YESTERDAY, TODAY AND TOMORROW OF SYSTEMS FOR SPATIAL DATA PROCESSING, ANALYSIS AND REPRESENTATION

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ABSTRACT:

The keynote paper is described through the personal history of the author relating to the activities of ISPRS for thirty years. The aims of the paper are to review the past and present of technical issues and to suggest the key issues for future. At first, the history of photogrammetry, remote sensing and GIS is reviewed. The advancement of computer technologies which influenced the key themes of ISPRS is explained. The theme of ISPRS Commission II has changed seven times in these fifty years which was resulted from the drastic change of technologies inside and outside ISPRS. The current technologies such as digital cameras, GPS/INS, laser scanner, airborne three line scanner etc. are also reviewed. At last, the author suggests what should be solved nowadays and key issues for future.

1. INTRODUCTION

ISP/ISPRS has kept the position of “Center of Excellence” in the technological advancement of photogrammetry and/or remote sensing. There were several epochs in her history as described later. However, as usual in the past ISPRS is standing on a front of big wave which will move drastically. ISPRS Commission II has changed the theme seven times since 1952, fifty years ago and will face also a drastic change in the twenty first century. The author tries to identify key issues for future and to suggest what problems should be solved.

2. HISTORY OF PHOTGRAMMETRY, REMOTE SENSING AND GIS

2.1 My Personal History in ISPRS

My first participation in ISP Congress was 1972 Ottawa Congress. Since then I continued to join the congresses of Helsinki (76), Hamburg (80), Rio de Janeiro (84), Kyoto (88), Washington (92), Vienna (96) and Amsterdam (00). This year my history in ISPRS has become just thirty years. I was lucky to be engaged in different roles as Secretary of Commission I (1976-80), Congress Director of Kyoto Congress (84-88), Secretary General (88-92), President (92-96), First Vice President (96-00) and finally Honorary Member (96-present). In my thirty year history, I continued to think of ISPRS in which direction we should go.

2.2 History of Photogrammetry

The history of photogrammetry is classified into the four generations as follows:

1. First Generation: 1850-1900; The history of photogrammetry started after the invention of photography in 1839. The main technologies were terrestrial and balloon photogrammetry.
2. Second Generation: 1900-1950; The epoch was the invention of airplane in 1905. Since then aerial survey has started with optical and mechanical technology, that is analog photogrammetry.
3. Third Generation: 1950-present: The epoch was the invention of computer in 1950’s which enabled analytical triangulation though analog photogrammetry was still available.
4. Fourth Generation: 1990-present; The epoch was invention of digital cameras or CCD sensors which made possible digital photogrammetry, though analytical photogrammetry is still working together.

I am involved in the third and fourth generation with the progress of computers. My first work as a photgrammetrist was to develop software of least square method in machine language in 1966. If I look back to that time, I could not imagine how fast the computer progressed up to the current stage.

2.3 History of Remote Sensing

The history of remote sensing can be said to start from the launch of LNDSAT-1 in 1972 though the remote sensing was involved in military and limited organizations before 1972.

1. First Generation: 1972-1985; Only American satellites such as LANDSAT MSS and TM were available. The resolution was 30-80 meters for 1/250,000 land cover map.
2. Second Generation: 1986-1998; International participation in space technology started. French SPOT (86), Japanese MOS-1(87) and JERS (92), Indian IRS-1A(88), ESA ERS (91), Canadian RADARSAT (94) etc. were the examples. The maximum resolution was 5.8 m of Indian IRS 1C and 1D and 10 m of SPOT HRV which made possible to produce up to 1/75,000 topographic maps.
3. Third Generation: 1999-present; Commercial high resolution satellite imagery such as IKONOS and Quick Bird with 1 meter or sub-meter resolution started available.

I was lucky to be involved in remote sensing since the pre- first generation in 1970. Therefore I will be able to review the history of remote sensing through my real experience.

2.4 History of GIS

1. First Generation: 1970's; Though the concept of GIS was proposed in 1960's, the actual history of GIS started since 1970's together with the advancement of computer and input/output devices. Digital terrain modeling (DTM) and digital mapping or automated drawing were main themes.
2. Second Generation: 1980's; Research and development (R&D) about GIS much progressed, which created GIS venture businesses and software vendors such as ESRI, Intergraph, MapInfo etc. Geographic Information System (GIS) was upgraded to Geo- Information Science or Geoinformatics/Geomatics.
3. Third Generation: 1990's to present; PC based GIS particularly web GIS was developed. Standardization together with the concept of clearing house has become an important issue to promote GIS. ISO TC 211 has been established to goal the standard format GIS data or interoperability of GIS software.

2.5 History of Computer Technologies with respect to ISPRS

The progress of computer technologies gave a great impact on the activities of ISPRS.

1. First Generation: 1960's; computers were not well developed with vacuum tube, but the impact was so big. The development of computer software for aerial triangulation was tackled by many photogrammetrists.
2. Second Generation: 1970'2; though computers were supported with transistors and magnetic core memory as well as FORTRAN, COBOL etc., analytical photogrammetry with analytical plotters was developed. The development of independent model and bundle adjustment was an epoch in ISPRS.
3. Third Generation: 1980's; as the computers were supported with IC memory, virtual memory, time sharing etc., mini-computers and Engineering Work Stations (EWS) were developed. Image processing including image matching and self calibration were major themes in ISPRS.
4. Fourth Generation: 1990's; personal computers (PC) with the support of operation system (OS) such as Windows as well as networking, started to replace the major role in GIS, computer aided photogrammetry, computer aided teaching etc.
5. Fifth Generation: 2000's (present); as parallel processing, Internet, digital camera, inexpensive color input/out devices etc., are available, knowledge base software such as image understanding to recognize man-made structures from digital imagery, and digital photogrammetry including automated orientation/ triangulation are major themes in ISPRS.

3. DRASTIC CHANGE OF TECHNOLOGIES

3.1 Change of Themes of Commission II

If one reviews the themes of Commission II together with the history of geoinformatic and computer technologies, it would be interesting to realize the change of themes of Commission II since 1948 as follows.

1. 1948-52: 4 years : Plotting Machines & Instruments The practical use of analog plotters was still an important issue at that time.
2. 1952-64: 12 years: Plotting, Theory and Instruments The mathematical development of relative, absolute orientation and atrip adjustment with a link of analog plotters was a main theme.
3. 1964-68: 4 years: Theory, Method and Instruments More attention was given to the theory and method of triangulation rather than plotting techniques.
4. 1968-72: 4 years: Plotting Theory, Methods and Instruments I suppose that plotting was added to delineate the theme of Commission II from the one of Commission III, but still analytical triangulation with the connection of plotters was a key issue in Commission II.
5. 1972-84: 12 years: Instrumentation for Data Reduction Though remote sensing was introduced into ISPRS, photgrammetry was still a major issue in Commission II with respect to instrumentation.
6. 1984-88: 4 years: Instrumentation for Data Reduction and Analysis. Error analysis for analytical photgrammetry as well as analytical plotters was recognized important.
7. 1988-92: 4 years: Systems for Data Processing and Analysis. It was an epoch to realize that Commission II took off the basic ground of photogrammetry but involved remote sensing and GIS in its theme. Data should be not only photogrammetric data but also remote sensing and geographic data.
8. 1992-present: 10 years: Systems for Data Processing, Analysis and Representation. Representation was added in recognition of the importance of image input/output, visualization and animation technologies.

3.2 Epochs of ISP/ISPRS in My Life

I was lucky to have faced many drastic evolutions in the field of geoinformatics as follows.

1. ERTS (LANDSAT-1) was launched in 1972 when I participated in Ottawa ISP Congress. The first image of LANDSAT-1 was displayed a day after the launch, that is 24th July 1972. It was a shock not only to me but to everybody.
2. Analytical plotter was demonstrated at Helsinki ISP Congress in 1976. It seemed a dream to photogrammetrists at that time, though the following marketing of analytical plotters was not very much successful as expected.
3. ISP was renamed to ISPRS in recognition of newly developed discipline of remote sensing at ISPRS Hamburg Congress in 1980.
4. SPOT with the resolution of 10m and stereo function was launched in 1986, when photogrammetry was added newly space photogrammetry in addition to aerial photogrammetry.
5. The Market shift from photogrammetry to GIS was realized at Kyoto ISPRS Congress when I was the Congress Director. Four major players of Zeiss Oberkochen and Yena, Wild and Kern shrinked their exhibition arrears from 1000 sq. meters to 200 sq. meters in total while GIS enterprises such as Intergraph and ESRI increased their exhibition much larger.
6. GPS started 24 hour service in 1993 which enabled operational use of GPS in not only geodesy but also in photogrammetry and remote sensing.
7. GIS and SIS were officially treated as a discipline of ISPRS at General Assembly of Vienna ISPRS Congress when I was the president of ISPRS. The title of ISPRS

archives was renamed as “International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences”.

8. The new logo and the subtitle of ISPRS ; “Information from Imagery” were officially approved at Amsterdam ISPRS Congress following the strategic meeting.

4. TODAY’S TECHNOLOGIES

4.1 Drastic Change of Technologies

Today’s key themes in ISPRS are supported by the following technologies.

1. Evolution of PCs
2. Increased resolution of digital camera
3. GPS/INS
4. Airborne laser scanner
5. Airborne three line scanner
6. High resolution satellite imagery
7. Web GIS

4.2 Japanese Digital Cameras

As of December 2001, there are 53 digital cameras with more than three million pixels on the market in Japan. Five or six million pixels are performed with honey comb signal processing, pixel shift, enhancement etc. Since the first digital camera of SONY MVC-C1 with 0.28 M pixels was on the market in 1988, almost twenty times denser cameras have been developed. For example, there were FUJIX DSX (0.3M) in 1989, CANON Power Shot 600 (0.5M) in 1997, CANON Power Shot Pro 70 (1.2M) in 1999, CASIO QV-3000 EX (3.2M) in 2000, MINOLTA DiMAGE 7 (5.2M) and so on.

Several digital cameras have been certified to be able to use for metric purpose. Such non-metric digital cameras would be a kind of breakthrough technologies in close range photogrammetry.

4.3 Current Technology of GPS/INS

The combination of GPS for positioning and INS or IMU for orientation has become a key issue for achieving aerial triangulation without control points or for drastic reduction of control points. There are two major problems in INS; the accuracy and the cost though GPS’s problem will be less. GPS with the data acquisition of 5-10 Hz must be interpolated along with the rate of image acquisition of 200-500 Hz. More problem will be communication between ground base GPS and onboard GPS, particularly to get permission of radio frequency for the communication.

INS based on gyro technology has a drift problem. GPS will be available for the calibration of the drift since the datum of three axis angles; roll, pitch and yaw are not fixed. The cost depends on the accuracy. If one requires similar accuracy with analytical triangulation in order to avoid control points, around 0.005 degree should be designed, which will make about 300,000 US Dollars. If a stabilizer is combined with a digital camera and INS with the similar accuracy, the cost will be double. Applaunix POS/V 510 will meet such requirement but this is without stabilizer. The airborne three line sensor called STAR IMAGER which was developed by STARLABO, Japan will be GPS/INS/Stabilizer based aerial digital photogrammetric system targeting photogrammetry without control points and aerial triangulation.

5. ASSESSMENT OF CURRENT GEOINFORMATICS

5.1 Digital Photogrammetry

Though I believe that photogrammetry can survive from a view point of recording capability, it has a strong competitor, that is, laser profiler or laser scanner. Photogrammetry has a handicap of complicate procedures such as aerial triangulation, stereo matching, stereo plotting, grouhnjd survey for geodetic control points etc. We need some more far way toward automated procedure.

5.2 Laser Scanning

Though laser scanner has a big merit of direct 3D measurement, a tough procedure such as noise filtering of a huge volume of point clouds, editing from DTM to DEM, verification of aerial triangulation etc.. I think that laser scanner will become a strong tool of 3D measurement, but if combined with phtogrammetry or photography, it will be strengthened with sharp edges of features taken.

5.3 Remote Sensing

High resolution satellite imagery with sub-meter resolution gave an impact against aerial photogrammetry, but it cannot overcome the existing method with respect to large scale of 1/2,500 or larger. Even the cost of digital color orthophoto would be more inexpensive than HRSI. Nevertheless HRSI is expected as a tool of efficient sources for updating the existing maps or databases.

5.4 GIS

Since GIS is defined as an IT(information Technology) in Japan, GIS will be more hopeful in commercial market. But still data acquisition or map digitization is too expensive or inefficient. In order to promote GIS more in developing countries, the cost of GIS software should be lowered. However GIS will be more commercialized than remote sensing in Asia.

5.5 Ground Survey

Since GPS became available in 24H, the ground survey faced a big revolution for positioning. However height measurement from the sea level has still problem of geoid measurement. If one likes to obtain very high accuracy, GPS should be fixed more than half day, even a day, because of fluctuation. Geographic Survey Institute, the Japanese government has decide to release GPS data of about 1,000 electronic control points (GPS Stations) based on RTK to the public. This will be big benefit to private sector.

6. WHAT SHOULD BE SOLVED?

I would like to propose several problems which should be solved for further development of geoinformatics.

1. Automated triangulation: this is almost solved for conventional aerial photgrammetry, but we have to extend to other airborne sensors such as three line scanner and laser scanner.

2. Photogrammetry without control points: on board positioning and orientation with high accuracy should be achieved. GPS/INS will be the solution, but still there are many things to solve.
3. 3D city modeling: this will be solved by integrating laser scanning and photography of both air and ground base.
4. Information extraction of man made structure: we have a far way for the goal. Roads and houses are current targets for achieving 3D GIS.
5. Mobile mapping: real time mapping is a big challenge for GIS data acquisition.
6. True orthophoto: airborne three line scanner will be more efficient to reduce overlapping than existing aerial photography.
7. Automated generation of DEM: automated processing or editing from DSM to DEM should be developed. Dense forest areas should be based on DSM, though clients request DEM rather than DSM.
8. Texture mapping: ground base mobile photography would be a solution. Otherwise gyro controlled oblique aerial photography will be a solution.
9. Integration of total station and digital camera for close range measurement: onsite processing for triangulation with ground based control survey has been developed. In future total station with digital camera should be developed.
10. Multi-sensor system: multi-sensor system with optical, NIR and thermal IR image sensors, GPS/INS/stabilizer, laser scanner, radar, high speed recorder etc. should be developed.
11. Interoperable GIS software: there is still big barrier for interoperability of GIS software.
12. Global digital map of 1/50,000: 50 meter grid base maps would be a target, though it will take many years to go. Full coverage of high resolution satellite imagery would be the alternative.

7. KEY ISSUES FOR FUTURE

I would like to raise several questions to the readers as follows.

1. How to achieve automated or semi-automated 3D measurement for wide coverage ? Which sensor; TLS, laser scanner, or radar? How about image understanding?
2. How to integrate Information and Communication Technology (ICT) with geoinformatics? Which tool will be more useful; PC, mobile phone, PDA, TV or others?
3. How to achieve real time mapping of moving objects from moving platform? How much GPS/INS/Stabilizer will be developed?

8. FUTURE TREND

In conclusion, I like to summarize the future trend as follows.

1. Two way communication using digital imagery and positioning will be more popularized.
2. Visualization and animation will be more available.
3. GIS market will be more expanded.
4. HRSI commercialization will more increase
5. Space technology will become more inexpensive