Modeling of Dynamic Perturbations in Images

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Introduction and Motivation

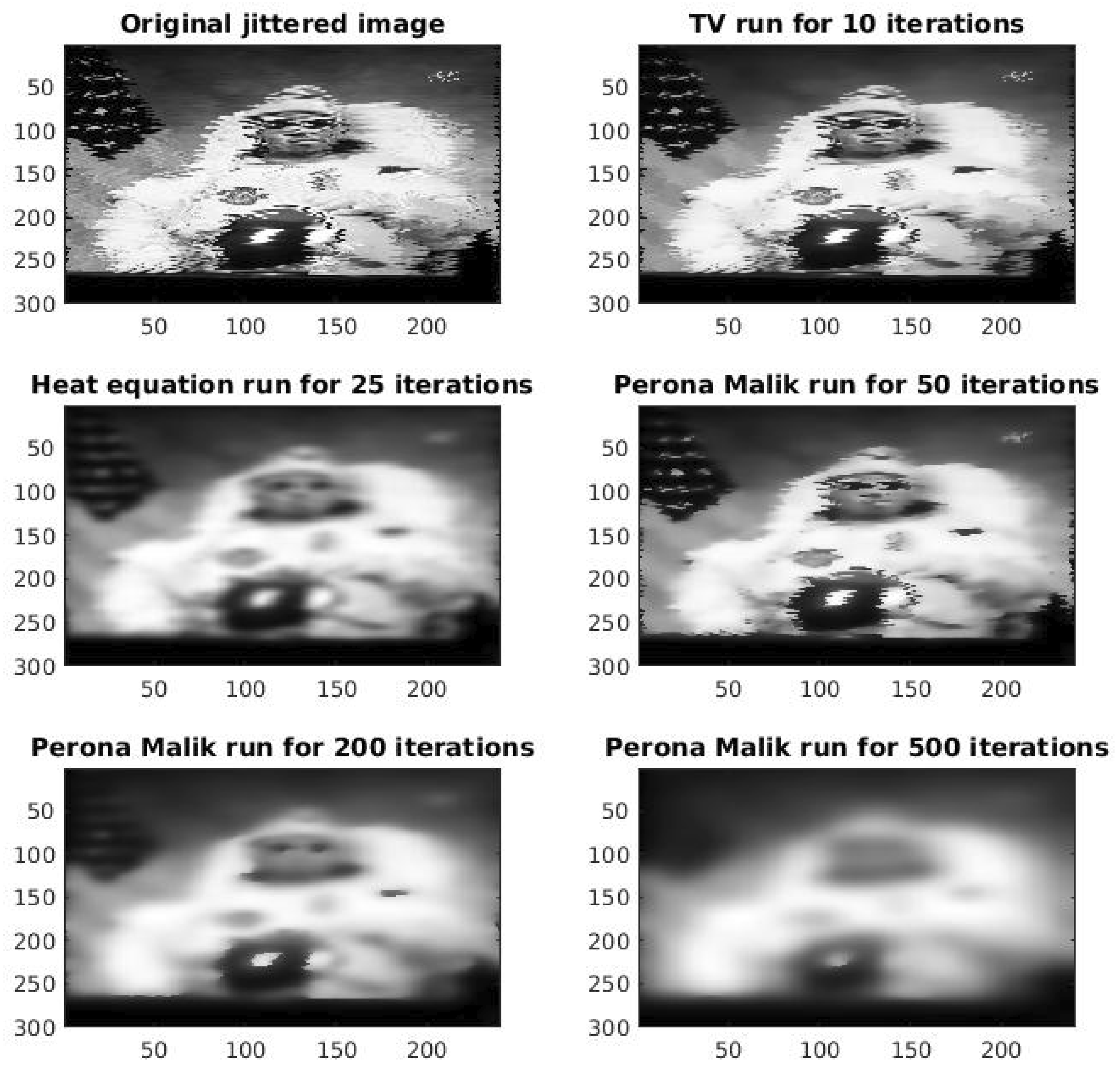
Videos captured on cameras in different places can be affected by different atmospheric turbulences that distort the true image to be captured in a scene. The image can be blurred or jittered and this causes issues if the scene must be seen in an ideal fashion. Our ideas for restoring this type of video were built off the principles learned from the Bake and Shake Paper by Kang and Shen.

Bake and Shake Algorithm

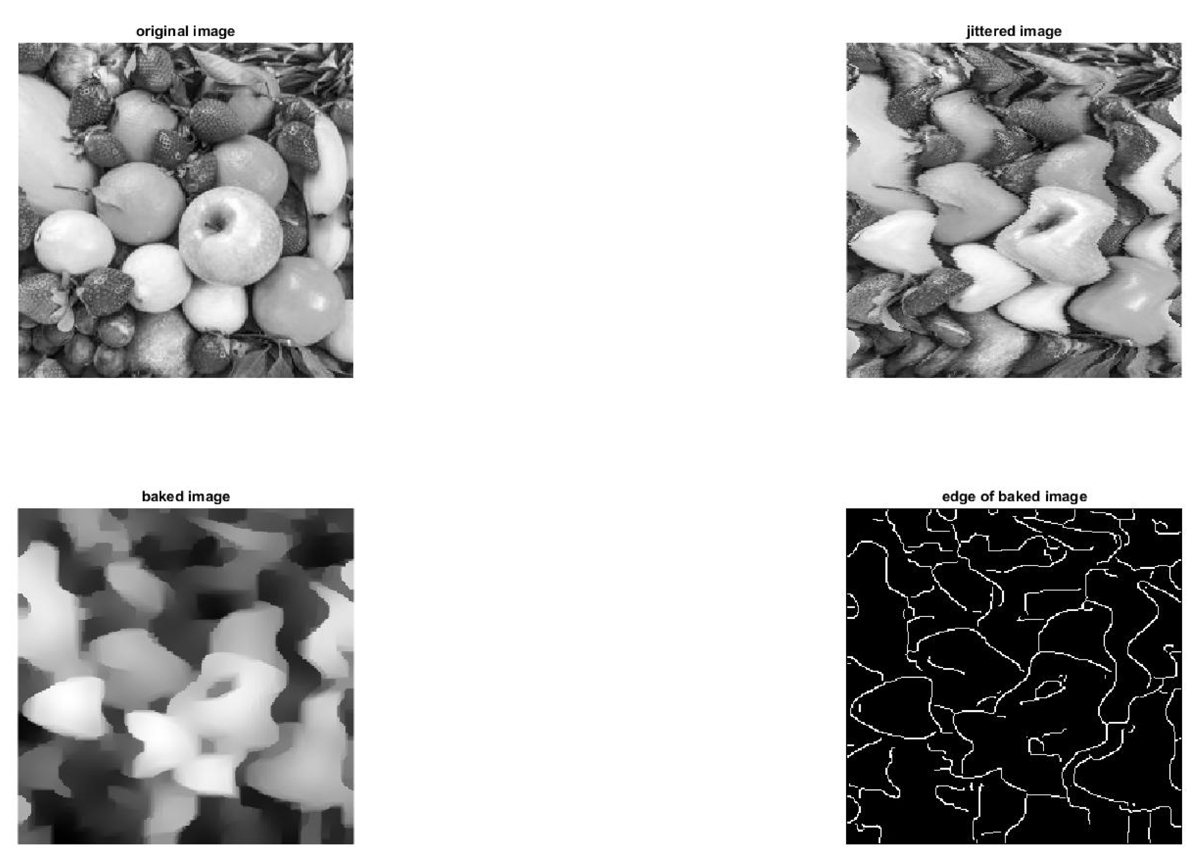
The Bake and Shake Algorithm attempts to correct jittering in video image frames. It uses an anisotropic nonlinear diffusion algorithm to help destroy random or uniform jitters in an image. This is called the bake step. The chosen anisotropic diffusion algorithm for the bake step was the Perona-Malik diffusion. The reason behind this choice is that it the random jitters may be reduced in an image, but Perona-Malik does not completely destroy some crucial information in in image frame, notably, edges.
There could be several different methods used for ”baking” an image. One option is the isotropic diffusion algorithm Heat Equation. Heat equation as it is isotropic does not take into account some of the information that we are looking to preserve in the image, like edges. It diffuses the entire image regardless of the key features. Another option is Total Variation Denoising (TV) which is an anisotropic diffusion algorithm. It is similar to Perona Malik as it is anisotropic but allows for less flexibility than Perona Malik.

In the figure to the right, some examples of the three diffusion algorithms are performed with different runtimes on a jittered image of an astronaut. After enough time, all three algorithms tend to start to destroy some of the information that is needed for the shake step, so it is important to not run the bake step for too long.
In the shake step, Newton’s method is used to iteratively move a horizontal line closer to the direction of the true image. This direction is determined from which direction the bake step moved each horizontal line.

Bake and Shake



The figure shows the original image, jittered image, baked image and edges in order.



Oscillatory Perturbation in Image

(The model for image jitters is $a * cos(by + c)$. Dejittering requires assumed knowledge of a clean image, such as constrains or a reference shape of local edge.)

An image which contains at least one continuous edge with vertical length greater than wave length of jitters should be sufficient to determine parameters of the perturbation model if there exits one-to-one mapping projects the edge to vertical axis.

- Reference Shape: $f(y) = x$
- Observed Edge: $f'(y) = x + a * cos(by + c)$
- Apply cos-curve fitting to $f'(y) - f(y)$

If a reference shape is given as function $f(y) = x$, then the observed edge is $f(y) = x + a * cos(by + c)$. The parameters a, b, and c can be retrieved through cos-curve fitting.
If the image is known to have non-frustrated edges, then a low-pass filter can be applied to the edge image to find proper reference edge.(Need a bit time on this demo.)

Oscillatory Perturbation in Image

(It should mention that model for image jitters is acos(by+ct)) With temporal information, if the clean image assumes static, the dynamic of perturbation is captured by the change of edges in time.

- Each point of edge acts as a standing wave in time
- a and c can be determined from one single point
- as a and c determined, b is determined

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