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博士論文

機械学習による OLED 製造工程での不良検出に関する研究

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Abstract

In this paper, we discuss the automatic detection of mura defects, non-uniformity of brightness or color, which has been a long-standing challenge in the display industries. Our purpose is to develop a method using machine learning, which automatically detects and classifies mura in the front-end process. This will enable prompt feedback to the manufacturing process and contribute to improvement of the productivity.

The dataset we made for this work consists of 8 classes and 1000 images for each class, totaling 8000 images obtained from an actual OLED (Organic Light Emitting Diode) manufacturing line, including four different types of mura which frequently occur in the manufacturing process.

In the evaluations of multiclass classifications using general machine learning models such as SVM (Support Vector Machine), CNN (Convolutional Neural Network), and Residual Neural Network (ResNet), the accuracy was improved to 0.830 by adjustments of parameters such as layer structures and training modes. However, weak mura with low contrast and small defective areas are difficult to be detected by such models because of the confusion with normal displays with no defects, and thus new approaches were necessary.

Our approaches are based on the human visual perception. One of the measures taken to ensure test accuracy in the human visible test is that test-images appropriate for each type of defects are used to clarify the deference between the defective area and the normal area. To reproduce this measure with machine learning, we enhanced contrast of the images of the dataset before inputting them into the machine learning models. Another measure to ensure test accuracy in the human visible test is boundary-samples which are compared with a display being tested when a human tester is unsure of the decision. We evaluated 2-class classifications based on the subspace method to reproduce the boundary-samples with machine learning.

We propose “Progressive Hybrid model” which consists of a multiclass CNN, a 2-class ResNet, and a 2-class CNN. The two 2-class models which reproduce the boundary-samples in the human visible test are for accurate classification between Normal displays and weak mura with low contrast and small defective areas. To reproduce the appropriate test-images used in the human visible test, we enhanced contrast of the images of the dataset using the sigmoid function. The proposed model showed the improvement of the accuracy from 0.830 in the general application of CNN to 0.884. It was also confirmed that the proposed model is particularly effective to improve the classification accuracy of Normal displays by reducing the confusions with weak mura with low contrast and small defective areas. As Normal displays are usually the most numerous in the manufacturing, the improvement effect of the proposed method is further beneficial in the practical use.

Keywords: Display, Machine Learning, Mura, Detection, Subspace Method, Contrast Enhancement