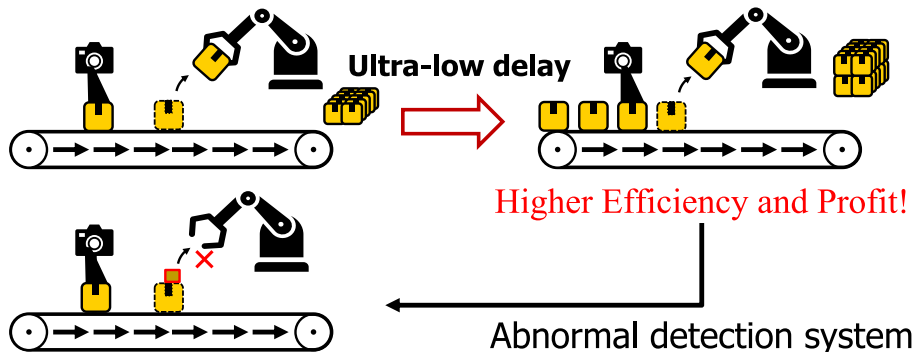


Edge-Augmented and Entropy Map-Guided HLAC with Gaussian Distribution-Based Weighted Feature Extraction for 1-ms Abnormal Detection System in Logistics

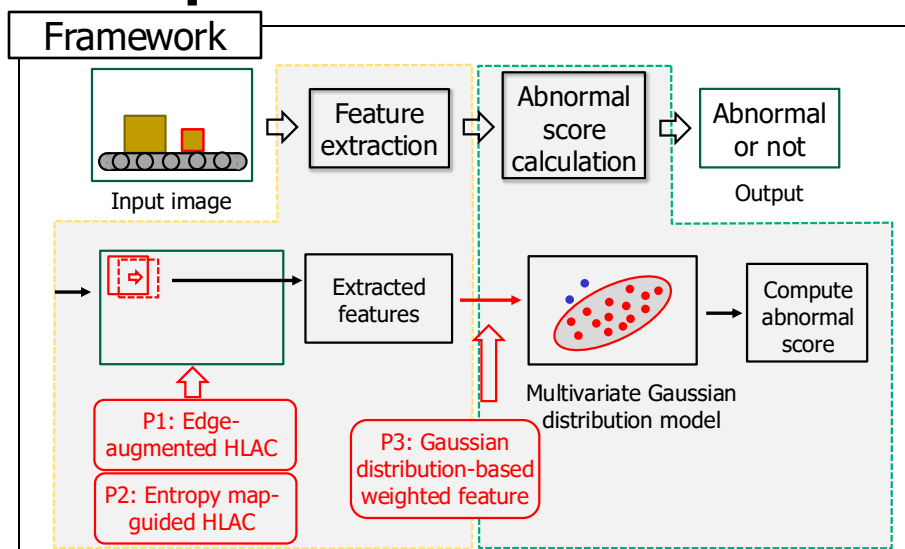
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Background

Abnormal detection in logistics



Proposals



Previous abnormal detection system

- Gaussian AD based transfer learning and MVG system
- Complex feature extraction network and hard to realize ultra-low delay

Target

- HLAC and MVG based ultra-low delay vision abnormal detection system in logistics

P1

Pixel difference

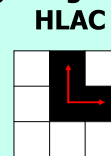
X_1	X_2	X_3
X_4	X_5	X_6
X_7	X_8	X_9

$X_1 - X_5$	$X_2 - X_5$	$X_3 - X_5$
$X_4 - X_5$	X_5	$X_6 - X_5$
$X_7 - X_5$	$X_8 - X_5$	$X_9 - X_5$

The direction information between neighboring pixels and center pixels

X_i : pixel value in 3X3 region

Edge-augmented HLAC



$X_1 - X_5$	$X_2 - X_5$	$X_3 - X_5$
$X_4 - X_5$	X_5	$X_6 - X_5$
$X_7 - X_5$	$X_8 - X_5$	$X_9 - X_5$

The direction between related and center pixels

Up and right direction

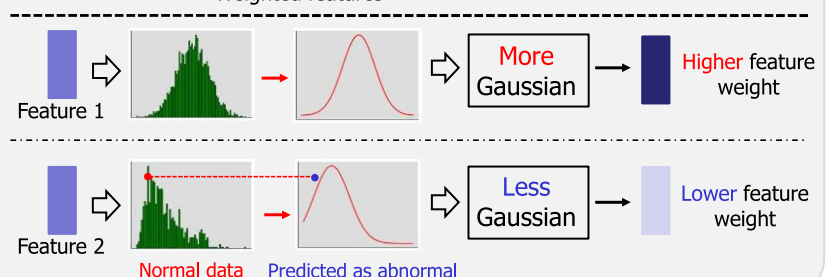
Integrate direction information into HLAC

P3

Set weights to features:

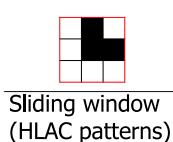


Multivariate Gaussian distribution



P2

HLAC:



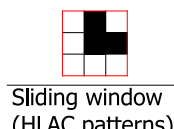
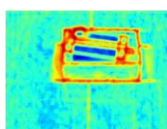
Full image's HLAC features

Local part's HLAC features may be covered by full image's features

Proposed:



Entropy map



Entropy map's HLAC features

Experiment Results

	Precision	Recall	AUROC	Device		ZCU104
Baseline	0.9897	0.7237	0.9661	Resource utilization	LUT	19064(8.27%)
+ P1	0.9961	0.8541	0.9807		BRAM	13(4.17%)
+ P1,P2	0.9962	0.8850	0.9822		IO	125(34.72%)
+ P1,P2,P3	0.9938	0.9018	0.9823	Performance	Frequency	300 MHz
GaussianAD	0.9947	0.8992	0.9851		Delay	0.961ms

Conclusion

- The proposed system achieves better performance in terms of Precision, Recall, and AUROC. Additionally, these hardware-friendly algorithms have been implemented on an FPGA with an ultra-low delay of 0.961ms.



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