A Study on a 3D Spatial Mapping System to Investigate Skyscrapers Using Drones

Sang-Su Kim
ICT Research Laboratory
ICTWAY Corporation
Dae-Jeon, Republic of Korea
sskim79@ictway.co.kr

Hee-Tac Jung
ICT Research Laboratory
ICTWAY Corporation
Dae-Jeon, Republic of Korea
htjung@ictway.co.kr

Seung-Jae Lee
ICT Research Laboratory
ICTWAY Corporation
Dae-Jeon, Republic of Korea
maco673@ictway.co.kr

Ji-Yeon Kang
ICT Research Laboratory
ICTWAY Corporation
Seoul, Republic of Korea
jiyeon@ictway.co.kr

Jin-Ho Park
ICT Research Laboratory
ICTWAY Corporation
Seoul, Republic of Korea
rookie96@ictway.co.kr

Jun-Hui Go
ICT Research Laboratory
ICTWAY Corporation
Seoul, Republic of Korea
jhGo@ictway.co.kr

***Abstract*—Recently, as the drone industry develops, related technologies are being used in various fields. In particular, drone technology is being used to search for missing people with large-scale manpower, detect cracks and rust in high-rise buildings, and perform safety inspections. However, there was a downside to using existing drones. First, after shooting the target, check the abnormal point in the original video with the naked eye and save it to the local memory as a file. Also, during AI analysis, it was processed as a cumbersome procedure in which batch-type files had to be analyzed in the analysis module and then the results had to be checked again. Accordingly, this paper proposes a method of visualizing 4K (3840X2160) still images transmitted from drones in real time and AI analysis in real time, and then visualizing the resulting data on a 3D web map.**

Keywords—search drone, 4K images, High Quality Images, Visualization, Drone Images Visualization

I. INTRODUCTION

Recently, the government held a public hearing on the 2nd Drone Industry Development Basic Plan (2023 ~ 2032) to discuss the vision and strategy of drone policy for the next 10 years [1]. The market for the drone industry in 2020 is about KRW 490 billion, and it is trying to expand to KRW 1 trillion by 2025 and leap forward to become one of the 7 major powerhouses (currently ranked in the top 10) [2]. In addition, the R&D budget for unmanned aerial vehicles (drones) is steadily increasing, increasing from 39.3 billion won in 2019 to 97.8 billion won in 2021, and the technological level and technology gap is 60%, 3.47 years (as of 2018) compared to leading countries, gradually increasing the technological level and narrowing the gap.As the government increases the R&D budget for drones, research using drones is being conducted in various fields. In addition, depending on the purpose of use, various sensors are attached to the drone body and missions are performed manually, and it is used in various fields such as searching for missing persons, inspecting facilities in skyscrapers, detecting people for dam discharge, and detecting abnormal vegetation of crops. However, the current use of drones has limitations in that after performing a mission, a video or still image stored in an internal memory such as an SD card is copied to a personal computer, analyzed by AI, and the analysis result is post-processed. In terms of time and economy, the more the number of mission-performing drones and the larger the captured image data, the larger the loss occurs. Accordingly, this paper proposes a method of visualizing still images with location information on a 3D web map in connection with a real-time transmitting aircraft. In addition, we propose a method of visualizing analysis result data on a 3D web map in connection with a module capable of real-time AI analysis.

II. RELATED WORK

A. Business Model

The business model is a service model designed by the Korea Electronics and Telecommunications Research Institute through the "DNA + Drone Technology Development Project" task of the National Research Foundation to be applicable to four major drone utilization fields. The four business models are:.

- **Police Drone BM:** This is a model that is continuously updated in cooperation with the National Police Agency, and suggests a drone search method according to the occurrence of missing persons. Search drones are largely divided into 4K video drones and 4K still image drones. 4K images transmitted from drones during search are transmitted to control vehicles or control centers, and are visualized on 2D web maps and analyzed by real-time AI.
- **Structure Drone BM:** It is a model that inspects abnormal points of buildings such as cracks and rust through video and AI analysis. Drones inspecting structures need to detect microscopic cracks, so ultra-high-definition (4K: 3840x2160) still images are used. Real-time images are acquired from drones and transmitted to a control vehicle or control center, and the transmitted images are analyzed by AI in real time and visualized on a 3D web map.
- **Water Drone BM:** A model that detects people in dangerous water areas and is a model to prevent human damage when dams are discharged. It is a model that takes still images with a drone in a dangerous area downstream of a dam, detects people in the collected still images in real time, and visualizes the results on a 2D web map.
- **Farm Drone BM:** This is a model that detects abnormal growth of crops and inspects abnormal growth of crops by mounting a hyperspectral camera and an EO camera on the drone. Until now, in order to see abnormal growth and pest damage, since the

information on diseases and insects applied to each crop and period is different, conventional methods are used rather than real-time. If abnormal growth points or specific diseases and insects are detected after AI analysis, pesticides are sprayed in the detection area using control drones. The 2D web map visualizes 4K still images provided as files and monitoring drone images monitoring control drones.

B. *Responsive Web Chart*

Various sites (google, d3, c3js, highchart, chartjs) support charts in JavaScript. Also, there are various types of charts such as bar chart, line chart, and pie chart. Also, JavaScript Sample Code is provided. However, it is entirely up to the developer to decide which chart to use and how to use it according to the characteristics of the data to be expressed.

C. *Mjpg-streamer*

mjpg-streamer is a command line application that copies JPEG frames from one or more input plugins to multiple output plugins. It can be used to stream JPEG files over an IP-based network from a webcam to various types of viewers such as Chrome, Firefox, Cambozola, VLC, mplayer, and other software capable of receiving MJPG streams[3].

It was originally written for embedded devices with very limited resources in terms of RAM and CPU. Its predecessor "uvc_streamer" was created because Linux-UVC compatible cameras directly produce JPEG-data, allowing fast and perfomant M-JPEG streams even from an embedded device running OpenWRT. The input module "input_uvc.so" captures such JPG frames from a connected webcam. mjpg-streamer now supports a variety of different input devices.

D. *AI Analysis Information*

AI analysis information is sent to the AI analysis module for 4K still images requested for analysis through RESTful Interface, and real-time analysis results are returned to the REST API. Upon return, the analysis results according to each business model are delivered in the standard protocol of JSON format agreed upon by different organizations, and are written with keys and values agreed upon for each business model. Among the analysis results, the most important information is location information (GPS), shooting date, detection object, and detection object bounding box information. When visualizing a 2D or 3D web map, the location is displayed based on the location information and shooting date, and the drone trajectory is visualized for each location.

III. DESIGN

This chapter designs a 3D web map visualization method for skyscraper investigation. Among the business models mentioned in Chapter 2, the Structure Drone BM corresponds to this, and the middleware design for collecting real-time drone images must be paralleled. AI Platform and interface are designed with REST API. The ETRI Media Server transmits the original image transmitted from the drone to the Web Server, and the Drone AI Post Processing SW transmits the original image to the AI Platform to request AI analysis. When the analysis is completed, the AI Platform notifies the analyzed image and the content including the analysis result to the web server through a RESTful interface (fig. 1). fig. 2. is a schematic design of the processing procedure between the web, AI Platform, and AI Inference Module. Web transmits Drone ID, Receive Result URI, and Original Image File to AI Platform. Receive Result URI is the address to which the analyzed image and result are sent. In addition, the original image file is delivered in the EXIF format of JPEG, and the meta information of the image file must include basic information such as GPS information and date time (or create time) information. AI Platform makes an inference request to the AI Inference Module linked with Docker and informs the inference result directly to the web server. The AI Inference Module must deliver the image information in Base64 format and include the analysis result in the "text" key value. The analysis result must use the JSON key value defined in advance with the Web (fig. 3).

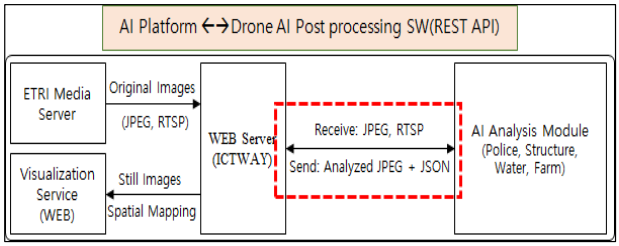

Fig. 1. AI Platform Inferface

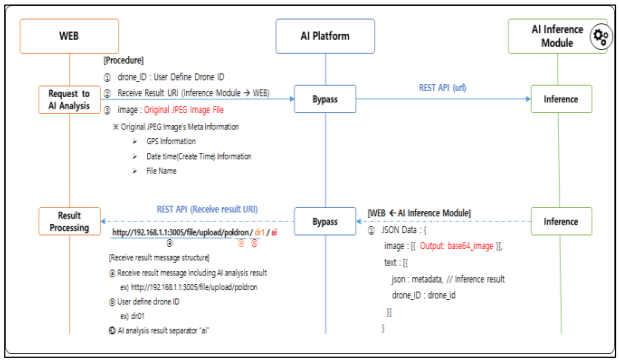

Fig. 2. Automation interface between WEB and AI inference module

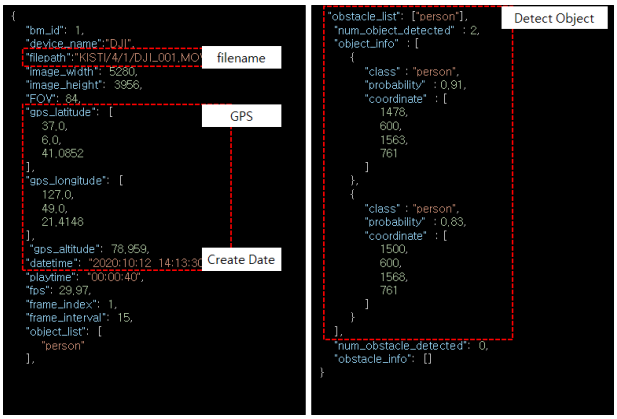

Fig. 3. Standard AI Result JSON

IV. IMPLEMENT

The software configuration of the 3D space mapping system proposed in this paper is as follows.

- Language: Spring, nodejs
- Middleware: Tomcat 8.5
- Database: PostgreSQL + PostGIS
- Map: V World 3D Map[4]

The original video and real-time AI analysis result data transmitted in real time through the developed web were visualized on a location-based 3D map, so that users could monitor where the drone is currently flying and how it is moving. The service screen is configured to suit the user's requirements and purpose for each business model, and AI analysis results are provided in a 3-dimensional graph to suit the purpose. The AI analysis agency analyzes "Pothole", "Repaired Pothole", and "Bad road marking" in the original video and returns the result. And after rendering the structure that needs inspection into a 3D object, convert it into a GLB object and visualize it on the v-world 3D map with CesiumJS(Using Web Browser - Client). Since a 3D object is an object converted from point cloud data to a GLB object, its capacity is created in GB units according to the number of points cloud representations. We need to re-render this in MB (1.2GB -> 80MB). If down sampling is not done in this way, it takes a lot of time when loading 3D objects in the web browser.

Fig. 4. AI Analysis Results.

Fig. 5. 3D Object (80MB)

The 3D visualization system proposed in this paper provides a web service screen as shown in the following figure. ① is a part that visualizes the original video being streamed, ② is the number of registered streaming drones, ③ is a visualization of the trajectory of the drone, video shooting location, and whether or not AI analysis results are retained, and ④ is a button to activate the recent work history. ⑤ is a visualization of the AI analysis result as a 3D Interactive Graph, and 6 is down sampling to 80MB and visualized on a V-World 3D map.

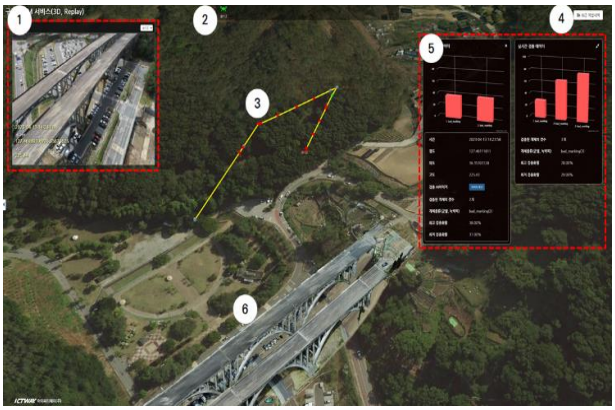

Fig. 6. Structure Drone BM's Web Service Page

The middleware receives the still image transmitted from mjpg-streamer in real time and extracts spatial information + date time information in the image. Based on the actual drone movement path and movement time, drone animation effects are displayed on the web to help determine the current drone location.

V. CONCLUSION

This paper proposed a 3D spatial mapping system and visualized it on the V-World 3D map, a 3D web map using actual drones. In addition, the possibility of service was secured by linking with the real-time AI analysis module. In addition, the system proposed in this paper is a service platform for visualizing images in real time. Also, it was found that the proposed service platform can visualize the flight of multiple drones by performing multi-drone flight experiments in parallel in addition to single drone flight experiments. Multi-drone flight experiment can be used in Police Drone BM among other business models, and it is expected that it will be possible to quickly find a missing person if several drones search for a missing person based on 3D terrain. However, there are technical limitations to use in Police Drone BM so far. In the case of object detection using AI, it is necessary to study a flexible detection algorithm even in a new environment and learn various lost articles as well as missing persons. If a self-learning AI analysis algorithm is studied to overcome these limitations in the future, it is expected that it will be used as a service platform that can be applied in the field.

ACKNOWLEDGMENT

This research was supported by DNA+Drone Technology Development Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Science and ICT(No. NRF-2020M3C1C2A01080819).

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