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Electromagnetic Wave Imaging with AI Technologies applied for Safety Life Supporting System

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Abstract

The research and development of the suspicious object recognition technology is presently under study using AI (Artificial Intelligence) technology in Japan. The conventional imagers including visible 4K, thermal and radio cameras is developed based on the electromagnetic wave imaging technology. However, the space resolution of the output image except 4K camera is very poor and not able to satisfy the required quality level of the suspicious object recognition. The feasibility study of the AI technology to the low-level resolution image for the purpose of realizing the future safety life supporting system is performed and introduced the activity in this paper.

I. Introduction

Recently, the number of surveillance camera in the public space is massively increasing to keep the pubic security against the terror in the metropolitan of the world [1]. The target of terrorists tends to shift from public facilities with high level security such as military installations to the Soft Targets with low level security. Many people always use not only the public transportation facilities, for example train, bus and its station but also attraction facilities including shopping mall, concert hall and stadium [2]. The Soft Targets exit in everywhere and it is very effective for the terrorists to employ deadly force about a few dozen of citizen because the movie information of terror incident would be immediately transmitted to the world using SNS (Social Network Service).

The performance of the surveillance camera is improved using the visible 4K and the thermal imaging technology regardless of the time of day and night. The ordinally safety life is supported by the report of a suspicious person. However, when the invisible suspicious objects including the knife, the gun and the liquid explosive bomb in small size (under 200cc) plastic bottle are hidden inside clothes, it is hard for the conventional surveillance camera to detect them. It is hard to recognize the object's shape because of degrading in the space resolution of the output image.

Human has primitive 5 senses which is divided into 5 categories like Gustatory sense, Haptic sense, Smell sense, Auditory sense and Visual sense. The personal space is defined as the maximum detection range of the visual sense and within 10 m. Every people should prepare the self-defending power for both suspicious person and object in the personal space using the high-tech imagers.

In this paper, the conventional imagers based on the electromagnetic imaging technology are briefly introduced and AI (Artificial Intelligence) technology applied to the recognition of the suspicious object is also describe.

II. Conventional Imagers

Every object consists of atoms and the atom includes both the electrons and the nucleus of atom which is also composed of protons and neutrons. The flow and the spin of the electron produces the electric and magnetic field, respectively. Therefore, every object

transmits the electromagnetic wave alternately actuated by the both fields. The strength of the electromagnetic wave depends on the wavelength and the temperature based on Plank Law.

Passive Imager

The array sensors of the passive imager should be detected the electromagnetic wave of the target object even if the strength is weak and almost imperceptible. The contrast intensity of the image of the passive imager forms the shape of the target object and the resolution of image depends on the output power of each sensor and the noise power. The detection range defined by the distance between detector and target object is short and the measuring time interval of one-shot image depends on the arrangement of the array sensors like one dimensional line typed or two dimensional face typed.

The body scanner system using the W-band (75GHz – 110GHz) radio frequency wave is already developed for the detection of suspicious substance in the security area of the airport [3],[4].

Active Imager

The principle of the active imager is based on the radar technology. The reflected electromagnetic wave would be received at the array sensors when the electromagnetic wave transmits toward the target object. The time of arrival and the direction from the target object would be able to evaluate accurately because of the coherent characteristic of the electromagnetic wave. The resolution of the output image depends on not only the thermal noise but also the speckle noise which is occurred by the interference of the reflected electromagnetic waves from the surrounding objects.

III. Sensor fusion based on AI technology

The feasibility study of the AI technology for the object recognition is presently advanced in the field of not only the suspicious person detection in the safety supporting system but also the obstacle detection around the own vehicle in the automated driving system [5], [6].

Signal Detection under noise environment

The threshold value of the signal detection in the radar system should be defined as the existence or non-existence of signal under the strictly noise condition. When the 1st detection error probability P_{N1} of the target signal existence in case that the reflected electromagnetic wave could not be received and the 2nd detection error probability P_{N2} of the target signal non-existence in case that the reflected electromagnetic wave could be received, the FAR (false alarm rate) P_{fa} and the target detection probabilityP_d are defined as $P_{fa}(= P_{N1})$ and $P_d(= 1 - P_{N2})$, respectively. It is very important to arrange the threshold value considering the vary of the background noise power in the actual case.

Information processing of Human' brain

The primitive functions of Human' brain is thinking, learning and forgetting. The capability of the thinking is improved by the learning. The forgetting is effective in order to select of information which should be keep a memory or not because of the limitation of the brain' memory size.

Figure 1 shows the information processing of human' brain. When the new incident occurred, the information processing steps is defined as the following steps,

Step 1) Point Arrangement

・The point of information is organized.

Step 2) Worth Decision

・The worth of the information is decided refer to the memory of the prior occurrence.

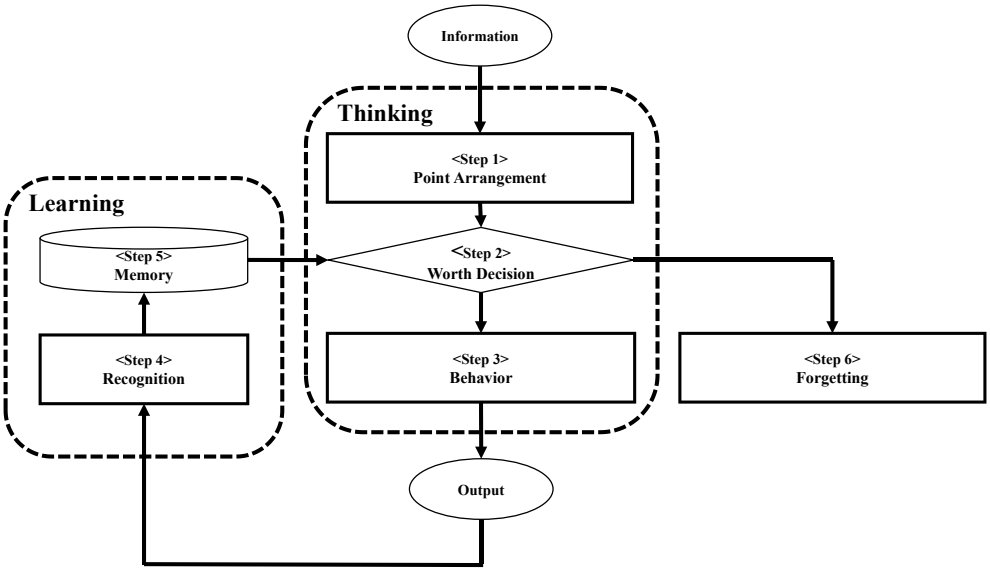

Figure 1 Information processing of human' brain

Step 3) Behavior
・Next actions would be made based on the results of the thinking in case of the beneficial information.
Step 4) Recognition
・ The result of the action which is success or not is analyzed. The essential points of the analyzed conclusions of the output is recognized in the learning process.
Step 5) Memory
・ The event is memorized in DB.
Step 6) Forgetting
・The non-beneficial information is forgotten.

Feasibility of AI technology

The deep learning based on the object recognition algorism is presently advanced because of the ultra-highspeed signal processing of the sever on the cloud network. The function of the deep learning corresponds to the part of the step 2 in Fig. 1. The big data collected by IoT (Internet of Things) devices is also stored in the data base (DB) like step5 in the Fig. 1. The object recognition process should be performed comparing the input data described step 1 in the Fig. 1 and the stored data in the DB.

The signal processing speed of human' brain is able assumed as 10^{16} Flops (Floating point number Operations Per Second). The signal processing speed of the No.1 highspeed computer in 2017 was about 10^{17} Flops and the processing speed would be predicted 10 times increasing in 4 years interval. When the human intelligence (HI) value is defined as 1 HI based on 10^{16} Flops, the HI value will increase as the 100 HI with 10^{18} Flops in 2021 and the 1000 HI with 10^{19} Flops in 2025. The HI value will be expected over 10000 HI in the end of next decade 2030. On the other hand, the population in the world will be exceed over 8.6 billion in 2030. From the viewpoint of the AI service providing for every people at once, the lack of the HI capability would become a social issue. However, the edge computing system as well as the cloud computing system is presently under study

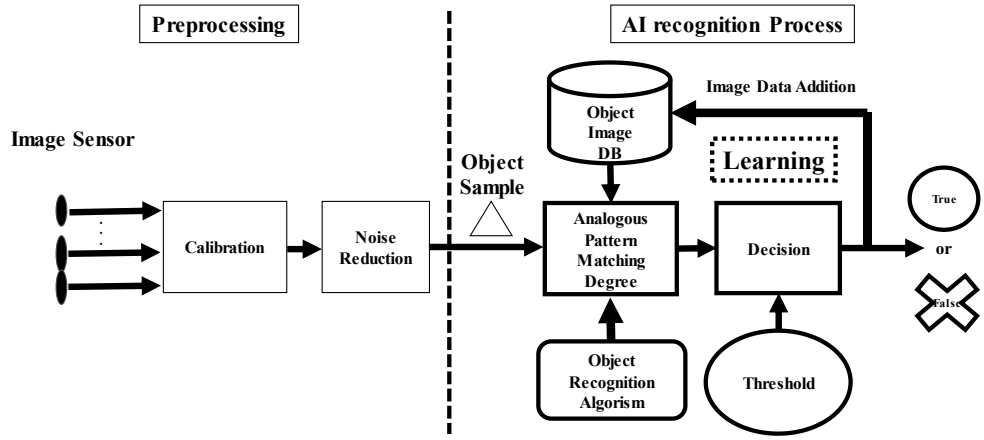

Figure 2 Block diagram of the suspicious object recognition system with AI technology (SORAI)

in worldwide. The distributed supercomputing system which is connect with ultra broadband communication networks would be expected to make a solution of this social issue in the future. Moreover, the information sharing would be also advanced using the communication networks for purpose of providing the knowledges of the leaning in the AI technology.

Therefore, the selection of the preferential usages of each step in Fig. 1 is very important in the limited resource which is defined by the HI value. The excess expectation of the AI technology should be not allowed in the thinking process, presently. However, the performance of thinking would be gradually increased by the learning process using the big data because the advantage of the machine learning would be able to utilize the rich memory in the DB comparing to human' brain.

Suspicious object recognition

Figure 2 shows the block diagram of the SORAI (Suspicious Object Recognition system with AI technology). Challenging to overcome the recognition limitation of the human' brain, the SORAI should be divided into two processing parts which are consisted of the preprocessing and the AI recognition process.

In the preprocessing part, the outputs of the many kind of the image sensors should be firstly calibrated considering the measuring conditions like the temperature of surrounding environment, the elapse time and the performance variation of each sensor devices. Secondly, the noise should be removed considering the stochastic characteristics of the noise with the high-level signal processing technology. The image of the object sample which is cleaned up in the preprocessing part would become the input of the analog pattern matching degree evaluation part in the AI recognition process.

The AI recognition process consist of several processing blocks. In the object image DB, the true or false images corresponding to the object sample image is stored and becomes the template image for the analog pattern matching. Moreover, the most recent object recognition algorism should be introduced in the evaluation part. The suspicious object could be decided as the recognition result of the true or the false object using the mentioned evaluation result and the pre-set threshold values. The learning function could be formed as the feedback loop configuration with these processing blocks. As above

mentioned, the advantage of the machine learning would be able to utilize the rich memory in the DB. Therefore, it is expected that the performance of the suspicious object recognition could be improved by the learning process with the feedback loop configuration.

IV. Conclusion

The products passing for the global market could be created by the innovation. The innovation should be activated with the invention as well as the new business, simultaneously. The success of the innovation would be expected when the researcher and the engineer challenge to the new invention, which is smartly integrated by the most-recent ICCSNT (Information, Communication, Control, Surveillance and Navigation Technology). Furthermore, it is very important to focus the target product considering the optimum solution which is related to the present troubles of the customer.

The national project of public security was already started by MIC (Ministry of Internal Affairs and Communications) of Japan in 2019. The author, as one of the starting member, make an effort to develop the safety life supporting system (3S). The 3S integrated with the information, communication and surveillance technology could become very helpful under the high-level possibility of the encounter of the threat in the daily life of Japanese people.

References

[1] https://www.comparitech.com/vpn-privacy/the-worlds-most-surveilled-cities/
[2] https://www.cisa.gov/securing-soft-targets-and-crowded-places
[3] https://www.maspro.co.jp/information/details/2016/06/AllClear.html
[4] https://www.cornestech.co.jp/tech/products/products_thruvision/
[5] https://www.alsok.co.jp/company/news/news_details.htm?cat=2&id2=898
[6] https://www.toshiba-clip.com/detail/2675

Biography

Kiyohito Tokuda was received the B.E., M.E. and D.E. degrees in Electrical Engineering from Hosei University in 1981, 1983 and 1996, respectively. He joined Communication Systems Laboratory, Research and Development Group, Oki Electric Industry Co., Ltd in 1983. Since then, he has engaged in research on the ITS communication systems based on mobile data transmission technology and signal processing technology. He was a general manager of Wireless Technology R&D department of Oki and retired in 2010. He is currently the senior researcher and Guest Professor of GITI of Waseda University, the Director and the Vice President of YRP International Alliance Institute and the founder of Kurouto Network company.