Integrated Industrial Visual Inspection Scheme in Combination with Training and Inference

WPI Shares Integrated Industrial Visual Inspection Scheme in Combination with Training and Inference based on Intel® EIS

To meet the increasing demand for defect detection in the industrial field, Intel and WPI have jointly launched the “Training + Inference collaboratively Integrated Intel® EIS (Edge Insight Software) Industrial Visual Inspection Scheme”. The system can be used to detect the defects of products with known types by using Balser camera, gateway and software application and supporting the acquisition of high-resolution images in combination with traditional vision, deep learning and vision algorithm. The product defect detection of aluminum parts in a well-known domestic factory is based on this framework as an example of application.

This scheme, based on computer vision, is to perform the operational processing of the acquired image data of an object through the special edge computing node device, and then to distribute the processed result:

1: Control the mechanical arm and give an alarm
2: Report the data to the edge server

The edge server collects data, processes and analyzes the data, and then completes the cloud connection.

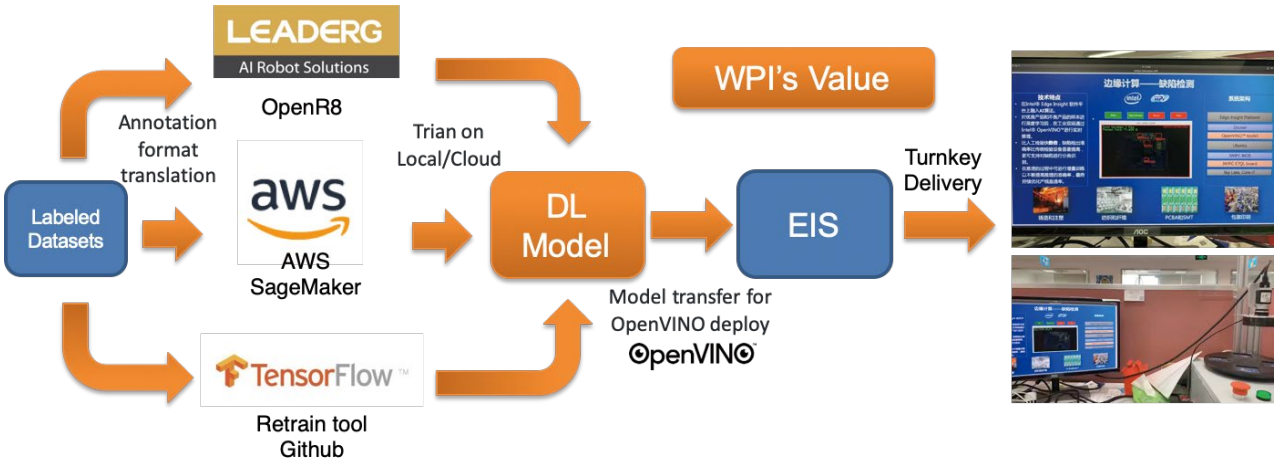

Figure 1 EIS Model Path Reference

1. Advantages of the Scheme

1.1 The overfitting degree of the recognition result is low

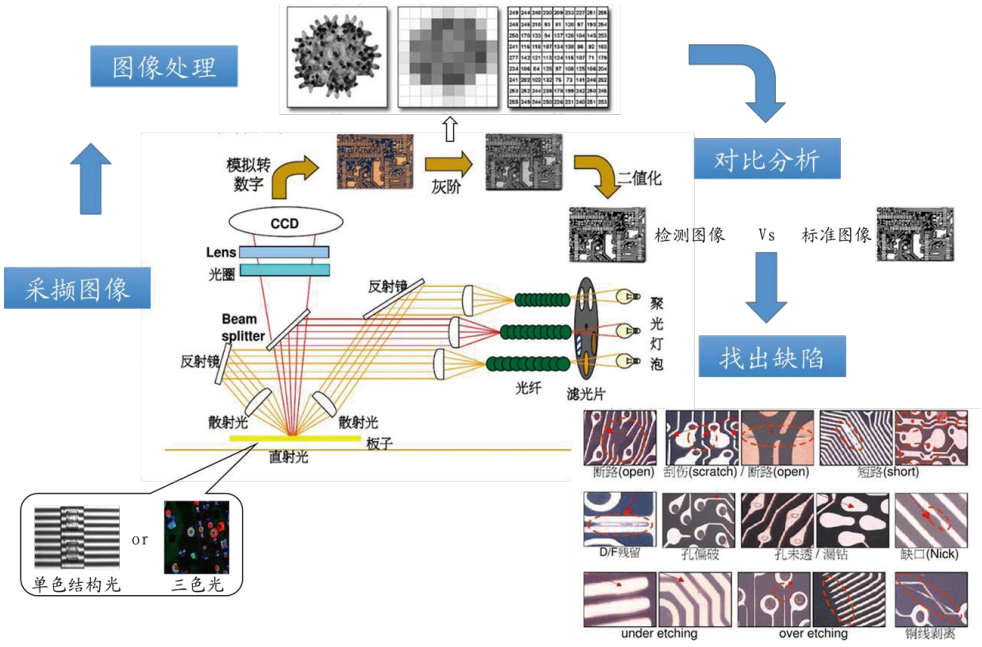

Figure 2 Schematic Diagram of Traditional AOI Defect Recognition Scheme

Because the traditional AOI scheme adopts the optical visual comparison analysis method to analyze the object to be inspected, the inspection overfitting rate is high, it is easy to misreport good products as defective products, so manual secondary screening is required at the backstage, which affects the production efficiency and increases the labor cost. At the same time, AOI defect recognition is based on the priori defect shape to make pattern recognition, and the defect types that can be classified itself are relatively limited, it cannot judge a problem, and then make a secondary classification.

This project bases on AI black box model for defect classification, at the same time, through the study of annotation of a large quantity of sample data, the defect target detection is automatically completed, the recognition accuracy is high, and the secondary review resources are reduced, at the same time, because the scheme uses deep learning technology, users do not need to match specific defect features, the statistics of all the features are completed automatically through artificial intelligence, so the number of defect classification can be greatly improved, compared with AOI, it can identify more subdivided defects.

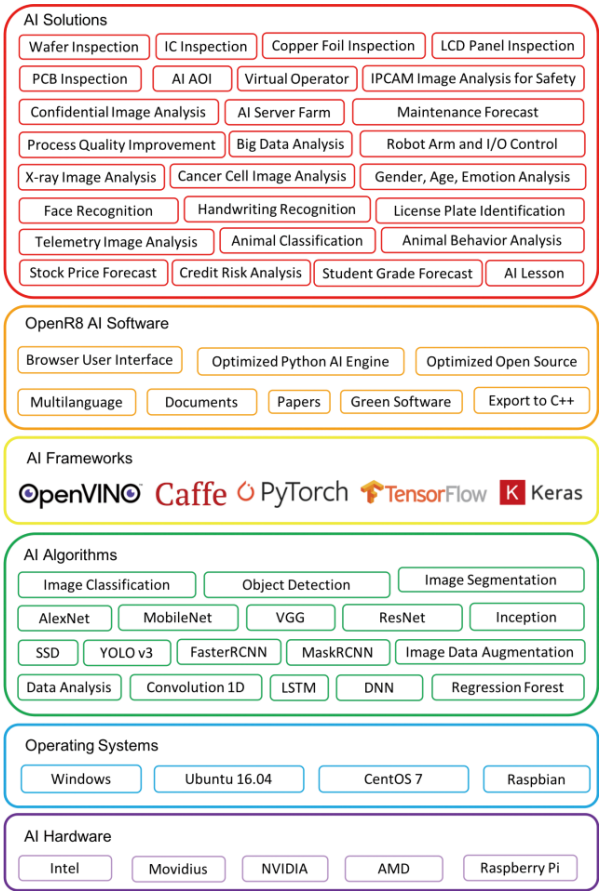

Figure 3 OpenR8 Function Framework

1.2 Modular deployment

Usually, when an industrial project has been approved, because the application scenario varies, the system architecture often needs to be redesigned according to the project requirements, which greatly increases the complexity and difficulty of the project deployment and consumes human resources. This scheme adopts the technology of Docker modular deployment, the step function tasks including data acquisition, integration, storage, analysis, algorithm deployment, message queue processing and so on are divided, and the underlying data logic is improved, thus the replicability of the system architecture is realized, so the system Integrator does not need to redesign the scheme architecture from beginning to end, as long as the selection of functional modules, parameter setting and model re-training are completed, the deployment of the whole scheme can be basically realized, which greatly reduces the difficulty of the project deployment and improves the reusability of the system.

1.3 Low training threshold

This project adopts LeaderG's OpenR8 graphical training tool, which has built in a variety of mainstream deep learning frameworks (Tensorflow, Caffe, Pytorch...) and algorithm models (SSD, MobileNet, GoogleNet…), users can easily create a deep learning model without mastering programming skills and by simply using the mouse through a simple browser interface.

2.Application Cases

- Greige cloth defect detection - real-time product quality inspection in the circular machine production workshop of the textile mill
- Order tracking based on image recognition - automatic order recognition of the garment factory
- Metal surface defect detection - product quality inspection of the aluminum die casting factory

3.System Configuration:

When a defective product is detected, the alarm indicator lights up. The operator shall check the product and system in detail, and press the reset button when confirming that there is no fault, the alarm indicator goes off.

3.1 Hardware scheme

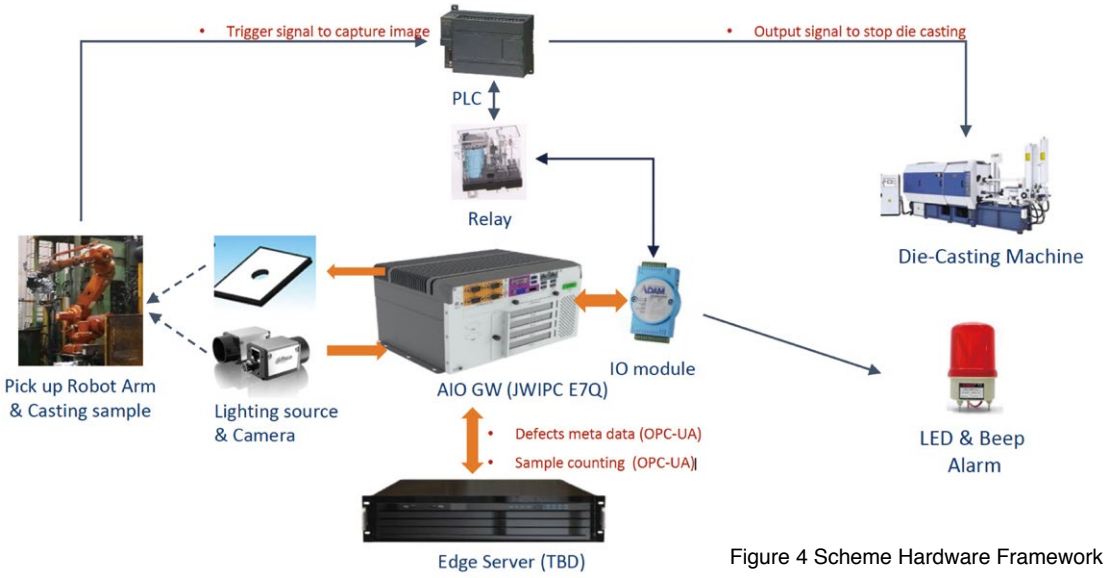

Figure 4 Scheme Hardware Framework

3.1 Hardware scheme

The edge computing node of this scheme adopts the E7QL model developed by JWIPC (cooperative manufacturer) based on Intel Core Platform, which is specially designed for industrial fields. Some of its main features are as follows:

- The operating environment temperature is relatively wide, the operating temperature supports-20 to 60 degrees.
- Fanless design avoids dust.
- The chipset Q170 adopted is a specialized industrial chip with good stability.
- Different CPU from i3 to i7 is provided to meet different computing power support. The top-end core i7 has strong computing power, 4 cores and 8 threads.
- Rich industrial interfaces, supporting a series of different interfaces, such as serial port, gigabit network card, GPIO, USB3.0 and MXM3.0, etc.
- Built-in PCIE expansion slot.
- Modular design gives users different configuration choices.

3.2 Software solutions

Based on TICK time series processing architecture, this scheme realizes modular software design mode.

- Telegraf - data acquisition
- InfluxDB - data reception and storage
- Chronograf - data summary and presentation
- Kapacitor - data processing, such as monitoring strategy

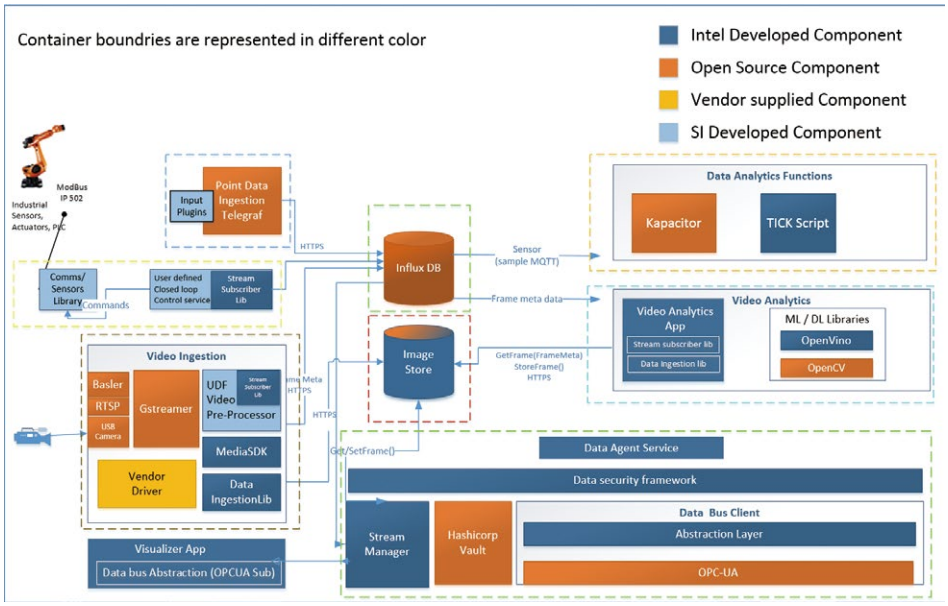

Figure 5 Scheme Software Framework

3.3 Prototype system

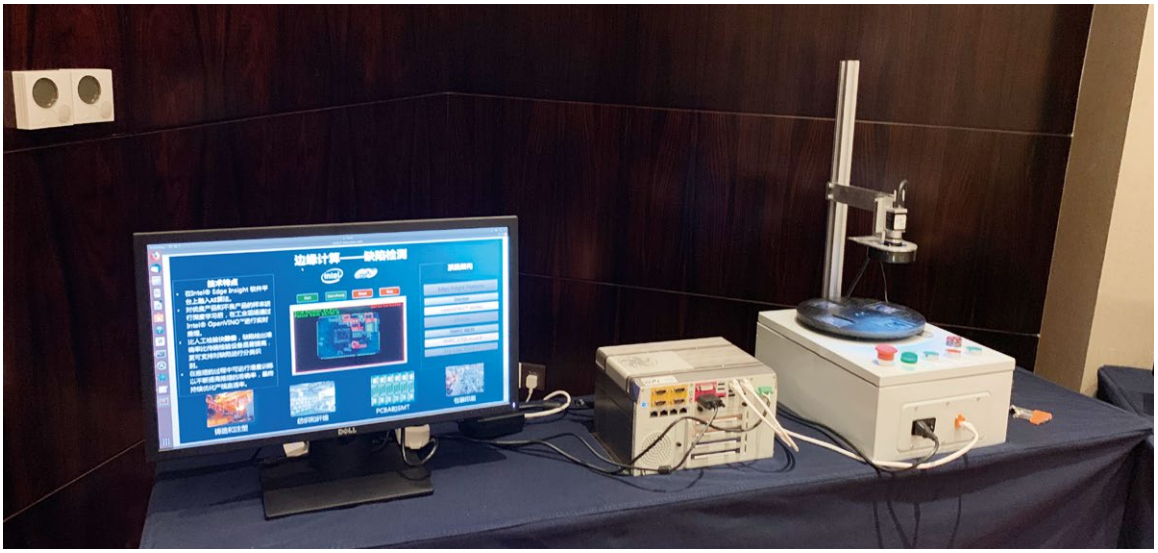

Figure 6 Scheme Prototype System Presentation

4 Key Technology

4.1 Key frame screening

In this scheme, OpenCV2 built-in algorithm is adopted to collect several positive bitmaps of the object to be inspected by setting the pixel point threshold, and the frame at the center of the picture is calculated and selected as the key frame of the object to be inspected for identification. At the same time, the meta data is extracted and transferred to the InfluxDB time series database.

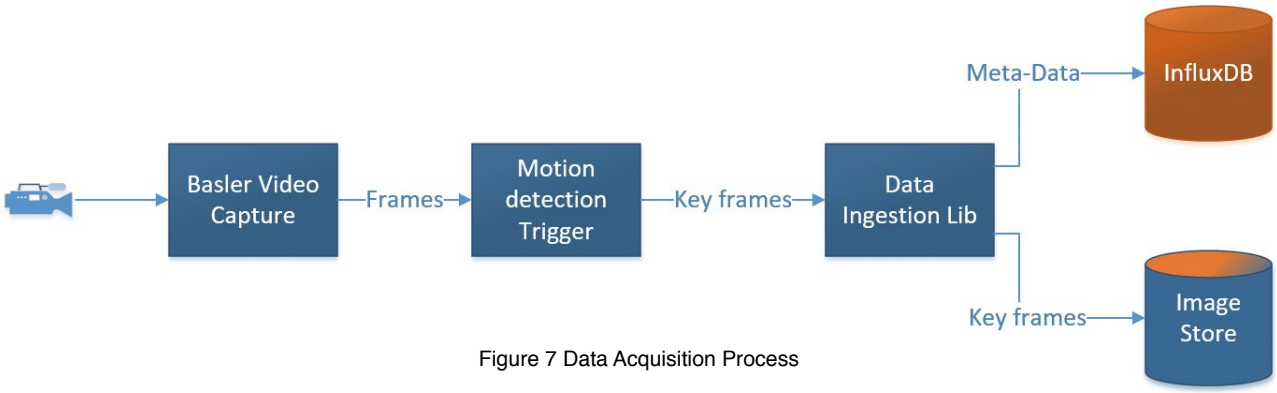

Figure 7 Data Acquisition Process

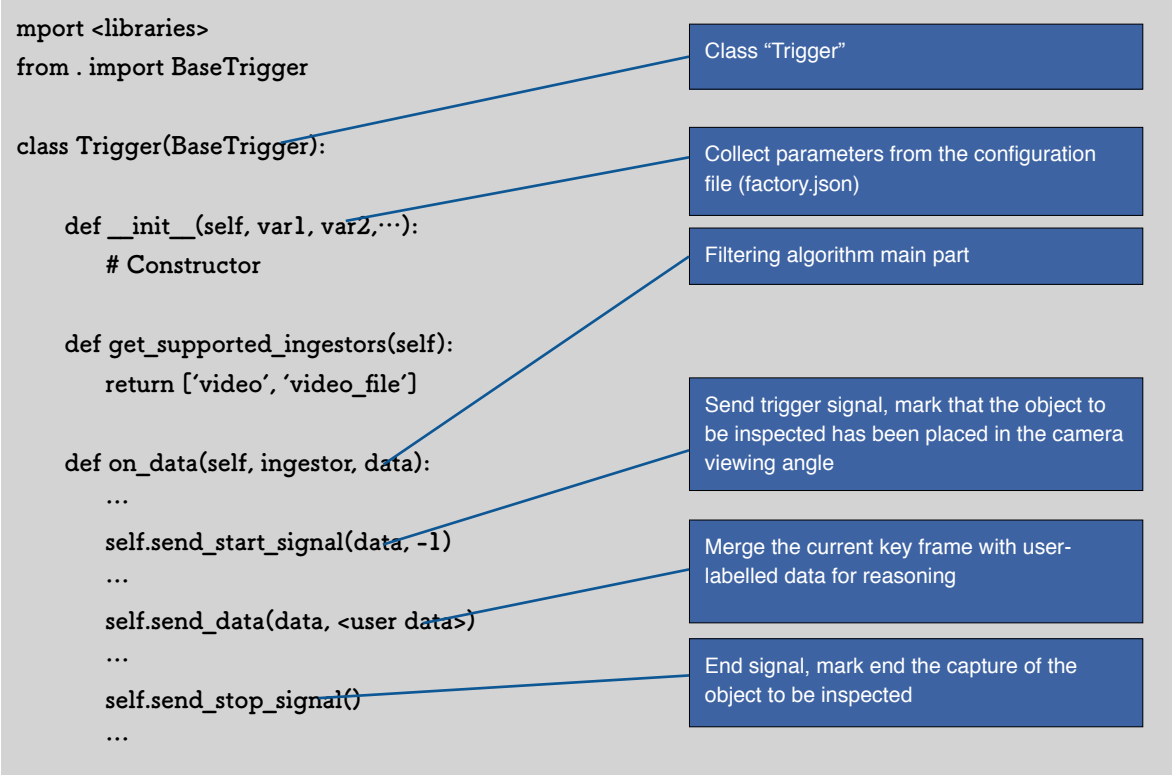

Figure 8 Key Frame Filtering Module Framework

4.2 Image positioning

In this scheme, OpenCV2 FlannBasedMatcher module is adopted to match the key points of the key frame with the reference picture, so as to adjust the size and angle of the key frame. Meanwhile, findHomography module is used to calculate the similarity between the reference image and the key frame and judge the validity of the key frame (whether it is the object to be inspected), so as to identify it.

```
# Find matching keypoints
    raw_matches = self.flann.knnMatch(ref_des, img_des, k=2)
    for m in raw_matches:
        # Lowe's Ratio Test
        if len(m) == 2 and m[0].distance < m[1].distance * 0.7:
            matches.append(m[0])

    if len(matches) <= minMatches:
        self.log.debug("""Found less than minimum # of matches
                    required to overlay""")
        return None

    self.log.debug("Number of good matches: {}".format(len(matches)))

    src_pts = np.float32([ref_kp[m.queryIdx].pt for m
                    in matches]).reshape(-1, 1, 2)
    dst_pts = np.float32([img_kp[m.trainIdx].pt for m
                    in matches]).reshape(-1, 1, 2)

    # Calculate homography
    M, mask = cv2.findHomography(src_pts, dst_pts, cv2.RANSAC, 4.0)
    score = float(mask.sum()) / mask.size
    return (M, mask, score)
```

Figure 9 Image location Source Code

4.3 Classification recognition

First, mark the ROI area of the object to be inspected, intercept the image of the ROI area, send it to the pre-trained neural network model for classification analysis, so as to obtain the confidence data of defect types in the critical position of the object and make judgment.

```
{
  "missing": {
    "A1_roi" : [ [530, 229, 580, 271],
                 [635, 640, 660, 679],
                 [915, 585, 965, 637],
                 [1204, 672, 1260, 705],
                 [1113, 255, 1175, 292]
               ]
  },

  "short": {
    "A1_roi" : [ [557, 589, 595, 627],
                 [1238, 815, 1284, 849]
               ]
  }
}
```

Figure 10 ROI Labelled File

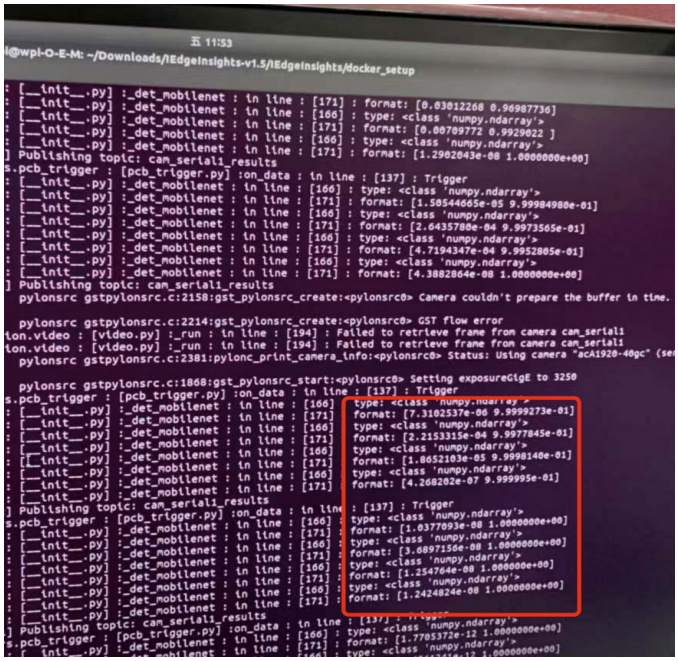

Figure 11 Confidence Information of the Recognition Result

```
mport <libraries>
from algos.dpm.defect import Defect
from algos.dpm.display_info import DisplayInfo
import openvino.inference_engine

class Classifier:

    def __init__(self, var1, var2, ···):
        # Constructor

    def classify(self, frame_num, img, user_data):
        # Main classifier algorithm
        ···.

        defect_array.append(Defect(<defect id>, (xmin, ymin), (xmax, ymax)))
        info_array.append(DisplayInfo("<string to display in UI>", priority#    ))
        return info_array, defect_array
```

Figure 12 Image Analysis Module Framework

4.4 Model training and deployment

The light weight model MobileNet_V2 based on Caffe framework is used for training, with low recognition delay and fast corresponding speed, which is very suitable for the production line with strict real-time requirements, the production line conveyor belt non-stop inspection can be realized.

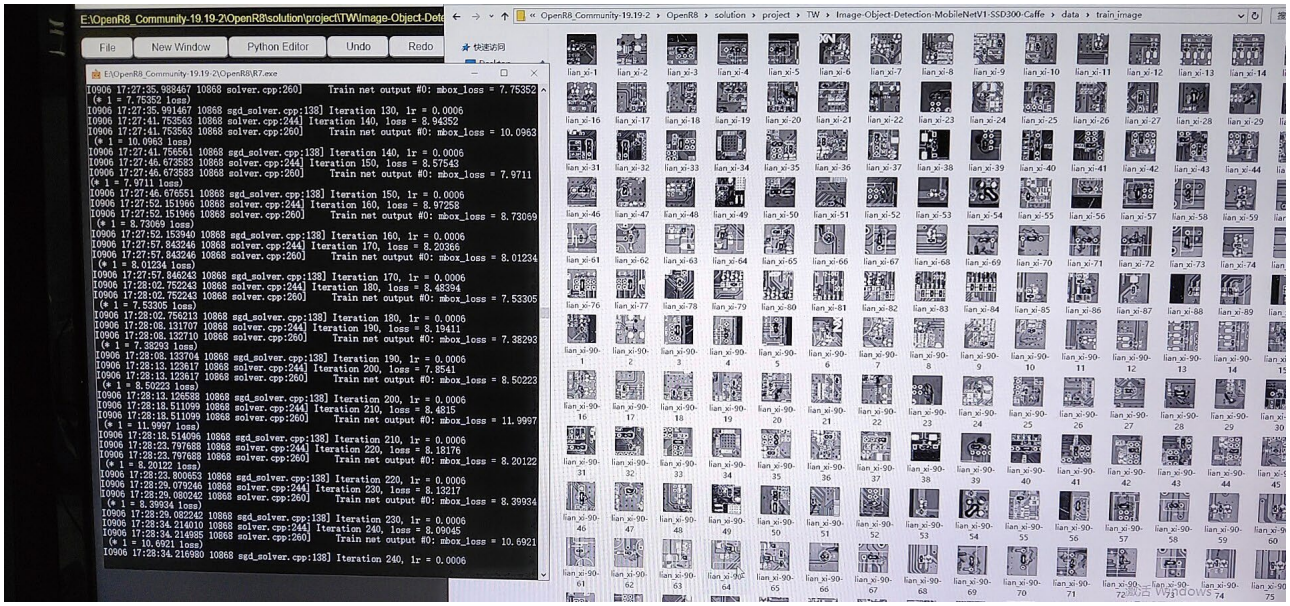

Figure 13 Data Annotation and Training

First convert the toolkit of Intel OpenVINO Model Optimizer to format files of .bin (Weight and Bias value) and .xml (model topology). Then, in connection with the model output data format, adjust the API interface calling method, present the detection result of ROI area identified on the prototype system, and push it to the background business logic. When a defective product is detected, the alarm indicator light lights up. The operator shall check the product and system in detail, and after confirming that there is no fault, press the reset button, and the alarm indicator light goes off.

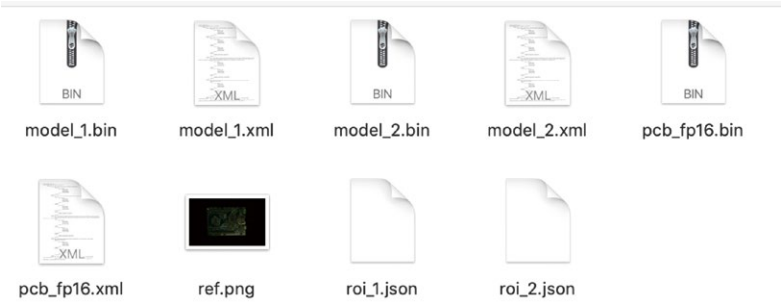

Figure 14 Deep Learning Model File

Figure 15 Human-computer Graphical Interface

Integrated Industrial Visual Inspection Scheme

	Intel	JWIPC	Leader G
Solution Name	Edge Insights Software (EIS) Reasoning Framework Software	E7QL Industrial Computer	OpenR8 Graphical Training Tool
Spec	• Free open source • Integrate OpenVINO and various pre-training models • Docker container deployment • Support domestic and foreign mainstream industrial camera specifications like Basler and Hikvision • Support InfluxDB timing sequence database	• Support Core™ i7 Processor with Q170 chip • Support Dual channel DDR4 SO-DIMM, Max support 32GB • Three display interface onboard (DP+DVI-D+VGA) • Max support 10 USB • Max support 6 Intel 1000 Mbps Ethernet port • Max support 8 COM Interface • Storage: 3HD(M.2-2242+2.5inch HDD+2.5inch HDD) • 2*PCIe+2*PCI slot • Power:12V~19V(standard configuration), 9V~36V (option module)	• Software package, using simple windows operating system, no need to use complex Linux operating system • Installation free, built-in Python, TensorFlow, PyTorch, OpenVINO, OpenCV, Caffe, which can be directly executed after decompression • User-friendly interface, no need to write a program, AI training and inference can also conducted with the mouse • Open source code • Runtime version, free of licensing fee • Professional version, reasonable price • Technical support for built-in solutions • Support deep learning • Support artificial intelligence algorithm • Support image processing • Support multiple image algorithms • Support image analysis • Support template matching • Support object analysis • Support bar code identification • Support QR code • Support multilingual coding • Computer that supports multiple cores and processors • Support GPU acceleration • Support custom function library

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