing requisite no. of seams alongside the formed seams.



(Fig. 1: A plot of seams on the image to be retargeted, by our method, and by SCMIT method)

It can clearly be seen that much less no. of seams pass through the object in our method than in the existing technique SCMIT.

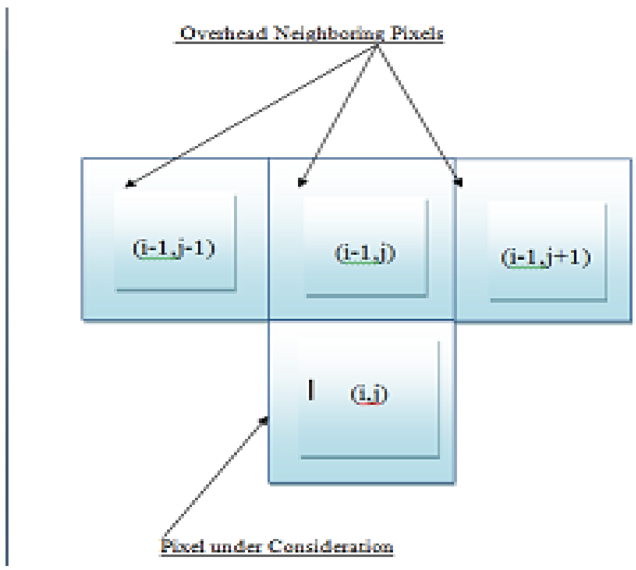
Pseudo code for finding the Energy using Canny:

```
FINDENERGY(image)

//Er, Eg, Eb: Energy map of red plane.

MeanEnergyMap←(Er+Eg+Eb)/3

return MeanEnergyMap

end
```

We have considered the mean energy map of R,G,B planes of the image using Canny's method (MATLAB).

Seam Carving Approach

A seam is a connected path of lowest energy pixels in the image, which blend effectively with their surroundings and removing which will not pose the threat of significant information loss in the image. These paths can be vertical as well as horizontal, depending on whether the rows have to be removed from the image (horizontal seams need to be removed) or columns (vertical seams need to be removed) or both. We first create an energy map for the image using Canny filter. After that we find the Cumulative energy map of the image employing the obtained energy map using Dynamic Programming, as follows:



(Fig. 2)

Consider a pixel (i,j), and its overhead N8 neighbors (i-1,j-1), (i-1,j) and (i-1,j+1) (See fig. 2). Of the three, we add the minimum cumulative energy to the energy of the pixel (i,j) to obtain the cumulative energy of the pixel (i,j). The first row of the cumulative energy map is copied as it is from the energy map as for the pixels lying in the first row there are no overhead N8 neighboring pixels. So we can infer:

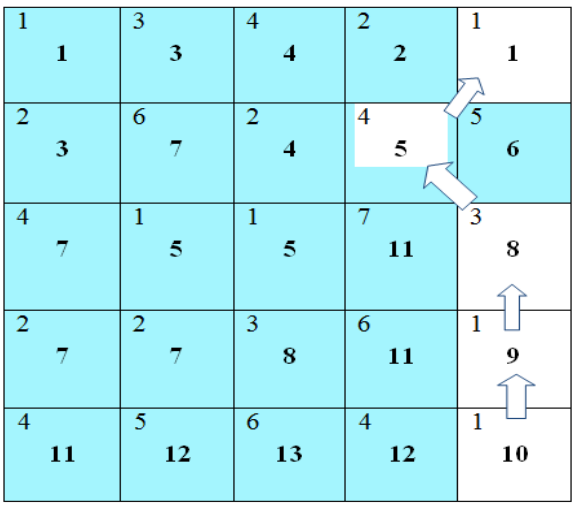
Let,

$C(i,j)$ = Cumulative Energy of a pixel (i,j)

$E(i,j)$ = Energy (from the energy map) of a pixel (i,j)

$$\boxed{C(i,j) = E(i,j) + \min\left[C(i-1,j-1),\ C(i-1,j),\ C(i-1,j+1)\right]}$$

Constructing the Seams



(Fig. 3: Seam Construction Illustration)

(Path shaded white is the first seam constructed)

See fig.3. It represents pictorially a section of an image, divided obviously into pixels. The numerals written in the top left corner in each pixel represent the actual energy values of the pixels. The numerals written in bold, in the center are the cumulative energies of the pixels finding which has been explained in the last article.

Once the cumulative energy map has been constructed, we can start forming seams from the last row (See fig. 3). We will side-by-side maintain another vector 'SeamVector' which will contain the indices (column no.s) of the pixels to be removed for a seam. First the pixel with the least cumulative energy is identified and its index is stored in SeamVector. Then its three overhead neighboring pixels are considered, and one with the minimum cumulative energy shall be incorporated with the previous pixels in the path being formed (seam) and the index of this pixel is also stored in SeamVector. This process shall continue till the first row is reached. Hence one complete vertical seam has been constructed, and using the SeamVector the pixels corresponding to the indices stored in SeamVector shall be removed. We will repeat the energy calculation after that as the pixels would have their importance values altered, even if slightly. After that from the remaining pixels least energy ones will form the second seam, and so on. The Process shall conclude with desirable no. of seams removed from the image.

This process removes vertical seams. To remove the horizontal seams, first transpose the image matrix, repeat the same process over it, and re-transpose the image after completion.

EXPERIMENTS FOR VALIDATION

We have evaluated our results on the MSRA1000 dataset, and implemented the methods on MATLAB. For finding the cumulative energy map, we used the code provided by Danny Luong [4]. For the purpose of Image Retargeting Quality Assessment (IRQA), we performed two experiments. In the first experiment, following metrics have been used to compare the results of our method (for 25% and 50% seam carving) with Cropping (CR), Scaling (SCL), Original Seam Carving [1] (SC), Seam Carving (MIT, 2016) (SCMIT), and SNS.: FSIM (Feature Similarity Index), ARS (Aspect Ratio Similarity), and FSIL (Forward Saliency Information Loss).

Pseudo code for finding the seam with lowest energy

```
FINDSEAMWITHLOWESTENERGY(x)

//To find a seam with lowest energy from given cumulative energy map.

seamVector ← Stores column no. of all rows of the seam selected

[row col]←size(x)

for i←row to 1

    if i equals row

    index←min(x(row,:))

    else

    if seamVector(i+1) equals 1

    index←min(∞, x(i,seamVector(i+1)),x(i,seamVector(i+1)+1))

    else if seamVector(i+1) equals cols

    index←min(x(i,seamVector(i+1)-1),x(i,seamVector(i+1)),∞)

    else

    index←min(x(i,seamVector(i+1)-1), x(i,seamVector(i+1)), x(i,seamVector(i+1))+1)

    end

seamVector(i)←index

end
```

Explanation

1.) Start from the last row.

2.) Select the pixel with the least energy.

3.) Store the column no. of this pixel in SeamVector.

4.) Now select the pixel with the least energy in its three overhead N8 neighboring pixels.

5.) Store the column no. of this pixel too in SeamVector.

6.) Repeat steps (4.)-(5.) until first row is reached.

NOTE: If the overhead pixels of a boundary pixel are to be considered in step (4), then select the pixel of the two existing pixels. Third overhead pixel won’t exist because of boundary.

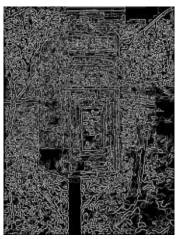
BLOCK DIAGRAM OF STRATEGY

Obtain the SALPROP object proposals for the image.

↓

Apply ROI based filtering (fspecial)

↓



Create energy Map of R,G,B planes of image using Canny's Method.

↓

Obtain the cumulative energy map of the image using Dynamic Programming

↓

Seams are formed using the seam vector, containing the indices (Column No.s) of the pixels to be removed for a seam.

↓

Using the seam vector, pixels corresponding to indices stored in seam vector are removed.

↓

The process concludes with the desirable no. of seams removed from the image.

Experiment-1 (Image Retargeting Quality Assessment, IRQA)

Following are the results of our method when implemented on five of the images available in the MSRA1000 dataset, as compared with the original image before retargeting and other methods to be compared with.

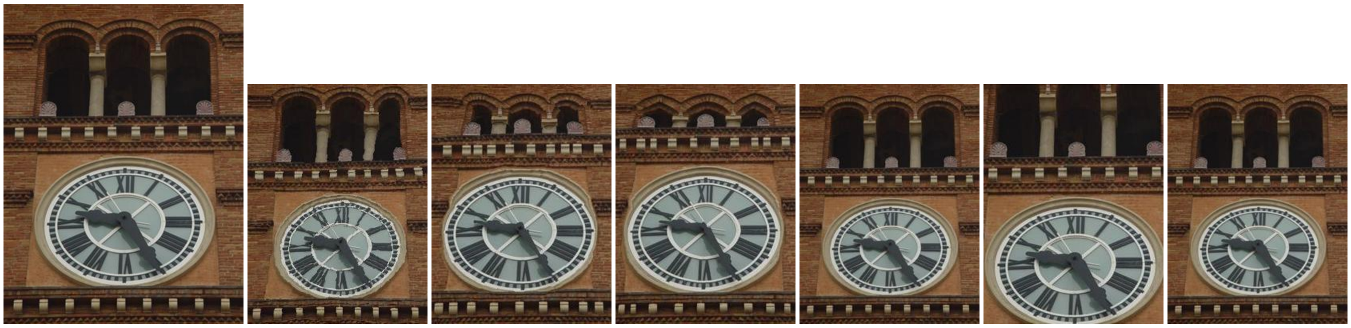
The block pair of the regular partitioned block in the original image and the corresponding block in retargeted image is utilized to calculate the local AR similarity scores. When the ARS score is close to 1, the block content in original image is generally kept in high quality in retargeted image, while when ARS score is close or equal to zero, it indicates that the retargeted block is suffering from serious information loss and distortion or even removed totally.

We calculate the maximal width wret and maximal height hret of each retargeted block. The width and height ratio changes can be denoted as $R_w = w_{ret}/w_{ori}$ and $R_h = h_{ret}/h_{ori}$.

$$ARS = ((2 \cdot R_w \cdot Rh + C)/(R^2_w + R^2_h + C))\cdot e^{-\alpha((Rw+Rh)/2-1)2}$$

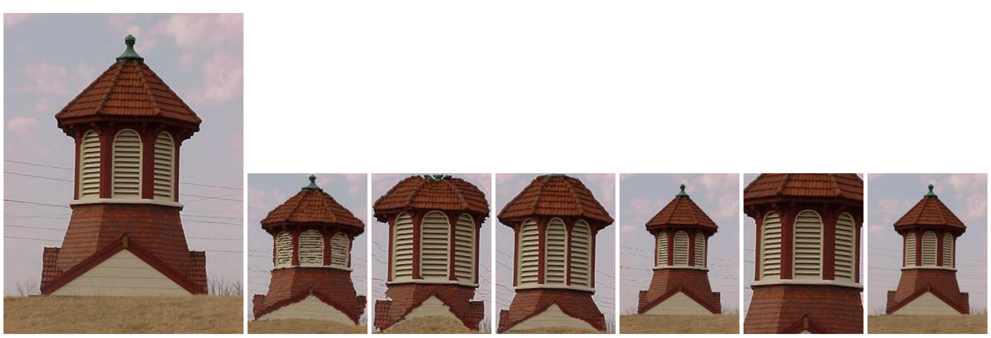
Feature Similarity Index (FSIM) is yet another metric for measuring similarity between original and retargeted images, based on low level features like Phase Congruency (PC) & Gradient Magnitude (GM).

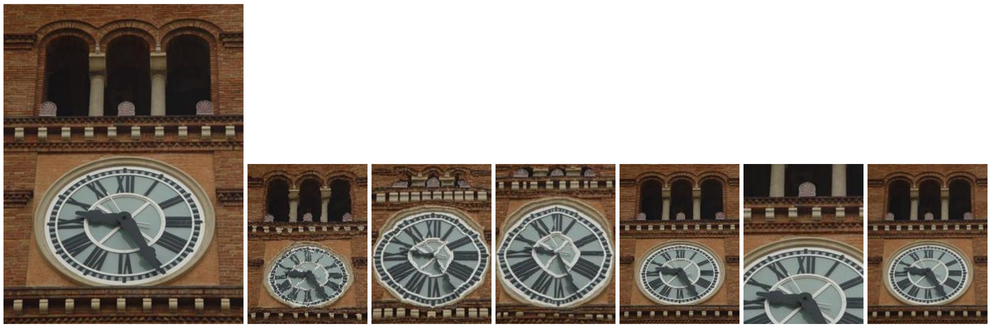
<u>Comparison of our method with other methods, 25% Seam Carving</u>



(Original Image) (Ours) (SC) (SCMIT) (SNS) (CR) (SCL)

<u>Comparison of our method with other methods, 50% Seam Carving</u>





(Original Image) (Ours) (SC) (SCMIT) (SNS) (CR) (SCL)

The results clearly show that our method is far better than contemporary seam carving (MIT, 2016) [2] and Cropping. Scaling shows better results in this case of 25% seam carving, but for seam carving ≥ 50% our method gives the best results of all the four methods.

Measure	Our	SC	SCMIT	SCL	CR	SNS
FSIM	0.6448	0.6246	0.6277	0.6343	0.63431	0.6440
ARS	0.9267	0.9637	0.9637	0.9637	0.9344	0.9631
FSIL	0.6160		0.6080			

(Metric values for 25% Seam Carving)

Measure	Our	SC	SCMIT	SCL	CR	SNS

FSIM	0.5975	0.5499	0.5690	0.6192	0.6058	0.6133
ARS						
FSIL						

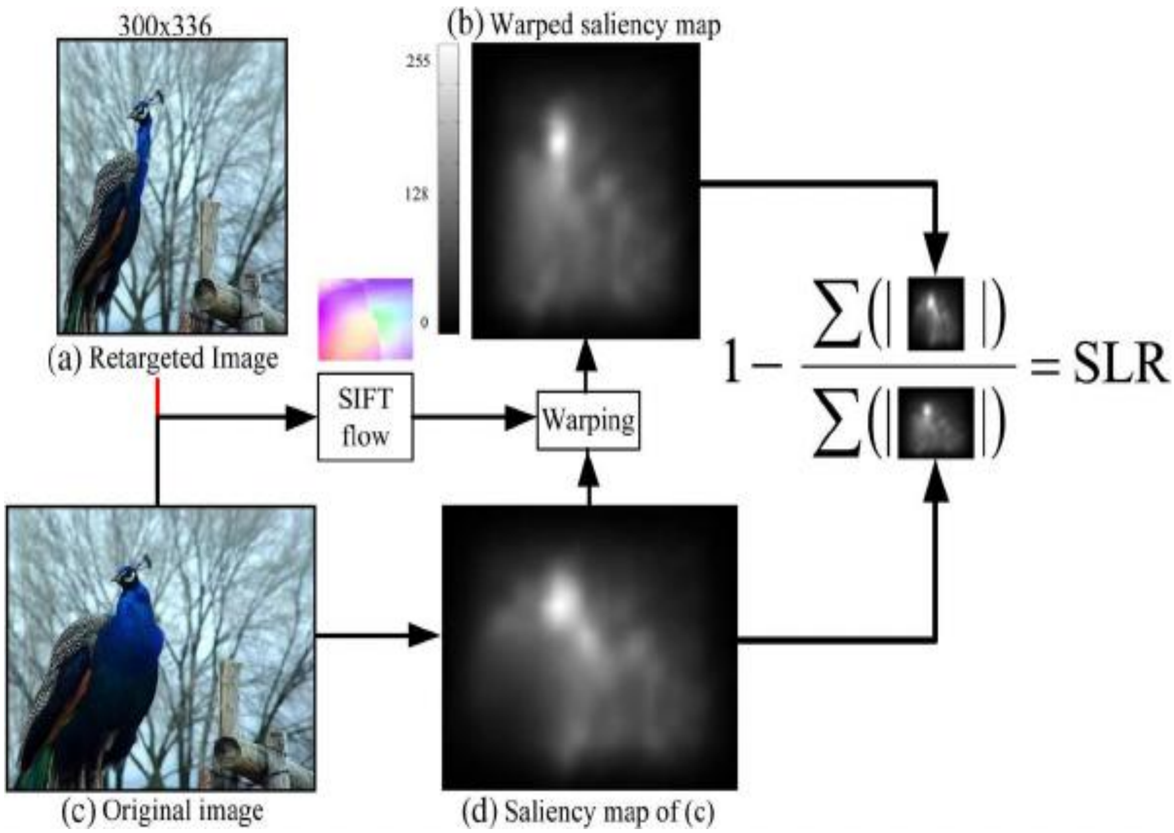
(Metric values for 50% Seam Carving)

Experiment-2: Image Information Loss Metric: SLR (Saliency Loss Ratio)

Let E_o denote the saliency value of any pixel in the original image, and E_r be the one in the retargeted image. Then the Saliency Loss Ratio is given as:

$$d_{SLR}=1- ((\sum_p|E_r(p)|) / (\sum_p|E_o(p)|))$$

This metric gives us an idea of the salient content left in the image after retargeting.



Seam Carving	Our	SC	SCMIT	SCL	CR	SNS
25%	0.3692	0.3697	0.3755	0.4277	0.3620	0.4283
50%	0.7150	0.7033	0.7065	0.7406	0.6947	0.7388

REFERENCES

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[5] Nichols, Matt. Image Retargeting with Seam Carving. Available: http://cs.brown.edu/courses/cs129/results/proj3/man1/#ec