



Defocus Stacking – Bokeh without aperture f/1.2

👤 Herbert Kopp

Motivation for Defocus Stacking



The silver bullet for taking photos with a beautiful blurred background are lenses with a wide aperture. Unfortunately these lenses are expensive. Software generated bokeh does not come up to the bokeh produced by an optical lens and by now there were few attempts to find a way out. In 2016 Thilo Gockel [2] introduced the term *Defocus Stacking* for a method which superposes a sharp image of the motif and a defocused image of the scene. It is a manual method requiring an exact mask of the motif and additional manual corrections.

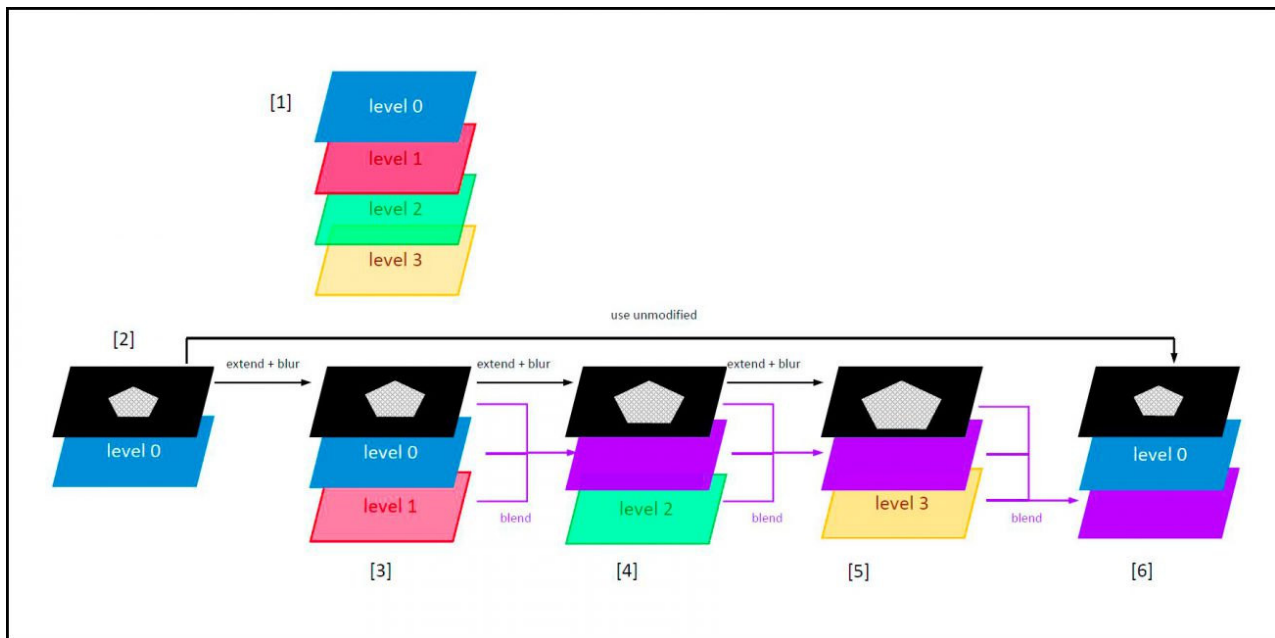
Here we present a new approach based on a picture stack consisting of a sharp picture of the motif at the top and increasingly defocused pictures beneath. It does not require an exact mask for the motif. Therefore we can use automatic segmentation algorithms and there is no need for manual corrections of the result.

The Defocus Stacking algorithm

The diagram below outlines the workflow of the new Defocus Stacking algorithm: A sharp picture of the motif constitutes the top layer of the stack. On the stack levels beneath we have additional pictures which are increasingly defocused. So, when shooting the picture stack we could start putting the focus plane on the motif and then shift the focus plane nearer and nearer towards the camera. The diagram shows close to [1] the top level of the stack as *level 0* and the lowest level as *level 3*.

The algorithm proceeds as follows:

- From the sharp picture at *level 0* the algorithm generates a mask isolating the motif from the background [2]. The mask must not be very exact, therefore automatic segmentation algorithms can be used.
- At first we extend and blur the mask and use it for blending the pictures on *level 0* and *level 1* of the stack [3].
- The picture obtained by this blending operation is shown as a purple symbol  in step [4]. It becomes the new 'foreground' picture for this step.
- Now we extend and blur the mask once more and use it for blending  with the picture on *level 2* of the stack [4].
- We repeat this for all following levels of the stack. In the diagram there is only one further step necessary for *level 3* [5].
- Finally we blend the sharp image from level 0 with the result from the preceding step using the original mask [6].



Schematic workflow of the Defocus Stacking process

The process outlined above yields good results if the generated initial mask approximately isolates the motif and if the defocus steps between the levels of the stack are not too large. Because we extend and blur the mask from level to level we get a smooth transition from the sharp motif to the fully blurred background of the lowest stack level. Moreover the initial mask must not be very precise.

The segmentation algorithms

The implementation of the algorithm outlined above offers two automatic segmentation algorithms to choose from:

GrabCut

is the newer and more powerful algorithm. It uses a concept from graph theory published by [Rother, Kolmogorov and Blake] in 2012. All pixels of an image are arranged in a graph, where adjacent pixels are connected by edges. The edges are weighted by the similarity of the pixels at their vertices. The segmentation between foreground and background pixels uses a graph theoretical method – a so-called 'minimal cut'. It decomposes the graph into two parts – foreground and background – by cutting its edges so that the weight sum of the cut edges is minimal.

Connected Components

identifies blobs in the picture, i.e. connected subareas with similar attributes such as channels of the color space or brightness [AI Shack Tutorials]. The *DefocusStacker* application uses the algorithm with only one attribute and by default it selects the largest blob as background. Our implementation allows to modify the assignment of the blobs to the foreground/background.

Defocus Stacking examples

Below you see a Defocus Stacking sample for a motif with distinct edges:



Sharp picture and grabcut mask for the motif

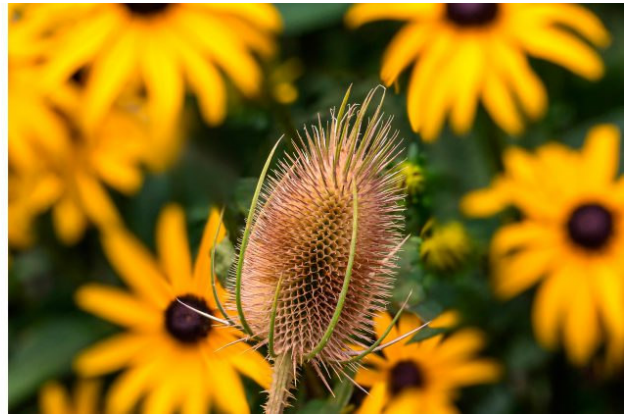
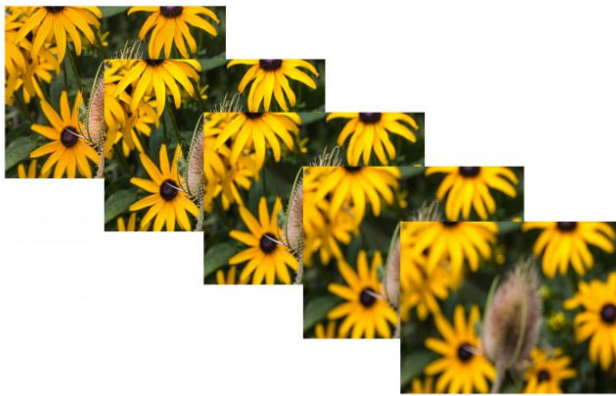


Stack with four pictures and Defocus Stacking result

Next you see a Defocus Stacking sample for a motif with complex edges:



Sharp picture and grabcut mask for the motif



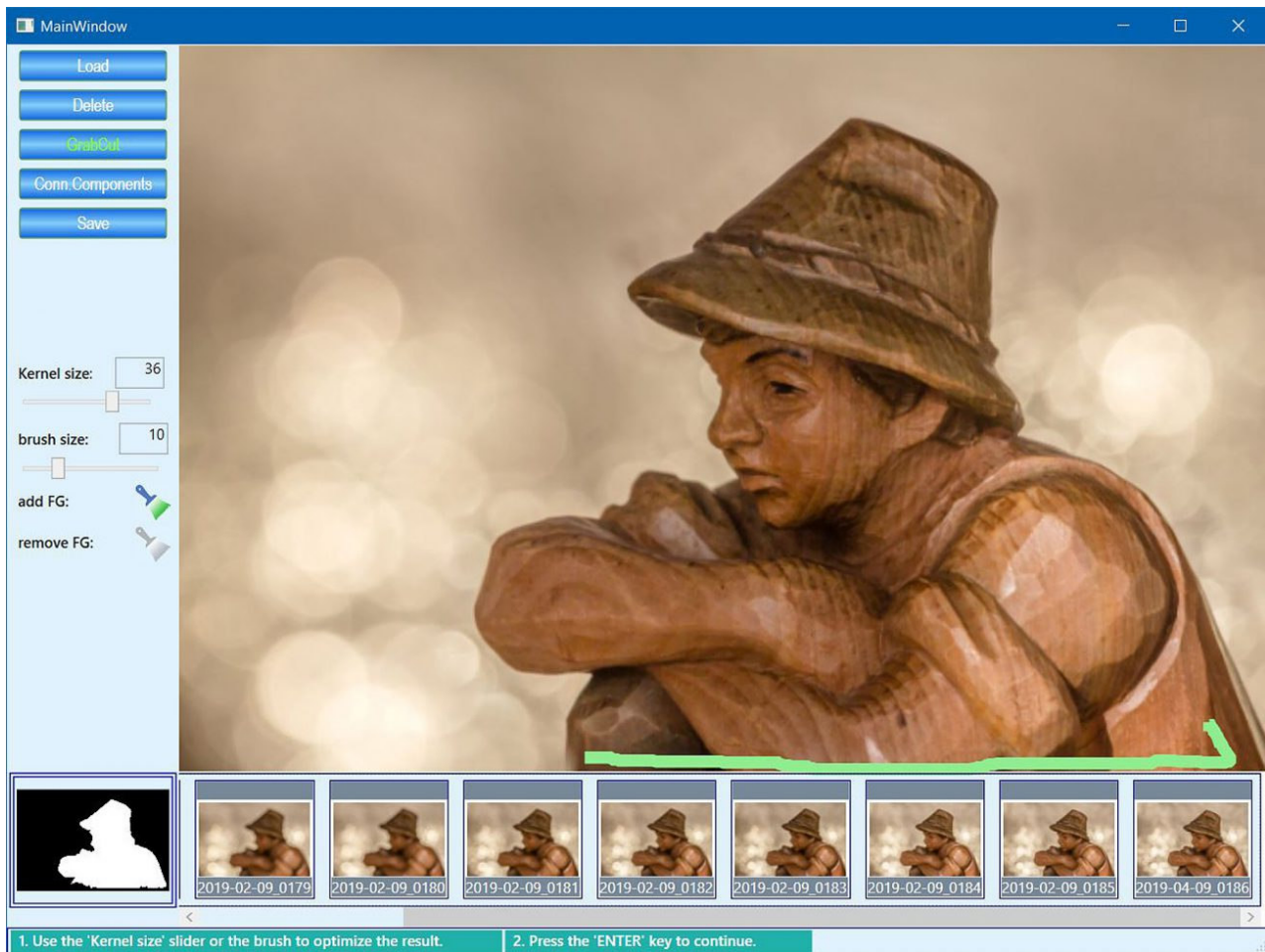
Stack with five pictures and Defocus Stacking result

The *DefocusStacker* implementation

DefocusStacker is an implementation of the algorithm demonstrating the feasibility of the method. There are two versions:

- a Windows implementation (for Windows 10 Version 1909). Its user interface is shown below.
- a Photoshop action plus jsx-script tested with Photoshop CS5 and CC2020.

The references contain download links for both implementations and user manuals for them.



User interface of the DefocusStacker application.

References

[Gulbins, Gulbins]

Photographic Multishot Techniques, Rocky Nook, 2009

[Gockel]

Bokeh, dpunkt, 2016

[Rother, Kolmogorov and Blake]

GrabCut – Interactive Foreground Extraction using Iterated Graph Cuts

<https://cvg.ethz.ch/teaching/cvl/2012/grabcut-siggraph04.pdf>

[AI Shack Tutorials]

Connected Component Labelling

<https://aishack.in/tutorials/pixel-neighbourhoods-connectedness/>

DefocusStacker application (for Windows10)

https://www.dropbox.com/s/ucgvpf5yh33e1f2/DFS_Setup.zip?dl=0

[*DefocusStacker(PS)*] (for Photoshop)

<https://www.dropbox.com/s/4h896z36wimsfcr/DefocusStacker%28PS%29.zip?dl=0>

About the author



Herbert Kopp