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Open Turbulent Image Set (OTIS)

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ABSTRACT

Long distance imaging is subject to the impact of the turbulent atmosphere. This results into geometric distortions and some blur effect in the observed frames. Despite the existence of several turbulence mitigation algorithms in the literature, no common dataset exists to objectively evaluate their efficiency. In this paper, we describe a new dataset called OTIS (Open Turbulent Images Set) which contains several sequences (either static or dynamic) acquired through the turbulent atmosphere. For almost all sequences, we provide the corresponding groundtruth in order to make the comparison between algorithms easier. We also discuss possible metrics to perform such comparisons.

1. Introduction

Turbulence mitigation algorithms aiming to restore a clean image from a set of distorted observations has been widely studied since more than a decade. See for instance [1–4,6–9] just to cite a few. Most contributions are based on the common idea of combining stabilization and deconvolution steps and they only differ on the techniques used in their implementation. Most of the time, each author has access to data which are not freely available hence making the comparison difficult. It becomes necessary to build an open dataset of images as well as select some metric which can be used by the community in order to get an objective comparison of the different developed algorithms.

The purpose of this paper is to propose such open dataset. It is made of a collection of sequences of static scenes as well as dynamic scenes (i.e. with a moving target). Most of the static sequences correspond to the observation of printed charts. Such approach permits to create a groundtruth associated to each sequence and then can be used by some metric to assess the reconstruction efficiency.

We want to emphasize that the purpose of this dataset is not to assess the turbulence itself but the visual enhancements provided by mitigation algorithms. Therefore, we do not provide any physical measurements (temperature, wind, C_n^2,...) and we categorized the observed turbulence as either “weak”, “medium” or “strong”.

The paper is organized as follows. Section 2 presents the equipment used and the acquisition procedure. The acquired sequences are described in Section 3. Possible evaluation metrics are discussed in Section 4 and Section 5 concludes this paper.

2. Equipment and acquisition procedure

2.1. Equipment

All sequences were acquired with a GoPro Hero 4 Black camera modified with a RibCage Air chassis permitting to adapt several type of lenses. We always used a 25 mm, f/2.0 14d HFOV 3 MP lens. The camera was setup at a 1080p resolution and a framerate of 24 frames per second (fps). A small tripod was used to hold the camera (see Fig. 1). The camera was controlled by the standard GoPro App on a Samsung Galaxy tablet.

The acquired sequences contain both natural elements from the observed scene as well as artificial “targets”. For the static sequences, we used two charts containing some geometric patterns at different spatial frequencies and orientations (see Fig. 2). These charts were printed on a poster (each chart has a size of 35 × 35 cm) and held up by a homemade wooden stand. For the dynamic sequences, we used a standard remote controlled car (see Fig. 3).

2.2. Procedures

All acquisitions were made on hot sunny days in order to guaranty a certain amount of atmospheric turbulence. All equipments

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Fig. 1. RibCage Air Modified GoPro Hero 4 Black camera with a 25 mm f/2.0 14d HFOV 3 MP lens on its tripod.

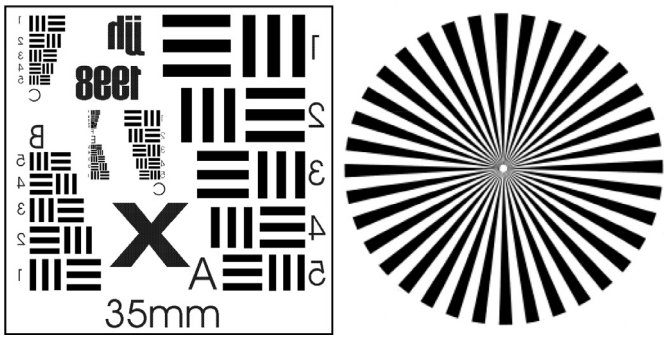

Fig. 2. The two charts serving as our static artificial targets after being printed on a poster.

were setup on a practice field at the San Diego State University. This field is equipped with artificial turf which reflects very well the sun heat, leading to high level of turbulence. The camera stood at about 10cm above the ground observing the target positioned at several distances.

After all acquisitions were done, the different recorded movies were downloaded on a Linux computer and split into sequences

Fig. 3. Remote Controlled car utilized as our moving target for the dynamic sequences.

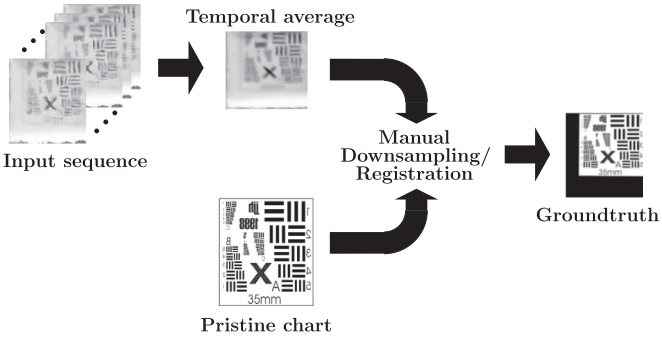

Fig. 4. Groundtruth images creation procedure.

of PNG image files using the *ffmpeg* command.[1] The different region of interest are finally cropped via the *convert* command (from the *imagemagick* library[2]) and saved as individual PNG sequences. Since the Matlab® software is widely used by the community, we also provide each sequence saved as a Matlab 3D matrix (the first two coordinates are the spatial coordinates while the third one corresponds to time) save in a .mat file.

Since the purpose of this dataset is to be used for evaluating turbulence mitigation algorithms, all sequences containing the two above mentioned charts are provided with a groundtruth image. This groundtruth image contains the pristine chart after being downsampled and registered to the actual sequence. In practice, we manually registered the pristine chart on a temporal average of the input sequence using the GIMP[3] software (this procedure is summarized in Fig. 4).

The dynamic sequences are also provided with their respective groundtruths. Each groundtruth is a sequence of binary images containing the bounding box corresponding to the moving target position. These groundtruths were created with the software *Sensarea*.[4]

3. Collected data

The different available sequences were acquired between June 18th and August 16th, 2016.

[1] https://ffmpeg.org/.
[2] http://www.imagemagick.org/.
[3] https://www.gimp.org/.
[4] http://www.gipsa-lab.grenoble-inp.fr/~pascal.bertolino/bin/download.php?file=sensarea.exe.