

CLAIMS

1. A computer-implemented method of base calling, the method including:
accessing an image whose pixels depict intensity emissions from a target cluster and
intensity emissions from additional adjacent clusters;
selecting a lookup table that contains pixel coefficients that are configured to maximize a
signal-to-noise ratio;
convolving the pixel coefficients with intensity values of the pixels in the image to
produce an output; and
base calling the target cluster based on the output.
2. The computer-implemented method of claim 1, wherein the signal maximized in the
signal-to-noise ratio is the intensity emissions from the target cluster, and the noise minimized in
the signal-to-noise ratio is the intensity emissions from the adjacent clusters, plus additional
noise sources.
3. The computer-implemented method of claim 1, wherein the pixels include a center pixel
that contains a center of the target cluster, and each pixel in the pixels is divisible into a plurality
of subpixels.
4. The computer-implemented method of claim 3, wherein the lookup table is a subpixel
lookup table.
5. The computer-implemented method of claim 4, further including:
depending upon a particular subpixel, in a plurality of subpixels of the center pixel,
which contains the center of the target cluster, selecting, from a bank of subpixel
lookup tables, the subpixel lookup table that corresponds to the particular subpixel,
the selected subpixel lookup table containing the pixel coefficients;
element-wise multiplying the pixel coefficients to the intensity values of the pixels in the
image and summing products of the multiplications to produce the output, the pixel
coefficients serving as weights and the output being a weighted sum of the intensity
values; and
using the output to base call the target cluster, including generating the output for each
imaging channel in a plurality of imaging channels and base calling the target cluster
using the output for each imaging channel.

6. The computer-implemented method of claim 5, wherein the element-wise multiplication adds a bias for given set of equalizer coefficients, wherein the bias is a DC offset that averages background noise intensity.
7. The computer-implemented method of claim 5, further including:
 - selecting additional subpixel lookup tables, from the bank of subpixel look tables, which correspond to subpixels that are contiguously adjacent to the particular subpixel;
 - generating, based on pixel coefficients of the selected subpixel lookup table and the selected additional subpixel lookup tables, interpolated pixel coefficients that are configured to maximize the signal-to-noise ratio;
 - convolving the interpolated pixel coefficients with the intensity values of the pixels in the image to produce an output; and
 - base calling the target cluster based on the output.
8. The computer-implemented method of claim 7, further including:
 - element-wise multiplying the interpolated pixel coefficients to the intensity values of the pixels in the image and summing products of the multiplications to produce the output, the interpolated pixel coefficients serving as weights and the output being a weighted sum of the intensity values.
9. The computer-implemented method of claim 1, further including training an equalizer using at least one of least squares estimation, ordinary least squares, least-mean squares, and recursive least-squares to generate the pixel coefficients.
10. The computer-implemented method of claim 9, further including training the equalizer in an offline mode in which the pixel coefficients of subpixel lookup tables are fixed after being trained on batches of training data from a previously executed sequencing run.
11. The computer-implemented method of claim 10, further including training the equalizer in an online mode in which the pixel coefficients of subpixel lookup tables are iteratively updated during an ongoing sequencing run.
12. The computer-implemented method of claim 11, further including accessing base-wise intensity distributions of each of the four bases A, C, G, and T generated during prior base calling of images in the training data, selecting respective centers of the base-wise intensity distributions as base-wise ground truth target intensities for corresponding color channels, and using the base-wise ground truth target intensities to train the equalizer.

13. The computer-implemented method of claim 12, further including pre-training the equalizer in the offline mode and retraining the equalizer in the online mode.
14. The computer-implemented method of claim 9, further including generating the lookup tables in the bank of subpixel lookup tables by together applying a single set of equalizer coefficients and a precalculated set of interpolation filters, including interpolating pixel intensities to generate inputs for the equalizer.
15. The computer-implemented method of claim 1, further including making the center of the target cluster concentric with a center of the center pixel by:
- registering the image against a template image and determining affine transformation and nonlinear transformation parameters;
 - using the parameters to transform location coordinates of the target cluster and the additional adjacent clusters to image coordinates of the image and generating a transformed image with transformed pixels; and
 - applying interpolation using the transformed location coordinates of the target cluster and the additional adjacent clusters to make their respective cluster centers concentric with centers of respective transformed pixels that contain the cluster centers.
16. A non-transitory computer readable storage medium impressed with computer program instructions to perform base calling, the instructions, when executed on a processor, implement a method comprising:
- accessing an image whose pixels depict intensity emissions from a target cluster and intensity emissions from additional adjacent clusters;
 - selecting a lookup table that contains pixel coefficients that are configured to maximize a signal-to-noise ratio;
 - convolving the pixel coefficients with intensity values of the pixels in the image to produce an output; and
 - base calling the target cluster based on the output.
17. The non-transitory computer readable storage medium of claim 16, wherein the signal maximized in the signal-to-noise ratio is the intensity emissions from the target cluster, and the noise minimized in the signal-to-noise ratio is the intensity emissions from the adjacent clusters, plus additional noise sources.
18. The non-transitory computer readable storage medium of claim 16, implementing the method further comprising training an equalizer using at least one of least squares estimation,

ordinary least squares, least-mean squares, and recursive least-squares to generate the pixel coefficients.

19. A system including one or more processors coupled to memory, the memory loaded with computer instructions to perform base calling, the instructions, when executed on the processors, implement actions comprising:

- accessing an image whose pixels depict intensity emissions from a target cluster and intensity emissions from additional adjacent clusters;
- selecting a lookup table that contains pixel coefficients that are configured to maximize a signal-to-noise ratio;
- convolving the pixel coefficients with intensity values of the pixels in the image to produce an output; and
- base calling the target cluster based on the output.

20. The system of claim 19, further implementing actions comprising training an equalizer using at least one of least squares estimation, ordinary least squares, least-mean squares, and recursive least-squares to generate the pixel coefficients.