Nepal Remote Sensing and Photogrammetric Society
(NRSPS)

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Editorial

As a pioneer professional organization working in the domain of Remote Sensing and Photogrammetry of Nepal, Nepal Remote Sensing and Photogrammetric Society (NRSPS) is pleased to see this Eleventh issue of Earth Observation Newsletter on your hand.

The use of photogrammetry and remote sensing technology in Nepal have come a long way since early nineties. The establishment of National Remote Sensing Center through the joint co-operation between HMG Nepal and U.S. aid in early nineties was a landmark in using remote sensing technology while photogrammetry technology was adopted very first by Survey Department for the preparation of basic topographic maps of East Nepal by capturing photos using airplane. Since then photogrammetry and remote sensing technology have been adopted by several government and semi-government organization, INGOs, NGOs, universities and private sector for different mapping and development goals.

Nepal has been witnessing the availability of state of art products of photogrammetry and remote sensing in three V's form i.e. volume, velocity and variety. However, the full capabilities of it have not been exercised yet. This is where artificial intelligence (AI) comes into play. At present, AI has been rapidly evolving and geoinformatics sector is the one of the areas where it has been making significant strides. There is a natural synergy between the geoinformation sciences and AI due to the vast quantities of geolocated and time stamped data being generated from various sources, including satellite imagery, street level images, and video and airborne and unmanned aerial system (UAS) imagery, as well as social media data, text data, and other data streams. AI has been helping to improve the efficiency and accuracy of geoinformatics operations and with AI algorithms, geoinformatics experts can now process large amounts of spatial data in real time, enabling them to make more informed decisions quickly. AI has ability to process large amounts of data at a faster rate than humans could ever achieve.

Artificial intelligence can be boon for the photogrammetry and remote sensing user in Nepal for creating up-to-date geospatial information. One of the significant benefit is its ability to automate repetitive tasks. This automation helps to reduce the workload on geoinformatics experts, allowing them to focus on more complex task that require their expertise. Additionally, automation helps minimize errors, making the operations more accurate, accessible and affordable. Another area where AI can particularly be useful in Nepal is disaster management. Nepal is prone to earthquakes, floods and landslide and the accurate and timely management of these disaster is critical. AI- powered tools can help predict and monitor these natural disasters, allowing authorities to take preventive measures and respond quickly in case of emergencies.

AI has tremendous potential to transform the geospatial sector but there are also concerns about the implication of AI on geospatial domain in Nepal. One is that there are no widespread implementation for promotion of AI in this domain. Another concern is the potential for bias in AI algorithms which could lead to inaccurate or unfair results. So, it is crucial to ensure that the technology is developed and deployed responsibly, with a focus on ensuring that its benefits are shared by all. With careful planning and responsible deployment, AI can help Nepal to pioneer geoinformatics domain contributing to sustainable development of the country.

This edition of the Earth observation Newsletter has focused on AI highlighting the applications and researches done by individuals and organizations using AI in geospatial domain. In this article, we bring into focus some of the use cases of AI done by Nepalese professionals in research and academic, and application domains. In the research and academic domain, we present the synopsis of research works done by Er. Janak Parajuli, Er. Tina Baidar, Er. Sanjeevan Shrestha and academic activities done by the Department of Geomatics Engineering, Kathmandu University, whereas in application domain, the work done by NAXA is presented.

Through this newsletter we aim to encourage geospatial engineers, scientists and administrators to create an amiable environment for optimal and systematic application of AI in geospatial domain. We also aim to inspire young generations to research and further develop and apply this fascinating technology for mapping and other development activities.

In this issue.....

Message from the President

Dear member of Nepal Remote Sensing and Photogrammetric Society

It is an honor to address you through this Eleventh issue of the Earth Observation, an annual newsletter, as the President of the Nepal Remote Sensing and Photogrammetric Society (NRSPS). I take this opportunity to express my sincere gratitude to all of you for your continued support and dedication towards the promotion and advancement of remote sensing and photogrammetry in Nepal.

As a society, we have achieved numerous milestones since its establishment in 1991, and it is all because of the collective efforts of our members. We have organized various national and international workshops, promoted the application of space technology and published newsletters that have helped in building the capacity of professionals and students in Nepal. Our members have also actively contributed to research and development in the field of remote sensing and photogrammetry, which has brought recognition to Nepal at the global level.

I would like to emphasize that the importance of remote sensing and photogrammetry has increased manifold in recent times, and it is crucial to continue our efforts in promoting these technologies in Nepal. These technologies have immense potential in addressing the challenges faced by our country, including mapping and development activities, disaster risk reduction, natural resource management, agriculture, and environmental monitoring, to name a few. As a part of promoting the recent technology in remote sensing and photogrammetry sector, we present 11th edition of newsletter based on the theme “Artificial Intelligence in Geoinformatics”.

As the President of NRSPS, I assure you of my commitment to support and encourage the initiatives of our members. I also urge you to actively participate in our upcoming events and contribute to the growth of our society.

Finally, I would like to thank all of you for your hard work and dedication, and take this opportunity to appeal all the readers of this newsletter and the members of NRSPS to play a role in promoting application of space technology and its education to outreach to a larger group of decision makers, professionals and academia.

Sincerely,
Rabin K. Sharma
President, NRSPS

CROP CLASSIFICATION AND YIELD ESTIMATION USING SENTINEL-2 DATA AND CONVOLUTIONAL NEURAL NETWORK

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As a part of the Copernicus European Earth Observation program, the Sentinel-2 (S2) mission offers global coverage of terrestrial surfaces by means of medium-resolution multi-spectral data. The S2 mission offers an innovative wide-swath of 290 km, a spatial resolution ranging from 10 m to 60 m, a spectral resolution with 13 bands in the visible, near infra-red and shortwave infrared of the electromagnetic spectrum and a temporal resolution with 5 days' revisit frequency. With the open availability of Sentinel-2 images, extensive opportunities have been unlocked for agricultural applications including crop mapping and monitoring. In order to obtain accurate crop classified areas and yield estimates, advanced and intelligent algorithms are essential together with high-quality remote sensing data. In this context, deep learning models such as Convolutional Neural Networks (CNNs) have shown a great potential.

With all these considerations, a research was conducted in order to classify rice crop pixels and predict its yield using Sentinel-2 data and CNN algorithm with a case study of Nepal. In particular, the research used patch-based 2D and 3D CNN algorithms to map rice crop and predict its yield in the Terai districts of Nepal. Firstly, the study reviewed the existing state-of-art technologies in this field and suitable CNN architectures were selected. Secondly, considering the rice crop phenology, multi-temporal S2 Level-1C MSI images were downloaded and processed for the years 2016-2018. The third stage dealt with design, implementation and analysis of chosen CNN architectures. The selected architectures were implemented and trained using S2 imagery, ground and auxiliary data in addition for yield estimation. The performance of the models was validated and then evaluated using performance metrics namely overall accuracy and F1-score for classification and Root Mean Squared Error (RMSE) for yield estimation. Additionally, visual inspection of classification and yield estimation maps were used as a means for qualitative evaluation. Lastly, the optimized performance of the chosen architectures was validated with reference to the corresponding works from which these architectures were adopted to verify the usability of S2 data and the approach in developing countries like Nepal.

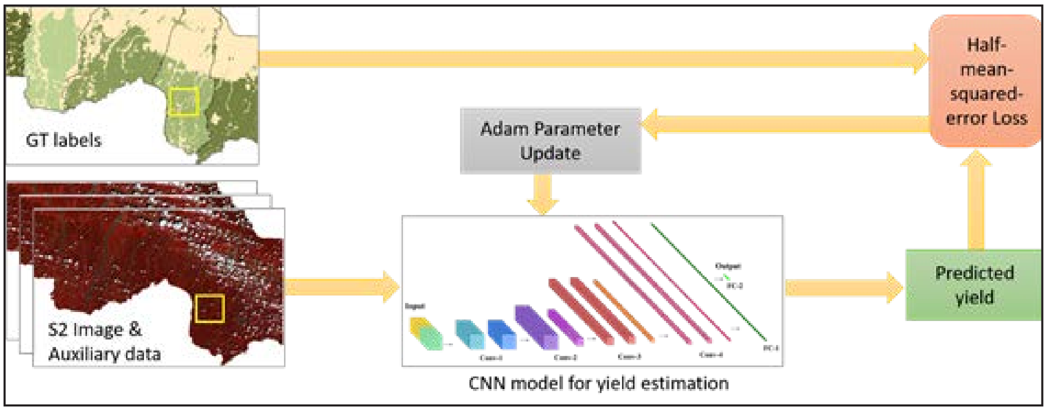

Fig: General Procedure for training yield estimation models

The research verified that the use of multi-temporal data in rice classification improves the classification accuracy as opposed to the use of images of single time period. In consistency with the existing works, the results demonstrate recommendable performance of the models with remarkable accuracy, indicating the suitability of S2 data for crop mapping and yield estimation in developing countries..

For more details: https://www.mdpi.com/2072-4292/13/7/1391
http://repositori.uji.es/xmlui/bitstream/handle/10234/187006/TFM_Baidar_,_Tina.pdf?sequence=1

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AUTOMATIC BUILDING EXTRACTION FROM SATELLITE IMAGERY USING IMPROVED FULLY CONVOLUTIONAL NETWORK

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Building extraction from remotely sensed imagery plays an important role in urban planning, disaster management, navigation, updating geographic/ topographic database, and several other geospatial applications. There are several published scientific contributions and several algorithms have been used in application sector for automatizing the building extraction process. In recent era, deep learning models such as Convolutional Neural Networks (CNNs) have shown a great potential. However, in all these contributions, high accuracy is always obtained at the price of extreme complex and large network architectures and vice versa.

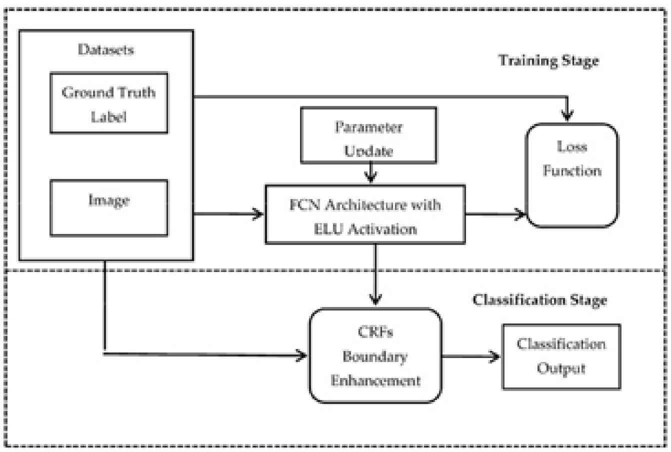

Fig: General Procedure for training building extraction models

With all these considerations, I did a research for automatic building extraction balancing high accuracy with low network complexity. In particular, the research used enhanced fully convolutional network (FCN) framework that is designed for building extraction of remotely sensed images by applying conditional random fields (CRFs). A modern activation function, namely, the exponential linear unit (ELU), is applied to improve the performance of the fully convolutional network (FCN), thereby resulting in more accurate building prediction. To further reduce the noise (falsely classified buildings) and to sharpen the boundaries of the buildings, a post-processing conditional random fields (CRFs) is added at the end of the adopted convolutional neural network (CNN) framework. The experiments were conducted on Massachusetts building aerial imagery. The results show that the proposed framework outperformed the fully convolutional network (FCN), which is the existing baseline framework for semantic segmentation, in terms of performance measures such as the F1-score and IoU measure. Additionally, the proposed method outperformed a pre-existing classifier for building extraction using the same dataset in terms of the performance measures and network complexity.

For more details:
https://www.mdpi.com/2072-4292/10/7/1135
https://run.unl.pt/bitstream/10362/33652/1/TGEO0173.pdf

A SYNOPSIS OF MACHINE/DEEP LEARNING APPLICATIONS FOR PRECISION AGRICULTURE AT THE DEPARTMENT OF GEOMATICS ENGINEERING, KATHMANDU UNIVERSITY

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The department of Geomatics Engineering of Kathmandu University is quite involved with the use of the machine and deep learning algorithms for agricultural applications in recent years. Some of the recent works include the identification of banana trees and the delineation of wheat and paddy fields.

A group of undergraduate students at the department applied Support Vector Machine (SVM) and Convolutional Neural Network (CNN) along with conventional methods for delineation of the individual banana tree. The results of the individual classifiers were analyzed based on different metrics. The analysis showed that the CNN algorithm outperformed the results from the SVM and conventional methods such as Object-Based Image Analysis (OBIA) and Nearest Neighborhood (NN) classification techniques.

In another work, Sentinel-2 and PlanetScope imageries were used for delineation of wheat cultivation areas. To identify the crop phenology of wheat, the NDVI time series were derived and studied from Sentinel-2 imageries on the Google Earth Engine (GEE) platform. The 3m spatial resolution PlanetScope imageries were used for image classification. Random Forest (RF) and Support Vector Machine (SVM) algorithms were used as pixel-based image classifiers to delineate the wheat cultivation area. The results from RF outperformed those from SVM based on overall accuracy.

In an ongoing research, we are utilizing about 4500 voluntarily collected Land Use Land Cover (LULC) and Crop Type ground reference data collected through the ODK Collect eco-system (a freely available Android app for data collection and Google Drive/sheet for data hosting) from the entire of the Terai region to delineate paddy fields. The team is testing SVM and RF algorithms among others for image classification.

ADVANCEMENTS OF DEEP LEARNING FOR FEATURE EXTRACTION FROM SATELLITE IMAGES

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Introduction

Computer vision is a way of 'seeing' images and classifying objects by computers. It is a scope of artificial intelligence which teaches computers to interpret the visual world. Artificial Intelligence (AI) are the smart machines which can copy traits from larger datasets. If AI makes computers think then computer vision makes them see by training computers to perform the functions of human vision. Some works of computer vision are object tracking, detection, classification and content-based image retrieval. AI when categorized to refer to the learning ability of computer machines to solve real world problems, the scope of Machine Learning (ML) is defined. ML deploy techniques likes Support Vector Machines (SVMs), regression, clustering, Bayes learning, decision trees and deep learning (DL). DL employ neural networks with nodes interconnected such that they resemble human brains. DL depicts hidden patterns and correlations from datasets in a continuous fashion of improving by learning. Deep neural networks can be of following types:

- Convolutional Neural Networks (CNNs): CNNs are efficient neural networks for object detection, feature extraction and image classification tasks. They are also used in other areas like natural language processing (NLPs).
- Recurrent Neural Networks (RNNs): RNNs are useful in extraction of information from images with reference to time. They use sensor device having time-stamped data for prediction and time-series applications.
- Autoencoder Neural Networks (Auto NNs): Autoencoders are unsupervised method of neural networks that create encoders from a given data. The encoders can be used by classifiers (both linear and non-linear) to extract information.

Feedforward Neural Networks (Ff NNs): These neural networks feed data from one layer to another in forward direction without the provision of feedback loops.

Evolution of DL

Elementary deep learning is found to have emerged as early as 1980s. Due to the scarcity of large datasets, sophisticated software and high performing hardware for computer vision tasks, it did not gain momentum until the second decade of 21st century. With the advancements in computation infrastructure for processing massive datasets, deep learning begin to grow in the field of visual recognition tasks like feature extraction, image classification, image interpretation and semantic segmentation. A form of machine learning viz. deep learning brought about numerous improvements in feature extraction tasks from satellite images.

The first convolution neural network called LeNet5 was developed by Yann Lecunn in 1995 to classify handwritten numbers from Modified National Institute of Standards and Technology (MNIST) dataset. Having three layers: convolution, pooling and non-linearity layers, LeNet5 was executed to recognize handwritten cheques in the United States. After the significant development in the computational power of the hardware and software, a deeper and wider version of LeNet model; AlexNet was developed and implemented by Alex Krizhevsky in ImageNet dataset in 2012. It reduced some problems like overfitting and time consumption with classification error dropped to 15% from 26%. AlexNet was improvised to introduce ZFNet which produced more distinct features and fewer dead ones by. Through a deconvolutional network, it was possible to reverse any convoluted features in human readable form. Simonyan et. Al. developed VGGNet in 2014 by reducing the higher dimension filters and increasing the layers depth of existing ConvNets. Due to the higher size of features in the layers, it was complained to be slothful and hence was suggested to reduce the number of features to save time. With the introduction of state-of-the-art architects like GoogleNet and ResNet, it was possible to process up to thousands of layers to obtain significantly better performance. The number of parameters required for processing images also dropped by 12 times with error-rate saturating well below 5%. While the inception of architectures like Inception-ResNet, Xception, SqueezeNet and ShuffleNet served the purpose of improving the error rate and reduction the network complexity, the innovation of DenseNet revolutionized the scope of convolutional neural networks. DenseNet was configured in the manner that each layer could directly communicate with every layer present thereby addressing the vanishing gradient problem. Wang et al innovated a combination of residual and attention networks (AttResNet) to create attention aware features. This Residual Attention mechanism chose only that information necessary for further processing inside the architecture thereby leaving out the unnecessary ones. This technique became handy in reducing the number of parameters and processing time eventually increasing the feature extraction accuracy.

On the other part, Howard et al proposed a MobileNet for decoding information from pixel patterns in videos or images. MobileNets are light weight deep networks that employ depth wise separable convolutions suitable for mobile applications. It was found to be effective in object detection, classification and geo-localization as well.

Case Study

A network called AttDenseNet was proposed by Parajuli et al by combining DenseNet and AttResNet in 2021. A total of four blocks; two from DenseNets namely dense blocks and transition blocks along-with other two from AttResNet namely residual blocks and attention blocks were integrated. They implemented the network to extract surface water features from Sentinel-2 images of Central Terai plains of Nepal. The properties of the AttDenseNet featured the reduction of vanishing gradient problems by DenseNets and creation of attention aware features by AttResNet. The authors found that the innovation was successful in highlighting only the water pixels by suppressing urban, barren and non-water pixels from the imagery. Ablation study verified the significant role of each four blocks in extracting water pixels inside the study area. This approach increased the accuracy performance achieved from DenseNet by 0.56% at the experimental patch size of 16. On the other hand, they also found neural networks to be better than index-based water extraction approaches. AttDenseNet was more successful in extracting riverbanks, small water bodies and dried rivers than traditional methods. The qualitative analysis seconded the findings of the quantitative analysis graphically.

Conclusion

It took more than three decades to revolutionize convolutional neural networks since it commenced in the 1980s. With the augmentation in the field of hardware and software in the recent decades of 21st century, CNN was left with no choice other than expanding multi-dimensionally. The innovation of direct connection of any layer with all the other layers in DenseNet revolutionized the scope of CNN. AttResNet was successful in creating 'attention-aware features' by suppressing the unnecessary features. With the combination of the two, a better way of surface water feature extraction from satellite image was found by Parajuli et al.

For more information: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9855876 DOI: 10.1109/JSTARS.2022.3198497

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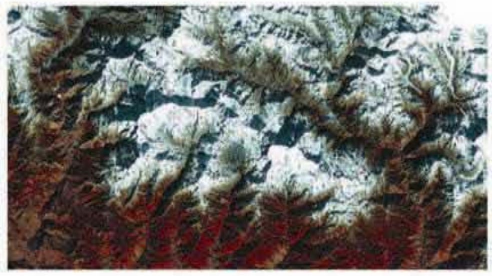

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TRAINING, DETECTING AND TRACKING DIRECTIONS OF VECHICLES IN NEPALI INTERSECTION DRONE FOOTAGE

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Background

Naxa is a Geo-ICT service provider company founded in 2014 with a focus on the development of geospatial and technological solutions. During our work to explore the frontiers in geographic information processing, we were intrigued by a problem faced by transportation engineers. For transportation engineers, the traffic flow of an intersection turns out to be a vital parameter to performing development, upgrade and support of different transportation infrastructures in the intersection. However, the process of gathering traffic counts to generate traffic flow parameters was still manual or semi-automated. We planned a computer vision and machine learning approach to automatically infer the traffic flow at an intersection from video data. The job was to track where the origin and destination of a vehicle are at an intersection.

Research and Development

There were three distinct problems: 1) Detecting objects, 2) Tracking their movement, and 3) Analyzing their start and end directions. The first step was to detect the objects in the scene. We did this by preparing screenshots from the video using FFMPEG and then manually annotated them using CVAT. The next step was to train and detect custom classes in the images/videos. For this we used RetinaNET. Once the objects were detected, the next step was to track their movement

At first, built-in trackers in OpenCV, a popular computer vision library, were used. A multiple object tracker is simply a collection of single object trackers. Some of the types of OpenCV trackers that we implemented are:

1. BOOSTING
2. MIL (Multiple Instance Learning)
3. KCF (Kernelized Correlation Filter)
4. TLD (Tracking, Learning, and Detection)
5. MEDIAN FLOW
6. MOSSE (Minimum Output Sum of Squared Error)
7. CSRT
8. Optical Flow

Although the built-in tracker of OpenCV is one of the best in our scenario, it lacked performance due to the high-resolution video where multiple vehicles are moving, a shadow in some parts, etc. Then, we implemented Optical Flow Computation using the Lucas-Kanade method for tracking purposes. Optical Flow is a vector field of apparent motion of pixels between frames. It works with a dense version where certain characteristic feature points are tracked. Furthermore, it is well known that gradient-based methods, such as Lucas-Kanade, are fairly accurate in producing angular estimation. It is useful for high speed, and robustness by a multiplicity of viewing angles. This shows improved results.

Fig 1: Shows the traced paths of objects detected in the video footage of a Nepali intersection. These traces are represented as white lines on the image. The traced paths provide information about the movement of the objects across the intersection, including their starting and ending points, and the direction in which they are moving.

Furthermore, we determined the direction in which the vehicle is moving. We also counted the number of vehicles moving. To count the vehicles, they must be tracked across a line. This means the object must be tracked prior to crossing the line. Lines must be placed in such a way that allows the object to cross.

Fig: 2: Shows line traces of the detected vehicles in the Nepali intersection drone footage. The line traces represent the path taken by each vehicle, along with its origin and end direction.

Also, a unique ID for each tracked object is necessary for counting objects and monitoring their performance. The input set as bounding box coordinates returns the value as x, y, width, and height of each object. These coordinates are saved as the previous frame and compared with the current frame. This is done by calculating the Euclidean Distance between the current frame and the previous frame for each object.

This, however, results in IDs being swapped between two or more objects, if they come close to each other (overlapping). Thus, to overcome these problems, Intersection Over Union (IOU) – which is a metric to find the degree of overlap between two shapes was used. Using IOU we calculated the overlap ratio between an object's bounding box and all the other existing bounding boxes. If the IOU was greater than 95% we assumed that it was the same object, making it possible to assign a unique ID to detected objects across multiple numbers of frames.

Figure 3 shows the detected vehicles in the Nepali intersection footage with bounding boxes around them.

Our method has the potential to revolutionize the manual and semi-automated process of gathering traffic counts, making it easier and more efficient for transportation engineers to perform development, upgrade, and support of different transportation infrastructures in the intersection. This demonstrates the power of computer vision and machine learning in solving real-world problems and advancing the field of geospatial and technological solutions.

CALENDER OF INTERNATIONAL EVENTS

RSCy2023- Ninth International Conference on Remote Sensing and Geoinformation of Environment	**Image Matching: Local Features and Beyond**
Date: 03-05 April, 2023	Date: 19 June, 2023
Country: Ayia Napa, Cyprus	Country: Vancouver, Canada
Website: https://rscy2023.cyprusremotesensing.com/	Website: https://image-matching-workshop.github.io/
UAV-g 2023 – Unmanned Aerial Vehicles in Geomatics 2023	**CIPA 2023 Symposium – Documenting, Understanding, Preserving Cultural Heritage, Humanities and digital technologies for shaping the future**
Date: 19-23 April, 2023	Date: 25-30 Jun, 2023
Country: Jeju Island, republic of Korea	Country: Florence, Italy
Website: https://isrs.or.kr/	Website: https://www.cipa2023florence.org/home
International Workshop on "Photogrammetric and computer vision techniques for surveillance, biometrics and biomedicine"	**13th International Symposium on Digital Earth**
Date: 24-26 April, 2023	Date: 11-14 July, 2023
Country: Moscow, Russia	Country: Athens, Greece
Website: http://technicalvision.ru/ISPRS/PSBB23	Website: https://pcoconvin.eventsair.com/isde23
ISRSE-39- 39th International Remote Environment Sensing Symposium	**IUGG General Assembly 2023**
Date: 24-28 April, 2023	Date: 11-20 July, 2023
Country: Antalya, Turkiye	Country: Moscow, Russia
Website: http://www.isrse39.com/	Website: http://technicalvision.ru/ISPRS/PSBB23
The 12th International Conference on Mobile Mapping Technology	**ISPRS Geospatial Week 2023**
Date: 24-26 May, 2023	Date: 02-07 September, 2023
Country: Padua, Italy	Country: Berlin, Germany
Website: https://www.cirgeo.unipd.it/mmt/	Website: http://www.iugg2023berlin.org/
RAST 2023- 10th International Conference on Recent Advances in Air and Space Technologies	**GEOBENCH- 2nd workshop on Evaluation and Benchmark of Sensors and Systems in Photogrammetry and Remote Sensing**
Date: 07-09 June, 2023	Date: 23-24 October, 2023
Country: Istanbul, Turkiye	Country: Cracow, Poland
Website: http://www.rast.org.tr/	Website: https://geobench.fbk.eu/
PCV23- Photogrammetric Computer Vision 2023 Workshop	**ACRS 2023- 2023 Asian Conference on Remote Sensing**
Date: 18 June, 2023	Date: 30 Oct - 03 November, 2023
Country: Vancouver, Canada	Country: Taipei, Taiwan
Website: https://photogrammetric-cv-workshop.github.io/	Website: https://acrs2023.tw/