A DEFECT DETECTION AND LOCALIZATION METHOD AND SYSTEM WITH FUSION DATA AUGMENTATION FOR PLASTIC INJECTION MOLDING PRODUCT

FIELD OF THE INVENTION

[0001] The present invention relates to a method and system for detecting defect for plastic injection molding product, in particular a defect detection method and system with fusion data augmentation for plastic injection molding product.

BACKGROUND OF THE INVENTION

[0002] In injection molding industry, products are produced under massive and fast production. Since the injection molding machine industry can adjust molds to meet various companies' needs, the products are widely applied in many fields, for example pharmaceutical, telecommunications, transportation, consumer products and medical sectors. During manufacturing procedure, the variation of the injection molding machine condition may cause defective production. For example, inadequate injection pressure may lead to product with sink mark or short shot while said short shot is a structural defect. A tiny defect within the injection molding product may result in a disastrous accident. To avoid the production of defective product, a defect detection is followed with the product production as the common practice in injection molding industry.

[0003] Traditional defect detection methods rely on manual detection, which is time-consuming and expensive. Furthermore, after extended periods of operation, efficiency decreases while the rate of human error increases. However, most of the defect detection methods in the market is by image classification of a single product with mono-class prediction. When more than one product or a product with more than one defect is detected using said traditional methods, a defective region cannot be clearly identified.

[0004] In recent days, there have been several approaches for defect detection on plastic injection molding products. Data augmentation is a crucial method to resolve the issue of limited defective samples in plastic injection molding products. Currently, the data augmentation method is a computational approach wherein an image dataset is pre-processed by modifying the 2-D (grayscale image) or 3-D (color image) array before entering the model. Variation is added based on the existing image dataset. The intrinsic noises or wrong features generated from the environment are reinforced and duplicated during data augmentation with a computational approach. For example, a bright lighting system adopted in the data collection stage may cause the defective region of a short shot (breaking) sample to have a shadow of high brightness contrast. In the dataset collected with high brightness contrast as the majority in the class of short shot, a shadow of high intensity contrast in a defective region may exist. Then, data augmentation with computational methods such as rotation or saturation adjustment may generate a huge number of variated images in the dataset with the same intrinsic feature. If this dataset is trained by a DDM model, the model may learn the intensity contrast of shadow as “break”. If this model is applied for defect detection, false classification of the shadow as the breaking region may occur frequently, reducing the accuracy and reliability of the model. Data augmentation with a solely computational approach may hence reinforce the learning of irrelevant features in the model, leading to false classification and reducing the model's accuracy.

[0005] In some applications, the installation of a lighting system is the only equipment installed for defect detection on plastic injection-molded products, whereas in others, no lighting system or environmental control equipment is installed. Defect detection from computer vision is sensitive to the camera frame. Noise from the environment, particularly background light and shadows cast by exterior objects, may cause the algorithm to make incorrect classifications. As the applied light source has dominance over the intensity of the frame, the use of a lighting system may reduce the effect of the surroundings. A significant improvement is thus achieved compared to the algorithm where the lighting system is absent. However, noise from surrounding objects, such as the shadow from a robot arm or other equipment may also reduce the detection accuracy and even cause false classifications by the algorithm accidentally. The lighting system can eliminate part of the noise from the surroundings but additional noise may be generated by the system itself. Shadow created by the light source may confuse the prediction because the shadow is commonly predicted as a breaking region or may blur the defective region.

[0006] Image classification and object detection are other common approaches for defect detection on plastic injection molding products. The lack of information about the defective region is the major limitation of image classification. Image classification can only predict a class for the input frame without identifying the defective region. Labelling of defective regions for prediction is important for industrial applications since the workers need to know the reason why a product is predicted as defective. Another limitation of image classification is the weakness of the detection of multiple defective classes or multiple objects since only a single class can be predicted for the frame. In fact, products from plastic injection molding are not constrained by only zero or one defect type. The limitation on multi-object detection may reduce the detection rate since the products need to be queued and detected one by one. Even worse, the multiple objects that occur accidentally in the frame may cause false classification.

[0007] Apart from that, the numbers of good and defective products during the detection, which are important for performance monitoring in industrial applications, are not commonly recorded.. Even if the numbers of good and defective products are recorded, the frames of defective products are not commonly recorded. False classification or localization may exist in the model prediction, and the reason for the false prediction should be identified for the purpose of model improvement. There is also a lack of tool for real-time production performance monitoring in recent defect detection method. Monitoring of production performance is important in industrial application for maintaining the quality of the products.

[0008] China Patent Publication No. 104850858 B discloses a kind of injection-molded item defects detection recognition methods. The method comprises the steps of: the normal image with the injection-molded item that there is known defect of collection, image is classified and generates sample; multilayer convolutional neural networks model is built; convolution neural network is trained with the sample images; and the trained convolutional neural networks model can classify and identify the image of actual measurement injection-molded item for defect detection. However, there is no disclosure of any environmental control equipment, in particular lighting system in the defects detection recognition methods. Defect detection from computer vision is sensitive to the camera frame. Noise from surroundings especially the background light and the shadow of exterior object may cause the false classification of the algorithm. Hence, there is a need to provide a lighting system that could reduce the effect from surroundings when the applied light source is dominant over the intensity of the frame.

[0009] China Patent Publication No. 110136116A discloses a kind of injection molding pump defect inspection method, device, equipment and storage medium. The method comprises the steps of: obtaining injection molding pump sample image and extracting the coordinate of the rejected region marked in advance in injection molding pump sample image, generating corresponding defect text information; inputting the injection molding pump sample image and defect text information in a deep learning neural network, training the deep learning training neural network to obtain target nerve network; validating the target nerve network using injection molding pump test image, adjusting the network parameter of target nerve network to obtain the defects detection model; and detecting defect. Data enhancement operations are also carried out to injection molding pump sample image, obtain the injection molding pump sample image of dilatation, the enhancement operations include symmetrical overturning and angle rotation. However, said data enhancement operations are carried out using computational approach wherein a huge number of variated images in dataset with the same intrinsic feature such as a shadow with high intensity contrast at the breaking region may be generated. Accordingly, this dataset which will be trained for deep learning model and the model may learn the intensity contrast of shadow as “break”. A false classification of shadow as the breaking region may occur frequently, thereby reducing the accuracy and the reliability of the model. The data augmentation operations solely with computational approach may reinforce the learning of irrelevant features in the model leading to false classification and reducing the model accuracy. Hence, there is a need to provide an improved data augmentation approach by adjusting environment and camera settings to avoid the duplication and reinforcement of the false features in the image dataset. The utilization of model YOLOv3 in the method may be limited in detecting multiple products and/or multiple classes. The limitation on multiple products detection may reduce the detection rate since the products need to be queued and be detected one by one. Even worse, the multiple products occur accidentally in the frame may cause false classification. An improved product detection is needed to overcome the shortcomings.

[0010] China Patent Publication No. 111487250 A discloses an intelligent visual detection method and system applied to injection molding defective product detection. The method comprising the steps of acquiring video stream data of a sample to be detected; decomposing video stream data into single frame image data; detecting the defect of the defective product through a defective product detection deep learning algorithm; classifying the defective products through a defective product classification algorithm; and counting the number of the detected samples and the number of the defective products by an injection part tracking detection algorithm, and displaying the detection result. The method can be used for rapidly detecting the defective products with different degrees in real time and at high accuracy, and has higher robustness and generalization capability compared with the traditional detection method. Although a light source system and a visual sensor are added in the injection molding defective product detection system, the light source system is merely a part of the data acquisition module for acquiring video stream data of a sample to be detected. Application of said light source system may reduce the effect from surroundings. A significant improvement is achieved comparing to the algorithm where the lighting system is absent. However, noise from the surroundings may also reduce the detection accuracy and even cause false classification of the algorithm accidentally. The lighting system can eliminate part of the noise from the surroundings but additional noise may be generated by the system itself. Shadow created by the light source may confuse the prediction because the shadow is commonly predicted as a breaking region or it may blur the defective region. Additional control of the environment with the lighting system should be applied in providing standard condition for accurate and robust detection. The utilization of model YOLOv3 in the method may be limited to detecting multiple products and/or multiple classes. The limitation on multiple products detection may reduce the detection rate since the products need to be queued and be detected one by one. Even worse, the multiple products occur accidentally in the frame may cause false classification. An improved product detection is needed to overcome the shortcomings.

SUMMARY OF THE INVENTION

[0011] It is an objective of the present invention to provide a defect detection method and system for plastic injection molding product that includes a data augmentation that adjusts the environment and camera settings, as well as a data augmentation with a computational approach that provides higher variation and sufficient image datasets in an unbalanced dataset in injection-molded products.

[0012] It is also an objective of the present invention to provide a defect detection method and system for plastic injection molding product, which provide a multiple products and multiple classes defect detection method and system with localization of the target region.

[0013] It is also a further objective of the present invention to provide a defect detection method and system for plastic injection molding product, which provide real-time production performance monitoring.

[0014] Accordingly, these objectives may be achieved by following the teachings of the present invention. The present invention relates to a defect detection method for plastic injection molding product, comprising the steps of: collecting product samples with normal and abnormal classes; collecting image dataset from the collected product samples with data augmentation; annotating the image dataset; applying data augmentation to the annotated dataset by a computational algorithm to increase the variation of the dataset; training a model using the generated datasets to prepare a defect detection model; localizing and labelling target region of the products; recording frames with defective products and detection information; and monitoring the production performance in real-time using the detection information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The features of the invention will be more readily understood and appreciated from the following detailed description when read in conjunction with the accompanying drawings of the preferred embodiment of the present invention, in which:

[0016] FIG.1 illustrates a system diagram of the defect detection for plastic injection molding product in the present invention;

[0017] FIG.2 illustrates a setup diagram of LEDs lighting system installed inside softbox in the present invention;

[0018] FIG.3 illustrates an example of defect detection in inference window;

[0019] FIGS.4a-4b illustrate a examples of dashboard monitoring in the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0020] For the purposes of promoting and understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and described in the following written specification. It is understood that the present invention includes any alterations and modifications to the illustrated embodiments and includes further applications of the principles of the invention as would normally occur to one skilled in the art to which the invention pertains.

[0021] The present invention teaches a defect detection method for plastic injection molding product, comprising the steps of: collecting product **102a** samples with normal and abnormal classes; collecting image dataset from the collected product samples with data augmentation **102b**; annotating the image dataset **102c**; applying data augmentation to the annotated dataset by a computational algorithm **102d** to increase the variation of the dataset; training a model **104a** using the generated datasets to prepare a defect detection model; localizing and labelling target region of the products; recording frames with defective products and detection information **106b**; and monitoring the production performance in real-time **108a** using the detection information.

[0022] In a preferred embodiment of the present invention, the collecting of image dataset from the collected product samples with data augmentation **102b**, comprising the step of: adjusting an environment of image capturing and a camera **202** setting; wherein the environment is a softbox **206** and deployed with a LEDs lighting **204** system.

[0023] In a preferred embodiment of the present invention, the adjusting of the environment for image capturing further comprising the steps of controlling and adjusting: brightness of LEDs lighting **204**; position and orientation of LEDs lighting **204**; reflection of LEDs lighting **204** inside the surface of softbox **206**; separation between camera **202** and target; and aperture of camera **202**, for generating additional images.

[0024] In a preferred embodiment of the present invention, the controlling and adjusting reflection of LEDs lighting **204** inside the surface of softbox **206** further comprising the step of: installing plates with different color and materials on the inner surface of softbox **206**.

[0025] In a preferred embodiment of the present invention, the controlling and adjusting aperture of camera **202** further comprising the step of: controlling depth of view and the effect of blur on fore or back-ground.

[0026] In a preferred embodiment of the present invention, the applying of data augmentation to the annotated dataset by the computational algorithm **102d**, comprising the steps of: cropping, rotating, flipping, hueing, saturating, exposing and mosaicking the data augmentation.

[0027] In a preferred embodiment of the present invention, the preparing of the defect detection model, comprising the step of: detecting at least one defect and at least one type of defect on at least one product **106a** of same kind using the defect detection model. The detecting method comprises the steps of: blocking all the exterior light source and product motion by the softbox **206** without affecting the frame inside the softbox **206**; eliminating influence from the surroundings of the product; and eliminating shadow from the lighting system by controlling reflection within the softbox **206**.

[0028] In a preferred embodiment of the present invention, the recording of frames with defective products and detection information **106b**, further comprising the step of: batching the results of the products in a pre-defined number.

[0029] The present invention also teaches a defect detection system for plastic injection molding product, comprising of: a data acquisition module **102** comprises a data augmentation and a data annotation **102c** for collecting product samples and image dataset; wherein the data augmentation is applied by adjusting an environment of image capturing and a camera **202** setting, and by a computational algorithm **102d**; a model training **104a** for training the annotated dataset; a detection module **106** for detecting defect of the product **106a** and recording relevant information **106b**; and a monitoring module **108** for real-time monitoring **108a** the production performance. The product samples comprise normal and abnormal classes.

[0030] In a preferred embodiment of the present invention, the data acquisition module **102** further comprises LEDs lighting system **204** that is installed in a softbox **206**.

[0031] In a preferred embodiment of the present invention, the data augmentation that is applied by computational algorithm **102d** is configured to increase the variation of the dataset. The data augmentation that is applied by adjusting the environment of image capturing and the camera setting is configured to control and adjust the brightness of LEDs lighting **204**, position and orientation of LEDs lighting **204**, reflection of LEDs lighting **204** inside the surface of softbox **206**, separation between camera **202** and target, and aperture of camera **202** for generating additional images. Plates with different color and materials are installed on the interior of the softbox **206** to control and adjust the reflection of LEDs lighting **204** inside the surface of softbox **206**. The aperture of camera **202** is controlled by depth of view and the effect of blur on fore or back-ground.

[0032] In a preferred embodiment of the present invention, the detection module **106** is configured to: block all the exterior light source and product motion by the softbox **206** without affecting the frame inside the softbox **206**; eliminate influence from the surroundings of the product; and eliminate shadow from the lighting system by controlling reflection within the softbox **206**. The detection module **106** is further configured to batch the results of the products in a pre-defined number.

EXAMPLE

[0033] A system diagram of the defect detection for plastic injection molding product in the present invention is illustrated in **FIG.1**. The system comprises a data acquisition module **102**, a model training **104a**, a detection module **106** and a dashboard monitoring module **108**. Product samples with both normal and abnormal classes are first collected in the data acquisition module **102**. Samples from different defective classes such as break, burn mark, and shrinkage are collected as abnormal samples. Image dataset is gathered from the collected product **102a** samples. Data augmentation by adjusting environment and camera settings is applied during the collection of image dataset **102b**. A setup with LEDs lighting **204** system installed inside a softbox **206** is prepared for data collection and illustrated in **FIG.2**. The LEDs lighting **204** system and softbox **206** are applied in the present invention for better control the defect detection system **106**.

[0034] The lighting system, softbox **206** interior, and camera **202** are kept adjusted during the image dataset collection **102b** to increase the sample size by enhancing variation of the dataset. The adjustments include: brightness of LEDs lighting **204**; position and orientation of LEDs lighting **204**; reflection of LEDs lighting **204** in interior surface of softbox **206** by installing plates with different color and materials on the interior of the softbox **206**; separation between camera **202** and target; and aperture of camera **202** by control depth of view and the effect of blur on fore or back-ground. These adjustments provide a high variation on the image dataset before being annotated.

[0035] Image dataset is being annotated **102c** after the data collection with data augmentation applied **102b**. The annotated dataset **102c** is further applied with data augmentation with computational approach **102d** to further increase the variation of the dataset. The methods of applying data augmentation to the annotated dataset by the computational algorithm **102d**, comprising the steps of: cropping, rotating, flipping, hueing, saturating, exposing and mosaicking the data augmentation. Said methods increase variation of dataset from different aspects such as geometry, color and intensity. The fusion of two data augmentations in the present invention which adjusts environment and camera **202** settings and uses a computational algorithm **102d** could avoid the duplication and reinforcement of false features in the image dataset.

[0036] The dataset is ready for proceeding to model training **104a** after the data augmentation. The defect detection model can carry product detection **106a** with multiple defects and multiple types of defects on at least one product in the video stream. Products are detected under a well-controlled environment with LEDs lighting **204** system installed inside the softbox **206**. Products can hence be detected without the influence (e.g., shadow) from surroundings. The detection environment in this invention can be standardized and hence is robust to be applied in any industrial line.

[0037] An example of inference window of the detection is shown in **FIG.3**. Localization of the defective region together with the confidence percentage is shown in the window. Accordingly, the 93% shown in the window of **FIG.3** indicates the defect or break area. Also, detection information such as frame per second (fps) and conclusion of prediction(s) is listed in the window. Frames with defective product(s) are recorded in PNG file. Information of those detections such as detection time, path of saved image, id number of the detection, and etc. is recorded **106b** in a defective log file in text format. The recorded frame of the product with defective region localization is further used for future review. The advantages of the review action include providing user with understanding of the defect produced from the current machine condition, providing a better understanding of the false classification, if any, and improving the model.

[0038] Results of products detection are batched by a pre-defined number, for example results of 100 samples in a batch. Information of the batch such as starting time of the batch, ending time of the batch, number of normal samples in the batch, and the number of defective samples in the batch are recorded in another text file. This defective log provides a clear record for further analysis.

[0039] Batch information recorded in the text file is used for real-time dashboard monitoring **108a**. The real-time dashboard monitoring **108a** displays the detection information in a table and/or a graph. Said table shows total number of normal and abnormal products, whereas graph shows number of defective products at time series. **FIGS.4a-4b** illustrate the examples of dashboard with two display modes of the graph. **FIG.4a** illustrates a frequency graph, whereas **FIG.4b** illustrates a cumulative frequency graph. Information is updated with the real-time detection results. Production performance in historical production id can also be reviewed in the dashboard.

[0040] The present invention explained above is not limited to the aforementioned embodiment and drawings, and it will be obvious to those having an ordinary skill in the art of the prevent invention that various replacements, deformations, and changes may be made without departing from the scope of the invention.

CLAIMS

WHAT IS CLAIMED:

1. A defect detection method for plastic injection molding product, comprising the steps of:

collecting product (102a) samples with normal and abnormal classes;

collecting image dataset from the collected product samples with data augmentation (102b);

annotating the image dataset (102c);

applying data augmentation to the annotated dataset by a computational algorithm (102d) to increase the variation of the dataset;

training a model (104a) using the generated datasets to prepare a defect detection model;

localizing and labelling target region of the products;

recording frames with defective products and detection information (106b); and

monitoring the production performance in real-time (108a) using the detection information.

2. The defect detection method for plastic injection molding product, according to claim 1, wherein the collecting of image dataset from the collected product samples with data augmentation (102b), comprising the step of:

adjusting an environment of image capturing and a camera (202) setting;

wherein the environment is a softbox (206) and deployed with a LEDs lighting (204) system.

3. The defect detection method for plastic injection molding product, according to claim 2, wherein the adjusting of the environment for image capturing further comprising the steps of controlling and adjusting:

brightness of LEDs lighting (204);

position and orientation of LEDs lighting (204);

reflection of LEDs lighting (204) inside the surface of softbox (206);

separation between camera (202) and target; and aperture of camera (202), for generating additional images.

4. The defect detection method for plastic injection molding product, according to claim 3, wherein the controlling and adjusting reflection of LEDs lighting (204) inside the surface of softbox (206) further comprising the step of:

installing plates with different color and materials on the inner surface of softbox (206).

5. The defect detection method for plastic injection molding product, according to claim 3, wherein the controlling and adjusting aperture of camera (202) further comprising the step of:

controlling depth of view and the effect of blur on fore or back-ground.

6. The defect detection method for plastic injection molding product, according to claim 1, wherein the applying of data augmentation to the annotated dataset by the computational algorithm (102d), comprising the steps of: cropping, rotating, flipping, hueing, saturating, exposing and mosaicking the data augmentation.

7. The defect detection method for plastic injection molding product, according to claim 1, wherein the preparing of the defect detection model, comprising the step of:

detecting at least one defect and at least one type of defect on at least one product (106a) of same kind using the defect detection model.

8. The defect detection method for plastic injection molding product, according to claim 7, further comprises the steps of:

blocking all the exterior light source and product motion by the softbox (206) without affecting the frame inside the softbox (206);

eliminating influence from the surroundings of the product; and

eliminating shadow from the lighting system by controlling reflection within the softbox (206).

9. The defect detection method for plastic injection molding product, according to claim 1, wherein the recording of frames with defective products and detection

information (106b), further comprising the step of:

batching the results of the products in a pre-defined number.

10. A defect detection system for plastic injection molding product, comprising of:

a data acquisition module (102) comprises a data augmentation and a data annotation (102c) for collecting product samples and image dataset;

wherein the data augmentation is applied by adjusting an environment of image capturing and a camera (202) setting, and by a computational algorithm (102d);

a model training (104a) for training the annotated dataset;

a detection module (106) for detecting defect of the product (106a) and recording relevant information (106b); and

a monitoring module (108) for real-time monitoring (108a) the production performance.

11. The defect detection system for plastic injection molding product, according to claim 10, wherein the data acquisition module (102) further comprises LEDs lighting system (204) that is installed in a softbox (206).

12. The defect detection system for plastic injection molding product, according to claim 10, wherein the data augmentation that is applied by computational algorithm (102d) is configured to increase the variation of the dataset.

13. The defect detection system for plastic injection molding product, according to claim 10, wherein the data augmentation that is applied by adjusting the environment of image capturing and the camera setting is configured to control and adjust the brightness of LEDs lighting (204), position and orientation of LEDs lighting (204), reflection of LEDs lighting (204) inside the surface of softbox (206), separation between camera (202) and target, and aperture of camera (202) for generating additional images.

14. The defect detection system for plastic injection molding product, according to claim 13, wherein plates with different color and materials are installed on the interior of the softbox (206) to control and adjust the reflection of LEDs lighting (204) inside the surface of softbox (206).

15. The defect detection system for plastic injection molding product, according to claim 13, wherein the aperture of camera (202) is controlled by depth of view and the effect of blur on fore or back-ground.

16. The defect detection system for plastic injection molding product, according to claim 10, wherein the detection module (106) is configured to:

    block all the exterior light source and product motion by the softbox (206) without affecting the frame inside the softbox (206);

    eliminate influence from the surroundings of the product; and

    eliminating shadow from the lighting system by controlling reflection within the softbox (206).

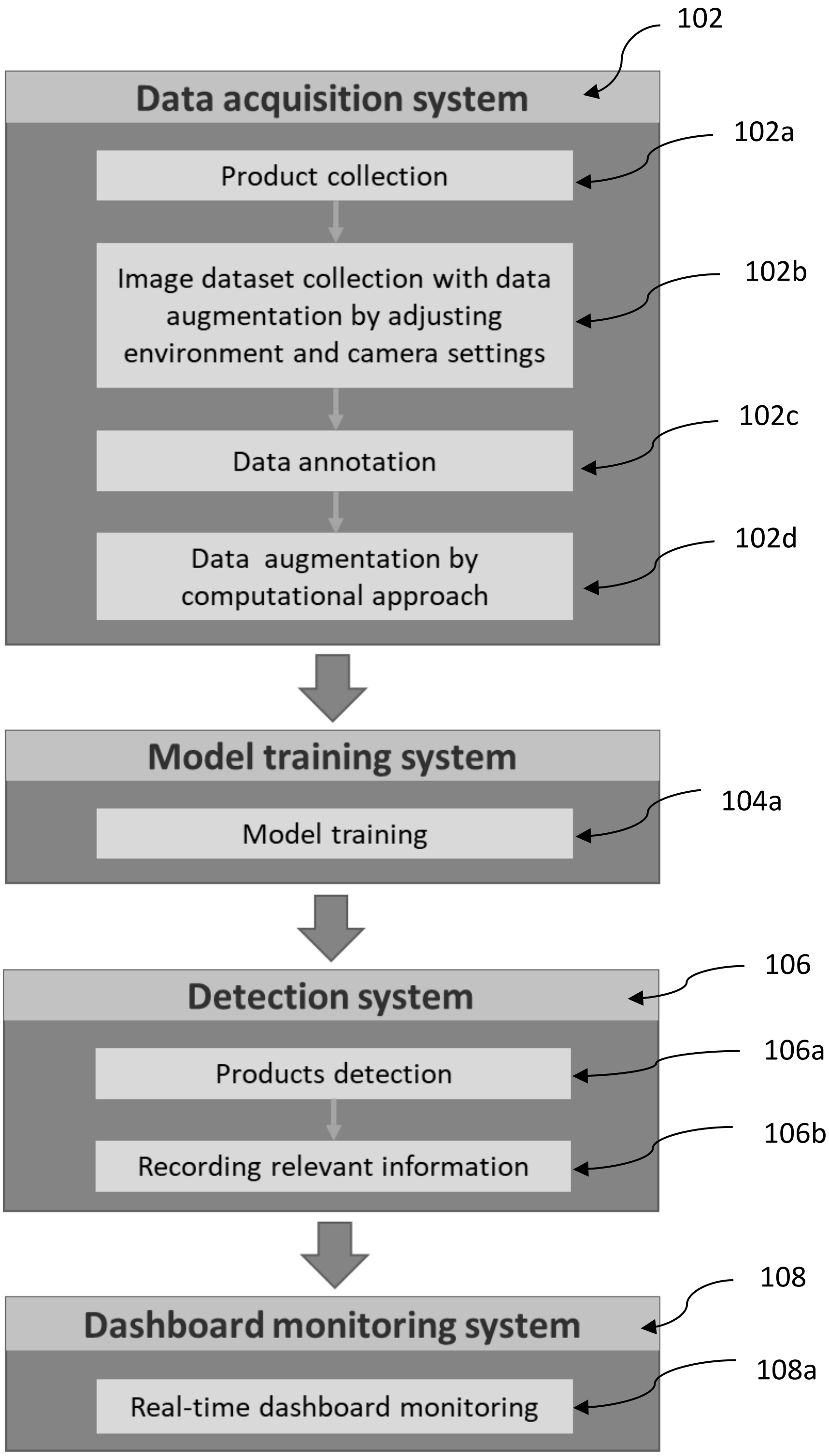
102
Data acquisition system
102a
Product collection
102b
Image dataset collection with data augmentation by adjusting environment and camera settings
102c
Data annotation
102d
Data augmentation by computational approach
Model training system
104a
Model training
106
Detection system
106a
Products detection
106b
Recording relevant information
108
Dashboard monitoring system
108a
Real-time dashboard monitoring

Figure 1

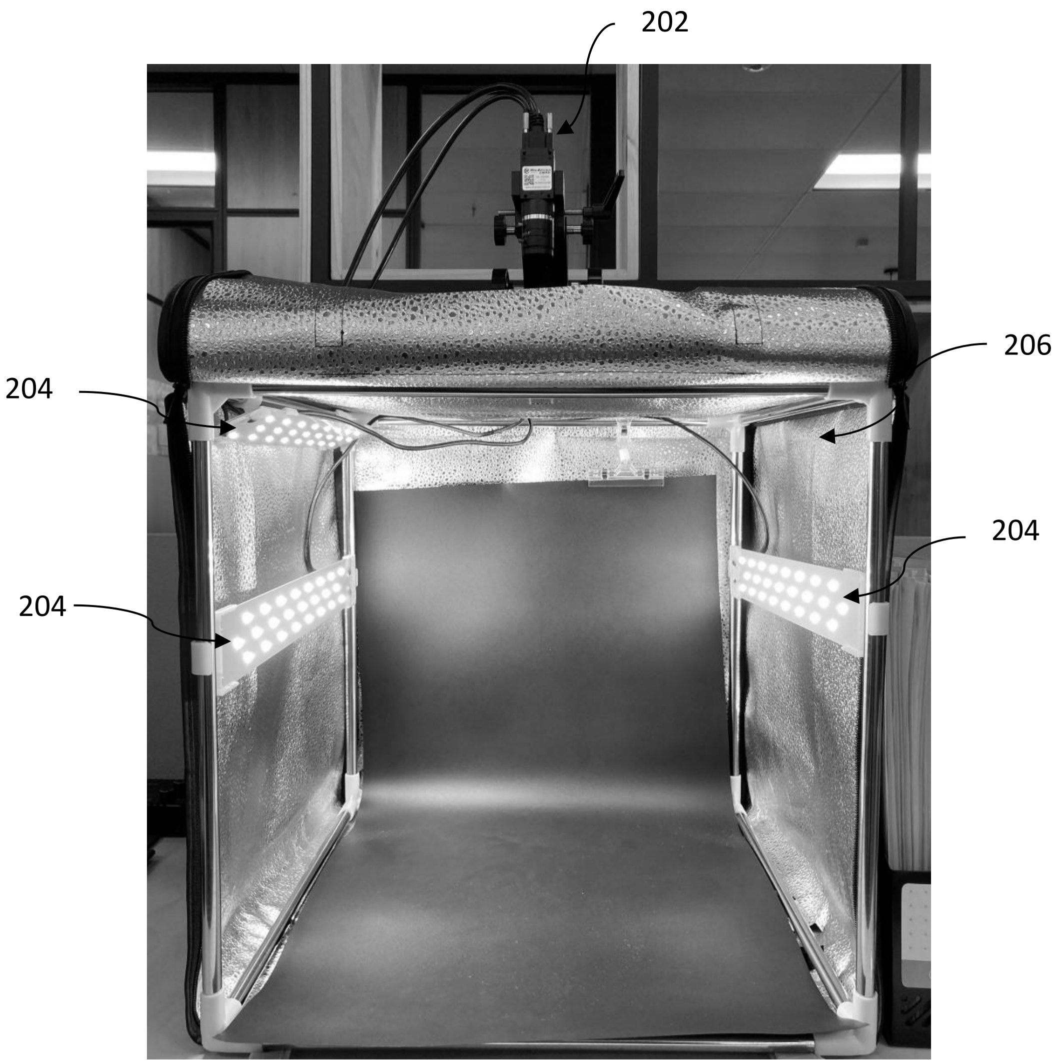

Figure 2

Figure 3

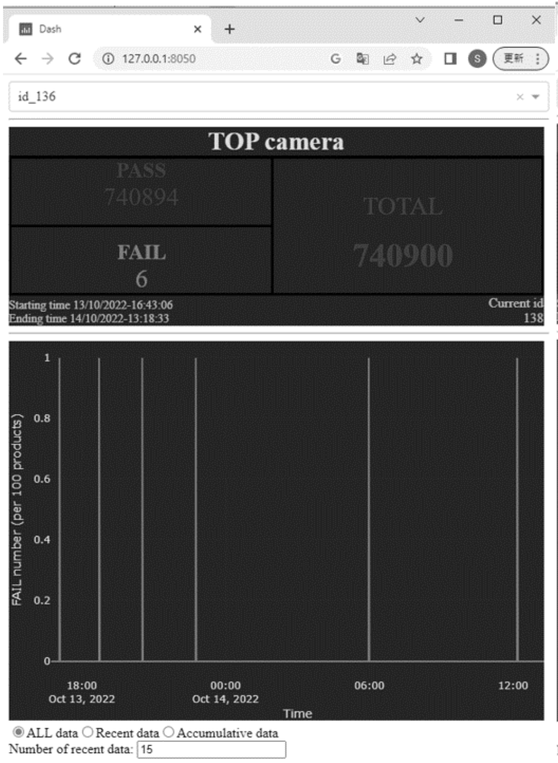

Figure 4a

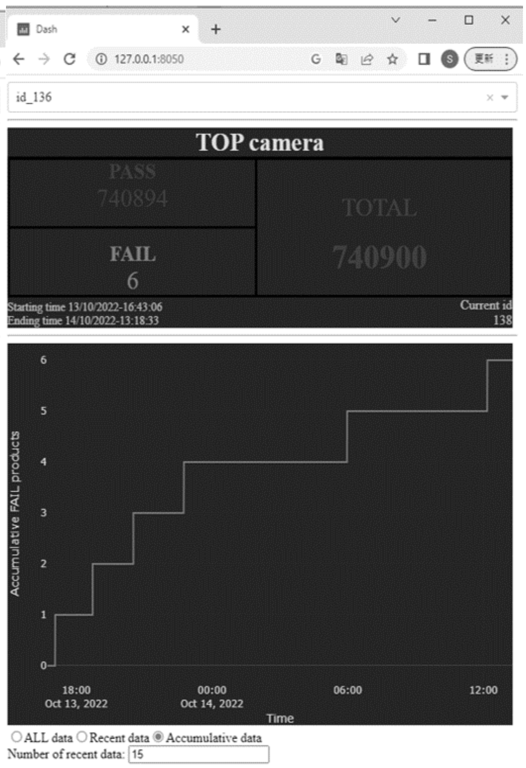

Figure 4b