Construction of 3D Spatial Information Using Unmanned Aerial System

Jin Duk LEE

Abstract: UAV (unmanned aerial vehicle) of which utilization continues to grow in various industry fields In recent years is in the spotlight as future core industry). Especially its economy and efficiency is excellent in constructing and renewing 3D spatial information for a small scale area. is to suggest the method for constructing 3D texture model with high quality and evaluate the results according to photography techniques quantitatively and qualitatively.

Keywords: unmanned aerial system, 3D spatial Information, UAV, 3D texture model, point cloud

1. Introduction

An unmanned aerial vehicle (UAV), commonly known as a drone, as an unmanned aircraft system (UAS), or by several other names, is an aircraft without a human pilot aboard. The flight of UAVs may operate with various degrees of autonomy either under remote control by a human operation or fully or intermitterently autonomously, by onboard computers. Compared to manned aircraft, UAVs are often preferred for missions that are too "dull, dirty or dangerous" for humans. They originated mostly in military applications, although their use is expanding in commercial, scientific, recreational, agricultural, and other applications, such as policing and surveillance, aerial photography, agriculture and drone racing. Civilian drones now vastly outnumber military drones, with estimates of over a million sold by 2015**.**

In recent years, the potential for utilization of UAV(unmanned aerial vehicle) in various industry fields continues to grow. Among others, ultra-light UAVs which weighs less than 1 kilogram are able to provide precise position information with improving performance of navigation equipment, cameras, processing software. Therefore the application of them are expandingly on the rise to construction of high precise spatial information such as update of digital maps, earth-volume calculation, agriculture environment and forest monitoring, cadastral survey and so on. Especially UAV is in the spotlight as future core industry because its economy and efficiency is excellent in constructing and renewing 3D spatial information for a small scale area. This paper illustrates a UAS-related case study which we have performed ourselves. The purpose of this research is to suggest the method for constructing 3D texture model with high quality and evaluate the results according to photography techniques quantitatively and qualitatively.

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2. Types of UAV

There are three types of fixed-wing, rotary-wing and vertical take-off and landing type in UAS

2.1 Fixed Wing UAV

Fixed wing UAVs consists of a rigid wing that has a predetermined airfoil (again another variable) which make flight capable by generating lift caused by the UAV's forward airspeed. This airspeed is generated by forward thrust usually by the means of a propeller being turned by an internal combustion engine or electric motor.

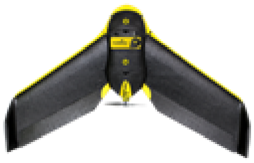


Figure 1 Fixed Wing UAV (Sensefly eBee)

Control of the UAV comes from control surfaces built into the wing itself, these traditionally consist of ailerons an elevator and a rudder. They allow the UAV to freely rotate around three axes that are perpendicular to each other and intersect at the UAV's center of gravity. The elevator controlling the Pitch (Lateral axis), ailerons controlling the Roll (Longitudinal axis) and the rudder controlling the Yaw (Vertical axis). The main advantage of a fixed wing UAV is that it consists of a much simpler structure in comparison to a rotary wing. The simpler structure provides a less complicated maintenance and repair process thus allowing the user more operational time at a lower cost. More importantly the simple structure ensures more efficient aerodynamics that provide the advantage of longer flight durations at higher speeds thus enabling larger survey areas per given flight. Another advantage of fixed wing UAVs is that the flight characteristics due to their natural gliding capabilities with no power.

2.2 Rotary Wing UAV

Rotary wing UAVs consist of 2 or 3 rotor blades that revolve around a fixed mast, this is known as a rotor. Rotary wing UAVs also come in wide range of setups consisting of a minimum of one rotor (helicopter), 3 rotors (tricopter), 4 rotors (quadcopter), 6 rotor (hexacopter), 8 rotors (octocopter) as well as more unusual setups like 12 and 16 rotors! Like fixed wing solutions, these setups can be further broken down, for example a Y6 setup consists of a tricopter with twin rotors on each arm, one pointing upwards and one pointing downwards and an X8 consists of a quadcopter with twin motors on each arm. Again each setup has their own unique characteristic advantages and disadvantages.

Figure 2. Rotary wing UAV

The biggest advantage of rotary UAVs is the ability for takeoff and land vertically. This allows the user to operate with in a smaller vicinity with no substantial landing/take off area required.

Figure 3. Vertical takeoff and land UAV

Their capacity to hover and perform agile maneuvering makes rotary wing UAVs well suited to applications like inspections where precision maneuvering and the ability to maintain a visual on a single target for extended periods of time is required.

Finally, due to their lower speeds and shorter flight ranges the operator will require many additional flights to survey any significant areas, another increase in time and operational costs.

2.3 Components of UAV

UAS is comprised of body frame, onboard sensors, GCS/remote controllers for drones and ground control and post processing software as shown in Figure 4.

Figure 4. UAS equipment component

3. Example of 3D Geospatial Information Generation Using Fixed-Wing UAV

The procedure of this research is shown in Figure 5.

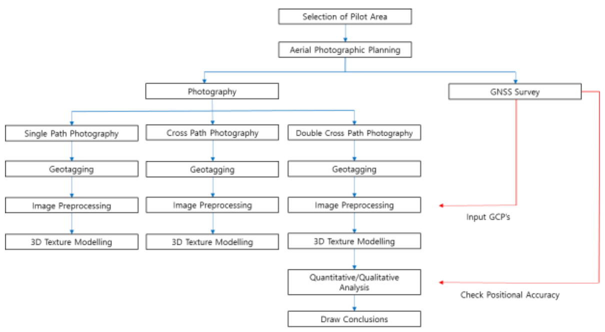


Figure 5. Flow diagram of the research

Fixed wing UAV used for this research is a Sensefly eBee model which is equipped with Sony DSC-WX220 camera. Topcon HiperII GNSS was used for ground control survey.

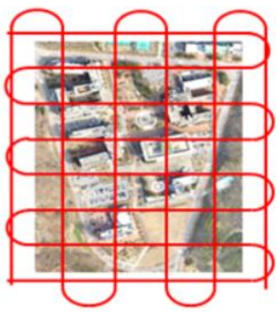
3.1 Image Acquisition

The campus of Kumoh National Institute of Technology selected as a pilot area was taken with the overlap of 85% and the sidelap of 70% at 120 meter height using the camera of 18 million pixel. Also, single path 130 images, cross path 278 images and double cross path 630 images were acquired as shown in Figure 6 using different photography methods. Four ground control points and five check points were surveyed by Network RTK-GNSS.

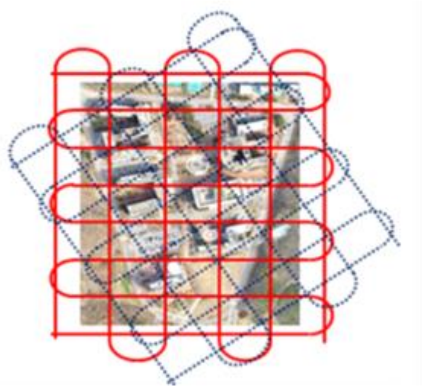
Table 1. Specification of fixed wing UAV

eBee (SenseFly)	
Weight	Approx. 700g
Flight speed	36~57km/h
Flight duration	Max. 50min.
Resistance to wind	12m/s
Camera model	SONY DSC-WX220, 1,8million pixels
Focal Length	4mm
CCD Sensor size	4896 × 3672

(a) single path



(b) cross path



(c) double-cross path

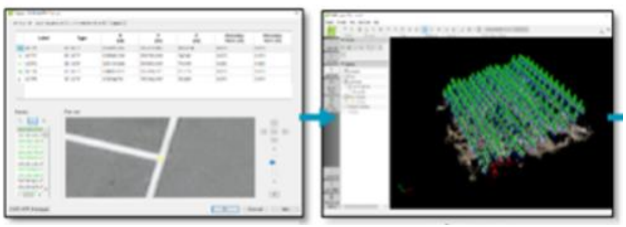
Figure 6. Flight paths of UAV

3.2 Data Processing and Analysis

Data processing including image input, ground control point input, tie point generation, automatic aerial triangulation, point cloud generation, mesh transformation and so forth was carried out with Pix4Dmapper (ver 2.1) software. Different 3D texture models was generated according to different photography methods.

In data processing, distinguishable singular points from photos were automatically detected and then exposure station coordinates and exterior orientation elements was computed by automatic aerial triangulation ground control points. And then key points recognized as the same point through cross-correlation among overlapped photos were automatically matched and then point cloud with 3D ground coordinates were generated from matched key points. Lastly, 3D texture models corresponding the flight paths were constructed by performing 3D mesh redering. Because octtree value, which determines the minuteness of 3D texture model in data processing, or texture resolution influence unintentionally on an end product of 3D texture model, the same values were applied regardless of photo flight path.

Table 2 shows the result of quantitative analysis for check points and Figure 8 illustrates the result of qualitative analysis which evaluates the quality of 3D texture model.



(a) Input of photos and GCPs (b) Automatic AT (c) Point cloud generation (d) 3D texture model product

Figure 7. Procedure of data processing

Table 2. Errors vs. photoflight path type (unit: cm)

	single path		cross path		double cross path	
	ΔXY	ΔZ	ΔXY	ΔZ	ΔXY	ΔZ
CP 1	4.2	5.6	4.7	4.9	4.1	6
CP 2	3.5	5.4	4	5.2	3.2	4
CP 3	4.6	6.9	4.2	6.3	3.6	7.9
CP 4	4	6.4	3.5	6.1	3.9	4
CP 5	4.3	6.6	4.5	5.5	4.6	5.7
mean	4.12	6.18	4.18	5.6	3.88	5.58
RMSE	2.03	2.48	2.04	2.37	1.97	2.36

(a) Single path

(b) Cross path

(c) Double-Cross Path

Figure 8. Comparison of quality of 3D texture model according to photographing path

Figure 9. High-quality 3D texture model of the study area

4. Conclusion Remarks

As a result of analyzing check points, horizontal and vertical errors were shown almost similarly regardless of photographing path. In qualitative evaluation, it was ascertained that the results of double path were high-quality 3D texture model closer to reality comparing to those of single path.

Above all, in order to acquire high quality 3D spatial information using fixed-wing UAV, various factors such as flight path, flight height, tilt of body, overlap, lens view angle and so forth should be considered.

It is advisable that double cross path which considers topography and building height is utilized for high-quality 3D virtual city, 3D cadastre, BIM, construction and so forth.

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