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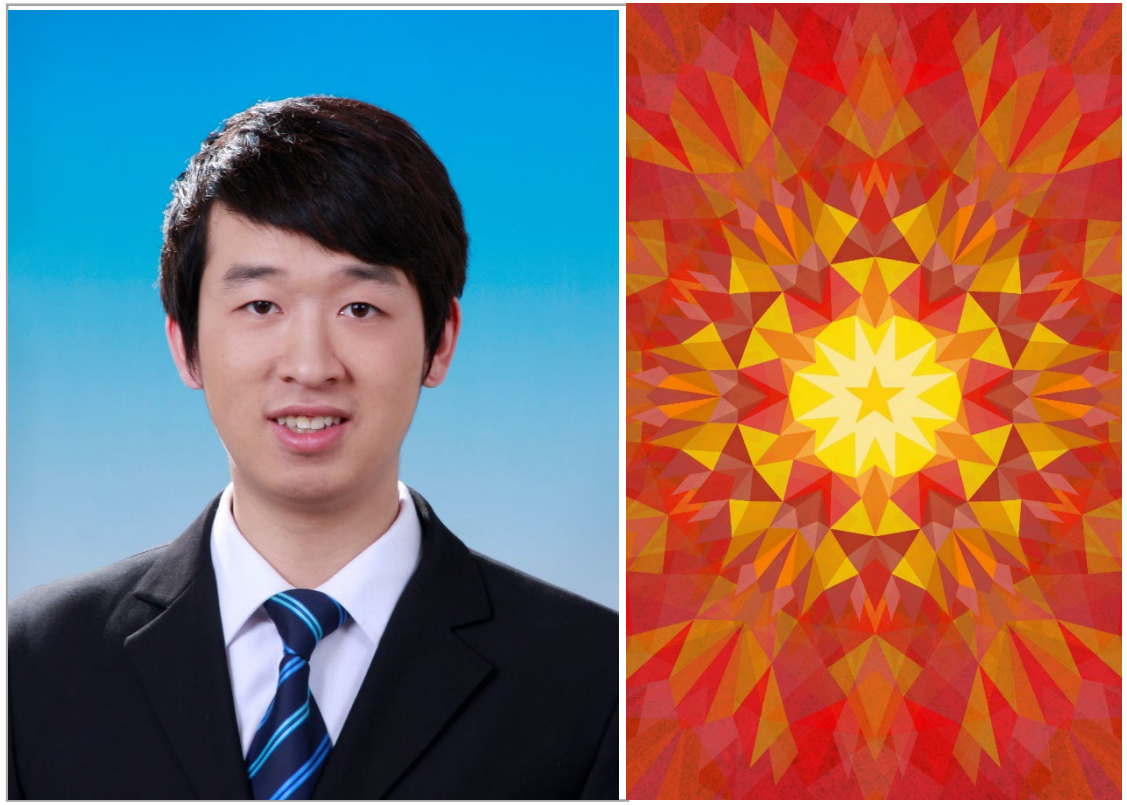
AI-BASED W-BAND SUSPICIOUS OBJECT DETECTION SYSTEM FOR MOVING PERSONS USING GAN: SOLUTIONS, PERFORMANCE EVALUATION AND STANDARDIZATION ACTIVITIES

*Yutaka Katsuyama, **Keping Yu**, San Hlaing Myint, Toshio Sato, Zheng Wen, Xin Qi*
Waseda University, Japan

Session 7 – AI, machine learning and digital transformation

Paper S7.1



AI-based W-band suspicious object detection system for moving person using GAN: solutions, performance evaluation and standardization activities

The contributions of this paper

Solutions

- We propose a solution to an AI-based W-band suspicious object detection system for moving persons. Compared with the traditional solution, it can provide non-stop automatic monitoring with W-band unidentified object detection for densely populated places.

Performance evaluation

- We evaluate the factors that affect the recognition rate of suspicious objects and analyze how to increase the service quality of AI-based W-band suspicious object detection systems for moving persons.

Standardization activities

- We describe the recent progress in the standardization of AI component technologies in ITU-T and other standards-oriented organizations.

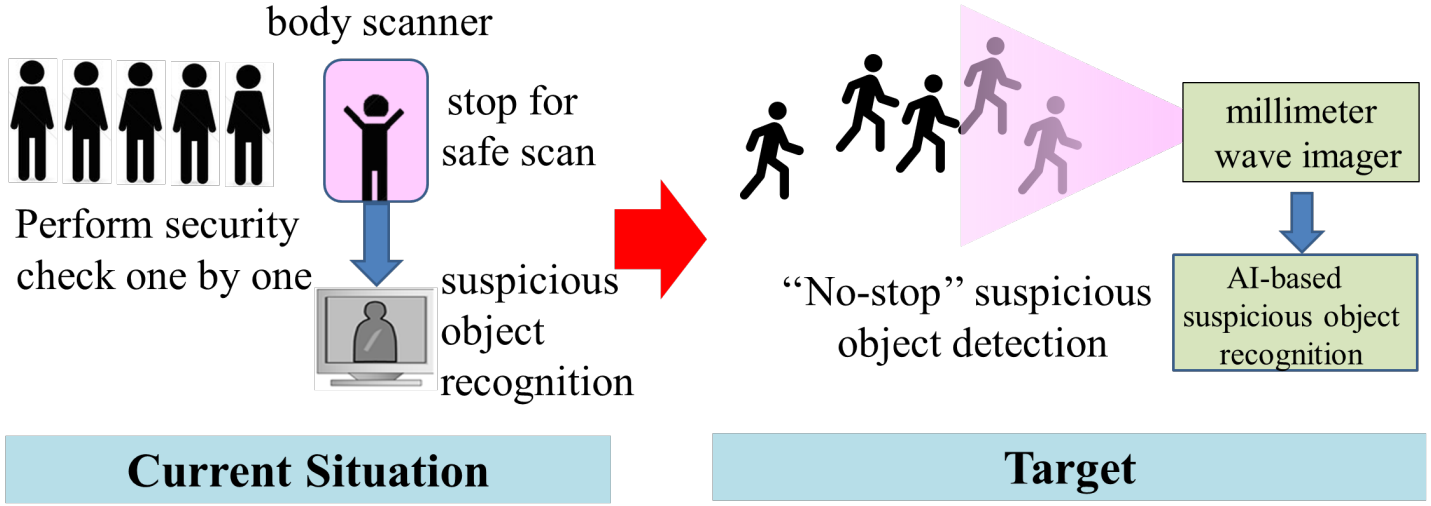
AI-based W-band suspicious object detection system for moving person using GAN: solutions
- Objective

The target of this paper is to develop sensing / imaging with AI-based W band (75-110GHz) technologies to recognize suspicious objects on moving persons.

To improve the safety of public places, especially in densely populated areas, the safety inspection for suspicious objects should be performed automatically and efficiently.

However, it is unwise to conduct security checks one by one at each entrance, as this will cause people crowded.

It is necessary to perform suspicious object detection on the moving people automatically.



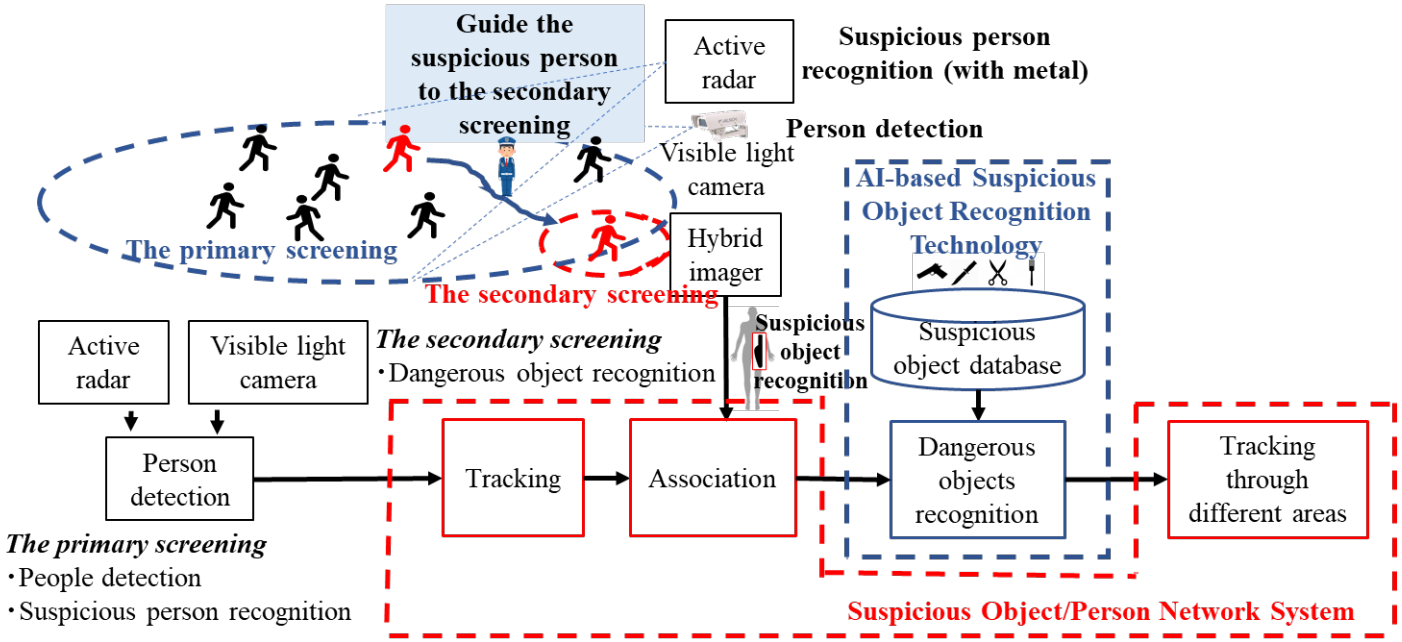
AI-based W-band suspicious object detection system for moving person using GAN: solutions
- System architecture

- ***Primary screening***

The system will use W-band radars with multiple visible light cameras to detect suspicious persons 15 meters away.

- ***Secondary screening***

The system will develop W-band hybrid imagers combined with visible light cameras to detect suspicious objects within 5 meters.

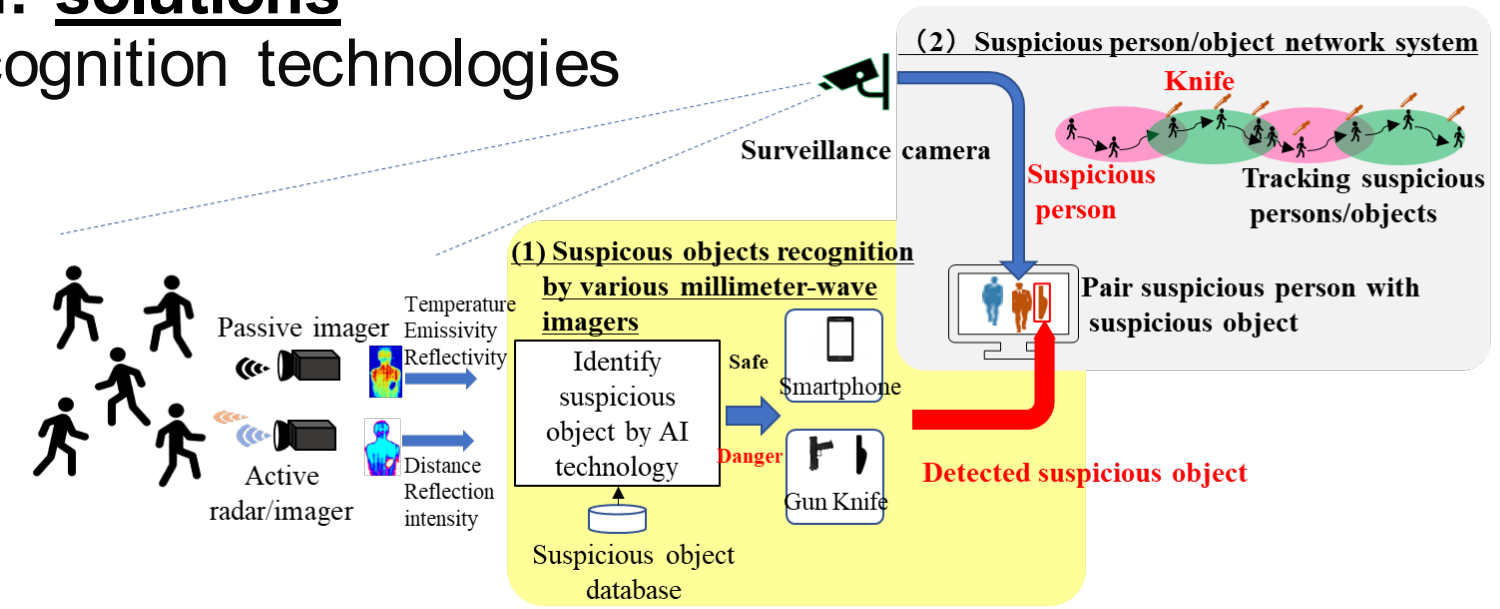


AI-based W-band suspicious object detection system for moving person using GAN: solutions

- AI-based suspicious object recognition technologies

To increase the probability of identifying suspicious objects in this system, we used AI technology to assist this process, which is based on the developed **suspicious object database**.

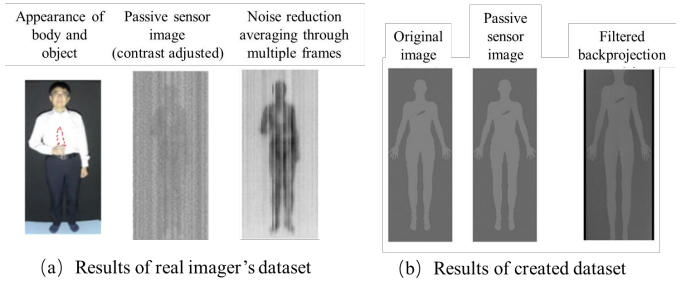
In this paper, we directly use CNN technology so the performance of the AI part is determined by the CNN.



AI-based W-band suspicious object detection system for moving person using GAN: solutions
- Suspicious object database

Simulation

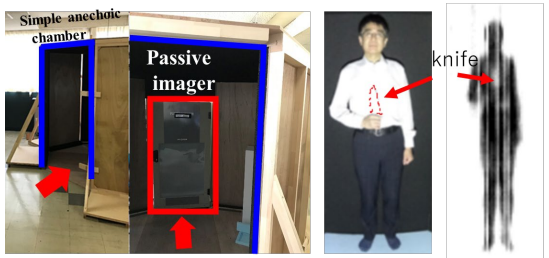
- We should consider the simulation environment of the entire system, including temperature, reflection, blur, variation, and noise.
- The parameters of suspicious objects should be considered, including the type, size, rotation, transformation, etc.



(a) Results of real imager's dataset (b) Results of created dataset

Active/passive imagers

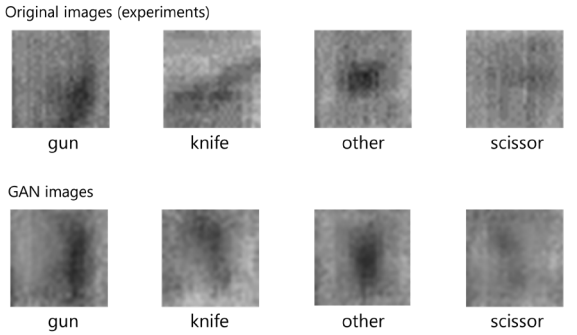
- We built a simple anechoic chamber using active/passive imagers to generate real image data.
- The position of the experimenter and the direction of suspicious object changes all the time



Passive imager shooting environment Example of passive imager data (right)

Generative adversarial network (GAN)

- We generate a large number of millimeter-wave images by GAN based on the original images, which will be used for CNN training.
- The below figure shows an example of GAN images which include gun, knife, other and scissor.



AI-based W-band suspicious object detection system for moving person using GAN: performance evaluation

The evaluation processing is under the CNN environment.

Figure shows the configuration of the CNN used to evaluate the proposed suspicious object detection system.

The network parameters for each layer are given in Table 1.

In this experiment, we used four types of suspicious objects for the training and evaluation of the CNN: gun, knife, scissor and others.

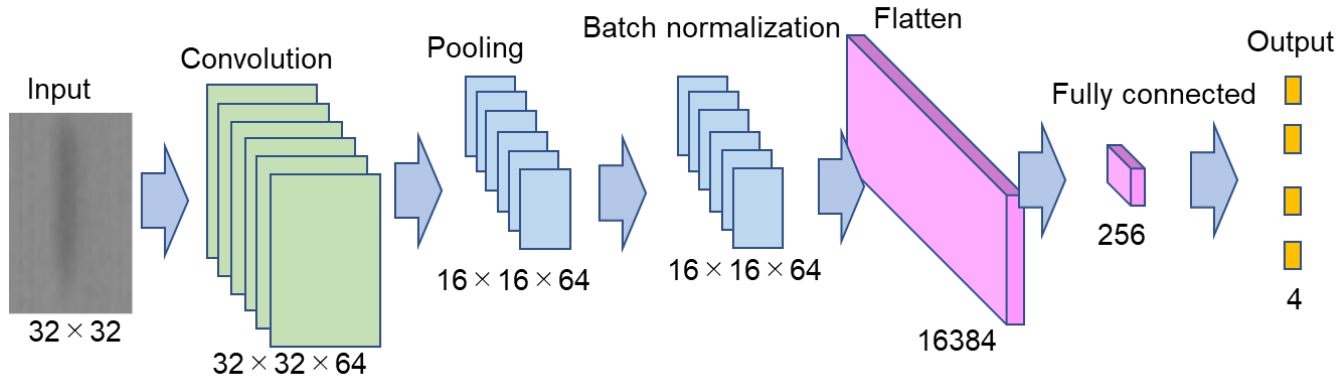


Table 1 – Network parameters

Layer (type)	Output shape	Param #
conv2d_18 (Conv2D)	(None,32,32,64)	640
max_pooling2d_17 (MaxPooling)	(None,16,16,64)	0
batch_normalization_14 (Batc)	(None,16,16,64)	256
flatten_17 (Flatten)	(None,16384)	0
dense_33 (Dense)	(None,256)	4194560
dense_34 (Dense)	(None,4)	1028

Total params: 4196484
Trainable params: 4196356
Non-trainable params: 128

AI-based W-band suspicious object detection system for moving person using GAN: performance evaluation - CASE 1

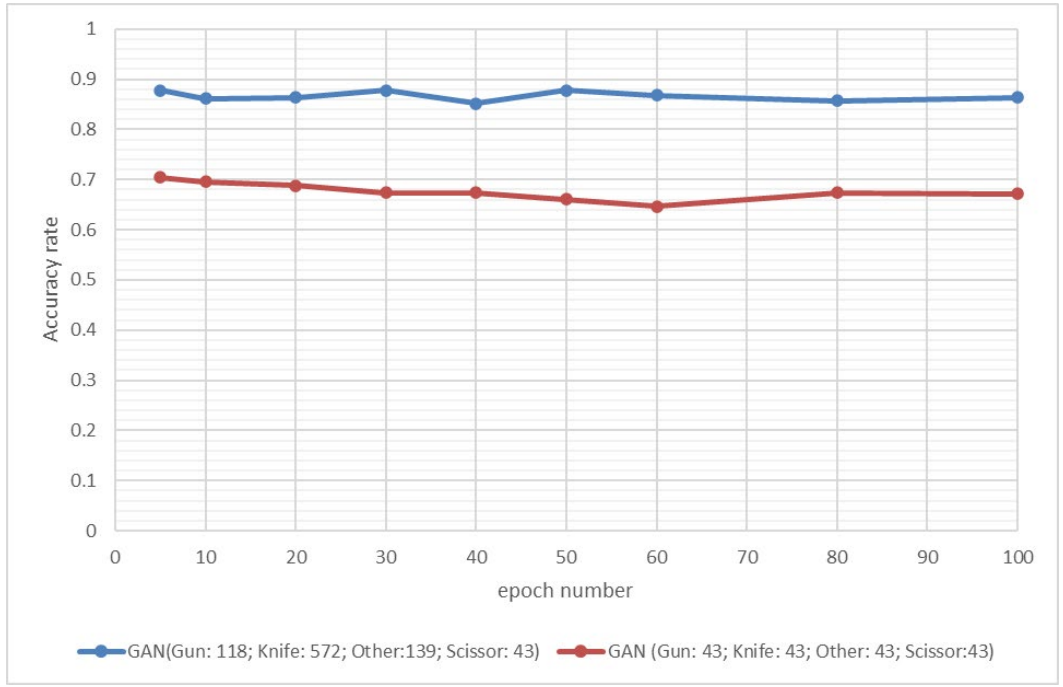


Table 2 – Object recognition results when epoch=5 (GAN training, gun: 118, knife: 572, other: 139, scissor: 43)

		Evaluation results						
		Gun	Knife	Other	Scissor	Total	Recall	Average recall
Input	Gun	53	1	4	0	58	0.913793	0.6828397
	Knife	3	269	12	1	285	0.94386	
	Other	9	3	57	0	69	0.826087	
	Scissor	0	19	1	1	21	0.047619	
	Total	65	292	74	2	433		
	Precision	0.815385	0.921233	0.77027	0.5			Accuracy rate
	Average Precision	0.751722						0.8775982

AI-based W-band suspicious object detection system for moving person using GAN: performance evaluation - CASE 2

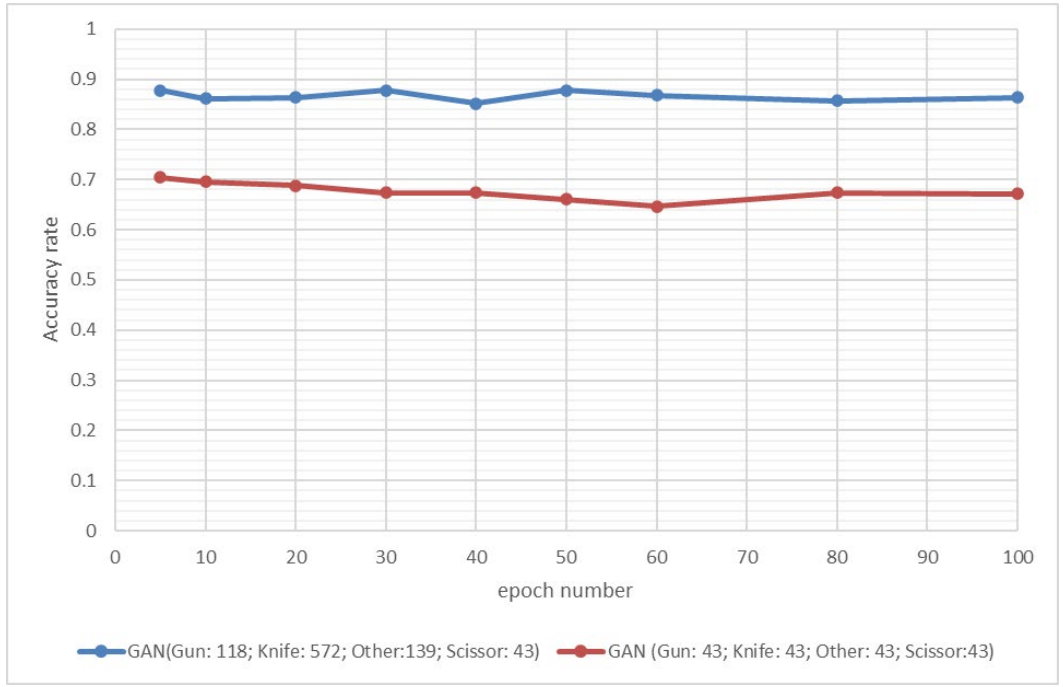
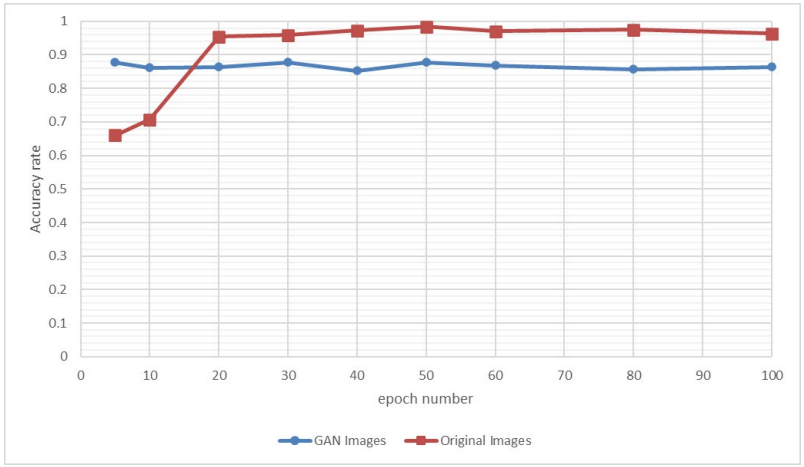


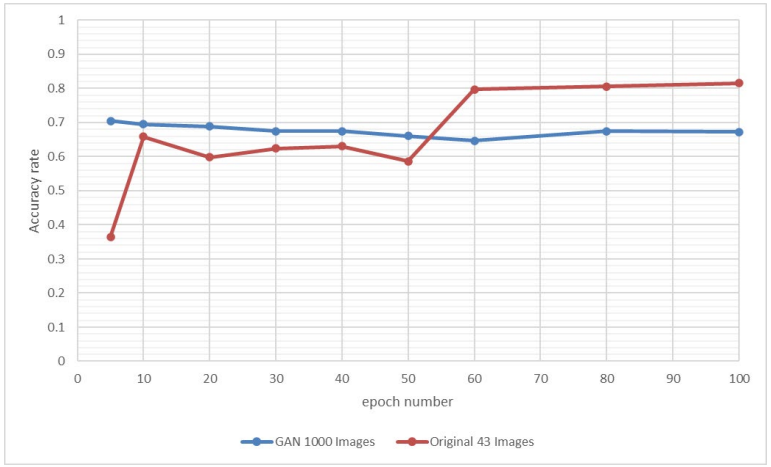
Table 3 – Object recognition results when epoch=5 (GAN training, gun: 43, knife: 43, other: 43, scissor: 43)

		Evaluation results						
		Gun	Knife	Other	Scissor	Total	Recall	Average recall
Input	Gun	42	1	14	1	58	0.724138	0.6867717
	Knife	5	193	33	54	285	0.677193	
	Other	5	4	60	0	69	0.869565	
	Scissor	1	5	5	10	21	0.47619	
	Total	53	203	112	65	433		
	Precision	0.792453	0.950739	0.535714	0.153846			Accuracy rate
	Average Precision	0.608188						0.704388

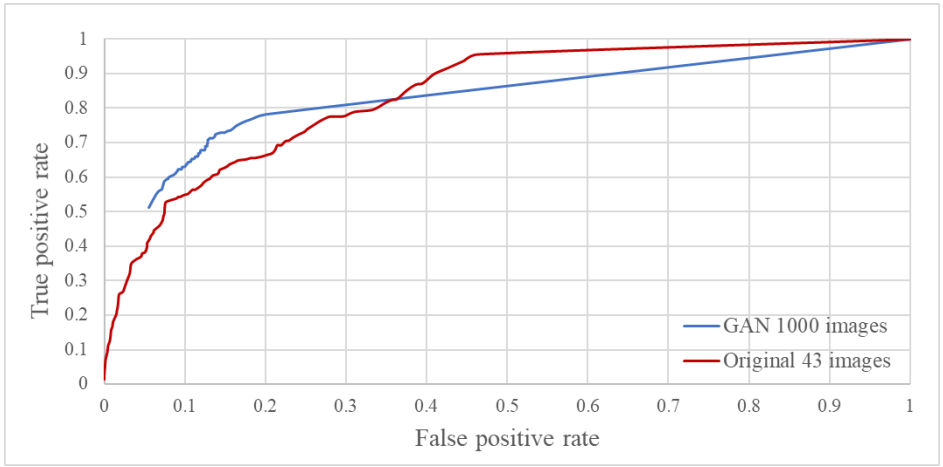
AI-based W-band suspicious object detection system for moving person using GAN: performance evaluation - CASE 3



Extend for CASE 1



Extend for CASE 2



ROC curve

AI-based W-band suspicious object detection system for moving person using GAN: standardization activities

- ISO/IEC JTC 1 has carried out relevant standardization in key areas of AI such as artificial intelligence vocabulary, human-computer interaction, biometric features recognition, computer image processing, and corresponding areas supported by AI technologies such as cloud computing, big data, and sensor networks.
- IEC has mainly carried out artificial intelligence standardization in the field of wearable devices (IEC TC100 and IEC TC124).
- ISO has mainly carried out AI standardization research in industrial robots (ISO 11593:1996, ISO 9946:1999, ISO 14539:2000, ISO 9787:1999, ISO 8373:2012), smart finance (ISO 19092:2008, ISO 14742:2010, ISO 19038:2005), and smart driving (ISO/TC 22 is responsible for formulating basic standards related to road vehicles, and is conducting research on standardization of intelligent connected vehicles).
- ITU has worked on the development of AI standards since 2016. ITU-T has proposed draft proposals for AI, including ITU-T Y.AI4SC (Artificial Intelligence and IoT) and ITU-T Y.qos-ml (Requirements of machine-learning-based QoS assurance), etc.

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Thank you!