Landslide Early Warning with Rainfall Data from Correcting Weather Radar Reflectivity Using Machine Learning

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Taiwan is located at the northwest side of Pacific Ocean and also in the Circum-Pacific Seismic Belt, as a result, suffers from frequently typhoons and earthquakes. The plate collision creates steep mountains account for 70% area of Taiwan. Averaged annual rainfall is 3600 mm in Taiwan, whenever typhoon or weather front brings heavy rainfall addition with geological instability thus increase the landslide occurrence. Rainfall gauge stations are sparse in the mountainous region, and the interpolated rainfall are usually underestimated. The error sources include 1.) variation of raindrop size distribution which is rarely known and varies in time and space (James, 1979); 2.) radar beam attenuation, the rainfall estimation will be underestimated as distance from radar to gauges increase (Joss, 1998); 3.) beam blockage by mountains, when the beam encounters terrain blocking, it will cause signal interference, which is known as ground clutter (Li and Chen, 2002). Therefore, it is necessary to overcome those issues while try to predict accurate rainfall via radar reflectivity in the mountain regions.

In this research, we use radar reflectivity combines ground rainfall gauges to compensate the forecasting rainfall. The first method uses the known radar echo intensity (Z) and the rainfall of ground stations (R) to calculate the A and b coefficients by genetic algorithm with the exponential relationship, \( Z = A \cdot R^b \), proposed by Marshall and Palmer. However, the results are unreasonable, the value of A is varying in 0.01-1000, mostly under 1, and the value of b is varying in 0.1-30. Hence, we decide to use another method. First, we assume that for a short distance (ex: 30 Km), the raindrop size correction factor is constant without attenuation and beam blockage. Second, we estimate the correction factor with the attenuation pattern with distance. Third, the beam blockage from mountains is then considered, and it also takes the first two corrections in consideration. The approach we used is artificial neural network (ANN) to compensate the estimated rainfall from real time radar reflectivity.

The purpose of this study is to estimate the accurate rainfall of potential landslide area hours ahead typhoon or weather front reaches, we use the historical route of radar echo to infer the path of movement of next hour. If the estimated rainfall exceeds landslide thresholds, the alarm system will be activated. With these efforts the estimated rainfall in the mountain region is improved 70% from tryout experiments. It is found that is correction for radar reflectivity is not an universal transformation, it is depended on the nature of water concentration and also the drop
size within the weather front.

Key words: Radar Echo, Artificial Neural Network, Early Warning