

# 工业AI落地思路分享

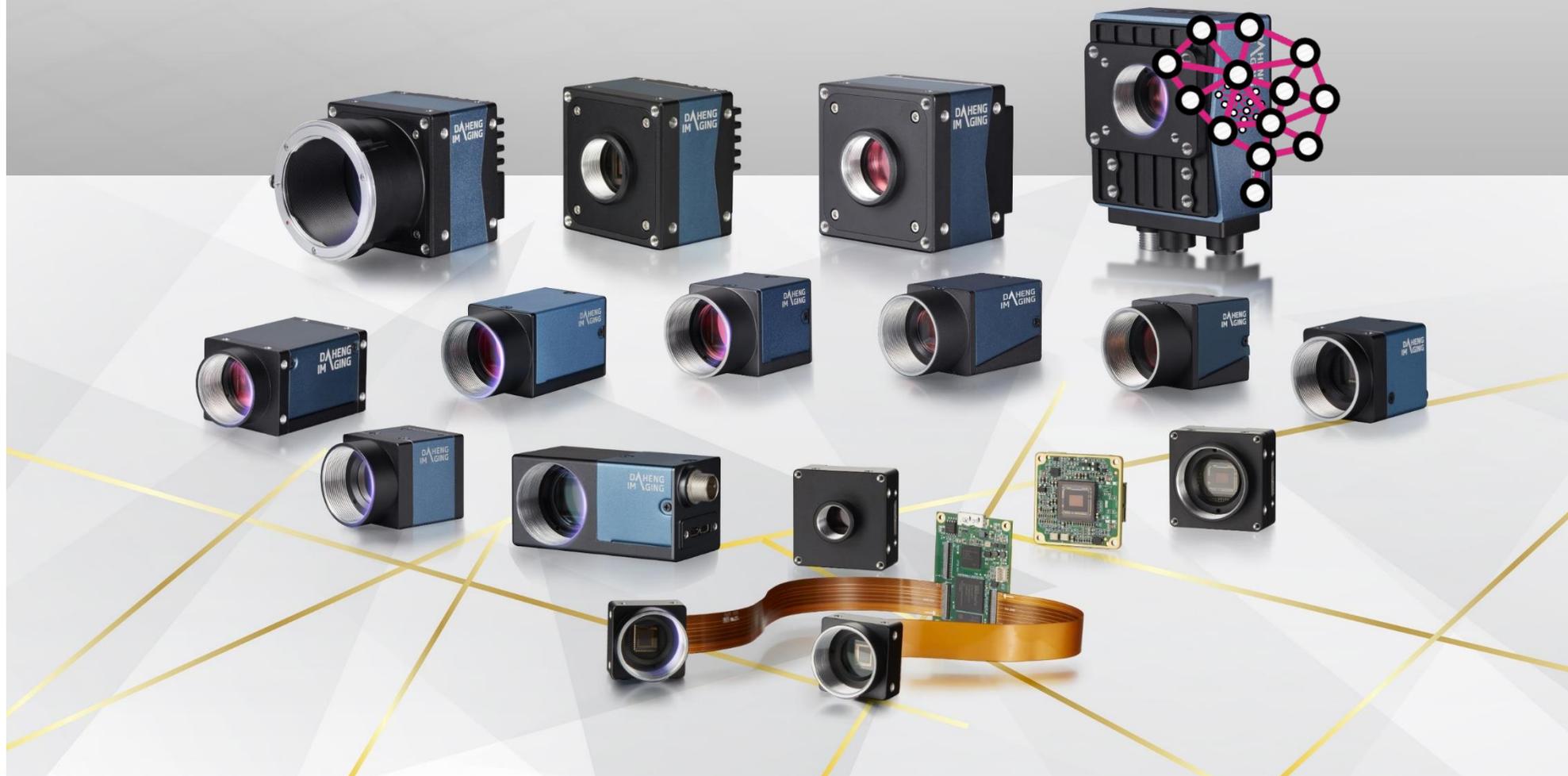
李东平

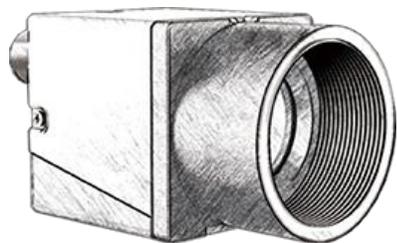
水星工业数字相机

火星大靶面工业相机

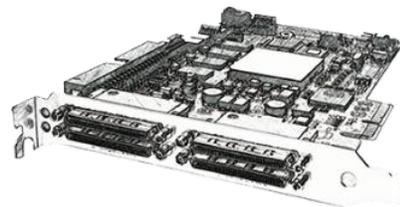
金星板级工业相机

智星智能相机

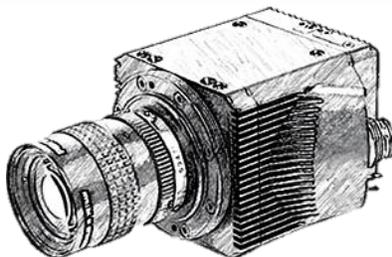




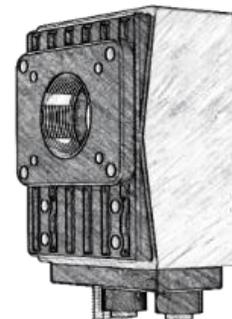
数字工业相机



图像采集卡



高速相机



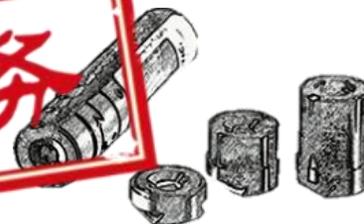
智能相机



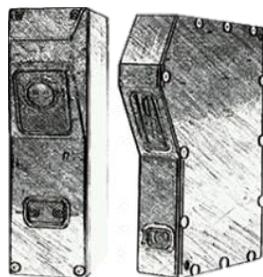
机器视觉镜头



机器视觉光源



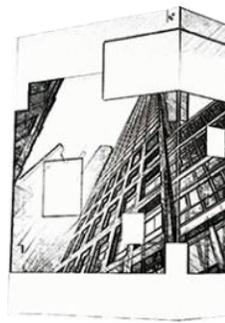
激光器



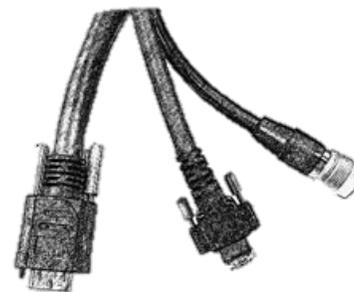
3D视觉传感器



机器视觉系统及解决方案



机器视觉软件



工业线缆

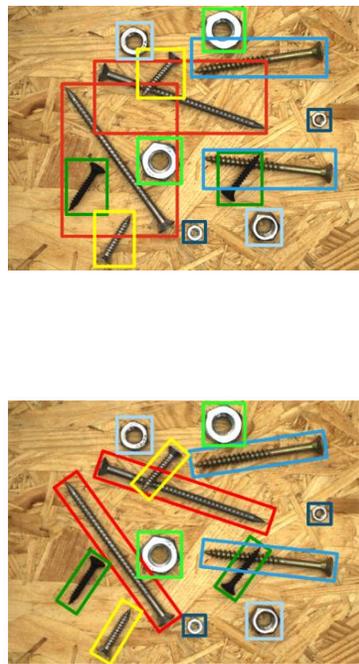
## 分类



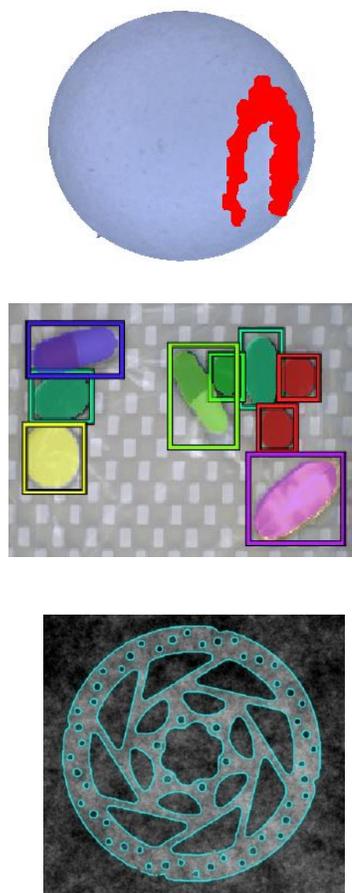
## 异常检测



## 目标检测



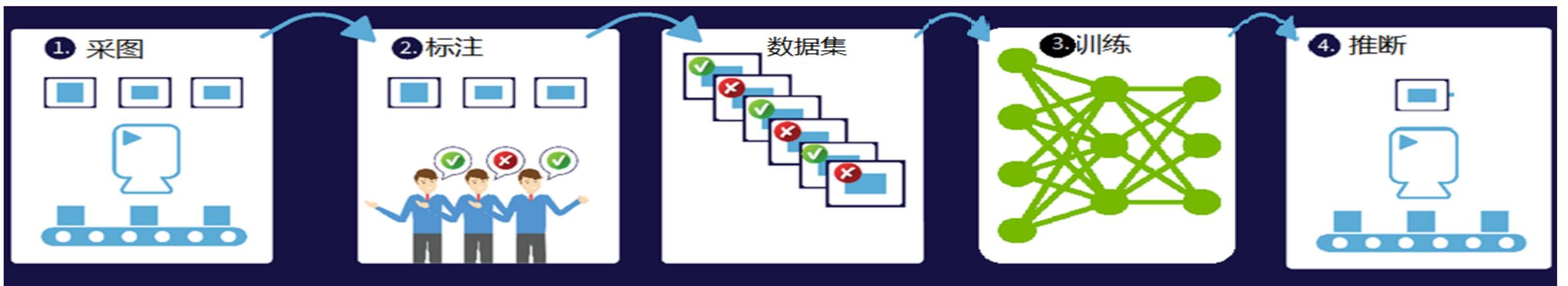
## 语义 / 实例 / 边缘 分割



## Deep OCR



# 大恒AI检测全流程



● 采集、标注图像

● 训练网络

● 在线检测  
● 越用越准



大恒相机  
及部件

分类      检测      分割      异常检测      OCR



大恒工业相机

GPU  
CPU  
ARM

Deep Learning Tool



大恒智能相机

HALCON

## ■ 标注

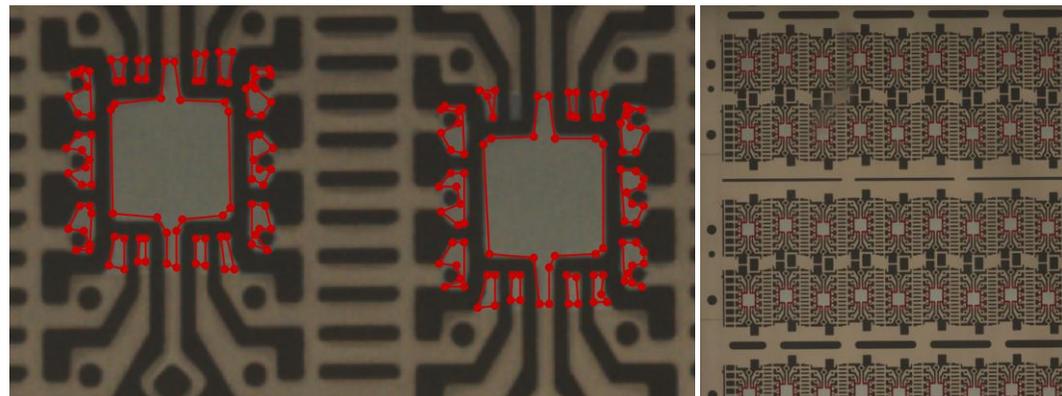
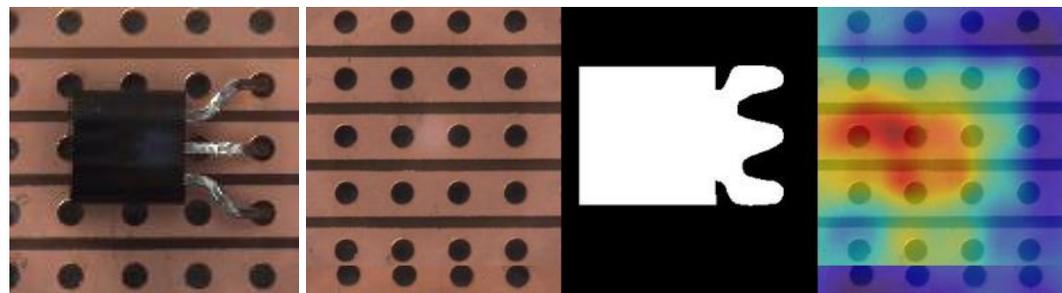
- 数据问题：正样品易得，缺陷样品不易获得，类别极不均衡
- 标注问题：图大，缺陷小、多、杂，标全不容易，不标有影响；  
有些缺陷难以标注：缺失、错位；标注工作量大；
- 开放问题：有些缺陷无法提前预知，新缺陷、未知缺陷的产生

## ■ 训练

- 工业制造追求良率提升：99%、99.9% ...
- 零漏检率与低误检率
- 理解模型的限制

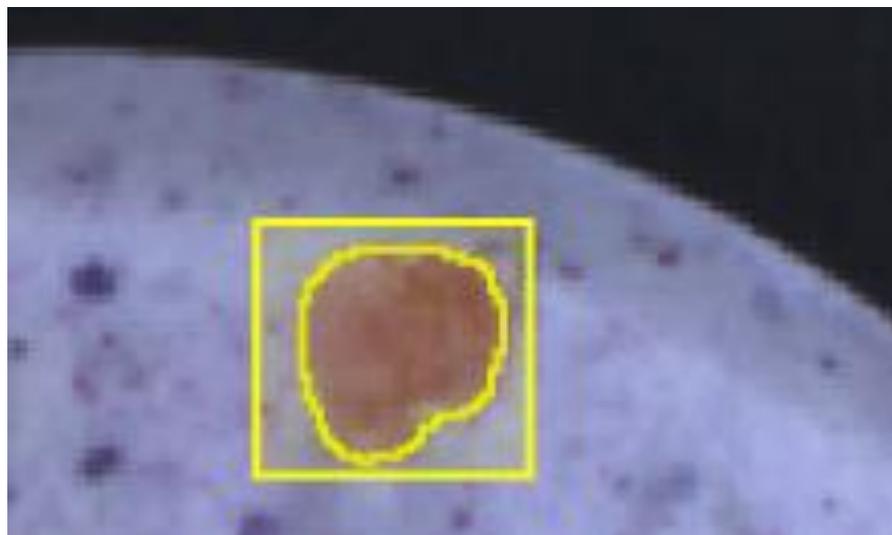
## ■ 部署

- 速度、成本
- 不同产品型号
- 模型安全
- 模型更新问题：训练时间越来越长，对新缺陷样本的数量要求越来越高，性能波动



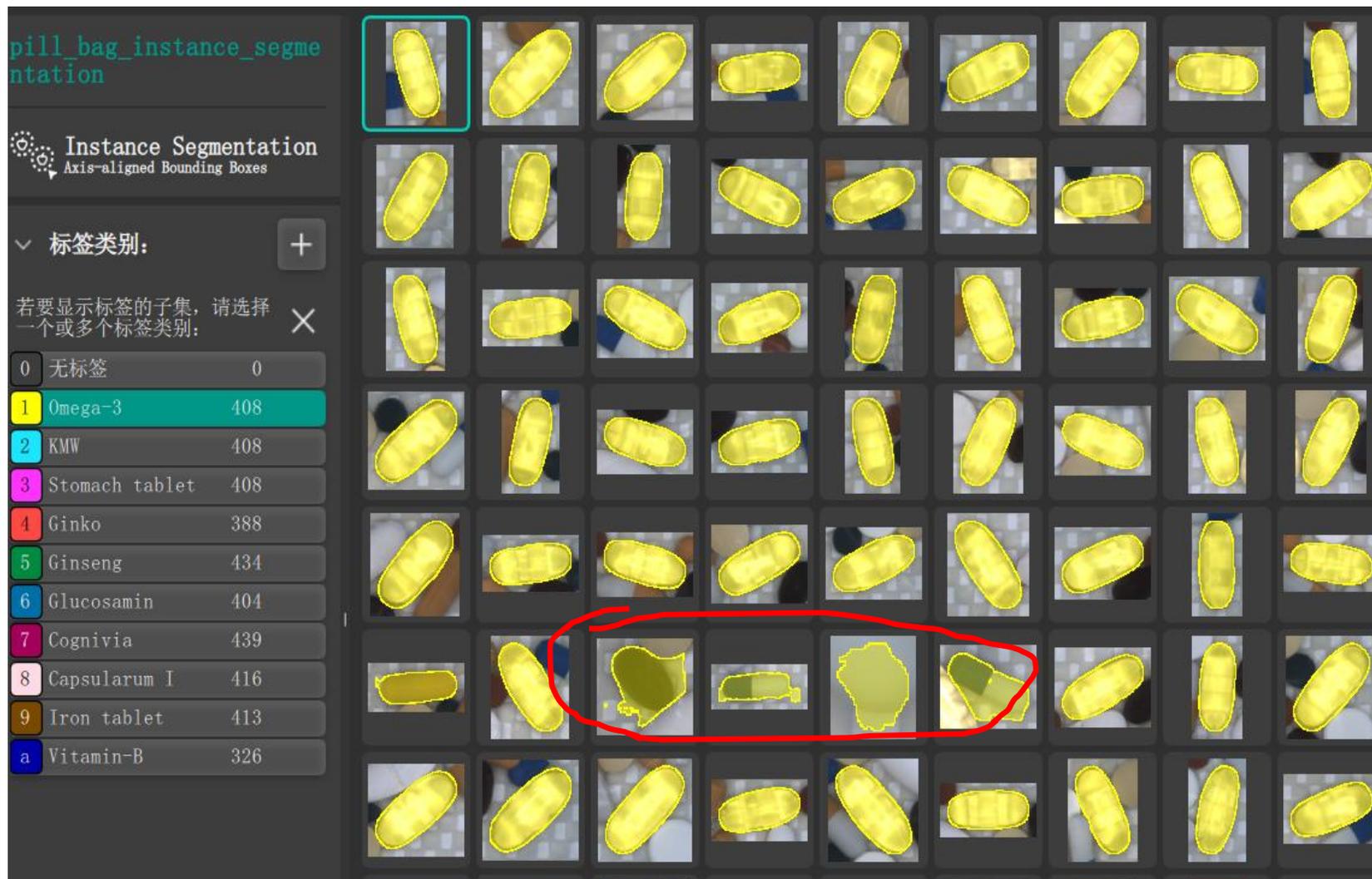
# 深度学习工具: Deep Learning Tool

- 支持分类、检测、分割、OCR标注
- 支持多人协作
- 简便的标注步骤 → 降低标注工作量
- 分类: 带标签导入
- 分割: 智能分割
- OCR: 智能识别



## ■ 标注信息统计与检查 → 确保标注质量

- 全!
- 对!
- 准!



# 深度学习工具: Deep Learning Tool

- 自定义类别权重 → 样本不均衡
- 数据增强 → 样本量少

The screenshot displays the configuration interface for a deep learning tool. It is divided into several sections:

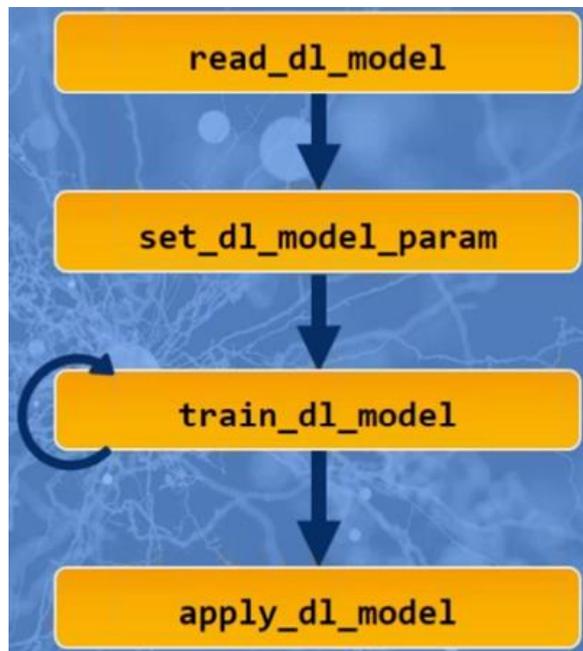
- 拆分 (Split):** Shows a pie chart and a table for data distribution. The split is labeled "Split-220209-141646".

类别	数量	百分比
训练图像	30	60%
验证图像	10	20%
测试图像	10	20%
拆分集中的图像	50	100%
- 神经网络 (Neural Network):** Includes settings for "预训练模型" (Pre-trained model: Compact), "图像宽度" (Image width: 224), "图像高度" (Image height: 224), and "通道数量" (Number of channels: 3).
- 超参数 (Hyperparameters):** Includes "Epoch 数量" (20.00), "迭代次数" (20), "批次大小" (32), "学习速率" (0.001), "动量" (0.9), and "权重先验" (0). A checkbox for "使用自定义类别权重" (Use custom class weights) is checked.
- 增强 (Augmentation):** Includes a checked checkbox for "启用图像增强" (Enable image augmentation). Other options include "旋转步长" (Rotation step length), "镜像" (Mirroring), "亮度变化" (Brightness change: [1, 255], 20%), "亮度变化点" (Brightness change point: [1, 255], 20%), "对比度变化" (Contrast change: %, 20%), "饱和度变化" (Saturation change: %, 20%), "裁剪绝对值" (Crop absolute value: px, 20), "裁剪相对值" (Crop relative value: %, 10), and "旋转范围" (Rotation range: °, 5).
- 配置 (Configuration):** Shows the device as "NVIDIA GeForce RTX 3090 (gpu:0)". There are checkboxes for "使用确定性算法" (Use deterministic algorithm) and "随机种子" (Random seed: 1).

The screenshot shows the "类别权重" (Class Weights) interface. It features a table with columns for "类别" (Class), "图像数量" (Image Count), and "权重" (Weight). Each row includes a colored numbered icon (1-5) and a horizontal slider for adjusting the weight.

类别	图像数量	权重
1 apple_braeburn	6	0.483
2 apple_golden_deli...	6	1.142
3 apple_topaz	6	0.758
4 peach	6	0.45
5 pear	6	1.22

# 训练过程：可视化



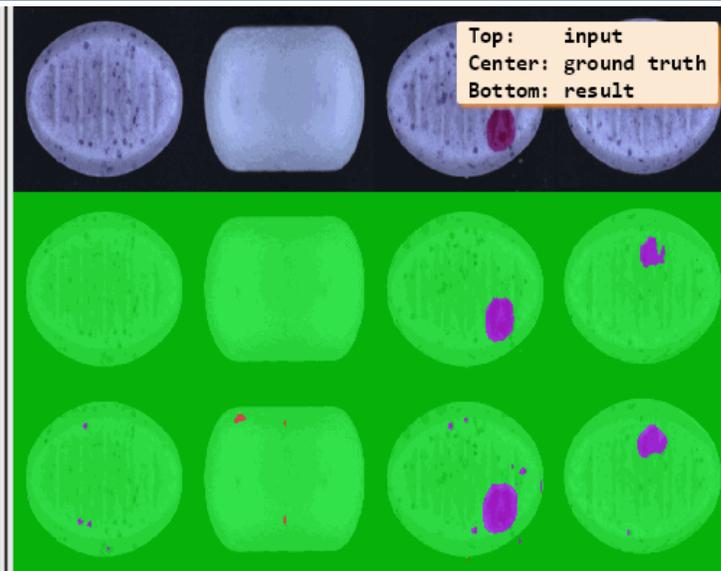
train\_dl\_model

Train status:

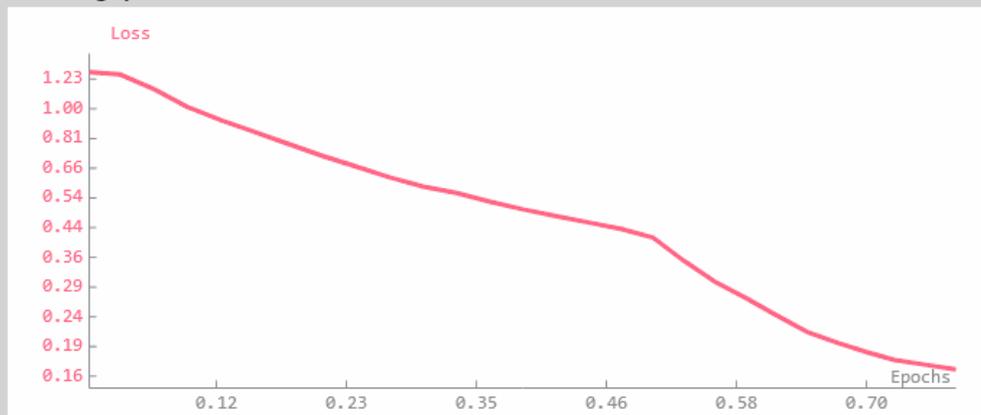
Epoch	0.8 of 10
Loss	0.1663
Time elapsed	56s
Time left	11m 14s

Model parameters:

'learning_rate'	0.000100
'batch_size'	5
'momentum'	0.990000
'weight_prior'	0.000050
'image_dimensions'	[400,400,3]



Showing plot 1/2:



# 验证结果可视化：误检率，漏检率，交互式混淆矩阵

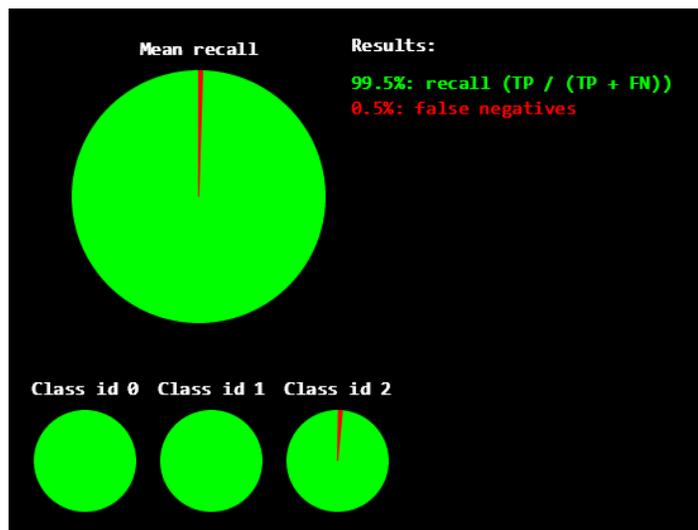


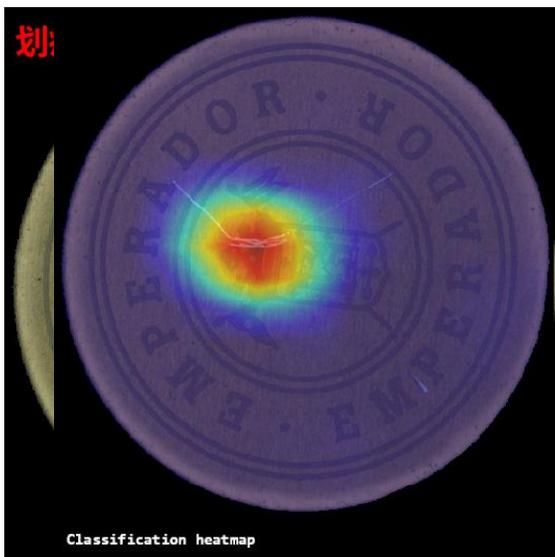
Ground Truth

	划痕	合格	脏污
划痕	55	0	1
合格	0	61	0
脏污	0	0	67

Predicted

Continue





分析图像中对分类结果影响比较大的区域

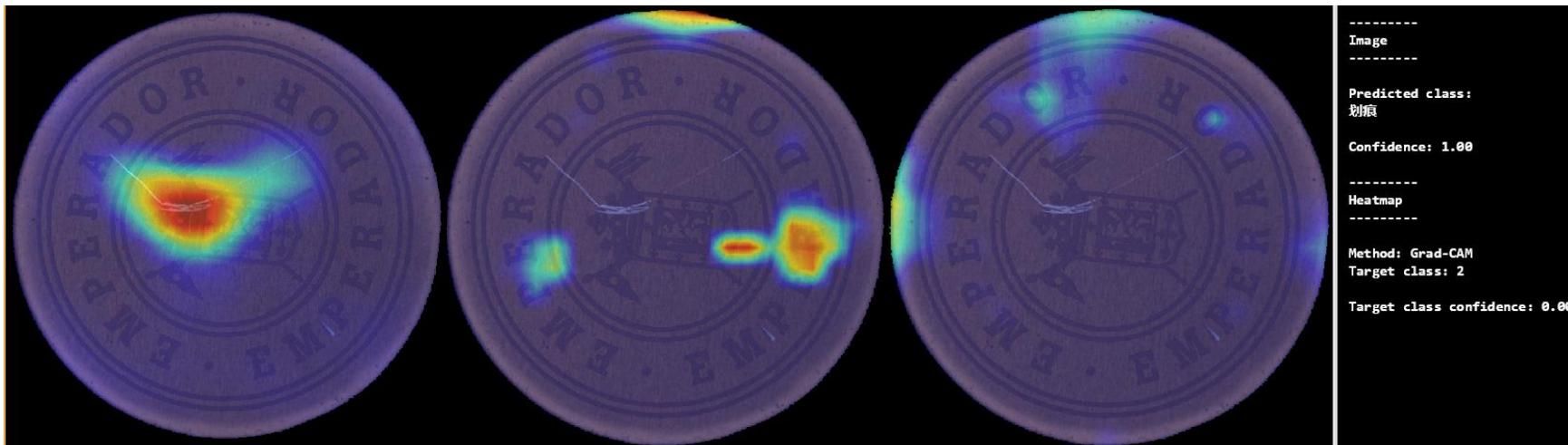
揭示可能影响分类类别的区域

鉴定对不相关特征的敏感程度

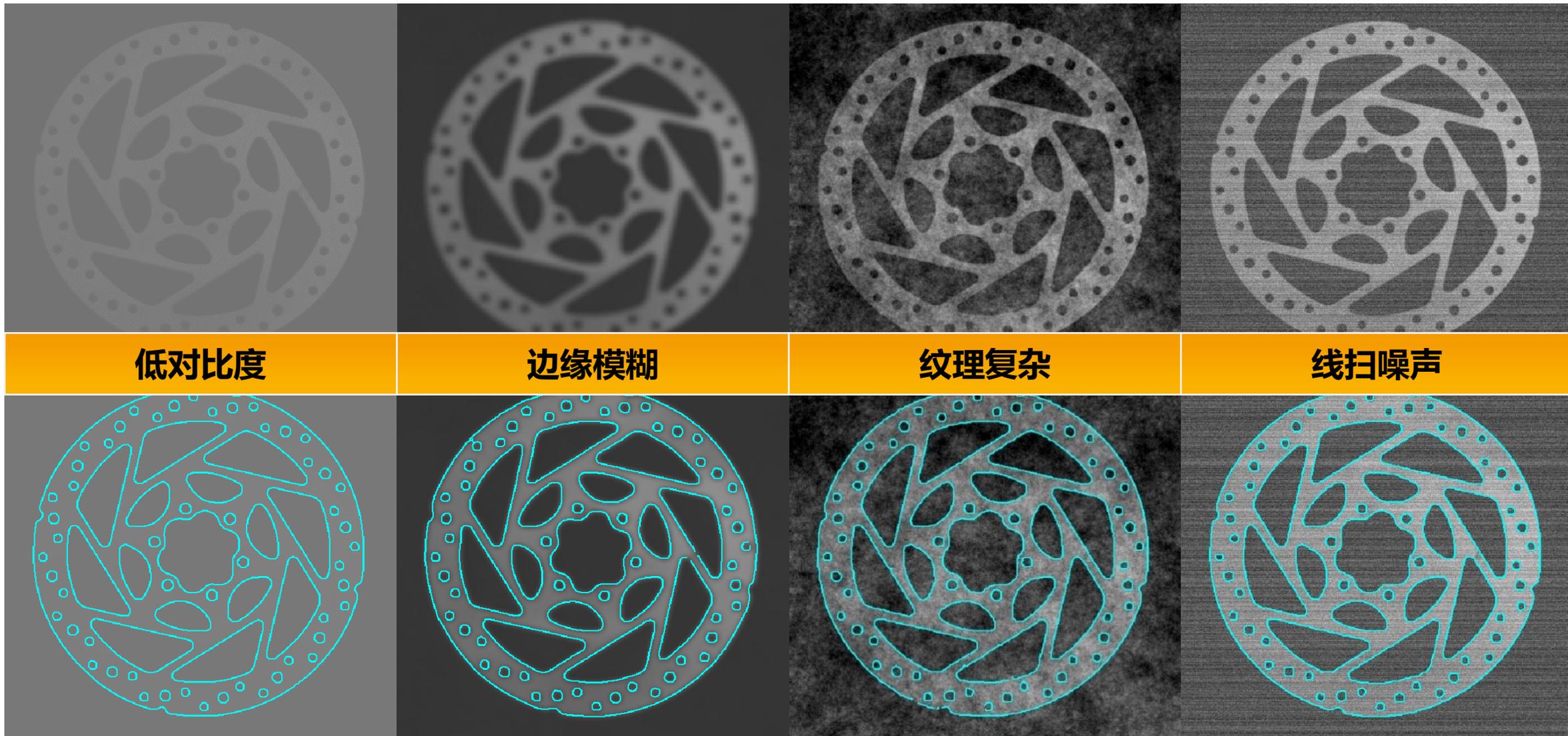
输出不同类别的热度图，帮助解决分错问题

同时推理和生成热度图，速度更快

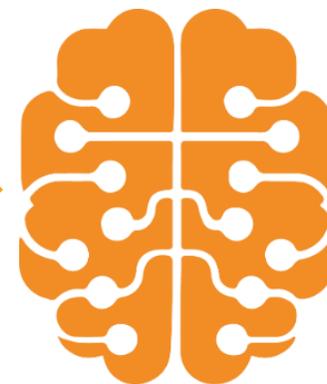
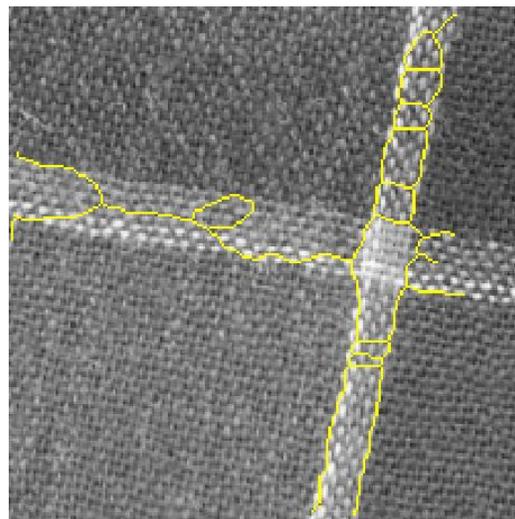
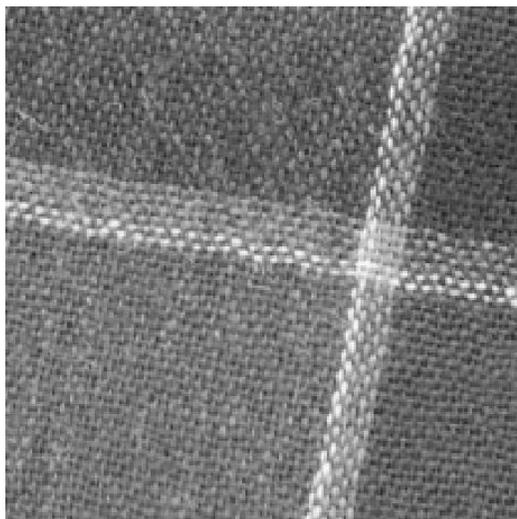
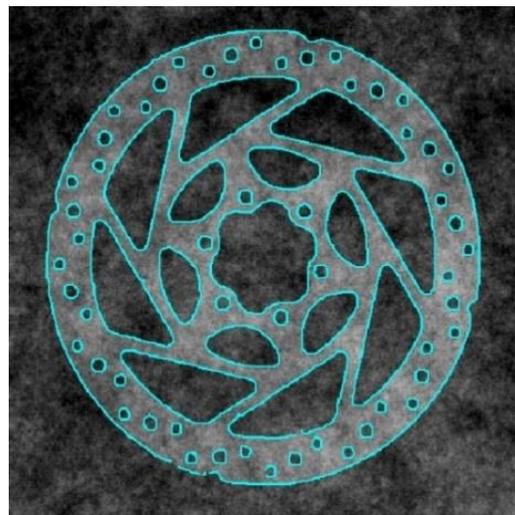
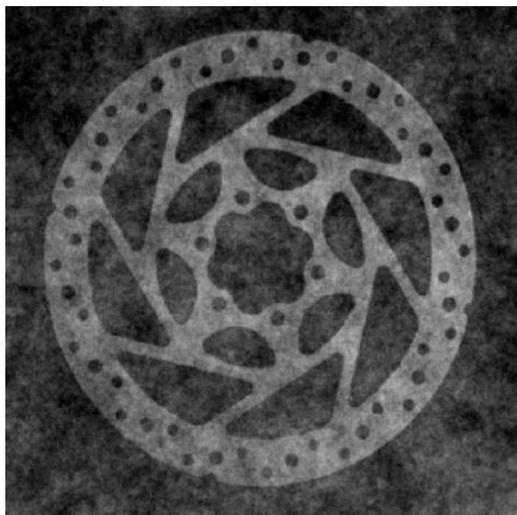
增加可视化和透明化

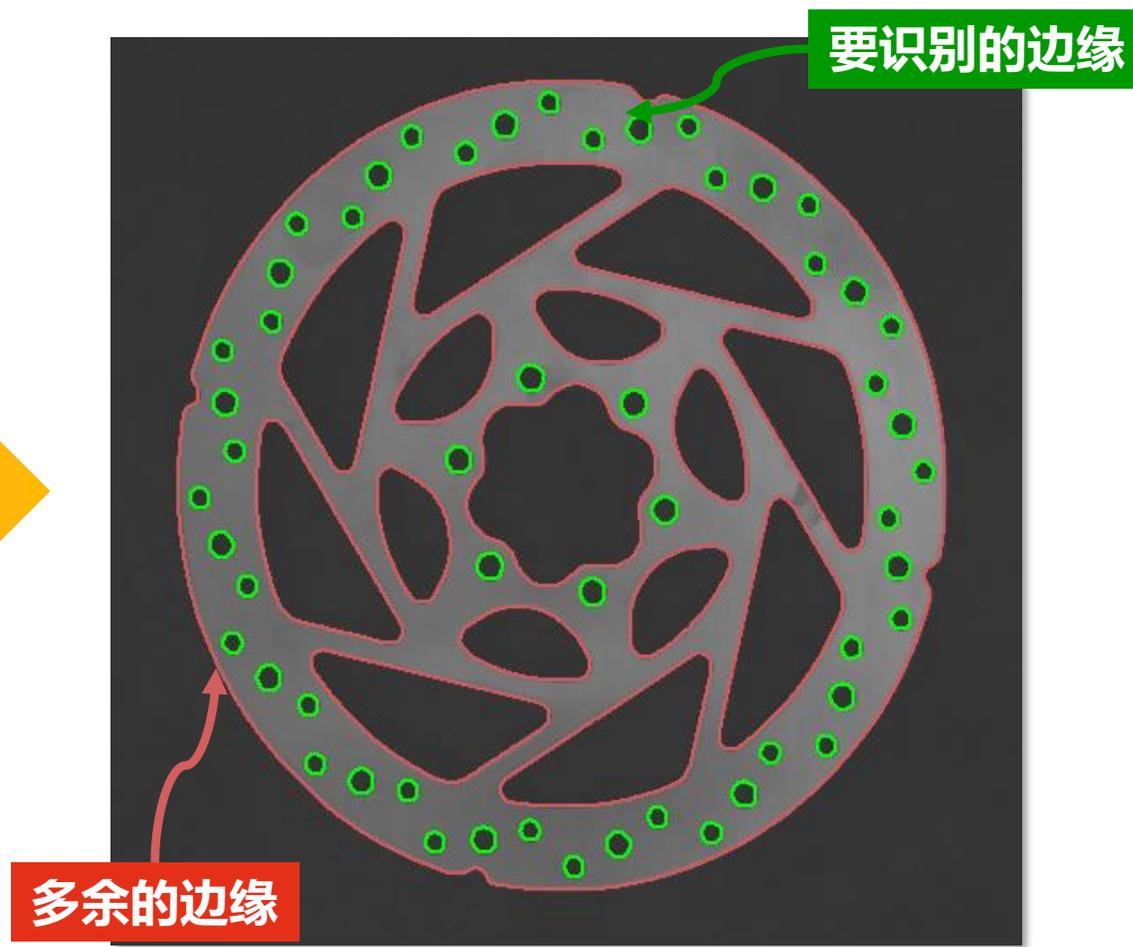
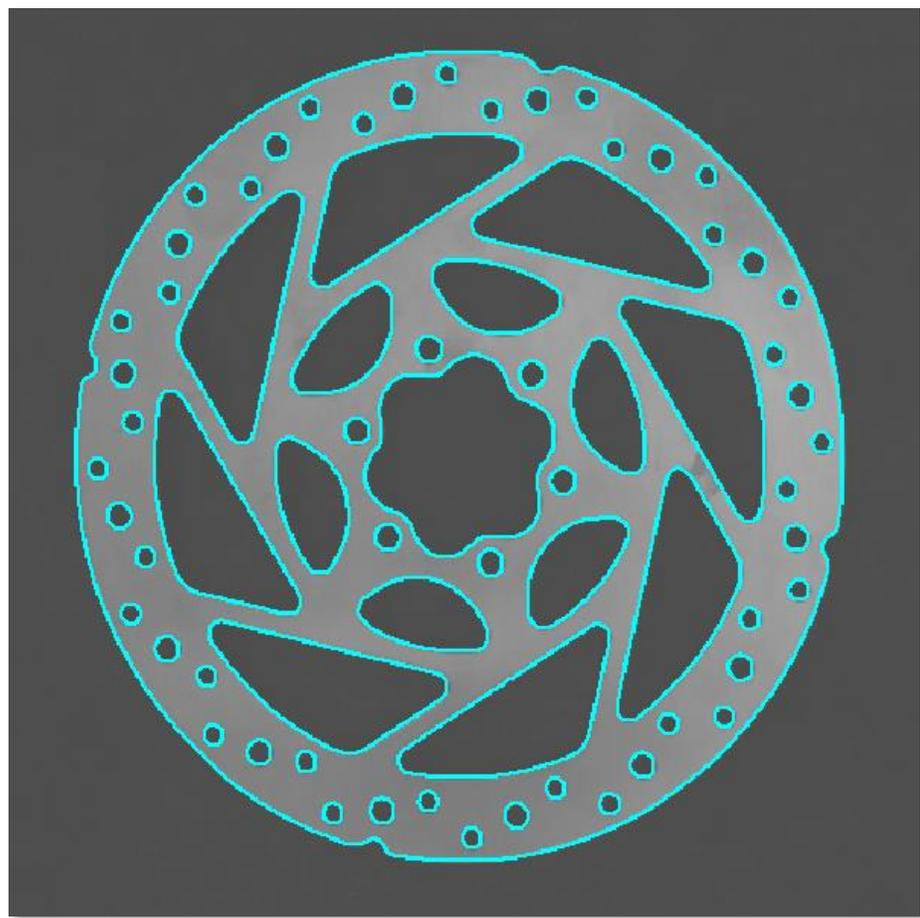


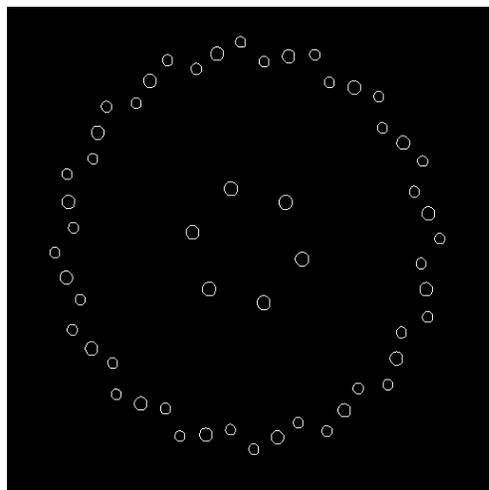
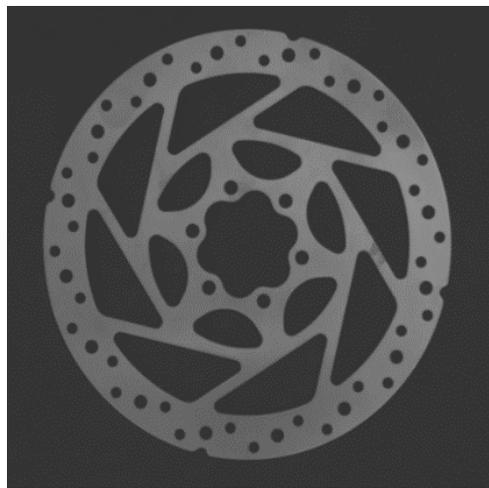
# 预训练模型：适用于复杂且具有挑战性的场景



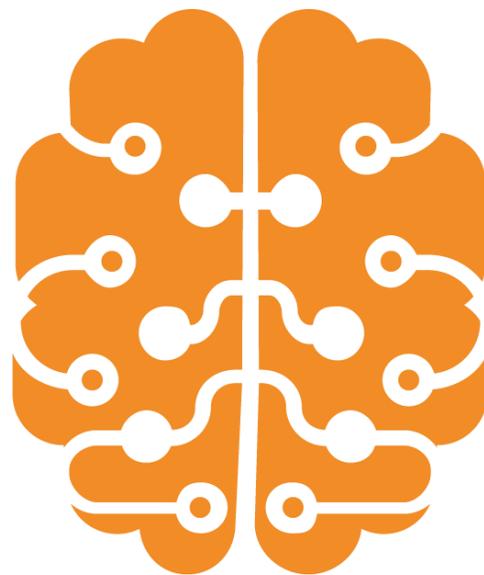
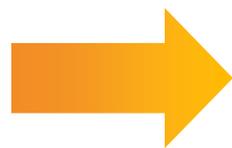
# 特定的边缘场景需要再训练



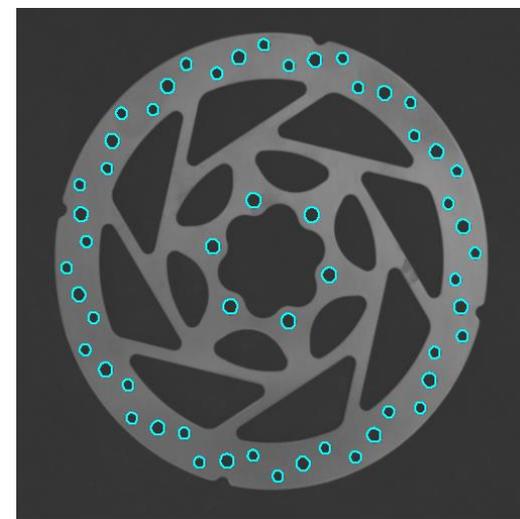




输入图像和标签



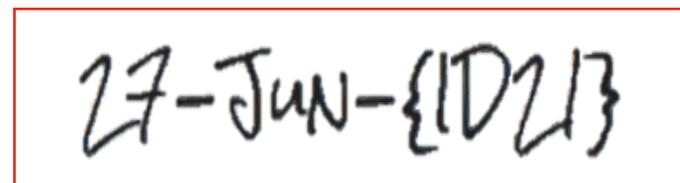
重新训练模型



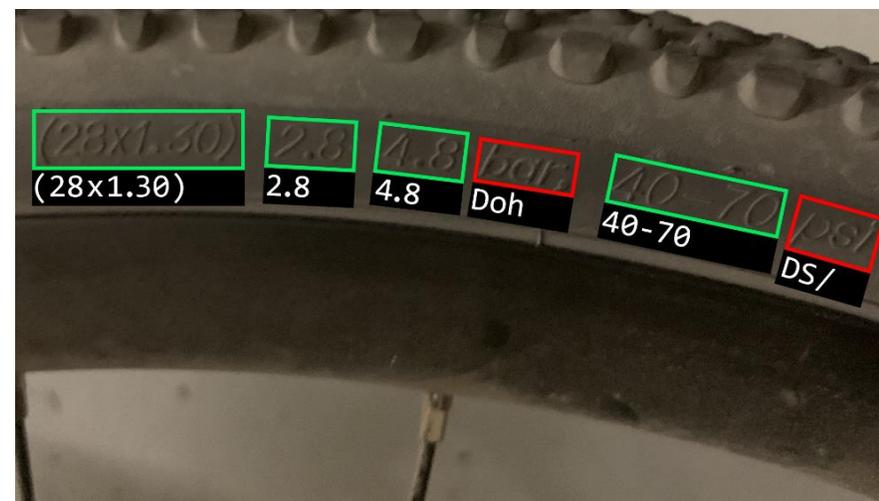
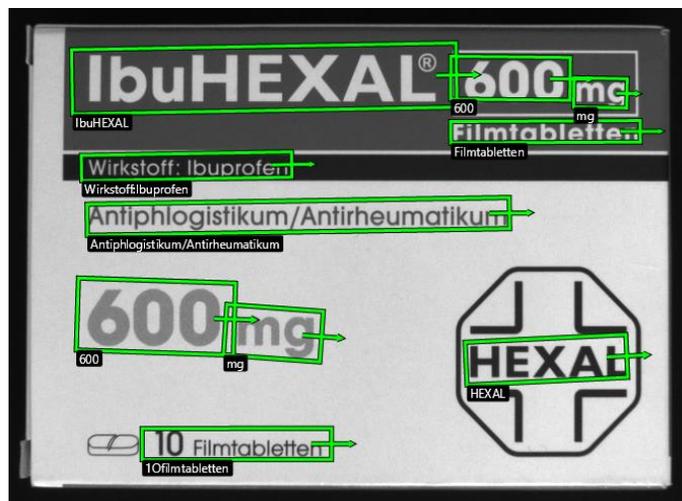
新推理结果

# 预训练&迁移学习

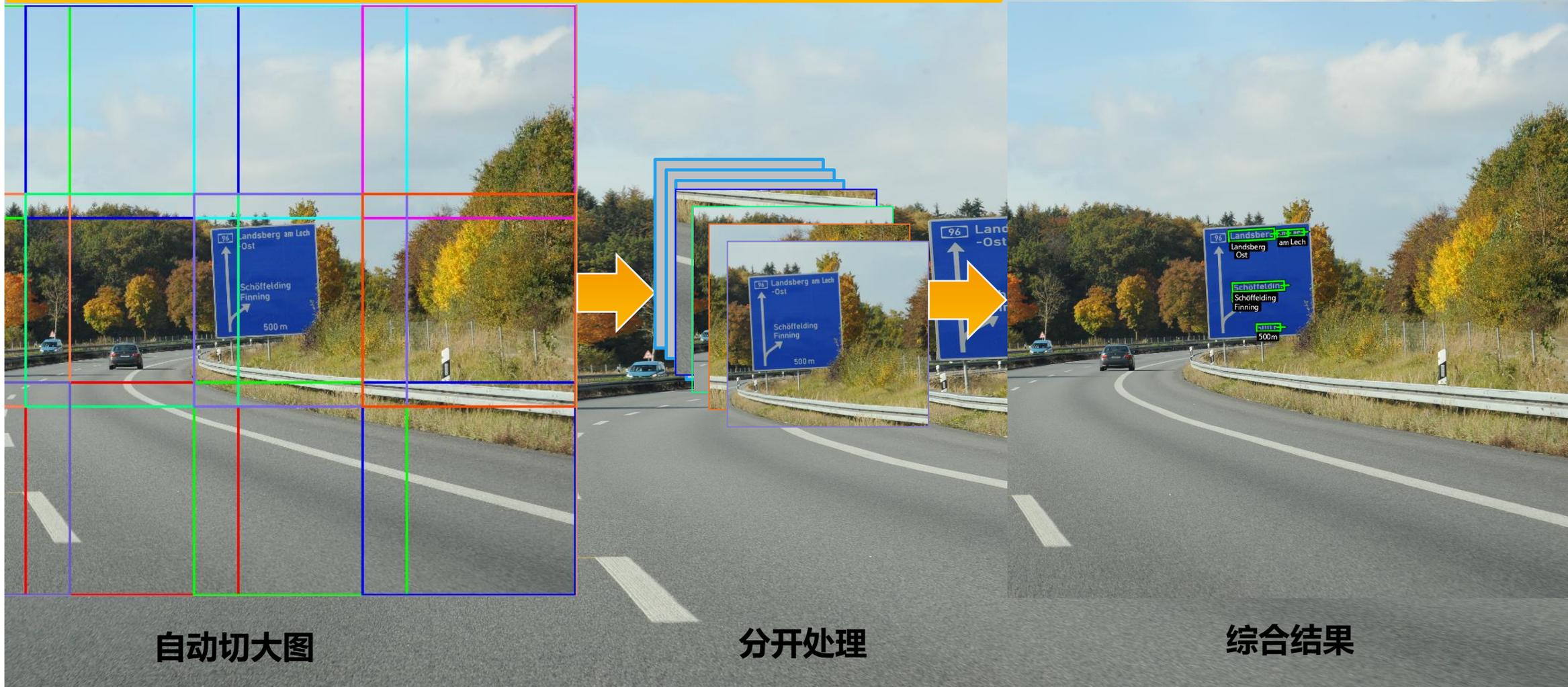
- 基于自有的、大量的工业字符数据集训练，无需调优直接可用
- 智能组词
- 特殊场景再训练：
  - 凹凸字符：低对比度
  - 手写体：与标注字体差异较大



27-JUN-LIDU

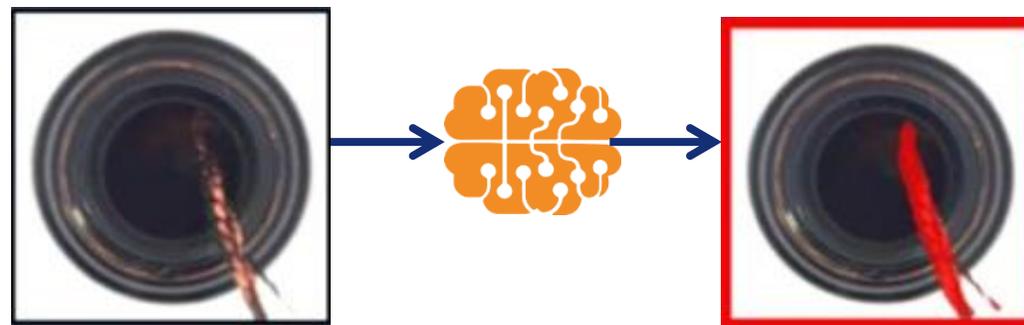
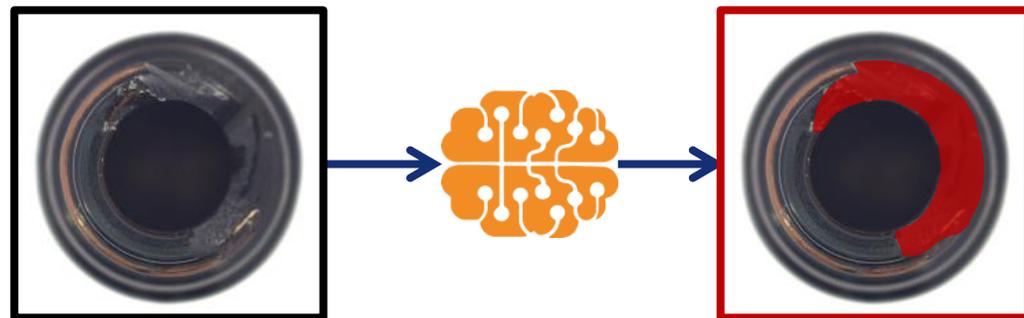
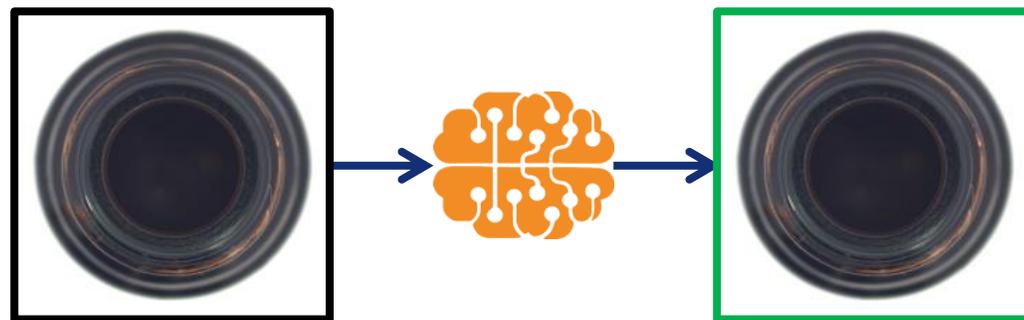
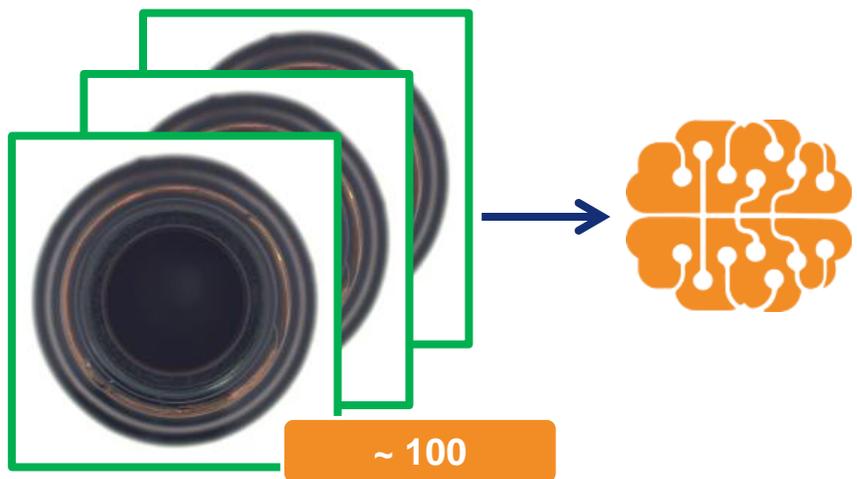


```
set_deep_ocr_param (DeepOcrHandle, 'detection_tiling', 'true')
```



# 缺陷样本太少怎么办？未知缺陷怎么办？只学正样本的异常检测

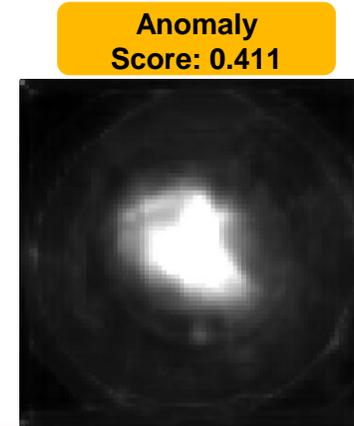
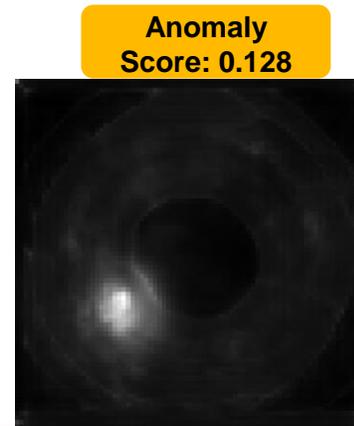
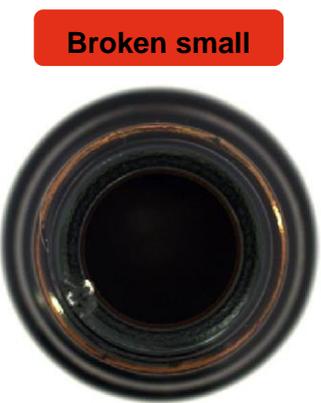
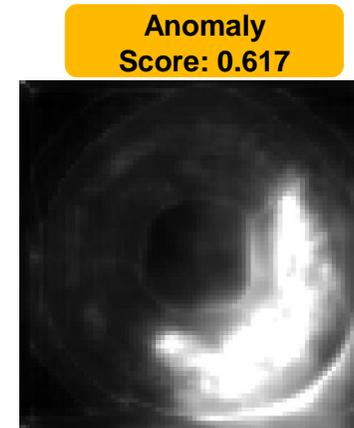
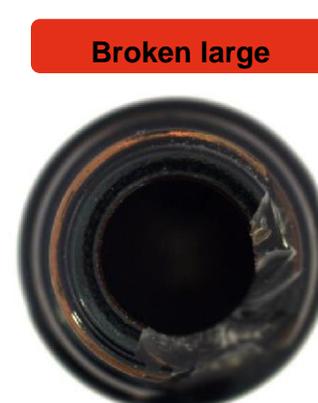
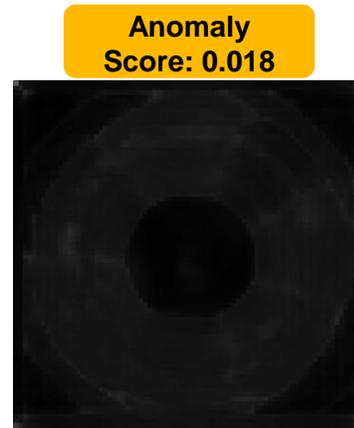
- 只学习少量好的样本
- 无需标注
- 可检未知缺陷



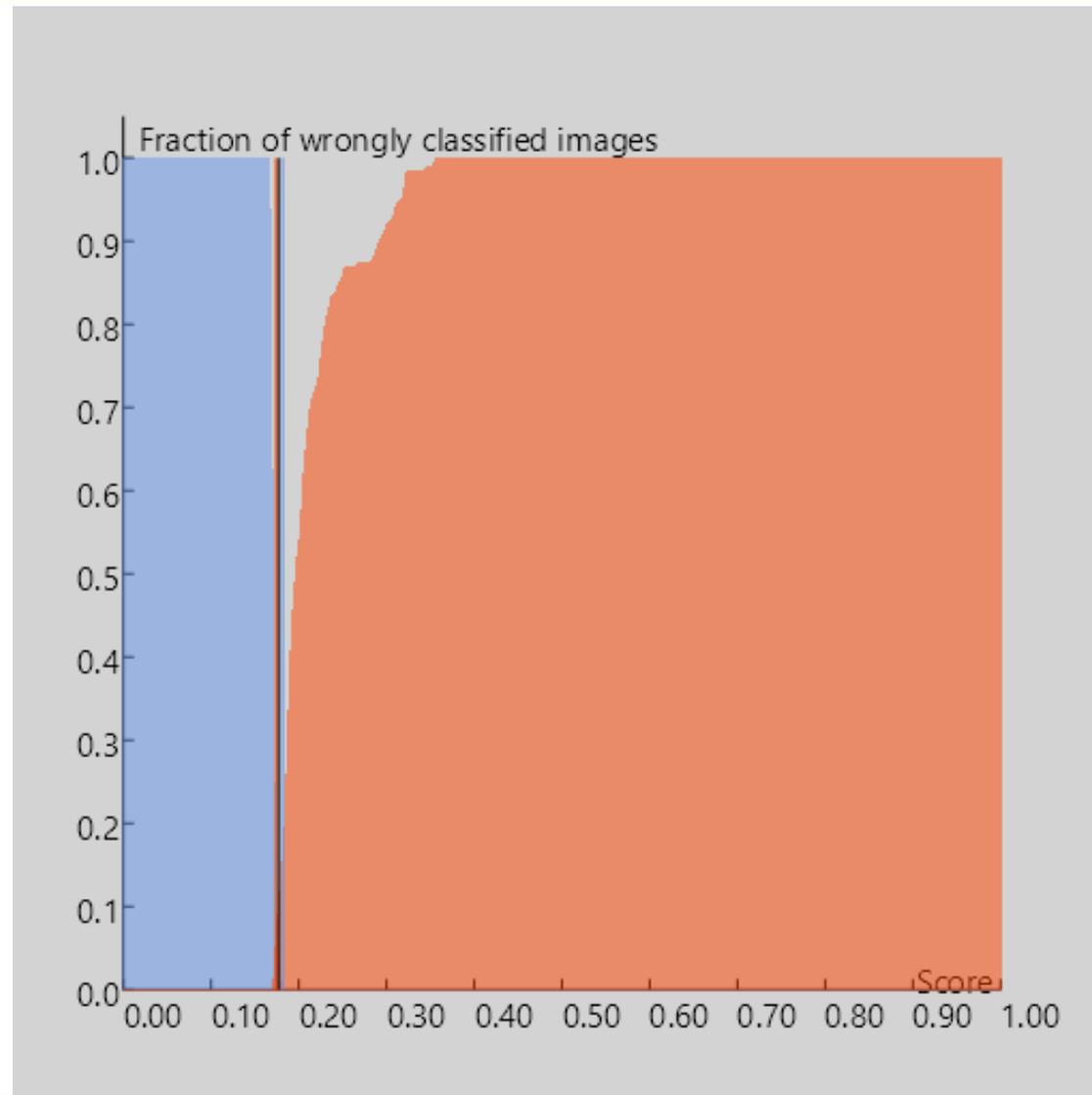
- 数据集：瓶口
- 分辨率：320×320
- 训练数据集：20张
- 训练时间：~ 5 min  
(8x Intel i7-6700K CPU)



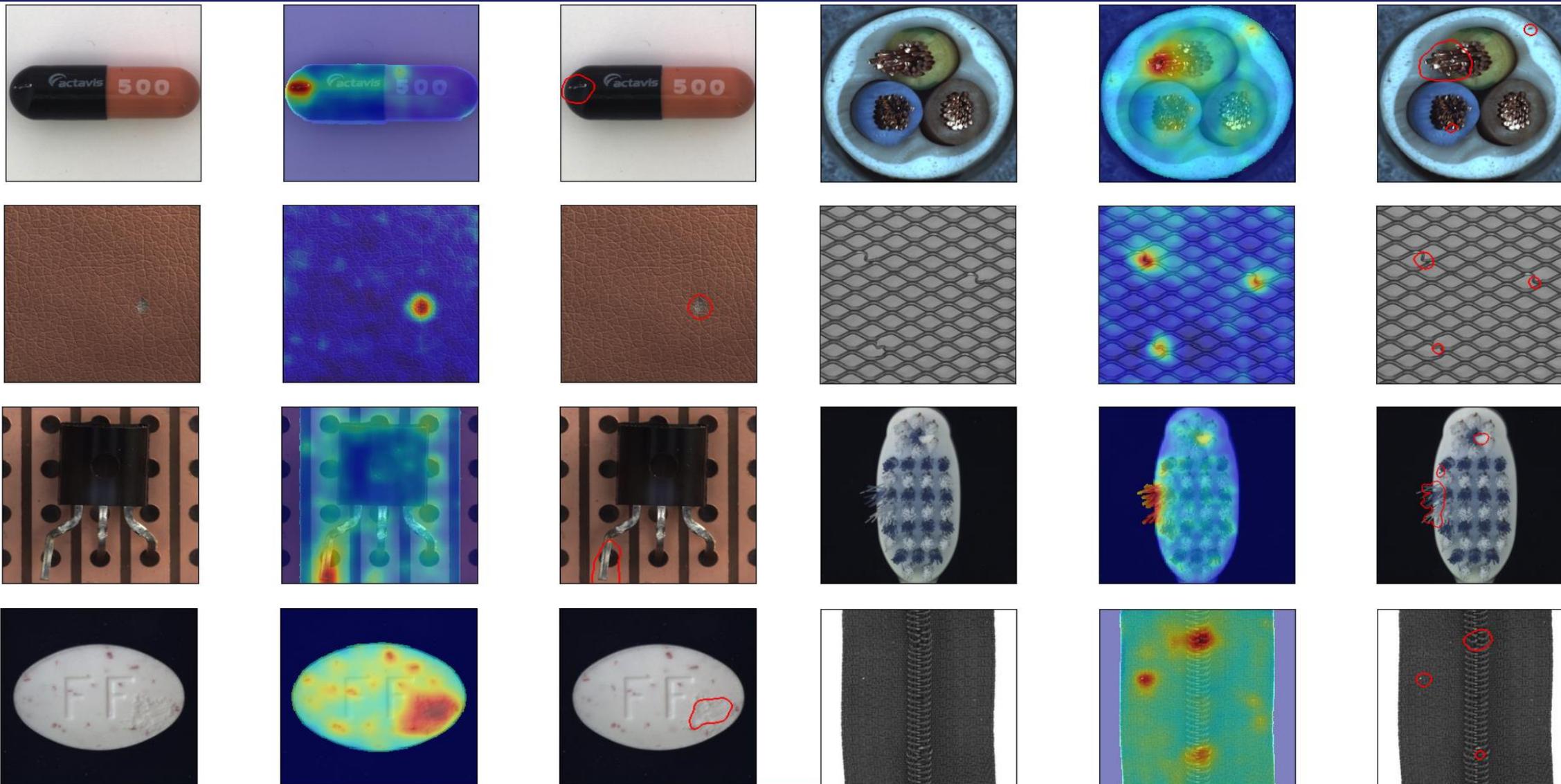
正常样本



# 合格品检测 (异常检测)



# 异常检测案例



## ■ 结构异常

➤ 杂质、异物、残损

## ■ 逻辑异常

➤ 缺失、残、漏 (如: 标签、灌液)

➤ 错位 (如: 上下、左右、旋转、镜像、颠倒、位置、角度、倾斜)

➤ 错配 (如: 多产品时的标签与实物错配)

➤ 高度长度变化 (如: 液面高度、少装、多装)

■ 正常样品之间的一致性较差, 外观、形状、相对位置变化较大

■ 正常样品有多种类别, 甚至多种多样

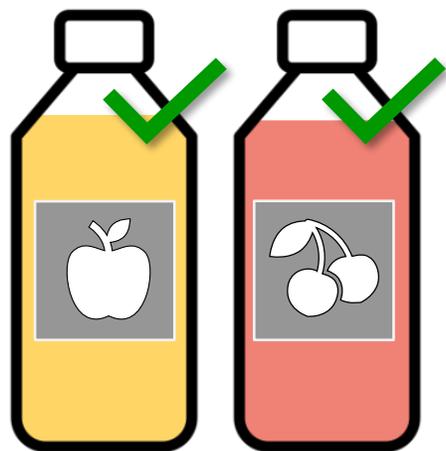
■ 正常样品各部分之间存在某种逻辑关系





异常检测

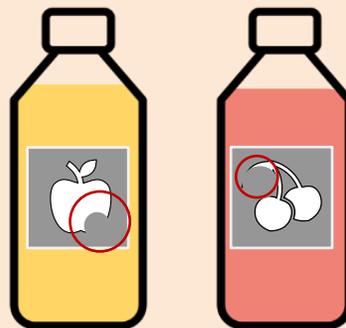




正样本训练

结构异常

标签印刷错误



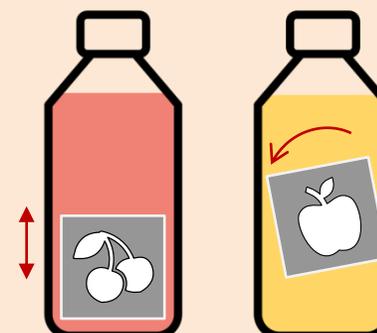
未知缺陷



漏装/错装



标签位置错误



NEW

逻辑异常

# 引入全局信息检测网络后的检测效果



全局异常检测



# 推理结果：局部、全局异常各自输出，也可单独输出

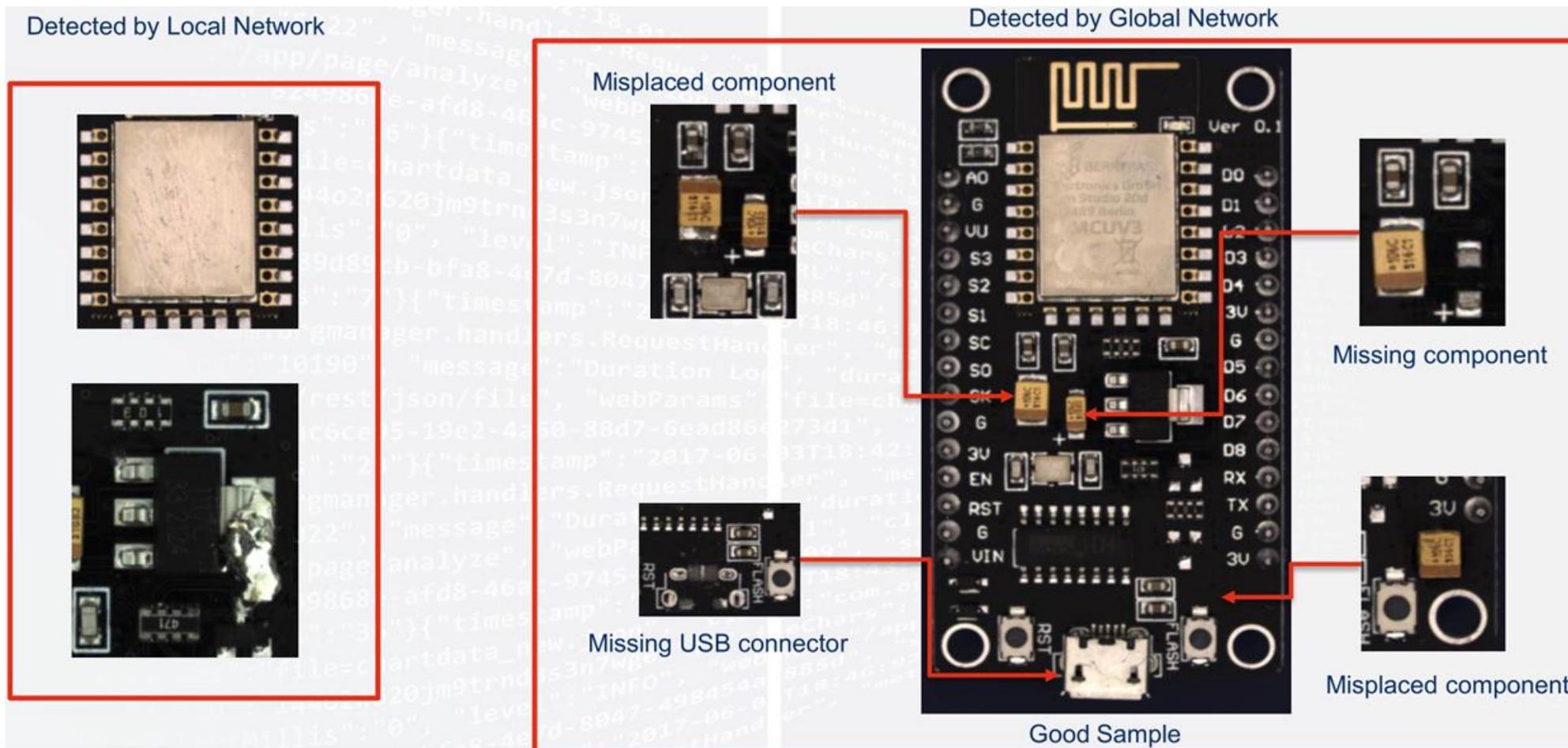
```
apply_dl_model (DLModelHandle, DLSample, ['anomaly_image_local', 'anomaly_image_global'], DLResult)
```

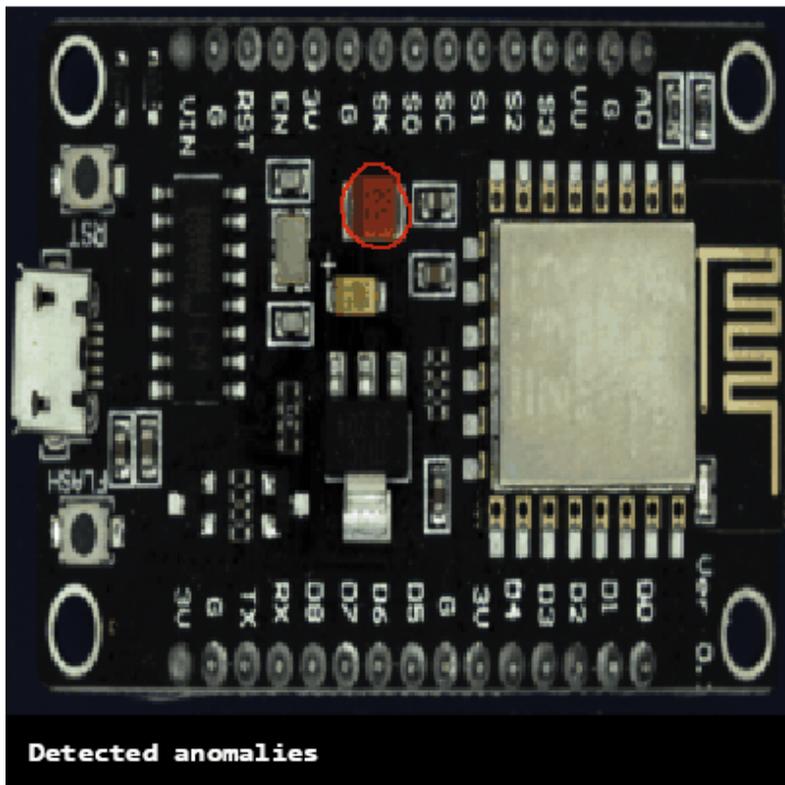
	 <p>anomaly_image_local</p>	<pre>anomaly_image_local 0 : 'ok' anomaly_score_local: 0.260</pre>	 <p>anomaly_image_global</p>	<pre>anomaly_image_global 1 : 'nok' anomaly_score_global: 6.442</pre> <p>Press F5 (continue)</p>
---	--	--	--	--

# 检测结果：局部异常、全局异常

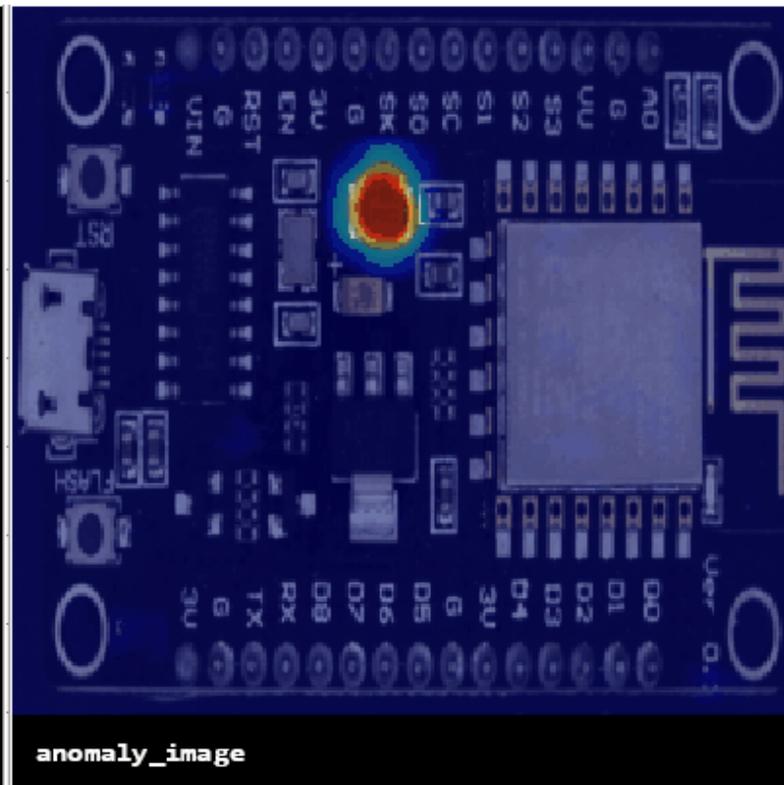


- 完整性检测：错、漏装
- 快速适应不同产品型号





```
Detected anomalies
-----
Results
-----
1 : 'nok'
anomaly_score: 1.496
-----
Thresholds
-----
Classification: 0.720
Segmentation: 0.501
```

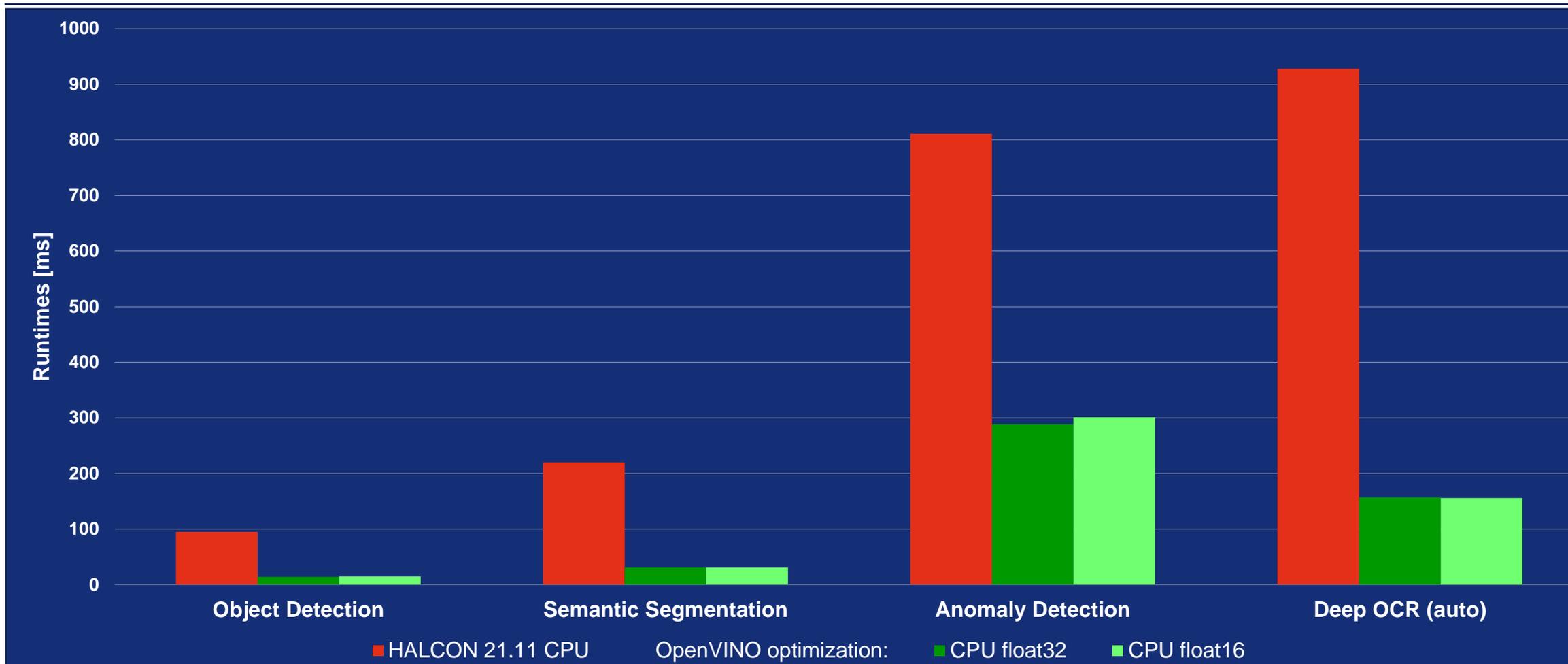


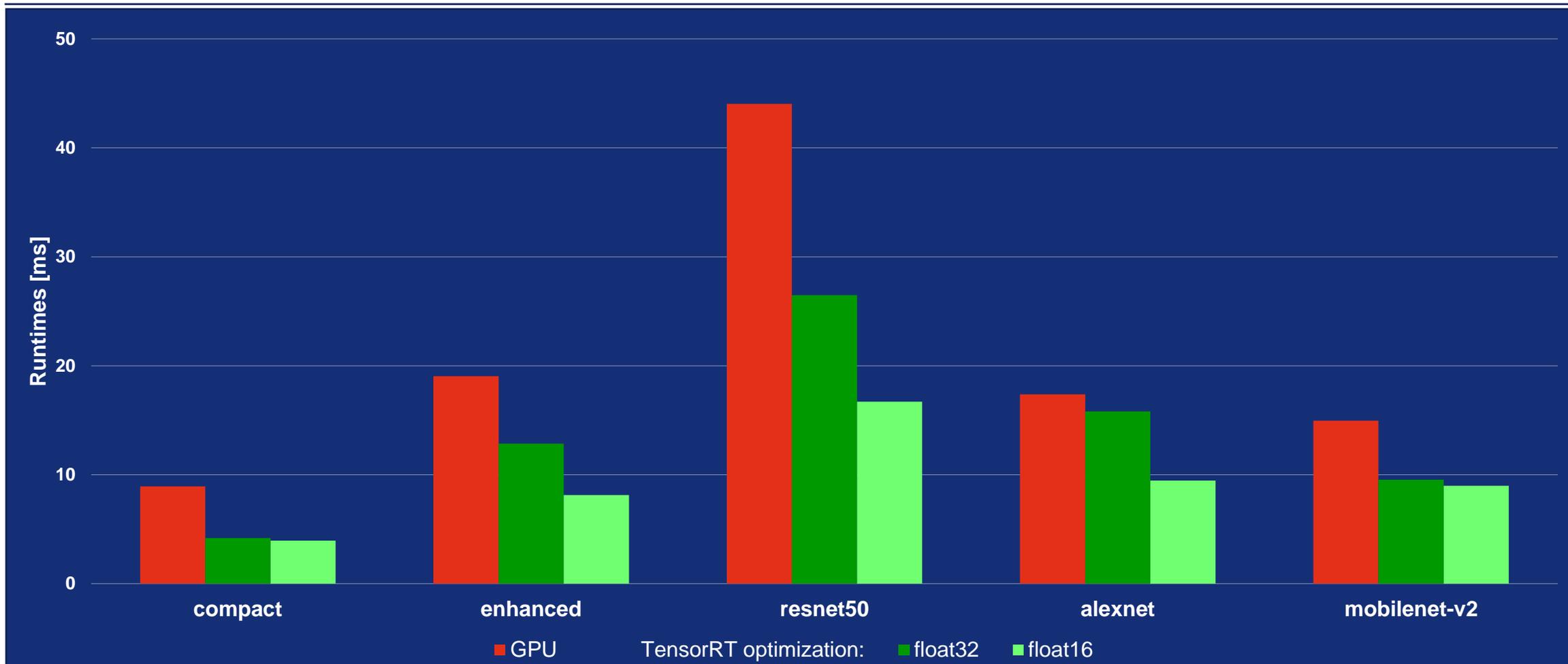
```
anomaly_image
1 : 'nok'
anomaly_score: 1.496
```

Model		HALCON runtime 'cpu'	OpenVINO CPU 'float32'	OpenVINO CPU 'float16'	OpenVINO MYRIAD 'float16'
compact	Runtimes (ms)	4.5	0.9	0.9	9.4
	Top1-Error (%)	0.17	0.172	0.172	0.172
enhanced	Runtimes (ms)	21.1	4.1	4.4	26.0
	Top1-Error (%)	0.17	0.172	0.172	0.172
resnet50	Runtimes (ms)	61.9	11.2	11.3	61.0
	Top1-Error (%)	0.13	0.134	0.134	0.134
alexnet	Runtimes (ms)	29.0	9.8	9.8	26.9
	Top1-Error (%)	0.21	0.21	0.21	0.21
mobilenet-v2	Runtimes (ms)	16.0	2.5	2.1	29.1
	Top1-Error (%)	0.36	0.362	0.362	0.362

- Inference on "MVTec Sweets" compared with an Intel Core i9-10900X CPU

# CPU推理加速 (各种任务)







-  数据安全
-  模型加密 (密码)
-  模型信息仅自己可见
-  保护您的投入与知识产权
-  所有模型适用

## ■ 标注

- 数据问题：正样品易得，缺陷样品不易获得，类别极不均衡
- 标注问题：图大，缺陷小、多、杂，标全不容易，不标有影响；  
有些缺陷难以标注：缺失、错位；标注工作量大；
- 开放问题：有些缺陷无法提前预知，新缺陷、未知缺陷的产生

## ■ 训练

- 工业制造追求良率提升：99%、99.9% ...
- 零漏检率与低误检率
- 理解模型的限制

## ■ 部署

- 速度、成本
- 不同产品型号
- 模型安全
- 模型更新问题：训练时间越来越长，对新缺陷样本的数量要求越来越高，性能波动

Deep Learning Tool

Halcon

- 清晰的问题定义：要解决的问题和评判标准
- 高质量数据：成像质量，样本数量，良好标注
- 理智认识目前AI的能力边界，把AI深度嵌入到垂直业务中
- 通用vs特定场景
- 选择合适算法
- 迭代验证：原始数据 -> 无监督算法 -> 人工标注 -> 特征工程 -> 有监督算法
- 分析错误结果原因
- 增加数量
- 增加变化
- 理解模型的限制：保持怀疑
- 全面评估模型性能，注意数据或方法中可能存在的偏差或限制
- AI与已有的人为规则：逐步替代、升级、迭代
- 持续监控，更新：性能，数据，问题
- 实践是检验真理的唯一标准



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