2. Leaking – the sealing unit for the reaction plate may be broken, which causing fluid to escape into an outer chamber; and
3. Assay spotting issues – for pre-spotted assay formats, some reaction units may not be loaded with the assay.

[0004] These sheet coating, reformatting or sample loading problems may be detected by visually checking reformatting and quality control (QC) images. Therefore, it is very important to automatically identify problems from QC images and quickly determine the root cause of failures during manufacture process. As PCR reactions may show anomalous behaviors such as sample loading problems in the images taken prior, during, or after the running of PCR for OpenArray or other array-based PCR platforms, it is desirable to automatically detect these types of failure modes in the customer facing software and make the troubleshooting step much more efficient and easier for customers.

SUMMARY

[0004a] An aspect of the present disclosure provides a system comprising a PCR system, a reaction array plate, a convolutional neural network (CNN) configured to receive a sequence of images of the reaction array plate, wherein the reaction array plate is receivable in the PCR system, and wherein the CNN is operable to generate failure mode predictions for the reaction array plate based on the sequence of images; and an output of the CNN coupled to a ~~control~~ setting for manufacture of the reaction array plate, or to a control for the PCR system, the output comprising the failure mode predictions.

[0004b] Another aspect of the present disclosure provides a method comprising operating a PCR system on a reaction array plate; applying a sequence of images from a plurality of subarrays of the reaction array plate to a plurality of convolutional neural networks (CNNs) during operation of the PCR system on the reaction array plate ~~array~~; operating the CNNs to generate failure mode predictions for the reaction array plate based on the sequence of images; and coupling an output of the CNNs to one or more of a setting for manufacture of the reaction array plate or to a control for the PCR system, the output comprising the failure mode predictions.

[0005] The present system utilizes a deep neural network, such as a convolutional neural network (CNN), to detect abnormalities in array plate reformatting and QC images to identify failure modes. The QC images, including both passing and failing sheets over a set period of time, are retrieved from a manufacturing data server. The data is classified based on passing or different failure modes. As each QC image may have more than one failure mode associated to one or multiple subarrays, the QC image is divided into (for example 48) subarray images and each subarray is annotated into passing or five failure modes including: Bright Rox, Rox Spotting, Rox Stripping, Stop Point Bridging, and Reformatting error. The annotated subarray images are used to train, evaluate and test CNN model. The trained and verified model may then be used to recognize failures and their modes in array plate reformatting and QC images.

[0006] Convolutional neural networks (CNNs) are particularly well suited to classifying features in data sets modelled in two or three dimensions. This makes CNNs popular for image classification, because images can be represented in computer memories in three dimensions (two dimensions for width and height, and a third dimension for pixel features like color components and intensity). For example a color JEG image of size 480 x 480 pixels can be modelled in computer memory using an array that is 480 x 480 x 3, where each of the values of the third dimension is a red, green, or blue color component intensity for the pixel ranging from 0 to 255. Inputting this array of numbers to a trained CNN will generate outputs that describe the

CLAIMS

1. A system comprising:

a PCR system;

a reaction array plate;

a convolutional neural network (CNN) configured to receive a sequence of images of the reaction array plate, wherein the reaction array plate is receivable in the PCR system, and wherein the CNN is operable to generate failure mode predictions for the reaction array plate based on the sequence of images; and

an output of the CNN coupled to a ~~control~~ setting for manufacture of the reaction array plate or to a control for the PCR system~~the reaction array plate~~, the output comprising the failure mode predictions.

2. The system of claim 1, wherein the control is a stop control to stop operation of the PCR system.

3. The system of claim 1, further comprising:

a mapping function between through hole centers of the reaction array plate and arrays in layers of the CNN.

4. The system of claim 1, ~~the output of the CNN transforming the sequence of images into~~wherein the failure mode predictions comprise a ROX spotting prediction, a ROX stripping prediction, a bright ROX prediction, a spot point bridge prediction, and a reformatting error prediction.

5. The system of claim 1, wherein the CNN lacks a final fully connected output layer.

6. The system of claim 5, further comprising at least one recurrent neural network (RNN) coupled to receive feature indications from the CNN, and to transform the feature indications into the failure mode predictions.

7. The system of claim 6, comprising multiple RNNs, wherein predictions of multiple RNNs are combined by a perceptron into a final prediction of at least one failure mode.

8. The system of claim 1, the CNN further comprising:

an input layer comprising a 54 x 54 array;

a first convolution layer comprising 32 54x54 arrays; and

a second convolution layer comprising 64 18 x 18 arrays.

9. The system of claim 8, the CNN further comprising:

a first fully connected layer comprising 192 nodes;

a second fully connected layer coupled to the first fully connected layer and comprising 48 nodes; and

an output layer coupled to the second fully connected layer and generating a binary pass or a fail output signal.

10. The system of claim 9, the output layer further generating a prediction of a failure mode for the reaction array plate.

11. A method comprising:

operating a PCR system on a reaction array plate;

applying a sequence of images from a plurality of subarrays of the reaction array plate to a plurality of convolutional neural networks (CNNs) during operation of the PCR system on the reaction array plate ~~array~~;

operating the CNNs to generate failure mode predictions for the reaction array plate based on the sequence of images; and

coupling an output of the CNNs to one or more of a setting for manufacture of the reaction array plate or to a control for the PCR system, the output comprising the failure mode predictions.

12. The method of claim 11, wherein the control is a stop control to stop operation of the PCR system.

13. The method of claim 11, further comprising:

mapping through hole centers of the reaction array plate to different ones of the CNNs.

14. The method of claim 11, ~~the output of the CNNs transforming the sequence of images into~~wherein the failure mode predictions comprise a ROX spotting prediction, a ROX stripping

prediction, a bright ROX prediction, a spot point bridge prediction, and a reformatting error prediction.

15. The method of claim 11, wherein one or more of the CNN lacks a final fully connected output layer.

16. The method of claim 15, further comprising coupling the output of the CNNs to at least one recurrent neural network (RNN) to receive feature indications from the CNNs, and to transform the feature indications into the failure mode predictions.

17. The method of claim 16, comprising multiple RNNs, wherein predictions of multiple RNNs are combined by a perceptron into a final prediction of at least one failure mode.