Design Considerations for an Intelligent Video Surveillance System Using Cloud Computing

Kyung-Soo Lim(✉), Seoung-Hyeon Lee, Jong Wook Han, and Geon-Woo Kim

Information Security Research Division, Electronics and Telecommunications Research Institute, Daejeon 34129, Korea
{lukelim, duribun2, hanjw, kimgw}@etri.re.kr

Abstract. Recently, deep neural network and cloud computing based intelligent video surveillance technology are growing interests in the industrial and academia. The synergy with both technologies emerges as a key role of the public safety and video surveillance in the field. Reflecting these trends, we have been studying a cloud-based intelligent video analytic service using deep learning technology. INCUVAS (cloud-based INCUbating platform for Video Analytic Service) is a platform that continuously enhances the video analysis performance by updating real-time dataset with the deep neural network on a cloud environment. The goal of this cloud service can provide continuous performance enhancement and management using image dataset from the real environment. In this paper, we consider the design requirements for online deep learning based intelligent video analytics service.

Keywords: Video surveillance · Intelligent video analysis · Deep learning

1 Introduction

The interests in recent ICT services based on deep neural networks are currently higher than ever. Especially, the research on intelligent image analysis technology, which is one of the most used fields in Artificial Intelligent (AI), is underway actively. On the other hand, the cloud-based CCTV solutions such as VSaaS (Video Surveillance as a Service) are also being popularized by mitigating increases for effective video management of large-scale control systems. The VSaaS is a web-based video surveillance service that includes video recording, video storage, remote viewer, intelligent video analysis, and so forth.

VSaaS is a business model where those services are offered under the software-as-a-service model. For service providers, these various services of VSaaS are a model of continuous profit making, so they are making efforts to publicize and popularize them. Meanwhile, the global market for VSaaS is estimated to reach the US $1.7 billion by 2020 [1]. Currently, it has based on the cloud platform to manage resources and enable elasticity and flexibility nowadays. It means that the existing video management system (VMS) has moved to a cloud solution.

Cloud computing has become one of the most discussed IT paradigms of recent years. With cloud computing, organizations can consume shared computing and

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storage resources rather than building, operating and improving infrastructure on their own. Cloud computing enables organizations to obtain a flexible, secure, and cost-effective IT infrastructure, in much the same way that national electric grids enable homes and organizations to plug into a centrally managed, efficient, and cost-effective energy source [2]. The most famous cloud service platform is Amazon Web Service (AWS) that provides on-demand cloud computing platforms to individuals, companies, and governments with computing power, database, storage, content media transfer, and so forth [3].

On the other hand, NVIDIA has launched NVIDIA GPU CLOUD (NGC) that is concentrated on the cloud service with GPU-accelerated high-performance computing for deep learning. NGC provides a comprehensive GPU -accelerated cloud service including deep learning software, third-party HPC applications, and other partner applications [4].

Likewise, cloud computing and AI-based intelligent video surveillance solution have emerged as a core technology in the field of city safety, and the interest in industry and academia is increasing. Recently, the video surveillance system is evolving into a large-scale intelligent CCTV system that integrates with core ICT technology trends such as cloud, mobile, and big data analysis. For example, DAS (Domain Awareness System) developed by New York City and Microsoft in the United States has been extended to San Francisco, Los Angeles and Brazil with the proven use of intelligent video surveillance technology [5].

Despite emerging the all-mighty CCTV technology, the intelligent video analytics analytic (IVA) solution is not quite acceptable or competent in real-world situation. In other words, the lab-level algorithms for computer vision, even if it has developed with the proving the performance on the test set, had resulted in drastic performance degradation when it applied to real environments. Although the image recognition technology is developed for various environments, it cannot be identical with the camera scene, which is installed in the field. Therefore, there is a need for a technique that can directly apply the image analysis engine developed by performing deep learning (DL) with the scene of a camera installed in the field, on the spot.

On the other hand, domestic video surveillance companies are hard to invest and develop the deep learning based IVA technology because of low-level of R&D capability and the high price of hardware especially GP/GPU(General Purpose Graphic Processing Unit). Thus, they are simply transforming or utilizing the open source library of IVA. It means that the performance and reliability of their IVA will might be quite low to apply for the real environment. Therefore, it is necessary to support the platform or service by the government or public organization to nurture related industries to follow recent global trends.

Reflecting these trends, we have been researching a cloud-based intelligent video analytic service using deep learning technology. INCUVAS (cloud-based INCUbating platform for Video Analytic Service) is a platform that continuously enhances the video analysis performance by updating the real dataset with the deep neural network on a cloud environment, as shown in Fig. 1. A client uploads the images of the site to the cloud server on the INCUVAS; it creates the image analysis engine based on the uploaded image by deep learning technology and applies it to the field. The goal of this cloud service can provide continuous performance enhancement using image dataset

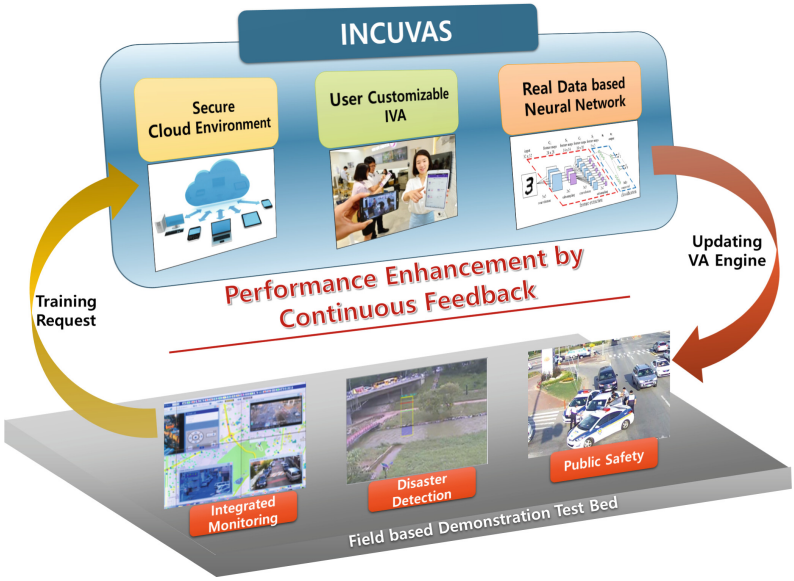

Fig. 1. The Goal of INCUVAS

from the real environment. In this paper, we consider the design consideration for online deep learning based intelligent video analytic service.

The biggest difference between INCUVAS and exiting cloud service are that INCUVAS trains and develops real datasets and it supports user-customized video analytic service, for example, face recognition, behavior analysis, and so forth [6, 7]. The organization for city safety, such as a police department, an integrated video surveillance center, who want an IVA with the proof guarantee for city safety. They can upload their video clips in the field and deploy the neural network engine after the learning and verification are completed.

2 Design Considerations for an Intelligent Video Surveillance System Using Cloud Computing

The definition of the incubator in this paper is one of the various forms of the virtualized machine (VM). It will be a VM instance based on the cloud platform or a container such as Docker. It will depend on the capability of the cloud cluster based on hardware specification. The INCUVAS assigns an incubator to the client who wants those services.

The purpose of ICUVAS provides cloud service, which is online deep learning from the uploaded dataset by the user to provide the most reliable and powerful intelligent video surveillance what he/she wants. For example, the client wants to launch the finding a missing child service in a national park. The client logged into INCUVAS server and chose the re-identification service for the missing child. Then,

the, he/she uploads video or images in the scenes to the incubating cloud server. After the uploading completed, the allocated incubator will learn the object recognition and detection techniques based on the scene of the field. When the neural network engine is created, the client will download and apply it to the IVA system. If its performance of downloaded IVA does not yield as expected, the client will request and update more appropriate IVA engine on the cloud service of INCUVAS.

There are four core requirements for providing an intelligent video surveillance platform using cloud computing. First, a cloud-based incubating platform supports a technology that continuously enhances and optimizes the performance of deep learning based IVA by real-time updating on a cloud environment. It can apply to all AI-inspired services using neural network technology. However, the INCUVAS aims to provide the IVA service on video surveillance for city safety. Second, neural network based IVA should provide the DL-based face/vehicle recognition, traffic accident detection, and license plate detection by deep-resolution technology, which are to support automatically recognize the real-time situation. Third, INCUVAS should be able to construct the image database for the online deep learning based on the real surveillance dataset in the field. It includes the semiautomatic feature for generating the ground truth (GT) dataset and online learning technology on a cloud platform with interoperability. Finally, it should support the field-based demonstration for intelligence public safety to establish the infrastructure for the provision of intelligence physical security through the cooperation of the National Police Agency and the local government. Thus, the completion stage of INCUVAS can contribute the real-time traffic accident recognition, identifying crime suspects (people or vehicles), and deep resolution for the plate number for the vehicle.

- Provide a neural network engine for IVA
- Support cloud platform for handling various clients

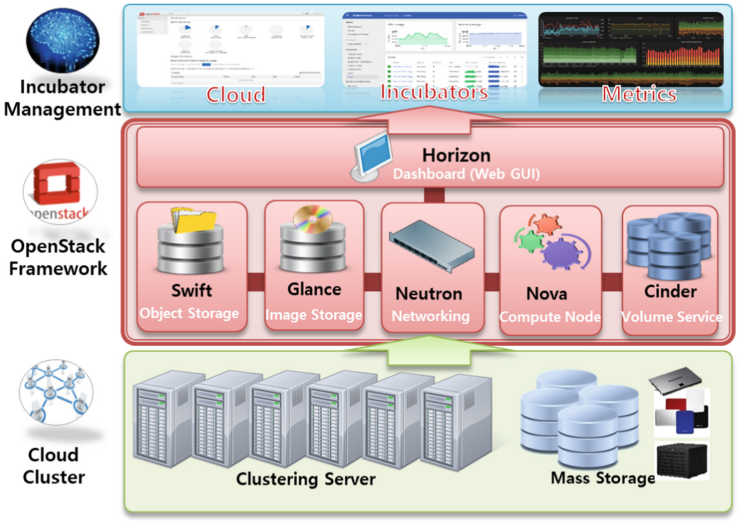

Fig. 2. The Structure of Openstack based INCUVAS

- Provide online deep learning service distributing various IVA
- Create a Field-based image database and semiautomatic GT dataset
- Provide Field-based test bed demonstration service for the law enforcement and city safety

Currently, we have built a prototype of Openstack based cloud platform. The instance created on this prototype supports the neural network for IVA, which used public video surveillance dataset for training as shown Fig. 2. Among the many features of the Openstack project, Keystone-based user access control meets the INCUVAS requirements for managing various clients with security [8, 9].

3 Conclusion and Future Works

As we described above, we have been researching a cloud-based intelligent video analytic service using deep learning technology. We called INCUVAS (cloud based INCUbating platform for Video Analytic Service) is a platform that continuously enhances the video analysis performance by updating the real dataset with the deep neural network on a cloud environment. The biggest difference between INCUVAS and exiting cloud service are that it trains and develops real surveillance datasets and it supports user-customized video analytic service. Those dataset provided e organization for city safety, such as a police department, an integrated video surveillance center, who want an IVA with the proof guarantee for city safety. They can upload their video clips in the field and deploy the neural network engine after the learning and verification are completed. It collects images through cooperation with those government organizations and uses them as a training dataset for the IVA development. Furthermore, those image dataset maintains security and access control to prevent the personal privacy infringement.

On the other hand, it is currently being tested on a prototype of INCUVAS. However, our research is underway for the developing the infrastructure and techniques to manage the thousands of incubators in the future.

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