Eastern Himalayan Glaciar Hazard Analysis Using UAV-A Brief Approach

Saurabh Das* (1), Swastika Chakraborty(2), Nirmal Rai (2), Aritra Dhar(2), Arnav Sadhu(2), Baishali Gautam(2), Pooja Verma(2), Anindita Singh(2), Chimila Sherpa(2) , Madhura Chakraborty(3)
(1)Centre of Astronomy, IIT Indore, Khandwa Road, Simrol, Indore, 453552, India. Email: das.saurabh01@gmail.com
(2) Electronics and Communication Engineering Department, Sikkim Manipal Institute of Technology, Majitar, Rangpo, Sikkim, India.
(3) Electronics and Communication Engineering Department, JIS College of Engineering, Kalyani, Nadia, W.Bengal, India.

Abstract

Reliable method of high accuracy and time efficient monitoring of lake formation due to glacier melting is a serious challenge of alpine Himalaya. The development of model for the Glacial Lake Outburst Flood (GLOF) requires the database which is not available so far. A few surveys are already carried out in this regard based on satellite imagery which are comparatively less accurate. Hence, there is an urgent need for proper information which can be originated from real time monitoring of glacier melting as well as lake formation as a result of that. Wherever there is a human habitat in close proximity of such lake, the development of a method to gather such information is a further crucial. An approach has been demonstrated in this paper to develop an end-to-end solution for real time monitoring of glacial lake using unmanned aerial vehicle (UAV) and providing the warning as well the continuous monitoring via android application to the appropriate authority.

1. Introduction

Development of a method to real time monitoring of glacier melting and lake formation as well providing the information to the appropriate authority requires information gathering of the interted region in real time fashion. Some methods are available [1] for better resolution glacier mapping compared to using satellite imagery data based on uncalibrated RGB data obtained by low cost custotmised UAV survey. The challenge of monitoring the Himalayan glacier with the help of UAV survey is more compex compared to any conventional field based method [2] because of difficult terrin, harsh climate and proximity to international boarder areas. To map glacier hazards using photogrammetry [3] obtained from different sources like UAV photogrammetry, close range photogrammetry and terrestrial laser scanning (TLS) indicate that the reliable and cost efficient performance of UAV based method. Survey of debris covered glaciar using hexacopter UAV based photogrammetry has been successfully conducted [4] at Cordillera Blanca,Peruand. It is claimed as of highest altitude survey done so far producing reliable result for monitoring dynamic decay of tropical debris covered glacier. Optical photogrammetry using UAVs are used to detect water level in the presence of wind generated wave on water [5]. For surveying inland lake shore and it's adjacent area, UAV based method is found to be efficient [6].
Therefore UAV can be successfully and reliably used with a combination of camera and some sensors for monitoring and mapping of morphological changes of glacier as well as the prediction of Glacial lake outburst flood (GLOF) . If the information picked up by the sensor and camera can be communicated to mobile phone using android application and appropriate wireless protocol, it will be one of the possible method to take necessary action in this regard.

In this paper, we report an initiative taken to develop an end to end solution to this problem for remote glacial lakes over Sikkim.

2. Study area

The study area here is a potentially dangerous glacial lake, Shako Cho Lake (SCL), formed by the melting of Glacier of the same name(Fig. 1 and 2) in North Sikkim, India. It is identified as a high risk zone due to it's potential to cause Glacial Lake Outburst Flood (GLOF). The terrain and environment is highly prohibitive for continuous monitoring of the lake using conventional techniques. Satellite based remote sensing is not adequate as the image resolution is too coarse for detailed investigation. The field based investigations of glacial lakes are limited due to their remote locations, harsh climate and there is often a shortage of field based information. The use of drones can bridge the gap between cumbersome field work and coarse resolution satellite imagery, and provide critical, detailed information about glacial lake change as well as depth of ice of glacier change.
In Sikkim Himalaya, a total of the 320 glacial lakes have been reported to exist. Of these, a total of the 14 glacial lakes are potentially dangerous in terms of GLOF.

Fig. 1. Aerial view of glacial lake and nearby village of Thangu.

Fig. 2.Shako Cho glacial lake and its natural embankment.

2. Design of State of art

3. System Description

The glacial monitoring system consists of three parts: drone with payload, ground station and android app.

3.1. UAV based measurement

The drone will be fitted with a payload consisting of Raspberry pi, LIDAR, GPS module and a high resolution camera. Raspberry pi, which is a small single board computer, is used as the controller of the payload. LIDAR is laser-based optical ranging sensor which will be used to find the depth of the lake surface. The GPS will give the location coordinates of the drone. USB Camera interfaced with Raspberry pi will capture and record images of the glacial lake. Zigbee module will be used for data transfer between payload and ground station as it gives the maximum physical range at low power. A python program will be developed and executed in the raspberry pi for interfacing, processing, recording and transmission of information obtained through camera, GPS and LIDAR.

3.2. Ground based measurement

Ground station consists of Raspberry pi and Zigbee module. It receives the payload data from the drone, process it and forward it to the user through Wi-Fi interface. It also forwards the user command given through android app to the payload through Zigbee interface.

3.2. Android Application developement

Android app will be used to control the operation of the payload of the drone. The operation includes controlling of camera and USB. The app will also be used to obtain and display the real time sensor data from temperature, GPS and ultrasonic sensor.

The collected data on lake depth from different sites will be processed through software to generate the bathymetric map of the SCL.

4. Block diagram of the proposed system

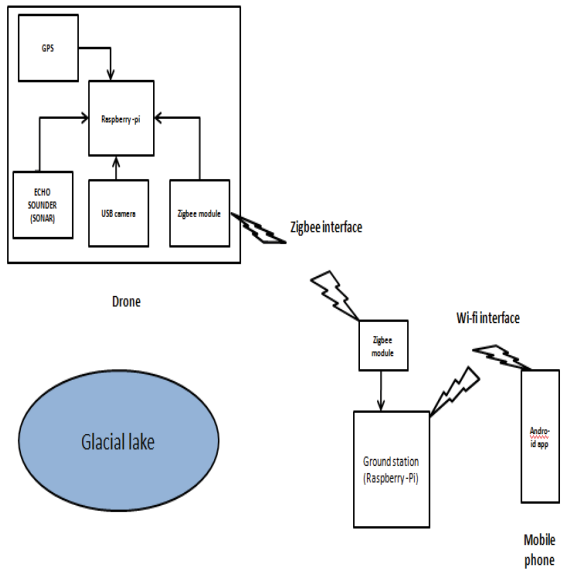

Fig. 3. Block Diagram of the GLOF Monitoring and awareness System

5.Methodolgy

An android application has been developed to control the paylod which will be attached to the drone. We have used **App Inventor,** which is an open-source web application originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT), for designing our android app. The app can control the paylod camera for taking and recording images of the lake. The GPS coordinates measured through the GPS sensor and depth of the lake measured through Echo sounder will be displayed in the app for realtime monitoring.

The Zigbee, GPS module, echo sounder and camera will be interfaced through USB with the Raspberry pi.The Zigbee module will be used for data transfer between payload and ground station as it gives the maximum physical range at low power. Between user and ground station there will be a Wi-fi interface.

A python program will be developed and executed in the raspberry pi for interfacing, processing, recording and

transmission of information obtained through camera, GPS and Echo sounder to the ground station.
The three dimensional data of the lake, x and y coordinates from GPS module and depth value from Echo sounder will be collected from various discrete poins in the lake. These collected dept and coordinates data will be processed to determine the volume of the lake.

6. Expected Outcome

1. Development of Drone based system for monitoring of glacial lake. Effective monitoring will help formulate effective strategies for mitigation of disaster due to GLOF. Monitoring will be done by capturing and recording high resolution images of the glacial lake through the drone based system.
2. Measurement of Ice depth through reflected signal from GPS.
3. The high resolution images are converted to recorded time series data for monitoring lake area through image processing.
4. To determine the depth of the lake, Bathymetric survey of the glacial lake will be carried out using drone and LIDAR. The collected data of the lake from the different sites will be processed using suitable software to generate bathymetric map of the lake.
5. Estimation of Lake Surface and volume.
6. Development of Android app for controlling operation of the monitoring system as well as for displaying real time sensor data. The sensor data provides information about depth of the lake, and coordinates of the Drones.
7. Create awareness about the potential of application of drones in the field of Glacier monitoring.

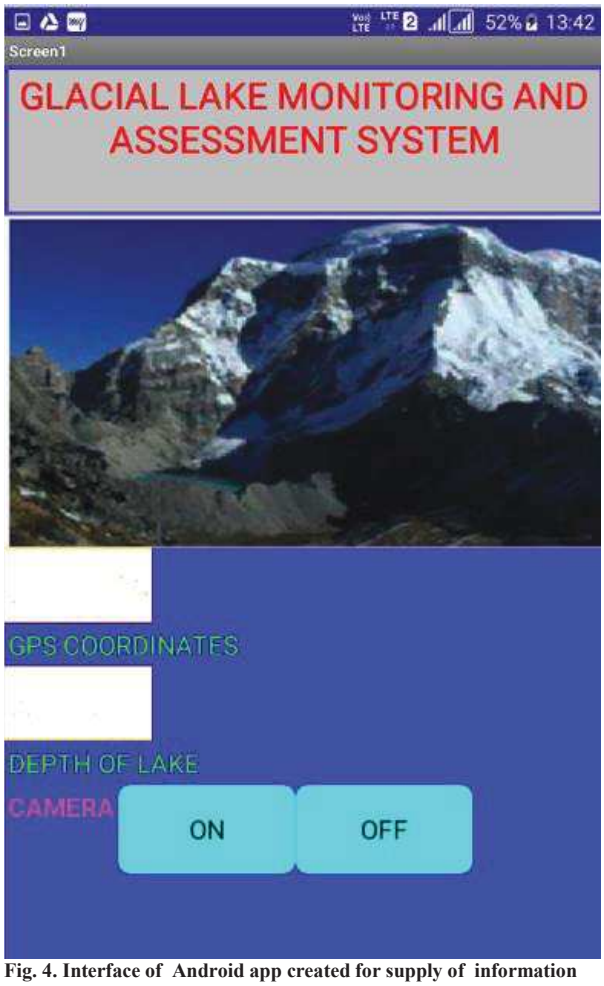

Fig. 4. Interface of Android app created for supply of information and early warning

Fig. 5: An example of a frozen lake

7. Present status

The android application has already been developed and shown in Fig. 4. It has been used to capture images of the GLOF. The camera is switched on from the above window to take pictures which are furher processed in the Raspberry Pi.
In Fig. 5, an example of image taken by the camera is shown here. Image is further converted to a binary image in MATLAB and the Image Analyzer tool is used to obtain the various parameters regarding the concerned lake. Part of the image shaded in pink is the concerned lake as shown in Fig. 6.

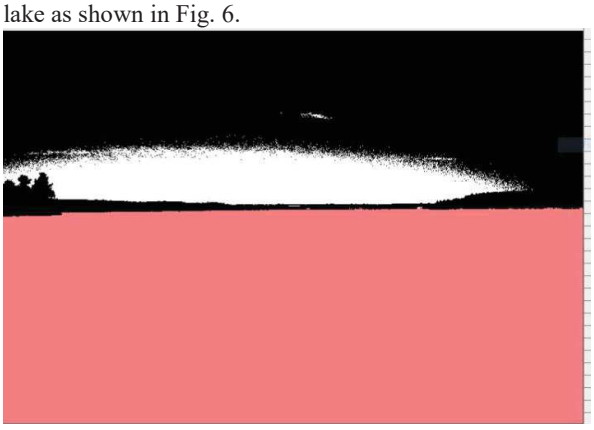

Fig. 6 Image Processing executed in Matlab for determination of volume of the concerned Lake

4. Conclusion

An system has been developed to monitor GLOF regions using remote sensors mounted on a UAV. An android appication is already developed to get the information on the mobile handset in real time fashion. The information in time can be really benefitial to the society by helping disaster preparedness and management. The system is still in development phase and will be soon deployed for real time application.

4. Acknowledgements

Authors thankfully acknowledge the support received from IEEE grand challenge contest award. Financial support received from DST- INSPIRE is also thankfully acknowledged by one of the authors (S.Das).

5.References

1.Davide Fugazza, Aantonell Senese, Roberto Sergio Azzoni, Claudio Smiraglia, Massimo Cernuschi, DavideSeveri and Guglielmina Adele Diolaiuti, "High-Resolution Mapping of Glacier Surface Features. The UAV Survey of the forni glacier (STELVIO NATIONAL PARK, ITALY)" ,*Geogr. Fis. Dinam. Quat*.,38 (2015), 25-33, 4 figg., 2 tab.

2.W.WImmerzel, P. D. A Kraaijenbrink, J. M. Shea, A. B. Shreshta, F. Pellicciotti, M. F. P Bierkensand S.M de Jong,"High-resolution monitoring of Himalayan glacier dynamics using unmanned aerial vehicles", *Remote Sensing of Environment*, 150, 2014, 93-103.

3.Davide Fugazza, Marco Scaioni, Manuel Corti, CarloD'Agata, Roberto Sergio Azzoni, Massimo Cernuschi, Claudio Smiraglia and Guglielmina Adele Diolaiuti,"Combination of UAV and terrestrial photogrammetry to assess rapid glacier evolution and map glacier hazards", *Journal of Atmospheric and Solar-Terrestrial Physics*,105, 97-100, 2013. (I.F. 1.474)

4.Oliver Wigmore and Bryan Mark, "Monitoring tropical debris-covered glacier dynamics from high-resolution unmanned aerial vehicle photogrammetry, Cordillera Blanca, Peru*", The Cryosphere***,** 11, 2463–2480, 2017.

5.Elena Ridolfi and PiergiorgioManciola, "Water Level Measurements from Drones: A Pilot Case Study at a Dam Site," *Water,* 9 March 2018.

6.Tomasz Templin, DariuzPopielayczyk, and RafalKosecki, "Application of Low-Cost Fixed-Wing UAV for Inland Lakes Shoreline Investigation", *Pure and Applied Geophysics,* 175(2018), 3263-3283.