Use of Genetic Algorithm in Rainfall Threshold Modelling for Landslide Early Warning Systems

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Landslides cause huge losses to lives and properties every year.

Early warning of such disasters help in reducing the amount of loss.

Depend upon many factors like the climatic, geological, and land use patterns of the region of interest.

For landslides that are induced by rain, a threshold is indicated by the quantity of rainfall that most likely results in a landslide.
Intensity-Duration (ID) model

- A classic model for predicting shallow landslides and debris flows is the intensity-duration (ID) model, first proposed by Caine (1980).
- It is a power function model which relates the intensity of rainfall (I) with the duration of the rainfall event (D).
- The form of the equation is
  \[ I = \alpha D^{-\beta} \]
  where \( \alpha \) and \( \beta \) are parameters.
  This is a constrained optimisation problem defined as follows:

Objective: minimize \[ \sum (I_i - \alpha D_i^{-\beta})^2 \]
Subject to: \( \forall (D_i, I_i) : I_i > \alpha D_i^{-\beta} \)

Caine, 1980
Genetic Algorithms

“It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change.”
- Charles Darwin

- Used in optimization and search problems
- Inspired by the process of natural selection
NSGA-II (Non-dominated sorting genetic algorithm II)

- Generates offspring using a specific type of crossover and mutation
- Selects the next generation according to nondominated-sorting and crowding distance comparison
- Diversity preserving mechanism
- Introduced by Deb et al, 2002
Case study: Development of threshold equations for Sikkim, India

- Rainfall data from rain gauge stations, India Meteorological Department during (1990-2017)
- Landslide details collected from GSI reports, online reports and newspaper reports
- Landslide susceptibility map (Fig. c) sourced from the Sikkim State Disaster Management Authority (SSDMA)

(Harilal et al., 2019)
Distribution of rainfall and major landslides that occurred in Sikkim during 1990–2017 plotted (Harilal et al., 2019)
Threshold development

Data collection

Development of threshold equation

Validation

NSGA-II (Non-dominated sorting genetic algorithm II)
Validation

Data for validation: rainfall data during 2015-2018 from the Amrita Early warning system deployed in Chandmari, Sikkim (Ramesh et al. 2009; Ramesh and Rangan 2014)

(Harilal et al, 2019)
To sum up ...

- Genetic algorithms are useful in developing threshold equations
- This is illustrated using a case study of I-D modelling for Sikkim, India
- More studies are needed to explore this further


Thank you