

CLAIMS

1. A method of training a convolutional neural network to identify and classify images of sections of an image generating chip resulting in process failure, including:
using the convolutional neural network, pretrained to extract image features, wherein the
pretrained convolutional neural network accepts images of dimensions $M \times N$;
creating a training data set using labeled images of dimensions $J \times K$, which is smaller than $M \times N$,
that depict process success and failure;
the labeled images are from sections of the image generating chip,
positioning the $J \times K$ labeled images at multiple locations in $M \times N$ frames,
using at least one portion of a particular $J \times K$ labeled image to fill in around edges of the
particular $J \times K$ labeled image, thereby filling the $M \times N$ frame;
further training the pretrained convolutional neural network to produce a section classifier using
the training data set; and
storing coefficients of the trained classifier to identify and classify images of sections of the
image generating chip from production process cycles,
whereby the trained classifier can accept images of sections of the image generating chip and
classify the images as depicting process success and failure.
2. The method of claim 1, wherein using at least one portion of a particular $J \times K$ labeled image to
fill in around edges of the particular $J \times K$ labeled image, further including:
applying horizontal reflection to the at least one portion of the particular $J \times K$ labeled image.
3. The method of claim 1, wherein using at least one portion of a particular $J \times K$ labeled image to
fill in around edges of the particular $J \times K$ labeled image, further including:
applying vertical reflection to the at least one portion of the particular $J \times K$ labeled image.
4. The method of claim 1, wherein creating the training data set using labeled images of
dimensions $J \times K$, further including:
producing the $J \times K$ labeled images by cropping out portions from larger images and placing the
 $J \times K$ cropped out portions in the $M \times N$ frames.
5. The method of claim 1, wherein labeled images of dimensions $J \times K$ are obtained by
downsampling high-resolution images from a scanner resulting in reduction in resolution of the
high-resolution images by $1/2$ to $1/50$ times per side.

6. The method of claim 5, wherein the high-resolution images obtained from the scanner have a size of 3600 x 1600 pixels.

7. A non-transitory computer readable storage medium impressed with computer program instructions to identify and classify images of sections of an image generating chip resulting in process failure, including, the instructions, when executed on a processor, implement a method comprising:

using a convolutional neural network, pretrained to extract image features, wherein the pretrained convolutional neural network accepts images of dimensions $M \times N$;
creating a training data set using labeled images of dimensions $J \times K$, which is smaller than $M \times N$, that depict process success and failure;
the labeled images are from sections of the image generating chip,
positioning the $J \times K$ labeled images at multiple locations in $M \times N$ frames,
using at least one portion of a particular $J \times K$ labeled image to fill in around edges of the particular $J \times K$ labeled image, thereby filling the $M \times N$ frame;
further training the pretrained convolutional neural network to produce a section classifier using the training data set; and
storing coefficients of the trained classifier to identify and classify images of sections of the image generating chip from production process cycles,
whereby the trained classifier can accept images of sections of the image generating chip and classify the images as normal or depicting process failure.

8. The non-transitory computer readable storage medium of claim 7, wherein using at least one portion of a particular $J \times K$ labeled image to fill in around edges of the particular $J \times K$ labeled image, implementing the method further comprising:

applying horizontal reflection to the at least one portion of the particular $J \times K$ labeled image.

9. The non-transitory computer readable storage medium of claim 7, wherein using at least one portion of a particular $J \times K$ labeled image to fill in around edges of the particular $J \times K$ labeled image, implementing the method further comprising:

applying vertical reflection to the at least one portion of the particular $J \times K$ labeled image.

10. The non-transitory computer readable storage medium of claim 7, wherein creating the training data set using labeled images of dimensions $J \times K$, implementing the method further comprising:

producing the JxK labeled images by cropping out portions from larger images and placing the JxK cropped out portions in the MxN frames.

11. The non-transitory computer readable storage medium of claim 7, wherein labeled images of dimensions JxK are obtained by downsampling high-resolution images from a scanner resulting in reduction in resolution of the high-resolution images by 1/2 to 1/50 times per side.

12. The non-transitory computer readable storage medium of claim 11, wherein the high-resolution images obtained from the scanner have a size of 3600 x 1600 pixels.

13. A system including one or more processors coupled to memory, the memory loaded with computer instructions to identify and classify images of sections of an image generating chip resulting in process failure, the instructions, when executed on the processors, implement actions comprising:

using a convolutional neural network, pretrained to extract image features, wherein the pretrained convolutional neural network accepts images of dimensions MxN;
creating a training data set using labeled images of dimensions JxK, which is smaller than MxN, that depict process success and failure;
the labeled images are from sections of the image generating chip,
positioning the JxK labeled images at multiple locations in MxN frames,
using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, thereby filling the MxN frame;
further training the pretrained convolutional neural network to produce a section classifier using the training data set; and
storing coefficients of the trained classifier to identify and classify images of sections of the image generating chip from production process cycles,
whereby the trained classifier can accept images of sections of the image generating chip and classify the images as normal or depicting process failure.

14. The system of claim 13, wherein using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, further implementing actions comprising:

applying horizontal reflection to the at least one portion of the particular JxK labeled image.

15. The system of claim 13, wherein using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, further implementing actions comprising:

applying vertical reflection to the at least one portion of the particular JxK labeled image.

16. The system of claim 13, wherein creating the training data set using labeled images of dimensions JxK, further implementing actions comprising:

producing the JxK labeled images by cropping out portions from larger images and placing the JxK cropped out portions in the MxN frames.

17. The system of claim 13, wherein labeled images of dimensions JxK are obtained by downsampling high-resolution images from a scanner resulting in reduction in resolution of the high-resolution images by 1/2 to 1/50 times per side.

18. The system of claim 17, wherein the high-resolution images obtained from the scanner have a size of 3600 x 1600 pixels.

19. A method of training a convolutional neural network to classify images of sections of an image generating chip by root cause of process failure, including:

using the convolutional neural network, pretrained to extract image features, wherein the pretrained convolutional neural network accepts images of dimensions MxN;
creating a training data set using labeled images of dimensions JxK, that belong to at least one failure category from a plurality of failure categories resulting in process failure wherein;
the labeled images are from sections of the image generating chip,
positioning the JxK labeled images at multiple locations in MxN frames,
using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, thereby filling the MxN frame,
further training the pretrained convolutional neural network to produce a section classifier using the training data set; and
storing coefficients of the trained classifier to identify and classify images of sections of the image generating chip from production process cycles,
whereby the trained classifier can accept images of sections of the image generating chip and classify the images by root cause of process failure, among the plurality of failure categories.

20. The method of claim 19, wherein using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, further including:

applying horizontal reflection to the at least one portion of the particular JxK labeled image.

21. The method of claim 19, wherein using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, further including:

applying vertical reflection to the at least one portion of the particular JxK labeled image.

22. The method of claim 19, wherein creating the training data set using labeled images of dimensions JxK, further including:

producing the JxK labeled images by cropping out portions from larger images and placing the JxK cropped out portions in the MxN frames.

23. The method of claim 19, wherein labeled images of dimensions JxK are obtained by downsampling high resolution images from a scanner resulting in reduction in resolution of the high resolution images by 1/2 to 1/50 times per side.

24. The method of claim 23, wherein the high resolution images obtained from the scanner have a size of 3600 x 1600 pixels.

25. The method of claim 19, wherein the plurality of failure categories include at least a hybridization failure, a space shift failure, an offset failure, a surface abrasion failure, and a reagent flow failure.

26. The method of claim 19, wherein the plurality of failure categories include a residual failure category indicating unhealthy patterns on images due to unidentified causes of failure.

27. A non-transitory computer readable storage medium impressed with computer program instructions to train a convolutional neural network to classify images of sections of an image generating chip by root cause of process failure, the instructions, when executed on a processor, implement a method comprising:

using the convolutional neural network, pretrained to extract image features, wherein the pretrained convolutional neural network accepts images of dimensions MxN;
creating a training data set using labeled images of dimensions JxK, that belong to at least one failure category from a plurality of failure categories resulting in process failure wherein;
the labeled images are from sections of the image generating chip,
positioning the JxK labeled images at multiple locations in MxN frames,
using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, thereby filling the MxN frame,
further training the pretrained convolutional neural network to produce a section classifier using the training data set; and
storing coefficients of the trained classifier to identify and classify images of sections of the image generating chip from production process cycles,

whereby the trained classifier can accept images of sections of the image generating chip and classify the images by root cause of process failure, among the plurality of failure categories.

28. The non-transitory computer readable storage medium of claim 27, wherein using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, implementing the method further comprising:

applying horizontal reflection to the at least one portion of the particular JxK labeled image.

29. The non-transitory computer readable storage medium of claim 27, wherein using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, implementing the method further comprising:

applying vertical reflection to the at least one portion of the particular JxK labeled image.

30. The non-transitory computer readable storage medium of claim 27, wherein creating the training data set using labeled images of dimensions JxK, implementing the method further comprising:

producing the JxK labeled images by cropping out portions from larger images and placing the JxK cropped out portions in the MxN frames.

31. The non-transitory computer readable storage medium of claim 27, wherein labeled images of dimensions JxK are obtained by downsampling high resolution images from a scanner resulting in reduction in resolution of the high resolution images by 1/2 to 1/50 times per side.

32. The non-transitory computer readable storage medium of claim 31, wherein the high resolution images obtained from the scanner have a size of 3600 x 1600 pixels.

33. The non-transitory computer readable storage medium of claim 27, wherein the plurality of failure categories include at least a hybridization failure, a space shift failure, an offset failure, a surface abrasion failure, and a reagent flow failure.

34. The non-transitory computer readable storage medium of claim 27, wherein the plurality of failure categories include a residual failure category indicating unhealthy patterns on images due to unidentified causes of failure.

35. A system including one or more processors coupled to memory, the memory loaded with computer instructions to train a convolutional neural network to classify images of sections of an

image generating chip by root cause of process failure, the instructions, when executed on the processors, implement actions comprising:

using the convolutional neural network, pretrained to extract image features, wherein the
pretrained convolutional neural network accepts images of dimensions $M \times N$;
creating a training data set using labeled images of dimensions $J \times K$, that belong to at least one
failure category from a plurality of failure categories resulting in process failure wherein;
the labeled images are from sections of the image generating chip,
positioning the $J \times K$ labeled images at multiple locations in $M \times N$ frames,
using at least one portion of a particular $J \times K$ labeled image to fill in around edges of the
particular $J \times K$ labeled image, thereby filling the $M \times N$ frame,
further training the pretrained convolutional neural network to produce a section classifier using
the training data set; and
storing coefficients of the trained classifier to identify and classify images of sections of the
image generating chip from production process cycles,
whereby the trained classifier can accept images of sections of the image generating chip and
classify the images by root cause of process failure, among the plurality of failure categories.

36. The system of claim 35, wherein using at least one portion of a particular $J \times K$ labeled image to fill in around edges of the particular $J \times K$ labeled image, further implementing actions comprising:

applying horizontal reflection to the at least one portion of the particular $J \times K$ labeled image.

37. The system of claim 35, wherein using at least one portion of a particular $J \times K$ labeled image to fill in around edges of the particular $J \times K$ labeled image, further implementing actions comprising:

applying vertical reflection to the at least one portion of the particular $J \times K$ labeled image.

38. The system of claim 35, wherein creating the training data set using labeled images of dimensions $J \times K$, further implementing actions comprising:

producing the $J \times K$ labeled images by cropping out portions from larger images and placing the $J \times K$ cropped out portions in the $M \times N$ frames.

39. The system of claim 35, wherein labeled images of dimensions $J \times K$ are obtained by downsampling high resolution images from a scanner resulting in reduction in resolution of the high resolution images by $1/2$ to $1/50$ times per side.

40. The system of claim 39, wherein the high resolution images obtained from the scanner have a size of 3600 x 1600 pixels.

41. The system of claim 35, wherein the plurality of failure categories include at least a hybridization failure, a space shift failure, an offset failure, a surface abrasion failure, and a reagent flow failure.

42. The system of claim 35, wherein the plurality of failure categories include a residual failure category indicating unhealthy patterns on images due to unidentified causes of failure.

43. A method of identifying process cycle images of sections of an image generating chip causing failure of process cycle, including:

creating input to a trained classifier including:

accessing the image of the section having dimensions JxK,

positioning the JxK image in an MxN analysis frame,

using at least one portion of a particular JxK labeled image to fill in around edges of the particular JxK labeled image, thereby filling the MxN analysis,

inputting to the trained classifier the MxN analysis frame,

the trained classifier, classifying the image of the section of the image generating chip as normal

or as belonging to at least one failure category from a plurality of failure categories, and

outputting a resulting classification of the section of the image generating chip.

44. The method of claim 43, further including, positioning the JxK image in a center of the MxN analysis frame.

45. The method of claim 43, wherein using at least one portion of a particular JxK image to fill in around edges of the particular JxK image, further including:

applying horizontal reflection to the at least one portion of the particular JxK image.

46. The method of claim 43, wherein using at least one portion of a particular JxK image to fill in around edges of the particular JxK image, further including:

applying vertical reflection to the at least one portion of the particular JxK image.

47. The method of claim 43, wherein creating the input to the trained classifier, further including:

producing the JxK image by cropping out portions from larger images and placing the JxK cropped out portions in the MxN frames.

48. The method of claim 43, wherein the JxK image is obtained by downsampling a high resolution image from a scanner resulting in reduction in resolution of the high resolution image by 1/2 to 1/50 times per side.

49. The method of claim 43, wherein the plurality of failure categories include at least a hybridization failure, a space shift failure, an offset failure, a surface abrasion failure, and a reagent flow failure.

50. The method of claim 43, wherein the plurality of failure categories include a residual failure category indicating unhealthy patterns on images due to unidentified causes of failure.