Research article

Drone Education, Research and Application

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Abstract

Kathmandu University (KU) is playing an important role in drone education, research and applications. This paper aims to strengthen the existing drone education and research activities and draw attention of all national and international drone community for their contributions to promote drone education, research and application in Nepal. This paper also deals with the application of drones, challenges and opportunities and the efforts made by KU to become a leader in the drone sector. The economic growth of any country involves effective surveying and mapping. This requires highly skilled and knowledgeable human resources and output oriented drone education, research and application. To make drone education, a leader courses in Nepal and also within the region in the future, KU has to overcome many challenges. Some challenges may be addressed at the national level, but some require collaboration and cooperation from an international level. Finally, drone education, research and its application help to develop quality drone professionals which in turn may incorporate the entire South Asia region as a potential drone market. KU is committed to developing a center of excellence in drone education and research.

Keywords: Drone; Education; Research; Application

Introduction

Unmanned aerial vehicles (UAVs), also referred to as drones, equipped with various kinds of advanced detecting or surveying systems, are effective and low-cost in data acquisition, data delivery and sharing [1]. Kathmandu University (KU) is playing an important role in capacity building of drone activities. It was established in November 1991 as an autonomous, non for profit, non-government, dedicated to maintaining high standards of academic excellence, public institution through private initiative. The university is committed to develop leaders in professional areas through quality education with the vision "To become a World Class University devoted to bringing knowledge and technology to the service of mankind". It is committed not only to develop leaders in professional areas through quality education but also develop as a center of excellence. Long term presence of the university is also intended to benefit the local communities in terms of development of small-scale business and community services. Under the University, there are seven schools: School of Engineering, School of Management, School of Science, School of Arts, School of Medical Sciences, School of Education and School of Law. Departments are headed by the school. Currently, the Geomatics Engineering program lies under the Department of Geomatics Engineering (DGE) within the umbrella of School of Engineering of Kathmandu University. Drone education research and its application in various programs of the Department of Geomatics Engineering is discussed in the following subsections.

Undergraduate program

Bachelor of Engineering (B.E) in Geomatics Engineering at Kathmandu University includes the courses on Surveying, GIS, remote sensing, various geospatial programming, SDI, Engineering projects, internship etc. This program also contains a photogrammetry course of 4 credit hours including drone applications. The general contents of the course are optics of photogrammetry, Photography and processing of aerial photography, Human eye and stereoscopic vision, Basic photogrammetry, Aerial Camera, Terrestrial photogrammetry, Aerial photography Planning, Analogue photogrammetric process orientation, Aerial triangulation, Aerial Photo interpretation, Mapping and Digital photogrammetry.

Graduate program

The subjects that are offered ME_MS in Geoinformatics program at Kathmandu University includes Introduction to Surveying and Geoinformation, Remote Sensing, Geo-visualization & Advanced Cartography, Geo-statistics, Spatial analysis and Modeling, Acquisition and Exploration of Geospatial data, Digital Image Processing, Research Methods and Skills, Problem Assessment Project and Thesis.

The following subjects are offered as electives. Scientific Geo-computing, Spatial Decision Support System for Land Use Planning and Environment Management, Spatial Data Infrastructures / OpenGIS, Geoinformation Project Management and Organization, Hyper Spectral Remote Sensing, Location Based Services (Mobile and Web), Application of Unmanned Aerial Systems, Geospatial Data Mining, Natural Hazards and Disaster Risk Reduction, Urban Planning and Management, Geo-information Science and Governance, Spatial Engineering in Agriculture and Forestry, 3D Geoinformatics. All of these subjects are for 3 credit hours.

Doctor of philosophy

The PhD related with drone on "Monitoring Rice Cropland and Yield Estimation using multi-sensor, multi-templar datasets and Citizen Science Approach is registered in 2019 at Department and is carried out in collaboration between University of Melbourne, Australia and Kathmandu University, Nepal.

Labs at Kathmandu University

Department of Geomatics Engineering, Kathmandu University has Geospatial Lab, Photogrammetry Lab, High Processing Computing Lab, CORS Station, Survey Lab, Workshop lab, computer lab, electrical lab, science lab and video conferencing labs. The lab activities are also conducted in cooperation with other departments and schools at KU.

Geospatial lab

The earthquake building damage assessment using UAV was conducted by Geospatial lab of Department of Geomatics Engineering (Figure 1).
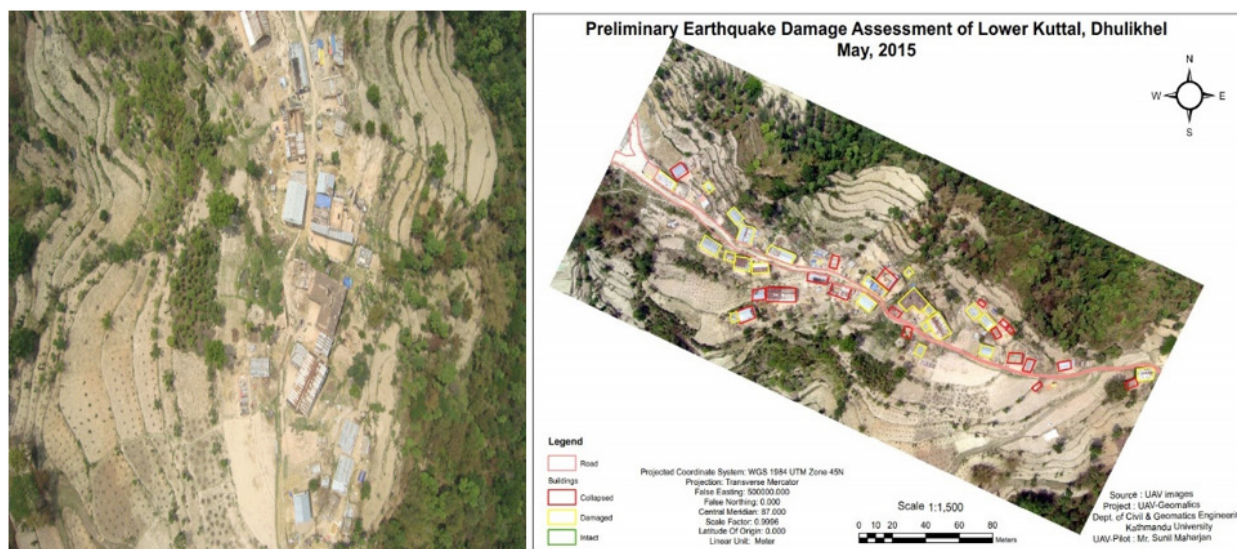

Figure 1: UAV mapping.

The study was carried out by Department of Geomatics Engineering in Kuttab village of Dublike municipality, and Panga and Tiago of Kantipur municipality of Nepal on devastating earthquake on April 25th, 2015. The team used emerging technology of Unmanned Aerial Vehicle, which the Geospatial Lab has been using for the Biomass Estimation Research Project here at Kathmandu University. The team collected the aerial images of these places with the Sony Digital Camera mounted on the UAV. The team deployed a self-assembled hex copter as a sensor carrier for serving the purpose.

Photogrammetry lab

This lab has following instruments DJI Phantom 3 Advanced – 6 and has problem with gimbal (adjust the position of the camera) and camera sensor and GPS embedded, Hex copter - 1 having problem with the rotor, DJI Mavic 2 Pro- 4 in working condition and Multispectral drone (Figure 2).

Figure 2: Drone certificates of registration.

High processing computing lab

HPC has been installed at Kathmandu university. Supercomputer consists of high-performance computing (HPC) servers and is donated by CERN based in Switzerland. Supercomputer has 184 CPU servers, 16 disk servers and 12 network switches with a total processor count of over 2,500 and 8 TB of memory [2].

Training and Workshop

Department of Geomatics Engineering, Kathmandu University and Cadaster International, the Netherlands jointly organized an international workshop on Flight 4 Purpose in Nepal on 26 July 2019 at Kathmandu University, Dublike. In the technical session, the discussion was made on international practices of UAV, historical background, legal framework and role of CAAN etc. The participants of the workshop were KU faculties, LMTC staff, officials from Survey Department, Ministry of Land Management, Co-operatives and Poverty Alleviation and Geomatics Engineering III year and Fourth students at Kathmandu University. Kathmandu University (KU) and We Robotics jointly organized a 3-day UAV training at KU from September 6 to 8, 2016. Thirty participants from Kathmandu University, Department of Urban Development and Building Construction (DUDBC), International Centre for Integrated Mountain Development (ICIMOD), Med AIR, Rural Development Initiative (RDI), Nepal Geomatics Engineering Society (NGES) and Robotics Association of Nepal (RAN) learned applications of UAVs, flying skills, data capturing as well as image processing.

Drone Research Projects

Completed projects

The following are the completed drone research project at Department of Geomatics Engineering

a.   Estimation of Above Ground Forest Biomass and Carbon Stock Using UAV Images funded by NASA through ICIMOD: The Geospatial Lab at the Department of Geomatics Engineering had used UAV and VISNIR sensor mounted on the UAV for above forest biomass estimation. The field work was carried out at Brandisher Protected Forest of Chitwan district. The area covered for the pilot test was approximately 0.5 sq km. The image processing and geo mosaicking and orthophoto generation were carried out. Besides, capturing VISNIR images, positional values of artificial markers placed for Ground Control Points (GCPs) were also measured using DGPS. Further, tree specific data like tree height, DBH, and tree species, among several others were also collected for 11 sample plots selected randomly within the area.

b.   Maize Biomass Estimation Using Images from Unmanned Platform using Consumer Grade RGB Camera funded by UGC and The International Maize and Wheat Improvement Center (CIMMYT): Department of Geomatics Engineering (DGE) had investigated maize health through NDVI camera mounted on a multi-rotor UAV at different crop growth stages. Along with health monitoring, DGE:

- Computes the vegetation indices and finds out the relationship between vegetation indices and soil nutrients.

- Identify the dragging factors like pests, weeds, fertilizers deficiency or excess and prepare the prescription map to improve the crop health.

DGE had used spreading wings UAV (Hexa-copter) with multispectral sensor (Sony Alpha A6000 VIZ-NIR camera) subjected to monitor the health of maize plant. The study area includes 18 plots located at Banshari covering an area of about 4000 sq. m. near to Kathmandu University. Total station survey was carried out to locate individual plot boundaries and evenly distribute the GCPs for post processing images acquired using the hexa-copter. Geo-located soil samples were taken from every plot and tested for various soil nutrients. Soil Maps showing the distribution of nutrients – nitrogen, potassium, phosphorous have been prepared based on the test result. DGE conducted flight recently on 27th May 2015 using RGB camera for instance. DJI Ground Station is used for flight planning. The circular red colored hard paper was placed on the top of GCPs to make it distinctly visible in the image. Later on, these GCP markers were used for geo-referencing images followed by mosaicking. Plant counting and DSM generation were performed.

On the next flight, DGE used VIZ-NIR camera. The images captured in NIR, Red and Green were extracted, and post processing operation (geo-referencing and mosaicking) was carried out. After mosaicking images, Normalized Difference Vegetation Index (NDVI) map was prepared which provides preliminary insight of the plant condition. NDVI is the indicator of greenness/health/status of the plant whose value ranges from -1 to +1 evaluated using NIR and Red band. The value near to 1 represents good health and greenness of the plant whereas the value near to 0 or negative indicates poor health or harvesting stage. The greenness is directly linked with the chlorophyll content in the plant leaves.

NDVI computed and the soil sampa particular were correlated to develop regression equation which then helps to determine soil nutrition at particular location based on the NDVI value. Thus, nutrition prescription maps can be produced which can be prescribed to farmers guiding to apply fertilizers at right time, right place and at right way. This helps increase profitability and sustainability, improved product quantity/quality, effective and efficient pest management, water and soil conservation as well as reduced adverse effect on farmers and consumer's health.

Research project

The following are the research project at Department of Geomatics Engineering

Cannabis surveying and mapping: Cannabis is the most common weed plants in Nepal and are used to address digestive problems in cattle, however, recreational use of the plant is common throughout the country. Government has deemed sales and usage of Cannabis as illegal. There is a huge discussion that economic loss due to COVID 19 can be recovery from Cannabis. Kathmandu University is exploring the possibility of Collaboration with Multidimensional Cannabis Research Centre (MCRC), USA and Faculty of Agriculture at Hebrew University of Jerusalem, Israel to carry out cannabis surveying and mapping.

Kathmandu Valley Mapping: There is a significant drop in air-traffic and gradual improvement of air-quality and visibility within Kathmandu due to the limitations on-road travel, and physical movement. UAV mapping had been carried out and in the stage of processing the UAV images. The collaborations between various organizations are being made through Multipartite MoU which includes Department of Geomatics Engineering, Kathmandu University, International Centre for Integrated Mountain Development (ICIMOD), Airlift Nepal Pvt. Ltd., Drone pal, Nixa Pvt. Ltd., Nepal Flying Labs and Pathway Technologies and Services Pvt. Ltd.

Challenges Opportunities and Way Forward

Availability of drone and software related with drone image processing, faculty expansion visiting experts (national/international) on drones, knowledge exchange programs relating to drone, expansion of further higher education and drone job market are the major challenges of drone education and research at Department of Geomatics Engineering in Kathmandu University. There are ample opportunities for the Department of Geomatics Engineering to become a center of excellence in drone education and research. Institutions like UT/ITC, University of Salzburg, Austria, Yeliz Technical University, Turkey, ICIMOD, private and government agencies are willing to support Department of Geomatics Engineering to achieve its goal [3]. The Department of Geomatics Engineering has expectations for expert advice from the national and international drone community. There is also an opportunity to lead as drone knowledge/data hub in the country.

Department of Geomatics Engineering has plan for an expansion of the programs (MS by Research in drone), strengthening academia & community /industry relationship, exploring new drone research projects and conducting national and international drone workshop/seminar/ conferences in collaboration other organizations [4-7].

Conclusion

The development of qualified human resources in the field of drones has become necessary. Drone education has become an emerging field as it directly deals with surveying and mapping. KU in collaboration with LMTC is playing a crucial role for drone education and research. To become a center of excellence in Nepal and also within the region in the future, KU has to grab the opportunities and overcome the challenges. Some of the challenges could be addressed at the national level but some require cooperation and collaboration from the international level. Therefore, it is essential to draw attention of all national and international drone community for their contributions to promote drone education and research in Nepal.

Acknowledgement

Conflict of Interest

None.

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