Social Tenure Domain Model And 3d Modeling By UAV Photogrammetry

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Key words: Cadastre 2014, Social Tenure Land Management, 4D- Image Map Archive, Photogrammetric 3D modeling, UAV bundle aerial triangulation

SUMMARY

FIG 2014 in Kuala Lumpur had reached to the summary of Cadastre 2014 vision. Cadastral system includes in an extended sense not only Land Administration Domain Model but also Social Tenure Domain Model and UN-habitat initiative. UN-Global Geospatial Information Management (GGIM) and UN-Global Geodetic Reference Frame (GGRF) initiatives were resolved in Social Economical commission of United Nations. Environmental issues, like peatland problems in tropical rain forest area, are keen phenomena to be solved, technologically, sociologically and economically. Research areas have been conducted by aerial photogrammetry for many decades, producing topographical maps. Now satellite photogrammetry to create 3D stereo models not only for mapping but also for infrastructural analysis has established with 3D photogrammetric system and 3D stereo viewing system with and without 3D glasses. Peatland and slash-and-burn farming are to be reported as successful results. For public projects, cadastral specification could be proposed as ALKIS German cadastral survey established as German style GIS (GeoInformationsSysteme in German).

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1. 3D IMAGE MODELING AS HISTORICAL REALITY OF THE LAND AND LANDSCAPE

3D image modeling and measurement has been well organized in mapping business, but the operational procedures are not well understood. As point clouds from LIDAR datasets and ortho- image driven 3D-diorama are popular in landscape watching and infrastructure viewing, the point measurement accuracy are not well compared. And old aerial photos were once used for photogrammetric mapping, with analogue, analytical and digital stereo-plotters, and are kept as roll- negative films and paper prints like documental records. If we could reconstruct 3D image models out of old aerial photos, since 1920 to 2000, we could construct 4D Image Map Archive with historical maps, since 1850s to 2000. Those 3D image models could be transformed into 3D diorama, which could be archived and measured as Historical Reality.

1.1 Historical maps on the CAD-Globe

In Japan, the most historical maps were edited in 1880s as 200K maps with 4 corners of Latitute and Longitude and Orthometric Height based on Bessel 1841 global ellipsoid. The original maps of sea shore lines in the above maps in 1880s were transferred to " ATLAS: Heinrich Berghaus : Physikalischer Atlas zu Alexander von Humboldt, KOSMOS, Entwurf einer physischen Weltbeschreibung" .

130 sheets of 200K maps in 1880s are now projected on CAD-Globe on AutoCAD- Infraworks as the standard platform of 4D-Image Map Archive in a scalable graphics, with compatible coordinate system and map projection in WGS84 ellipsoid. Since then Japanese mapping system had been based on Bessel 1841 ellipsoid and polyhedron map projection based on plane table surveying. In 1952, Japan introduce UTM and TM map projections, parallel with USGA transition from polyconic to UTM map projections worldwide. And in 2000 Japan geodetic datum was transformed into GRS80 ellipsoidal geodetic datum. Now UN-GGRF initiative is being promoted in the world, accelerated by GNSS technology.

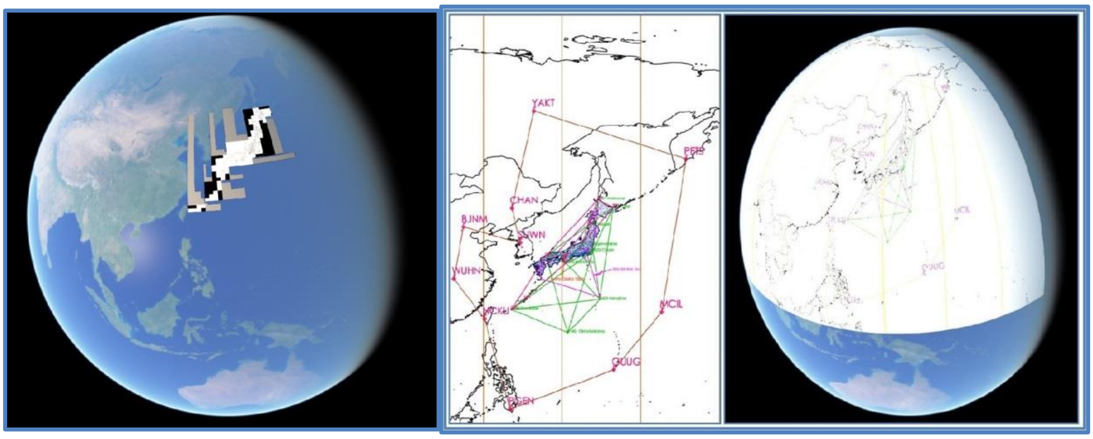


Fig. 1 1880 Japan maps on CAD-Globe and IGS-Japan Network on AutoCAD Infraworks

1.2 Historical aerial photos and 3D Image Modeling on 3D-CAD system

Historical aerial photos of Angkor Wat were taken by BRAF in 1945 with reconnaissance camera, and stored in University of London and Kyoto University, Center for South East Asian Studies, with other "Gaihou-Zu: Japanese Military Maps before and during the WW II.

In 2017, 50 photo images on 2 strips were generated as 3D Image models on Summit Evolution and AutoCAD- Civil 3D. In 2010s, some of the aerial photos in Japan were also created as 3D Image models after bundle triangulation. Some common identified GCPs are used to transform 3D image models into common geodetic datum and map projections.

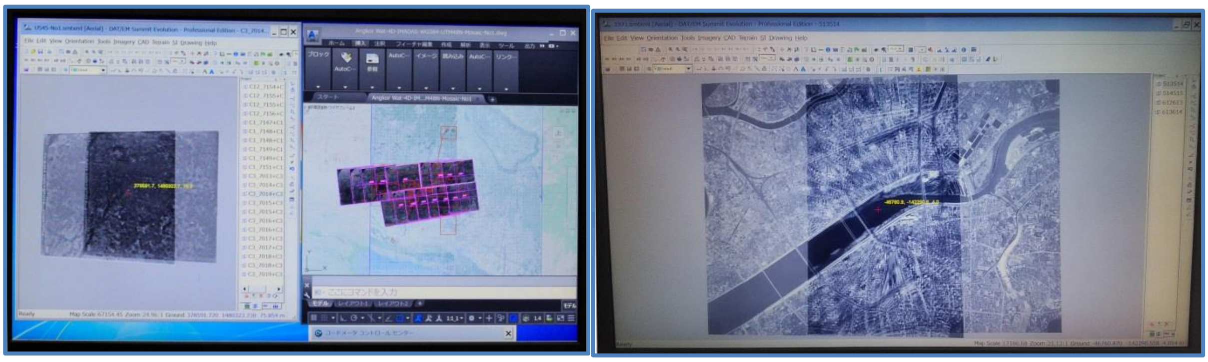


Fig.2 Summit model - Civil3D 1945 and Summit Evolution – Osaka 1971

1.3 Historical Reality of land ownership

Land ownership and territory are originally natural boundaries, such as mountain ranges, water streams island sea shorelines, but later divided by artificial consensus between the parties of interest. So to reconstruct the boundaries on 3D image model based on formal coordinate system is one of the basis of reasonable approach, parallel with documental evidences on treaties and other diplomatic materials. For consensus between the parties, as Historical Reality, 3D image models are presented on 3D display in the environment of 3D-CAD supported by map projections. For this purpose, we could use 3D- synchronic glasses on 3D display, or non-glasses (naked eyes) on 3D display as the following figure.

Fig.3 3D-displays without and with Glasses

1.4 landscape approach of social tenure domain model

Christiaan Lemmen of the University of Twente says " Land Administration Systems (LASs) provide the infrastructure for implementation of land polices and land management strategies in support of sustainable development. This infrastructure includes a legal framework, institutional arrangements, processes, standards, land information, management and dissemination systems, and technologies required to support the allocation, markets, valuation, control of use and development of interests in land. In many countries such infrastructure is not available with a nationwide coverage. In fact this is the case in only 25 to 30 countries worldwide. Most developing countries have less than 30% cadastral coverage. Moreover, it can be observed that existing land administration systems have limitations because of the fact that informal and customary tenures cannot be included in these registrations, which particularly affects the poor in society. Existing land administration systems require substantial changes to include all existing types of tenures. But the need for this is not always recognized and institutional changes are not so easy to implement. The Global Land Tool Network (GLTN), facilitated by UN-HABITAT, is a coalition of international partners, which has taken up this challenge and is supporting the development of pro-poor land management tools, to address the technical gaps associated with unregistered land. The security of tenure of people in these areas relies on forms of tenure different from individual free hold. Most off register rights and claims

are based on social tenures. GLTN partners support a continuum of land rights, which include rights that are documented as well as undocumented, from individuals and groups, from pastoralist, and in slums which are legal as well as illegal and informal.
The overarching goal of the project has been the development of a prototype of a pro-poor land information management system for use in supporting the land administration of the poor in urban and rural areas, allowing the accommodation of local social tenures, which can also be linked to the existing cadastral system in order for all information to be integrated. This system is called the Social Tenure Domain Model (STDM).
The objectives of the project were the following:
* Development of a conceptual model explaining the objective, flexibility, capability and operability of the STDM in relation to management of a wide range of land tenure issues and with a specific emphasis on empowering the poor;
* Development of a prototype open source software for the core content of the STDM;
Testing and validating the core STDM software; and
* Development of relevant documentation and a user-friendly guide and training material."
Then from technological standpoint, we could propose Photogrammetric 3D image modeling.

2. PHOTOGRAMMETRIC 3D IMAGE MODELING

2.1 Drone Photography and Photogrammetry

Drone photography or UAV(Unmanned Aviation Vehicle) is now leading engine of photogrammetry, reducing the following restrictions and expanding the feasibilities.
1) Unmanned and auto controlled capability, with viewing like a bird
2) Easy to learn and to go operations for un- experienced photogrammetrist
3) Application oriented usage, for forestry, disaster research and viewing around tourism
4) Smart phone/ Tablet supported image communication in real time mode
5) We could expect further more development with Robotics and Artificial Intelligence.
On the other hand, comparing with existing photogrammetry, especially close-range photogrammetry, contemporary technological gaps as follows;
1) Accuracy standard: mainly camera calibration and 3D Image modeling (Orientations)
2) Operational range, limited by communication control reliability
3) Weather conditions, restricted by the drone specifications
4) 3D image model configuration based on bundle adjustment is not mature
Then authors applied the most popular drone system ; DJI Phantom 4 in Kalimantan Peatland

research project. Starting from basic operations, flight planning and area covering flight control have been successfully completed, and proceeded to Pix4D 3D Image modeling software and presentation of 3D diorama (point cloud) of research area.

Fig.4 Kalimantan/ Indonesia DJI Phantom 4 /
Flight control Drone tutorial course / Boat yard/ Start flying/ during flight

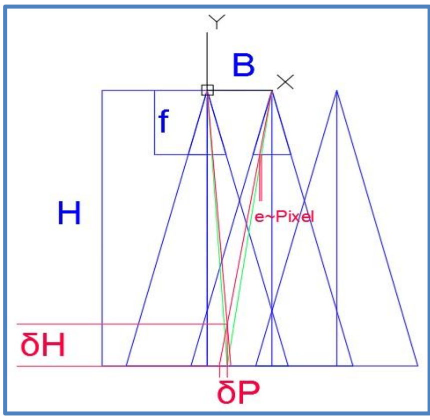
2.2 Helicopter Photogrammetry

Helicopter Photogrammetry is an authentic approach of close-range photogrammetry which is described in the most advanced textbook, like " Close-Range Photogrammetry and 3D Imaging ". 3D image models are precisely measured at the level of 1/3- 1/5 pixel size. So in 3D image model, in case of vertical imaging, accuracy models are expressed, as a rule of thumb, in the following formula.

Planimetric Accuracy : $\delta P = H/f \quad * \varepsilon$ (≈ pixel size)

Height Accuracy : $\delta P = H/B * H/f \quad * \varepsilon$ (≈ pixel size)

In case of vertical photography (Imaging)



Freight Height (H)	300m	300m	Aviation regulation
Focal Length (f)	70mm	300mm	Canon zoom lens
Image Scale(f / H)	1/ 4,286	1/1,000	
Image Size (36mm x 24mm) Base (60% O.L.)	(154.3m x 102.9m) 36mm x 0.4 x Image Scale = 61.7m	(36m x 24m) 36mm x 0.4 x Image Scale = 14.4m	On the ground
H/B ratio	4.86	20.8	Sensitive on Height Accuracy
Image Pixel Size	5um	5um	
Planimetric Accuracy : δP	21mm	5mm	
Height Accuracy : δP	101mm	104mm	

Fig. 5 Accuracy calculation : Flight plan B/H ratio issue

And standard procedures in photogrammetry is as follows;

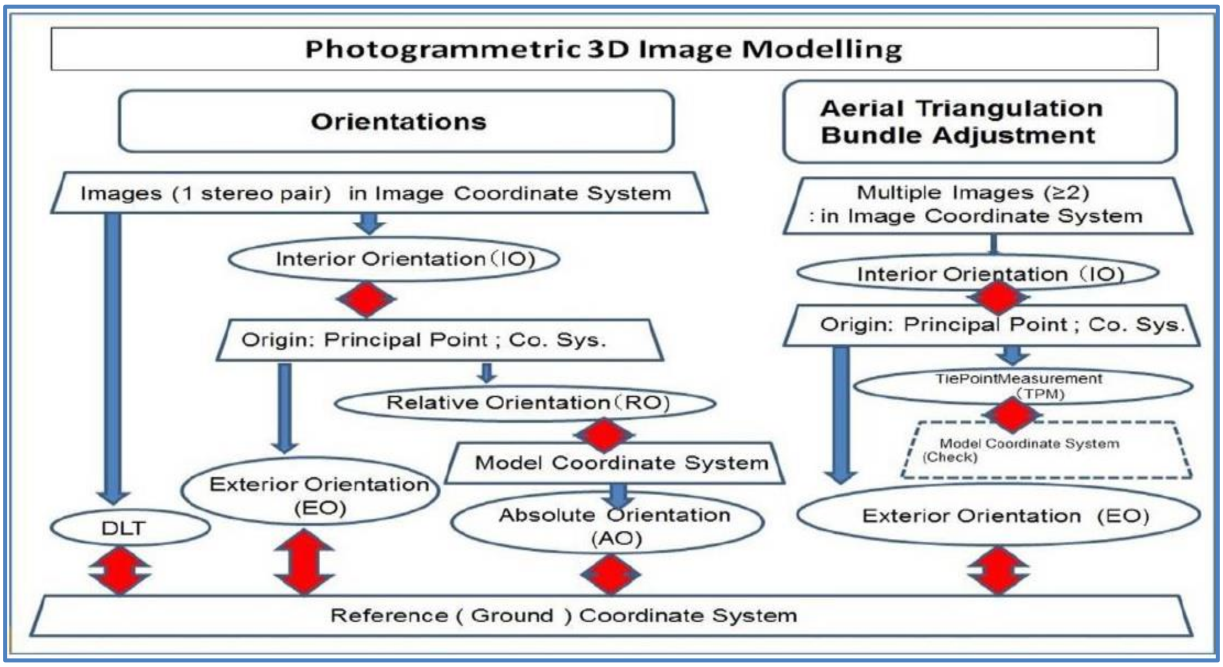


Fig. 6 Photogrammetric 3D Image Modelling

2.3 Satellite Photogrammetry

Satellite photogrammetry deals with different type of image stereo set, from camera stereo 3D image model as follows;

Fig. 7 Satellite Photogrammetry

For 3D image modeling, RPC (Rational Parameter Coefficient) parameters are used, but in photogrammetric 3D image measuring system, like Summit-Evolution, X-, Y- parallaxes should be got rid of tie point measurement module, to establish the parallax- free model. This procedure requies further rigorous absolute orientation different from " Spatial Similarity Transformation". Currently the reached accuracy is about the size of ground pixel size (50cm) at check points measured by FKP –GNSS surveying (σ= 1cm).

In this respect, satellite photogrammetry could set up 3D image models with the accuracy of pixel size, then this is the reason why we recommend to launch 3 directional Line-sensor satellite for 3D mapping on the ground. The other advantage of 3 directional Line- sensor satellite is the height accuracy derived from B/H ratio of this structure.

Essential steps for satellite photogrammetry is relative 3D modeling of stereo images and so-called Absolute Orientation according to the characteristics of the Line- sensor images.

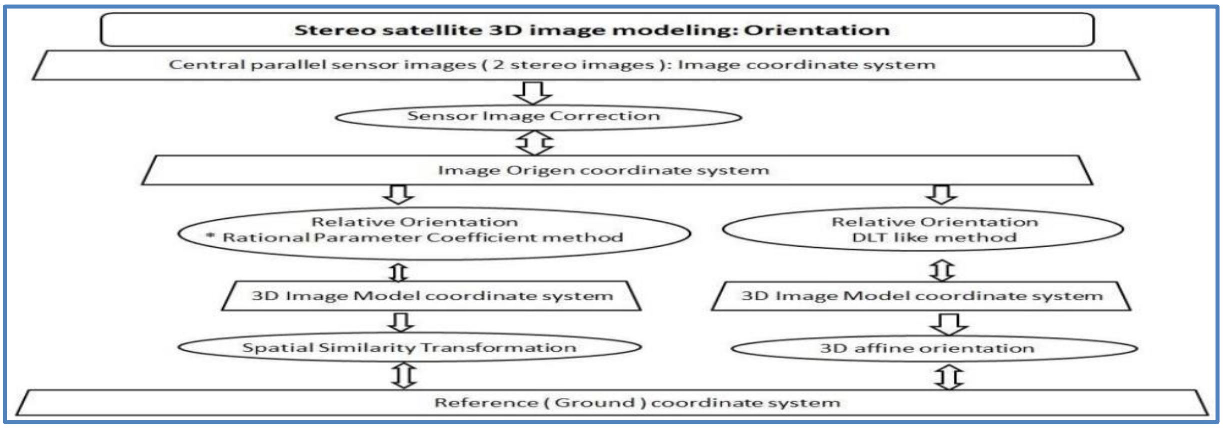


Fig. 8 Stereo satellite 3D image modeling - Orientations

3. CADASTRAL 3D MAPPING

Cadastral standard is well described "Cadastre 2014" after 20 years research works. Along this vision, Land Administration Domain Model and Social Tenure Domain Model are proposes. Land ownership, land administration and land registration are quite differ from country to country in the world. One of the major tasks of Geographic Information System or GeoInformatics is cadastral survey and system configuration based on the maps.

3.1 Cadastral 3D mapping in rural area and social tenure area

In the vast rural area, the ordinary topographical mapping with aerial cameras are now abandoned with film type large frame camera and photo-laboratory. Instead satellite photogrammetry is not well suited for 3D mapping, and digital cameras are to be modernized with flight-planning, flight-control and bundle adjustment for 3D Image measuring system.

In 3D image modeling, social tenure area is also large size area for mapping, and the products, 3D map or 3D models are not yet administrative tools for cadastral survey.

3.2 Cadastral 4D mapping in Oil exploration business

We could learn from Oil exploration business, like Mexican gulf, that they established uniformed map projections in 4D (X,Y,Z and T) according to the exploration rights.

3.3 Cadastral 3D mapping and 3D city modeling

Cadastral 3D mapping is closely related with taxation purposes of tall buildings in urban area, and 3D city modeling is now most urgent tasks of land administration authorities.

3.4 Cadastral, topographical, land-use, soilology-geology maps

Efficiency and popularity of Google-Map and Google-Earth has already influenced map production policies, for topographical, land-use, soilology- geology map productions. For this we do need new definition of map object, presentation method and representation media for various purposes in administrative organizations and citizenship.

4. CONCLUSION : PEATLAND 3D CADASTRAL MAPPING

Facing to climate change and natural disasters, vast area of tropical forest is now changing to other land-uses and land-ownership. Layer structure of peatland should be well mapped for administration purposes, and Land Administration Domain Model and Social Tenure Domain Model are to be realized in Peatland 3D cadastral mapping.

4.1 Peatland features

Peatland features are derived from generation/transition/ process of each peatland. Different aspects and viewpoints need to have specified mapping expressions according to peatland features.

4.2 3D modeling approaches

Applicable approach for 3D modeling are listed as follows;

1. Photogrammetry: drone, helicopter, satellite photogrammetry
2. LIDAR terrain surfacing
3. Satellite sensor terrain surfacing and presentation

As major products, 3D image model, Ortho-image, DEM height data and derived analysis data sets.

4.3 Peatland oriented topographic map

As Kalimantan Peatland area has the largest portion of the area, so ground control, topographic mapping could be realized in defining peatland features with facility features.

4.4 Peatland oriented cadastral map

As for land registration process, Peatland oriented cadastral mapping is geo-referenced and timely representation of the area, using the above mentioned major approaches.

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BIOGRAPHICAL NOTES

Hiroyuki Hasegawa obtained a BA in Human Geography in 1971 from Kyoto University, Japan. In 1976 he was graduated from ITC, The Netherlands as Photogrammetric Technologist. From 1971 until 1999 he worked at PASCO Corporation in Tokyo, Japan.

From 1999 until now he is working in GeoNet, Inc. in Osaka, Japan.

In 2014 as the researcher of Graduate School of Asian and African Area Studies Kyoto University, Japan, he presented a paper in FIG2014 " Cadastre2014 Japan-Initiative".

Currently, for newly revised cadastral survey specification, he has been conducting accuracy-efficiency evaluation projects with governmental cadastral survey office.

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