BIL 717 Image Processing-Spring 2016 Final Project Analysis of Two Non-Uniform Motion Deblurring Studies

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Abstract

In this paper we evaluate two blind motion-deblurring methods in the recent literature using a non-traditional metric that was developed in order to create a more perceptionally sound deblurring comparison criteria. In general terms, the first method, which was developed by Sun et al. [6], uses a convolutional neural network (CNN) to learn non-uniform motion blur removal. The second method, which was developed by Whyte et al. [7], proposes a geometric model to define the blurring kernels. Both methods tackle with the same blind non-uniform motion blur removal problem. In the upcoming sections we first define the blind motion-deblurring problem, then we discuss the related work focusing mostly on the recent literature, next we describe the two methods along with the no-reference metric, subsequently we define the methodology and experimentation, and we finish with conclusion.

1. Introduction

Motion blur is caused by moving the camera or objects within view when the camera shutter is open. This harms sharpness and causes losing the edges and thus objects in the scene seem intermingled. If the entire scene was blurred in the same way, this type of blur is called uniform blur. Non-uniform blur arises when the blur does not show the same type or magnitude of intermingling throughout the scene. A typical example of non-uniform blur emerges when the camera is rotated when the camera shutter is open and the recording of the information of the outside world is under way. When this happens the scene gets blurred in a rotational pattern (different parts of the scene blurred depending on the distance to a certain rotational center) [EXAMPLE]. Another example would be moving the camera towards or away from the scene (transposition in the

depth axis). In this case the blurring pattern looks more like a tunnel effect; namely blurring happens less in magnitude around a certain center in the scene (like a target), and more and more towards the image boundaries [EXAM-PLE]. More complex movements such as a combination of transposition and rotation of the camera complicate the issue even further.

Uniform deblurring typically have been defined as a convolution of an image with a kernel and added noise. Therefore, the basic approach is to subtract the noise and deconvolve the image with the same kernel. The problem with this approach is that the kernel is generally unknown. When the blur kernel is unknown, the problem is called blind deblurring problem. Researchers have attacked this problem with a range of different approaches. Some of the approaches will be covered in the next section. In this paper we analyze two of the recent papers that tackle with blind motion-deblurring problem.

In Sun *et al.* (2015), the authors attack the problem of removing non-uniform motion blur from a single image using deep learning. The method they use depends on predicting motion kernels at a patch level. In order to do this they formulate the non-uniform blur as a field throughout the image. To find this field they divide the image into overlapping patches, estimate the kernels at this level and then smooth the field depending on a smoothness of motion assumption. CNN is used to learn deblurring at a patch level. The general view of the CNN is seen on (Figure) [6].

Before training, the authors generated motion blur kernels with varying sizes from 1 pixel to 25 pixels with interval of two, and orientations ranging from 0 degree to 150 degree with intervals of 30, totaling 73 kernels. These kernels can be seen in (figure). To train the CNN model, the authors used these 73 kernels to artificially generate 1.4 million blurred patch/kernel pairs using PASCAL VOC 2010 database. They then used these patches as the input to the CNN during the training phase [6].

As can be seen in (figure) the CNN finds a probability distribution at the softmax layer. The authors state that the kernel space, which consists of 73 kernels, is not dense enough to represent all types of motions. To overcome this problem, they extend the motion kernel set by rotating image patches in the range between 0 and 24 degrees and use the trained CNN on these patches. Note that at this point they do not retrain the CNN, but rather they use the trained CNN with rotated images. By doing this they overcome the trainability problem of a high number of motion kernels and get a good amount of motion orientation detail [6].

1.1. Language

All manuscripts must be in English.

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The LaTeX style defines a printed ruler which should be present in the version submitted for review. The ruler is provided in order that reviewers may comment on particular lines in the paper without circumlocution. If you are preparing a document using a non-LaTeX document preparation system, please arrange for an equivalent ruler to appear on the final output pages. The presence or absence of the ruler should not change the appearance of any other content on the page. The camera ready copy should not contain a ruler. (LaTeX users may uncomment the \cvprfinalcopy command in the document preamble.) Reviewers: note that the ruler measurements do not align well with lines in the paper — this turns out to be very difficult to do well when the paper contains many figures

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Please number all of your sections and displayed equations. It is important for readers to be able to refer to any particular equation. Just because you didn't refer to it in the text doesn't mean some future reader might not need to refer to it. It is cumbersome to have to use circumlocutions like "the equation second from the top of page 3 column 1". (Note that the ruler will not be present in the final copy, so is not an alternative to equation numbers). All authors will benefit from reading Mermin's description of how to write mathematics: http://www.pamitc.org/documents/mermin.pdf.

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Blind review means that you do not use the words "my" or "our" when citing previous work. That is all. (But see below for techreports.)

Saying "this builds on the work of Lucy Smith [1]" does not say that you are Lucy Smith; it says that you are building on her work. If you are Smith and Jones, do not say "as we show in [7]", say "as Smith and Jones show in [7]" and at the end of the paper, include reference 7 as you would any other cited work.

An example of a bad paper just asking to be rejected:

An analysis of the frobnicatable foo filter.

In this paper we present a performance analysis of our previous paper [1], and show it to be inferior to all previously known methods. Why the previous paper was accepted without this analysis is beyond me.

[1] Removed for blind review

An example of an acceptable paper:

An analysis of the frobnicatable foo filter.

In this paper we present a performance analysis of the paper of Smith *et al.* [1], and show it to be inferior to all previously known methods. Why the previous paper was accepted without this analysis is beyond me.

[1] Smith, L and Jones, C. "The frobnicatable foo filter, a fundamental contribution to human knowledge". Nature 381(12), 1-213.

If you are making a submission to another conference at the same time, which covers similar or overlapping material, you may need to refer to that submission in order to explain the differences, just as you would if you had previously published related work. In such cases, include the anonymized parallel submission [4] as additional material and cite it as

[1] Authors. "The frobnicatable foo filter", F&G 2014 Submission ID 324, Supplied as additional material fg324.pdf.

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We describe a system for zero-g frobnication. This system is new because it handles the following cases: A, B. Previous systems [Zeus et al. 1968] didn't handle case B properly. Ours handles it by including a foo term in the bar integral.

The proposed system was integrated with the Apollo lunar lander, and went all the way to the moon, don't you know. It displayed the following behaviours which show how well we solved cases A and B: ...

As you can see, the above text follows standard scientific convention, reads better than the first version, and does not explicitly name you as the authors. A reviewer might think it likely that the new paper was written by Zeus *et al.*, but cannot make any decision based on that guess. He or she

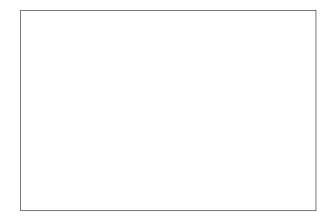


Figure 1. Example of caption. It is set in Roman so that mathematics (always set in Roman: $B \sin A = A \sin B$) may be included without an ugly clash.

would have to be sure that no other authors could have been contracted to solve problem B.

FAQ: Are acknowledgements OK? No. Leave them for the final copy.

1.7. Miscellaneous

Compare the following:

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\begin{array}{ll} & \text{$\tt conf_a\$} & conf_a \\ & \text{$\tt mathit\{conf\}_a\$} & conf_a \\ & \text{See The TeXbook, p165.} \end{array}
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The space after e.g., meaning "for example", should not be a sentence-ending space. So e.g. is correct, e.g. is not. The provided \eq macro takes care of this.

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This is incorrect: "... subsequently developed by Alpher $et\ al.$ [2] ..." because reference [2] has just two authors. If you use the \etal macro provided, then you need not worry about double periods when used at the end of a sentence as in Alpher $et\ al.$

For this citation style, keep multiple citations in numerical (not chronological) order, so prefer [2, 1, 4] to [1, 2, 4].

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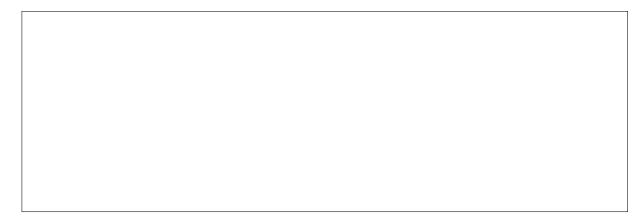


Figure 2. Example of a short caption, which should be centered.

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\setcounter{page}{1}
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Make sure the first page is numbered by commenting out the first page being empty on line 46

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AUTHOR NAME(s) and AFFILIATION(s) are to be centered beneath the title and printed in Times 12-point,

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¹This is what a footnote looks like. It often distracts the reader from the main flow of the argument.

Method	Frobnability
Theirs	Frumpy
Yours	Frobbly
Ours	Makes one's heart Frob

Table 1. Results. Ours is better.

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References

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