Landslide Risk Estimation Based on 5G Network RSSI

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***Abstract*—Landslides are downward movements of soil, rock, and debris along slopes, and pose significant risks to communities, especially in inhabited areas as they can cause severe damage, including the destruction of infrastructure and loss of life. Solutions for prediction and mitigation strategies are crucial, which often relying on rainfall forecasting and monitoring through sensor and IoT technologies. However, such solutions can be costly and challenging to implement, particularly in developing countries. By taking advantage of 5G networks, this paper proposes an innovative Received Signal Strength Indication (RSSI)-based solution to estimate the landslide risk and assist in mitigation actions in advance. Our solution also incorporates Software-Defined Networks (SDN) to manage the collected real-time data, compute the landslide risk, and notify users in the affected area. Results show that adopting 5G RSSI can significantly improve the accuracy in detecting rains and landslides, as shown by a high Pearson correlation coefficient (0.984), a Mean Squared Error (MSE) of 0.0087, and a coefficient of determination (R^2) of 0.6185 for the RSSI-bases solution.**

***Index Terms*—Decision Support, RSSI, 5G Networks, SDN, Landslides**

I. Introduction

Landslides are mass movements characterized by the sliding of solid materials, such as soil, rock fragments, and other debris, along a slope. When they occur in inhabited areas, they pose a significant risk to the community, as they can cause the collapse and destruction of houses, buildings, road blockages, displacement, injuries, or even loss of life. For instance, from 1998 to 2017, landslides affected an estimated 4.8 million people and caused more than 18,000 deaths globally [1], [2]. Studies such as those conducted in Sri Lanka and other regions affected by landslides show that these events have a significant impact on the socio-economic conditions of affected communities, destroying properties, disrupting infrastructure, and resulting in substantial economic losses [3].

Climate changes and accelerated urbanization have driven the occurrence of landslides [1]. It is expected that climate changes, including rising temperatures, will trigger more landslides, especially in mountainous areas with melting snow and ice [1]. In this respect, rainfall forecasting and monitoring have been crucial to predict these events and anticipate actions to mitigate their effects. Sensor technologies and Internet of Things (IoT) have been promoted to compose monitoring solutions such as in [4] and [5]. However, these solutions require the deployment of devices to collect data from the environment (e.g., measurement of rainfall) and the communication infrastructure to send it to a center for merging and analysis. This incurs costs, specially when the number of areas to be monitored is high, which may be beyond the budget of some municipalities or authorities in developing countries.

Recently, the Fifth Generation (5G) of mobile networks has brought several advances to wireless communications such as elevated throughput, increased data capacity and coverage area, ultra low latency, and higher connection density, enabling different service types (e.g., enhanced Mobile Broadband, massive Machine-Type Communications, and Ultra Reliable Low Latency Communication. To provide these facilities, improving the coverage and system capacity, network densification is an enabler for 5G networks [6]. It employs base stations (BSs) with different capacities overlapping the same area. As a consequence, users can be served with shorter transmission links and have connection stability even when they move.

Besides the advantages, the network densification employmemt raises challenges, specially when millimeter wave communication (mmWave) is adopted, since the communication signal may be more sensible to interference. Being rain one cause of signal change in mobile networks [7], several studies have analyzed the effect of the rainfall on cellular network signal or proposed attenuation models that describe this relationship [8] [9] [10] [11], but focusing on the communication quality. Rare works apply this analysis to estimate other events or assist systems, such as flood warning system in [7].

By addressing this gap and taking advantage of 5G network features, this work proposes a Received Signal Strength Indication (RSSI)-based solution to estimate the landslide risk and assist in mitigation actions in advance. We analyzed the 5G network RSSI caused rainfalls via a mathematical model and estimate the risk of landslide occurrences. In addition, to manage the collected real-time data, compute the landslide risk, and notify users in the affected area, our proposal incorporates Software-Defined Networks (SDN), where a SDN controller has a global network view, receives collected data,