Rules for the HDC2021

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1 Introduction

The Finnish Inverse Problems Society (FIPS) proudly presents the *Helsinki Deblur Challenge 2021* (HDC2021). We invite all scientists and research groups to test their deconvolution algorithms on our real-world data.

Can you make it the top of the leaderboard on September 30, 2021, when the challenge closes?

The top participants of the challenge will be invited to a minisymposium at the Inverse Days Conference to be held in Tampere, Finland, in December 2021.

The journal *Inverse Problems and Imaging* will run a special issue publishing articles from participants of the HDC2021 competition.

Figure 1: Left: original, properly focused photograph. Right: blurred (misfocused) and noisy photograph.

2 What is deconvolution?

Image deconvolution is a fundamental inverse problem, where an unknown picture is blurred by a point spread function (PSF) and further degraded by random noise. In practice, images are often blurred by camera shake (curve-like PSF), by poor focusing (disc-like PSF) or by bad optical quality (more complicated PSF). See Figure 1 for an example of blur resulting from misfocus. The goal of deconvolution is to recover the original picture from the blurred and noisy image.

On one hand, deconvolution is a simple inverse problem since it is linear and can be accurately described with the help of the Fourier transform (FT) as severe damping of high-frequency components of the image. This is because FT turns convolution into point-wise multiplication in the frequency domain, and because the FTs of typical PSFs are close to zero at high frequencies.

On the other hand, image deconvolution is very ill-posed and difficult to solve when the PSF has wide extent and decays rapidly in the frequency domain.

The HDC2021 competition is based on real-world disc-like PSFs of increasing sizes, realized by misfocusing a digital camera. We produced a large set of photographic data with both sharp and blurred image of the same target. This allows development and testing of deconvolution methods, including approaches based on supervised machine learning.

In a data challenge it is important to have an objective and quantitative measure for reconstruction quality. We chose strings of random characters of the latin (roman) alphabet as targets in our images. The success of a deconvolution algorithm can then be measured by applying an Optical Character Recognition (OCR) software that turns the photograph into a text file. The resulting text can be compared to the original text, leading to a discrete error measure that is same for all participants of the challenge.

Questions? Send email to hdc2021 ("at") fips.fi.

3 How the data was measured

We showed random strings of text to two digital cameras simultaneously using an e-ink display and a beamsplitter arrangement (half-transparent mirror at 45° angle). One of the cameras was properly focused while the other one was progressively misfocused, and sporting a neutral density filter, resulting in blurred and noisy images.

We recorded also images of dots and other technical targets with the same camera settings than we used for the actual targets. This makes it easier for the competitors to estimate the PSFs empirically.

You can find all the details of the measurement of the public dataset in this ArXiv preprint: http://arxiv.org/abs/2105.10233

The data is available here: https://doi.org/10.5281/zenodo.4916176

Note: The publicly available dataset will not be used by the committee for measuring the quality of the algorithms submitted to the challenge. These are reserved for developing the algorithms. We measured some extra data for that. The PSFs are the same as in the categories of the public dataset. However, the targets are slightly different in a way that will be made public only after the deadline.

4 Deadlines and what needs to be submitted

Deadline for registration: Register before 23:59 EET (Eastern European Time) on July 31, 2021, using this electronic form.

Deadline for submission: Send your submission to hdc2021 ("at") fips.fi before September 30, 2021 23:59 EET (Eastern European Time).

What needs to be submitted? See below for instructions. Only submissions that fulfill the requirements listed below will be accepted.

The algorithms must be shared with us as a private GitHub repository at latest on deadline. The codes should be in Matlab or Python.

After the deadline there is a brief period during which we can troubleshoot the codes together with the competing teams. This is to ensure that we are able to run the codes.

4.1 Github repository

Competitors can update the contents of the shared repository as many times as needed before the deadline. We will consider only the latest release of your repository on Github.

Attention: Simple commits to the main branch will not be considered. You MUST also create a release. Please see Github's documentation on how

to create releases[1]. If the latest release does not work we will not accept older versions.

Your repository must contain a README.md file with at least the following sections:

- Authors, institution, location.
- Brief description of your algorithm and a mention of the competition.
- Installation instructions, including any requirements.
- Usage instructions.
- Show a few examples.

The teams can submit more than one deconvolution algorithm to the challenge, each algorithm must be in a separate repository. The maximum number of algorithms is the number of members of the team. The teams don't need to register multiple times in case they decide to submit more than one algorithm to the challenge.

4.2 Your code on Github

The repository must contain a main routine that we can run to apply your algorithm automatically to every image in a given directory. This is the file we will run to evaluate your code. Give it an easy to identify name like main.m or main.py.

Your main routine must require three input arguments:

- (string) Folder where the input image files are located
- (string) Folder where the output images must be stored
- (int) Blur category number. Values between 0 and 19

Below are the expected formats of the main routines in python and Matlab:

Matlab: The main function must be a callable function:

```
function main(inputFolder,outputFolder,categoryNbr)

...
your code comes here
...
```

Example calling the function:

```
>> main('path/to/input/files', 'path/to/output/files', 3)
```

[1] https://docs.github.com/en/github/administering-a-repository/managing-releases-in-a-repository.

Python: The main function must be a callable function from the command line. To achieve this you can use sys.argv or argparse module.
Example calling the function:

```
$ python main.py path/to/input/files path/to/output/files 3
```

The main routine must produce a deconvolved PNG file in the output folder for each image in the input folder. The output PNG images must have the same dimensions of the input files and the same filename apart from the extension.

The teams are allowed to use freely available python modules or Matlab toolboxes. Toolboxes, libraries and modules with paid licenses can also be used if the organizing committee also have the license. For example, the most usual Matlab toolboxes for image processing and deconvolution can be used (Image processing toolbox, wavelet toolbox, PDE toolbox, computer vision toolbox, deep learning toolbox, optimization toolbox). The teams can contact us to check if other toolboxes are available.

5 Rules of the competition

The data is arranged into categories of gradually increasing difficulty, with the last ones being pretty much impossible. The HDC2021 competition is structured accordingly step-wise like this:

1. All teams start with Category 0 containing only slightly blurred images. If their algorithm leads to 70% or more of the characters in Category 0 being identified correctly by the OCR, and passes the "sanity check", they earn the right to compete in Category 1. (Below we describe the OCR procedure and explain the sanity check.)

2. Recursion: once a team's algorithm reaches at least 70% of correctly identified characters in Category N, they earn the right to compete in Category N+1. The algorithm is required to have an input parameter specifying the blur category. The sanity check may be applied at all categories.

3. Denote by Nmax the largest category number that at least one team could enter. If there is only one team, they win. If there are several teams competing in Category Nmax, they are ordered in the leaderboard according to the number of characters correctly identified in Category Nmax material.

4. In case of a tie in Category Nmax, the previous categories, starting from Nmax-1, will be compared until one of the competitors win. If there is still a tie, the organizing committee will increase the percentage threshold to make the final decision on the winner. If the tie persists, the organizing committee will make the final decision on the winner.

The spirit of the competition is that the same algorithm is used at all blur categories, and that it is a general-purpose algorithm, capable of deblurring also other kinds of images than text images. The organizing committee has the right to disqualify an algorithm trying to violate that spirit.

Conflict of interest: researchers affiliated with the Department of Mathematics and Statistics of University of Helsinki will not be added to the leaderboard and cannot win the competition.

5.1 OCR and string matching method

All deconvoluted images will be quantitatively measured by applying the tesseract OCR via `pytesseract` Python module, followed by a comparisson with the true text using the Levenshtein distance between the strings, implemented in the `FuzzyWuzzy` Python module. The same set of parameters in pytesseract and FuzzyWuzzy will be used to assess all deconvoluted images.

Note: Only the middle text line out of three will be measured.

5.2 Sanity check

The sanity check basically means that the algorithm should serve as a deconvolution method for general images, not only for images of text. This is to prevent approaches that always output text, regardless of the input. The sanity test image material contains some technical targets and some natural images, and the threshold for passing is very low. It's enough to have some sort of deconvolution effect, even a poor one, instead of always producing images of text.

5.3 Open science spirit of HDC2021

Finally, the competitors must make their GitHub repositories public at latest on October 31, 2021. In the spirit of open science, only a public code can win HDC2021.

6 The Grand Prize

The top participants of the challenge will be invited to a minisymposium at the Inverse Days Conference organized by the Finnish Inverse Problems Society (FIPS) to be held in Tampere, Finland, in December 2021.

The journal *Inverse Problems and Imaging* will run a special issue publishing articles from participants of the HDC2021 competition.

On top of eternal glory as the Supreme Deconvolver, the winner also receives the Ultimate Imaging Device. It is a vintage viewfinder camera model Konica Auto S2 shown in Figure 2.

Load a roll of legendary Kodak Tri-X film into this beautifully engineered classic camera and shoot away! You will surely need a top-notch deconvolution