| Date of Submission | August 24 2024 |
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# IPL Project Proposal Form 2024

(MAXIMUM: 3 PAGES IN LENGTH)

1. Project Title: Intelligent Debris Flow Monitoring System
   (1) New project
2. Main Project Fields
   (1) Technology Development
   A. Monitoring and Early Warning,
3. Name of Project leader : Ko-Fei Liu
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   Core members of the Project
   Louis Ge : Professor, Chairman, department of Civil Engineering, National Taiwan University
   Shih-Chao Wei : Assistant professor, Depart of water and soil conservation, Chung-Hsing University
4. Objectives: (5 lines maximum; what you expect to accomplish?)
   To have a intelligent debris flow system which can automatically identify debris flow and flood, automatically issue warning through various channel to authorities and affected region. The warning message contains the degree of threat and estimated arrival time and affected region. The system must be mobile enough so it won't take more than one hour to setup everything. This will be a useful tool for any future disaster reduction in regional or watershed scale.
5. Background Justification:
   Debris flow warning in Taiwan is a precipitation-based system. Each area has its warning accumulated precipitation amount. Once that warning amount will be reached, residents must be evaluated. But precipitation based system is not very accurate, many people are forced to evaluated even there is no debris flow at all.
   A precision monitoring and warning system is to be established, so only affected region need to be evacuated.
   There are already 16 fixed debris flow monitoring stations and 3 mobile monitoring system in Taiwan. None of the monitoring station has the ability to issue automatic warning. (This is true for almost all monitoring stations in the world) The accurate detection method of debris flow with multiple devices (Wei & Liu (2019); Liu et. La. (2022)) are available. Therefore, an automatic warning system can be established. If a warning system can further get physical parameters of the flow, such as flow depth and flow velocity, a precise prediction of the impact area and impact time can be obtained. This feature can drastically increase the accuracy and usefulness of the monitoring and warning system. If the monitoring and warning system is cheap enough, this can even change the debris flow disaster prevention concept.

6. Study Area:
   Yu-Shui river in Kaohsiung County, central Taiwan

7. Project Duration:

   Three years

8. Resources necessary for the Project and their mobilization

   Total funding 35000 USD in three years.

9. Project Description: (30 lines maximum)

   A debris flow monitoring and warning system will be installed on midstream Yusui Stream, Taiwan. The monitoring station will be a fully automatic warning station. The system can demonstrate it is possible to have a precise prediction of debris flow impact time and place through monitoring in upstream area.

   The system will be composed of 2 CCDs, 2 MEMS, and one rain gage. The monitoring and warning system will have the following functions and the project will be performed following the steps below.

   (1) Select relatively cheap device such as household webcam to replace expensive CCD in the field. Using acceleration chip detects ground vibration signal to replace traditional geophone with digital signal. All devices must use PoE cable. This is to reduce the cost for the warning system and assure the cover range of the system. (Cheap and easy to installed system can be treated as disposable once its mission is accomplished)

   (2) The arrival of debris flow is detected using grey level method with video images. The region of interest for analysis must be chosen automatically.

   (3) The arrival of debris flow is detected using energy method for ground vibration signal.

   (4) Debris flow arrival will be double-checked with both CCD and MEMS signals.

   (5) Real time analysis using the above methods must be ensured.

   (6) Flow depth variation will be detected using CCD image using simple search algorism.

   (7) Flow velocity can be estimated using double ROI within one CCD image.

   (8) Debris flow traveling speed can be obtained using time difference from arrival time with two MEMS.

   (9) Numerical simulation of the given river for different amounts of landslides in upstream area will be performed. The simulated water level at the monitoring station with its temporal variation will be recorded.

   (10) When debris flow events occur, the monitored flow depth can be compared with the simulated result. The corresponding landslide amount and the downstream affected area can be obtained through pre-simulated results.

   (11) Warning can be issued to affected area through automatically.

   (12) Once debris flow is detected around the monitoring station, Warnings will be issued through on-site control, voice messages, line (social software) messages, broadcasting, web-warning and auto control of traffic control facility.

10. Work Plan/Expected Results: (30 lines maximum; work phases, milestones and publication)

    2024 system installed and ready for warning.

    (1) Easily installed mobile system is established at the end of 2024

    (2) Debris flow detection software for ground vibration and image is ready.

    (3) Warning for detecting debris flows should be ready

    (4) Preferably with real events tested record.

    2025 Intelligent website for the system and all analyzing modules are ready

(1) Flow depth module ready with 10% or less error

(2) Flow velocity module is ready with 20% or less error

(3) Testing for modules

(4) Simulation of various landslide amounts should be finished.

(5) Flow depth variations for different landslide inventory are plotted.

2026 Documentation for all devices and function

(1) Integration of all modules and warning methods are complete

(2) Event tested and record

(3) Warning system with auto control bridge for road way will be designed

There will be two papers submitted to Landslides as well as documented system layout in the Open Access Book Series P-LRT in two `years.

11. Deliverables/Time Frame: (10 lines maximum; what and when will you produce?)

End of 2024 One year for complete system establishment

(1) Structure, layout and hardware facilities will be listed and fully functioned in the field

(2) Tested record

End of 2025 Real warning and hazard reduction recording

(1) Real event capture and full record for debris flow event will be completed

(2) Flow depth and velocity modules tested result

(3) Graphs for flow depth vs time according to simulation results

End of 2026 Precision warning ability establish

(1) System using simulation to provide precision warning will be finished.

(2) Design of high way bridge is finished

12. Project Beneficiaries: (5 lines maximum; who directly benefits from the work?)

High way in Yu-Shui river mouth and all transportation.

Two elementary school students.

Official debris flow prevention team

If this precision warning system works fine, it will change the future of debris flow prevention work.

13. References (Optional):

(1) Shih-Chao Wei, Ko-Fei Liu (2019, Dec). Automatic debris flow detection using geophones. Landslides DOI 10.1007/s10346-019-01258-9..

(2) Liu, K.F., T.I. Kuo and S.C. Wei (2022) Debris Flow Detection Using a Video Camera. Proceeding Workshop on World Landslide Forum, Kyoto, pp 141–147

(3) Sudhan Regmi, Shih-Chao Wei, Ko-Fei Liu (2023) Landslide detection using total gray level method, 5th World Landslide Forum, 14-18, Nov. Florence, Italy

Note: Please fill and submit this form by 15 August 2024 to:

KLC secretariat <klc2020@landslides.org> and ICL Network <icl-network@landslides.org>