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A Study of Construction of Utilization of Realtime Digital Map (RDM) Using CCTV and Multi-source Data Tools

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Abstract: *3D spatial information is a field of study that targets overcoming the limitations of conventional 2D spatial information and handle and utilize 3D geographic information in diverse fields of application. It adopts all related factor technologies including 3D graphic processing technology, 3D spatial data models, spatial database control technology, realtime big data-processing technology, Internet application technology, big data base application technology and virtual reality technology. The U-CITY's spatial information technology aimed to provide services anytime and anywhere by adding high-tech information and communication technology to urban infrastructure is also available in diverse forms. This study aims to suggest a Realtime Digital Map (RDM) construction method that can be reflected utilizing realistic 3D spatial information services and realtime spatial information using visual media and differences from conventional services and develop a utilization plan applicable to the U-City.*

Keywords: *U-City, 3D spatial information, Image Processing, City Management, Urban Planning*

1. Introduction

Thanks to the growth and development of IT and optical technologies, spatial information construction & service technology has been studied with various spatial data from 3D spatial information to realtime multidimensional spatial information [1]. Some research has investigated the connection of multidimensional spatial information and attribute information (especially social networking services and big data) [2]. At present, many studies are ongoing. In addition, 3D spatial information construction methods include the Lidar-based method, which acquires 3D coordinates in person, the stereo image-based method and the method that uses multiple images obtained through single or diverse sensors [3]. However, general supply-centered construction and development of spatial data and services have limitations in diversity, utilization and realtime aspects [4]. To overcome these obstacles, this study proposes the user-involved spatial information service 'RDM technology' and suggests a field applicable to the U-City by analyzing differences with conventional technologies.

2. Realtime Digital Map

2.1. Scenario

The RDM uses CCTV images and multi-source data (ex: camera, mobile phone, dash cam, action cam, etc.) that are updated in realtime by users[5]. In terms of CCTV images, 3D-point cloud data are extracted through diverse image processes with the stereo-modulated images[6]. For blind areas that cannot be covered by CCTV cameras, 3D data are extended using the multi-source data provided by users. The 3D spatial information construction technology based on CCTV images that are filmed in realtime and large amounts of multi-source

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data is usable in precise augmented reality (AR) by providing LBS to users. It attempts to improve the limitations of conventional supply-centered spatial information services with a cyclical structure in which users participate in data construction. Fig. 1 reveals a conceptual scheme for the construction of user-involved spatial data through the RDM.

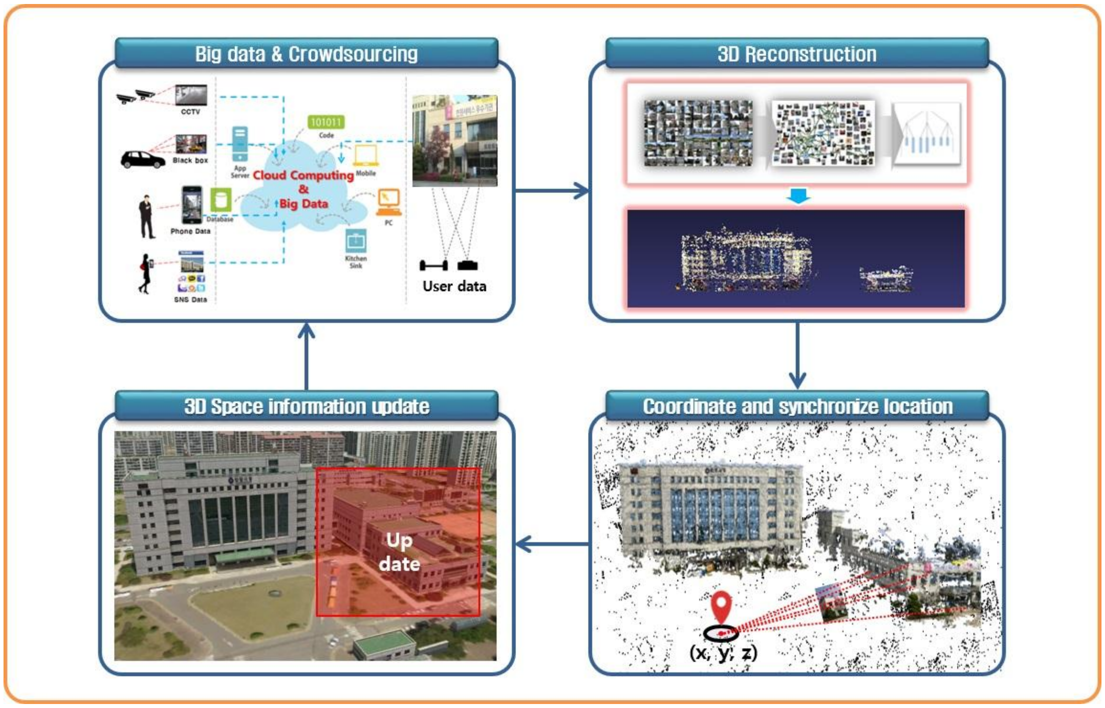

Fig. 1: Conceptual Scheme for Construction of User-involved Spatial Data.

2.2. Differences from Conventional Technology

The conventional location-awareness technologies include a Global Navigation Satellite System (GNSS), WiFi location-awareness technology and RFID and Bluetooth-based location-awareness technology. The RDM-based technology has the following differences: First, the GNSS offers user location anywhere in the world in realtime and guarantees high accuracy (as high as for-measurement information). However, it requires high-price equipment for accuracy. In case of conventional GPS receivers (ex: smartphone, car navigation system, etc.) used by the general public, an error of about 10 meters occurs. However, a satellite signal cannot be received inside a building. In an area with a high density of high-rise buildings, error increases. Second, the WiFi-based location-awareness technology includes a triangulation method and fingerprint method. With WiFi technology, user location can be detected even inside a building. However, this is only available in places where WiFi services are offered and cannot be used in areas where there is no power. Third, the Near Field Communication (NFC) sensor-based location-awareness technologies such as RFID and Bluetooth are available in any place where a sensor is positioned. In contrast, they cannot be used in areas where no sensor is available. Because it is a proximity sensor, there is a limitation in reception distance. If necessary, a particular reader can be needed.

The RDM construction-related studies require time and money to construct initial 3D spatial information. Once constructed, however, it can be updated with user data so that suppliers don’t have to update the data separately, which in return reduces maintenance costs and data update time. Unlike conventional technologies, in addition, it is available inside and outside buildings. With the use of CCTV images and multi-source data, it can be available with a communicable image acquisition system without additional system installation. It is available in places without power supply as well(Fig.2).

Fig. 2: Conceptual Scheme for Construction of User-involved Spatial Data.

3. Research Method

The CCTV image and multi-source data-based RDM construction method consists of three steps: i) image matching, ii) calculation of a camera matrix by using the points on the 3D absolute coordinates and corresponding coordinates of image points, iii) calculation of a 3D point cloud using the matching point and camera matrix. In the image-matching process, the CCTV data are converted into images and properly calibrated[7]. The RBG images prior to the use of the SIFT algorithm are divided into gray, red, green and blue bands. Then, the separated images are histogram-equalized and subdivided into 8 bands[8]. After that, matching points are extracted and overlapped[9][10]. Using the RANSAC, outliers are removed[11][12][13]. Then, 3D-point cloud data are constructed using the Direct Linear Transformation (DLT)[14][15]. In the added multi-source data, a camera matrix is calculated using the VGPS, and the 3D-point cloud is extracted. The RDM can calculate positions where images are filmed using the extracted data. With the VGCP, a point having the highest reliability among the extracted matching points, and related DLT coefficient, the shouting coordinates (filing location) are calculated. Fig. 3 below shows the flow of the research process.

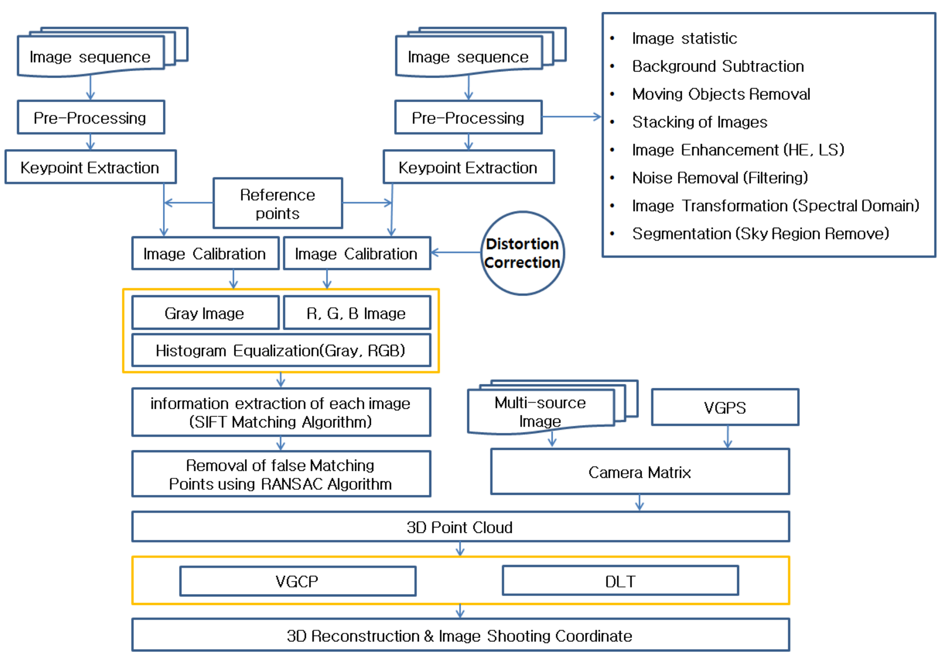

Fig. 3: Flowchart of the Research Process.

4. Experiments and Results

For an experiment, a part of the Konkuk University dorm was chosen. In terms of resolution, the stereo CCTV images used for the test were 1280x720 while the smartphone camera images additionally added for positioning were 1632×1224.

Using SIFT techniques between stereo CCTV images and additional images, matching points were extracted. Then, the most reliable point ‗VGCP' was chosen among the extracted matching points. After extracting 3D-point cloud, each DLT parameter was extracted with the corresponding VGCP as input data. Then, the filming coordinates for additional images were calculated, using DLT parameters. To assess the accuracy of filing coordinates, the filming coordinates were directly measured through GPS. Table 1 below reveals GPS and DLT-based coordinates and the Root Mean Square Error (RMSE) of X, Y and Z coordinates.

TABLE I: Comparison of GPS and DLT Coordinates

		X(N)	Y(E)	Z		X(N)	Y(E)	Z
1	GPS	546469.211	193832.367	14.564	DLT	546456.938	193830.736	17.730
2	GPS	546465.879	193839.464	14.569	DLT	546462.582	193841.160	14.909
3	GPS	546463.734	193842.186	14.564	DLT	546462.582	193841.160	14.909
4	GPS	546460.716	193843.148	14.538	DLT	546455.651	193837.722	16.981
5	GPS	546455.821	193843.427	14.527	DLT	546454.326	193838.784	16.567
6	GPS	546446.099	193843.777	14.433	DLT	546448.829	193839.683	16.040
7	GPS	546441.150	193846.228	14.372	DLT	546441.344	193845.478	14.398
8	GPS	546440.036	193843.208	14.365	DLT	546439.598	193843.344	14.199
9	GPS	546439.192	193838.290	14.369	DLT	546448.246	193837.850	12.824
10	GPS	546435.974	193833.909	14.422	DLT	546446.094	193831.505	18.635
11	GPS	546435.963	193830.868	14.413	DLT	546437.904	193831.181	15.410
12	GPS	546437.916	193824.554	14.370	DLT	546447.542	193827.463	21.563
13	GPS	546438.146	193819.495	14.378	DLT	546440.078	193815.363	14.385
14	GPS	546439.887	193815.304	14.393	DLT	546440.647	193816.084	14.735
15	GPS	546445.656	193815.176	14.491	DLT	546452.946	193824.593	16.499
RMSE	X(N) : 5.7915163885			Y(E) : 3.498399083			Z : 2.5003428644026	

5. Application

5.1. Car Augmented Reality

With dash cam images, absolute coordinates can be calculated. The coordinates acquired by complementing image coordinates are more accurate than the use of the GPS only in calculating position. In fact, they can even instantly reflect the direction in which a vehicle is moving. They can calculate a car's location in areas where GPS does not reach or is weak such as high-density high-rise building areas, underpasses and parking lots. In addition, they are able to create commercial services by providing diverse information to drivers through the use of the AR.

5.2. Indoor Navigation

After developing indoor 3D spatial information, it can be used for indoor navigation. A user's indoor position can be detected through communication with service, using his/her mobile camera or inner sensor without the installation of a separate sensor for localization or WiFi AP. By updating 3D spatial information using user data, then, the latest information can be reflected on a Realtime basis and provided.

5.3. (Near) Realtime 3D Map

Using the CCTV image and multi-source data-based 3D spatial information construction technology, a 3D map can be made. After providing the RDM technology to portals, 3D spatial data can be constructed with the portals' database. By utilizing big data updated on the Internet, in addition, 3D spatial data can be updated. If user-updated data are linked to Google Earth or V-world, furthermore, (near) realtime 3D spatial data can be constructed. Based on the 3D spatial data, moreover, AR and user location-based services can be provided.

5.4. Utilization of Urban Plan

Efficient urban planning and management are enabled through 3D urban modeling. To construct real locational information in 2D, field investigation and actual measurement are required. However, the RDM-based technology builds 3D spatial information that makes it possible to determine underground facilities or invisible places without an actual visit with 3D geospatial information, facilitating proper maintenance and management. In addition, it offers (near) realtime monitoring in a glance for disaster conditions and trends by collecting social big data and visualizes urban planning information and attribute data across the nation collected by local authorities. As a result, anti-over-development policy, anti-speculation policy and land use regulation rationalization policy can be developed.

5.5. Available in Urban Landscape Analysis And Management

The 3D spatial information enables the establishment of an urban landscape management plan. In addition, it is able to advance the review of resource preservation and regulations through urban landscape simulation and the system aimed to predict landscape changes by the block. Furthermore, it can predict and model civil complaints on the infringement of the right to enjoy sunshine and prospect right infringement. As a result, the time and money needed to handle the related duties can be saved.

5.6. Used in Urban Planning

The 3D spatial information is visually easy to understand allowing it to play the role of a decision-making support system. Therefore, it eliminates the trouble of field investigation and saves time in handling related jobs. In addition, it secures validity in the development and promotion of an urban plan and enables its utilization by providing logical analysis results at the investigation and analysis stage of urban planning.

5.7. Applicable to the Prevention of Disasters

Using the data on geographical features, buildings, roads and many other facilities, damage caused by natural disasters can be simulated based on 3D geospatial information. At the occurrence of urban disasters such as fire and earthquake, in addition, it is able to find the fastest emergency service, locate various facilities and develop and reflect a plan to minimize damage using the 3D spatial information in realtime.

5.8. Computerization of Urban Administration

The 3D urban modeling visualizes accurate 3D data, improves work efficiency and enhances the transparency of administrative processes. In combination with an e-government, it builds a virtual village and helps villagers have a better understanding of their community. In addition, it makes it easy to understand the issues arising from urban planning and construction and establish logical policy steps regarding various civil affairs.

6. Conclusion

If a location can be detected with images only without the use of any positioning system provided by conventional spatial data through the suggestion of the RDM spatial data construction method using the CCTV images and multi-source data and image-based location-awareness technology, it would be possible to overcome conventional supply-centered limitations. Furthermore, if image quality-improvement technique and diverse image-processing techniques are used, and studies on the environmental factors which occur during the filming continue, more accurate 3D spatial data could be obtained. Then, if location-based services are provided to users, and, at the same time 3D data are updated, they would make a big contribution to the growth and development of a U-City.

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