出國報告(出國類別：國際會議)

IGARSS 2011 國際會議
出席會議報告

服務機關：國立中興大學(土木工程學系)
姓名職稱：蔡榮得教授、葉精國博士生
派赴國家：加拿大-溫哥華市
出國期間：民國 100 年 7 月 25 日至 8 月 2 日
報告日期：民國 100 年 8 月 19 日

一、摘要

派出者與所指導之博士班研究生出席 IGARSS 2011 國際會議，在 2011 年 7 月 27 日下午主題議程『SAR Data Analysis II』會場中共同發表論文『Self-Calibrated Direct Geo-Referencing of Airborne Pushbroom Hyperspectral Images』，經由互動式研討之過程，與現場出席之各國菁英進行解說與研究意見交換，使作者得到許多寶貴的意見及不同的研究方向，有利於本研究之後續發展。參與本次 IGARSS 2011 國際會議，經由參與各項議題之口頭發表與互動式海報發表過程，可深刻了解全球於遙感探測與相關科學技術上最先進的發展與目前相關領域之主軸發展趨勢，並攜回論文集 DVD 光碟片乙片，內含本次會議中所有口頭發表及互動式論文，可供研究需要參考。

二、報告內容

1. 背景

IGARSS 2011 為國際電子電機工程師學會(IEEE)之國際地球科學與遙測學會(IEEE Geoscience and Remote Sensing Society; IGRSS)舉辦之 2011 年國際會議，為地球科學與遙測科技學術界與產業界之最重要國際論壇會議之一，對促進國際上應用遙測資訊決策發展之新知與技術作為全球永續發展(Global Sustainable Development)之基礎技術與學術研究發展上，均具有很重要的地位。本次國際會議原定於 2011 年 8 月 1 日至 5 日在日本-仙台市舉行，然而因為 3 月 11 日於日本發生大地震及引起海嘯與福島核電廠輻射外洩災害，經 IGRSS 與原日本主辦單位協議，改於 7 月 24 日(星期日)至 29 日(星期五)於加拿大-溫哥華市舉行。

2. 目的

藉由出席國際性研討會，除發表研究成果論文、增進國際交流、吸收新知、與了解同一領域之國外研究動態以外，並拓展提昇同行博士班研究生之國際視野與國際觀。

3. 過程

本次會議於溫哥華會議中心(Vancouver Convention Center)舉行，研討議程主要分為口頭發表（Oral Presentations）及互動式海報發表（Poster Interactive Presentations）兩部分進行：口頭發表分為 10 間研討室五天議程分別進行，共分為 174 個議題，總計 1400 餘篇論文發表；互動式海報發表部分為三天各 26 區，共計 76 項主題，總計約 660 餘篇論文進行海報發表，由報告者於大會排定時間內，在張貼之海報旁與其他出席者進行論文解說及學術意見交流。若以 1 篇論文 1 人出席計算，則本會議出席人數超過 2000 人。各項論文探討之課題可主要分為：

(1)主動式與被動式遙測系統之發展與應用、
(2)合成孔徑雷達(Synthetic Aperture Radar，SAR)感測技術之發展、資料處理與率定，
(3)高解析 SAR 影像之應用，
(4)高光譜影像資料處理、分類與應用，
(5)多來源與多時期遙測資料融合，
(6)地球資源環境監測與管理，
(7)大氣及植生參數推求，
(8)遙測影像分類與特徵萃取，
(9)地理資訊系統技術，

等全球最前端、先進的研究成果報告於大會中進行技術分享及意見交流。於海報發表會場中，並有各國廠商設立攤位，如美國國家航空暨太空總署(National Aeronautics and Space Administration，NASA)、日本ERSDAS(Earth Remote Sensing Data Analysis Center, ERSDAS, Japan)、日本三菱電機股份有限公司(Mitsubishi Electric, Japan)、韓國 KARI(Korea Aerospace Research Institute, KARI, Korea)等各國產官學界相關廠商，提供最新進儀器展示說明及遙測技術介紹。

於本次會議中，蔡榮得教授與所指導之博士班研究生葉精國，共同發表一篇論文『Self-Calibrated Direct Geo-Referencing of Airborne Pushbroom Hyperspectral Images』(全文收錄於DVD光碟及IEEE eXplore電子資料庫，海報如附件)，於7月27日(星期三)下午主題議程『SAR Data Analysis II』（WEP.B.7）中採海報互動式發表方式，本論文主要應用自率法平差，藉由精確的地面控制資料，解算整合空載推掃式高光譜感測系統ISIS與直接地理對位系統求取各掃描影像之外方位參數時，於整合系統上存在的各項系統誤差參數，藉以有效提升ISIS影像之幾何改正精度。於會中與多位學者進行現場解說與研究意見交換，多數學者針對本研究中之自率法平差技術較為陌生，但經由研討及意見交換之過程中，了解整體系統模式、選用系統改正參數及地面控制情況，並經由互動式研討之過程，使作者得到許多寶貴的意見及不同的研究方向，有利於本研究之後續發展與前景，增進學術交流與提升研究生國際視野。

4. 心得及建議事項

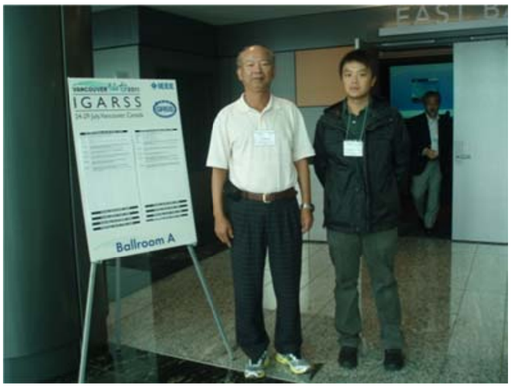
參與本次IGARSS 2011國際會議，經由參與各項議題之口頭發表與互動式海報發表過程中，可深刻了解當下全球於遙感探測與相關科學技術上最先進的發展，與目前相關領域之主軸發展趨勢，如本次會議中主動式遙測系統及SAR影像感測系統與應用之相關論文佔了相當多的比重，由於SAR影像其較不受天候影響，且可獲得高解析地面資訊等特性，使高解析SAR影像發展應用儼然為目前全球遙測領域非常熱門的課題之一。於遙測技術發展上，各項技術皆不斷的持續發展，經由參與此等國際性會議，方得增進學術交流與增廣識界及國際觀，建議於經費許可情形下，應多鼓勵本校教師及研究生參與國際學術活動。

本次會議攜回論文集DVD光碟片乙片，內含本次國際會議中所有口頭發表及海報互動式發表論文，可供研究需要之參考。

三、出席會議照片與相關資料

(a)會議地點：溫哥華會議中心(East)

(b)註冊報到會場留影



(c)口頭發表會場留影

(d)IGARSS 2011 論文集 DVD 光碟

(e)大會議程秩序冊

IEEE International Symposium on Geoscience and Remote Sensing – IGARSS 2011 in Vancouver

WEP.A: Wednesday, July 27, 17:00 - 18:30

WEP.A — **Bistatic SAR I**
Session Type: Poster
Time: Wednesday, July 27, 17:00 - 18:30
Place: Poster Area A
Chair: Francisco Lopez-Dekker, German Aerospace Center (DLR)

WEP.A.1 — **SPACE TIME ADAPTIVE PROCESSING FOR MOVING TARGET DETECTION AND IMAGING IN BISTATIC SAR**
Viet Thuy Vu, Thomas K. Sjögren, Mats I. Pettersson, Blekinge Institute of Technology, Sweden

WEP.A.2 — **TARGET IDENTIFICATION BY A PASSIVE BISTATIC MONOCHROMATIC WAVE RADAR**
Mojtaba Amiri-Sazi, Franck Daout, Francoise Schmitt, SATIE, ENS Cachan, CNRS, UniverSud, France

WEP.A.3 — **AN EXPERIMENTAL STUDY ON ENHANCEMENT OF THE CROSS-RANGE RESOLUTION OF ISAR IMAGING USING ISDB-T DIGITAL TV BASED PASSIVE BISTATIC RADAR**
Shohei Nakamura, Kei Suwa, Shinichi Morita, Kazuhiko Yamamoto, Toshio Wakayama, Tadashi Oshima, Ryoji Maekawa, Shoji Matsuda, Mitsubishi Electric Corporation, Japan

√ WEP.A.4 — **GPU-BASED PARALLEL BACK PROJECTION ALGORITHM FOR THE TRANSLATIONAL VARIANT BISAR IMAGING**
Xin Zhang, Xiaoling Zhang, Jun Shi, Zhe Liu, University of Electronic Science and Technology of China, China

WEP.A.5 — **MULTISTATIC SAR EXPLORATION USING MULTI-CHANNEL RECEIVING SYSTEM**
Yunkai Deng, Robert Wang, Zhimin Zhang, Jiaiang Hou, Space Microwave Remote Sensing System Department, China; Otmar Loffeld, Holger Nies, University of Siegen, Germany

WEP.A.6 — **POTENTIAL APPLICATIONS OF HYBRID BI- AND MULTI-STATIC SAR BASED ON GEOSYNCHRONOUS ORBIT ILLUNINATOR**
Yunkai Deng, Robert Wang, Haisheng Xu, Yue Liu, Institute of Electronics, Chinese Academy of Sciences, China; Otmar Loffeld, Holger Nies, University of Siegen, Germany

WEP.A.7 — **EXPERIMENTAL STUDY FOR GNSS-R POLARIMETRY**
Ryuta Kato, The University of Tokyo, Japan; Hirobumi Saito, Seisuke Fukuda, Japan Aerospace Exploration Agency, Japan

WEP.A.8 — **NONPARAMETRIC FEATURE SELECTION AND SUPPORT VECTOR MACHINE FOR POLARIMETRIC SAR DATA CLASSIFICATION**
Yasser Maghsoudi, Michael Collins, University of Calgary, Canada; Donald Leckie, Pacific Forestry Centre, Canada

WEP.B: Wednesday, July 27, 17:00 - 18:30

WEP.B — **SAR Data Analysis II**
Session Type: Poster
Time: Wednesday, July 27, 17:00 - 18:30
Place: Poster Area B
Chair: Irena Hajnsek, German Aerospace Center (DLR)

WEP.B.1 — **COMPRESSIVE SENSING APPLIED TO IMAGING BY GROUND-BASED POLARIMETRIC SAR**
Riafeni Karlina, Motoyuki Sato, Tohoku University, Japan

WEP.B.2 — **AN EFFICIENT VISUAL SALIENCY BASED TARGET DETECTION ALGORITHM FOR SAR IMAGE**
Wei Zhou, Jian Guan, Naval Aeronautic and Astronautic University, China

WEP.B.3 — **COSMO-SKYMED SAR DATA TO OBSERVE SMALL METALLIC OBJECTS FROM OCEAN CRASHED AIRCRAFT**
Rafael Lemos Paes, Institute for Advanced Studies, Brazil; Ferdinando Nunziata, University of Naples, Italy; Elcio Hideiti Shiguemori, Institute for Advanced Studies, Brazil; Maurizio Migliaccio, Antonio Montuori, University of Naples, Italy

WEP.B.4 — **COMPRESSIVE SAMPLING FOR MICROWAVE TOMOGRAPHY**
Roberta Autieri, Università di Napoli Parthenope, Italy; Michele D'Urso, SELEX Sistemi Integrati S.p.A., Italy; Stefano Malonga, Vito Pascazio, Università di Napoli Parthenope, Italy

WEP.B.5 — **TERRAIN CHARACTERISATION OF HEARD, MCDONALD AND MACQUARIE ISLANDS USING MULTI-FREQUENCY INTERFEROMETRIC SYNTHETIC APERTURE RADAR (INSAR) DATA.**
Anthea Mitchell, Alex Hay-Man Ng, Jung Hum Yu, Linlin Ge, University of New South Wales, Australia

WEP.B.6 — **JPSS CGS TOOLS FOR RAPID ALGORITHM UPDATES**
Kerry Grant, Gary Route, Raytheon Company, United States

WEP.B.7 — **SELF-CALIBRATED DIRECT GEO-REFERENCING OF AIRBORNE PUSHBROOM HYPERSPECTRAL IMAGES**
Ching-Kuo Yeh, Victor J. D. Tsai, National Chung Hsing University, Taiwan

WEDNESDAY

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(f)論文發表議程

IEEE IGARSS 2011, Vancouver, Canada

SELF-CALIBRATED DIRECT GEO-REFERENCING OF AIRBORNE PUSHBROOM HYPERSPECTRAL IMAGES

Ching-Kuo Yeh and *Victor J. D. Tsai*[*]
Department of Civil Engineering, National Chung Hsing University,
Taichung 40227, TAIWAN

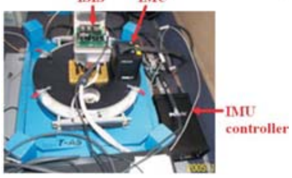
The basic idea of direct geo-referencing (DG) was realized and refined in this paper by introducing 19 additional parameters for self-calibration of airborne pushbroom hyperspectral images with in-flight GPS/IMU data. It is demonstrated that the proposed self-calibrated DG approach significantly rectify the geometric distortions caused by misalignments in GPS/IMU, aircraft vibration, interior parameters of the sensor's optical system, and variations in pixel ground resolution and topography.

Advantaages of Airborne Hyperspectral Imager

1. High spectral resolution
2. Mobility in image acquisition
3. Abundant wealth of spectral variations of the ground surface within tiny spectral bandwidth

Integrated airborne hyper-spectral ISIS scanner

1. Manufactured in 2004 by ITRC of NARL
2. Partially supported by NCHU
3. 240 bands in spectral range between 435~945 nm
4. ISIS scanner, IMU, and GPS
5. IGI AeroControl CCNS4
6. Applanix POS AV510

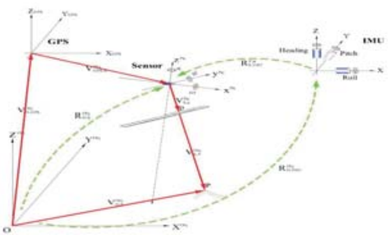


METHODOLOGY

The DG approach for orthoimage production using line scanner imagery usually implements three-dimensional conformal transformations

$$\vec{r}^{\,Obj}_{O-P} = \vec{r}^{\,\Pr j}_{O-S} + s_G \cdot R^{Obj}_{O-S} \cdot \vec{r}^{\,\Pr j}_{S-p}$$

$\vec{r}^{\,Obj}_{O-P}$:the vector of target point to origin in object space
$\vec{r}^{\,\Pr j}_{O-S}$:the vector of center of sensor to origin in object space
s_G :the scale factor from image frame to object space
R^{Obj}_{O-S} :the rotating matrix between image frame and object space
$\vec{r}^{\,\Pr j}_{S-p}$:vector of center of sensor to point p in image frame



Additional parameters of the self-calibrated DG approach

1. GPS receiver lever-arm offsets
2. Misalignments in IMU boresight angles
3. Scaling factors of the on-board T-AS platform
4. Variation of the sensor's CCD size in column direction
5. Interior orientation parameters of the sensor's optical system including offsets
6. The topography of the earth surface

These parameters were determined in a least squares solution of the linearized observation equations formed by using a series of well-distributed GCPs and DEM data describing the topographic surface. Bilinear interpolation technique was thereby applied for radiometric resampling of the rectified images during the process of georeferencing.

EXPERIMENTS

A strip of raw ISIS images with 2250 lines x 1150 pixels in 1.16m ground resolution covering the north bank of Tachia river in Waipu District, Taichung, Taiwan was used in the experiment. Thirty eight GCPs, whose ground coordinates were surveyed by using GPS-RTK approach, along with the GPS/IMU data for each scan line and 20m DEM data were used to solve for the 19 additional parameters by least squares method.

Raw ISIS images in 1.16m ground resolution (2250 lines x 1150 pixels; Red: λ182=869.9nm, Green: λ94=654.6nm, Blue: λ52=551.9nm).

Self-calibrated DG rectified ISIS images in 1.0m ground resolution (2998 lines x 3133 pixels)

Residuals of GCPs after applying the proposed self-calibrated DG approach ($RMSE_X$=2.31m, $RMSE_Y$=2.06m, $RMSE_H$=0.84m, RMSE=3.21m).

Residuals of GCPs after applying the conventional DG approach without calibration ($RMSE_X$=18.89m, $RMSE_Y$=14.86m, $RMSE_H$=1.98m, RMSE=24.11m)

CONCLUSIONS

The GPS/IMU data recorded on board Applanix POS AV510 provides a rough solution to the conventional DG approach. The basic idea of DG was refined in this research by introducing 19 additional parameters for self-calibration of the airborne pushbroom ISIS hyperspectral images. The experimental results showed that the proposed self-calibrated DG approach significantly reduces the geometric distortions caused by misalignments in GPS/IMU, aircraft vibration, variations in CCD resolution, interior parameters of the scanner's optical system, and topographic variations.