A NEW METHOD FOR DETERMINATION OF MOST LIKELY INITIATION POINTS AND EVALUATION OF DIGITAL TERRAIN MODEL SCALE IN TERRAIN STABILITY MAPPING

Paolo Tarolli¹ and David G. Tarboton²

¹University of Padova, Land and Agroforest Environments Department, Padova, ITALY (paolo.tarolli@unipd.it)
²Utah State University, Civil & Environmental Engineering Department, Logan, UT (dtarb@cc.usu.edu)

ABSTRACT

Physically-based models have been used previously to model and map the spatial distribution of shallow debris slides, and areas of potential instability. Here we use the SINMAP stability index (SI) defined as the probability that a location is stable (FS > 1) assuming uniform probability distributions of the uncertain geophysical parameters (Pack et al., 1998).

THEORY OF MLIP

The MLIP method is based on the D<inf>f</inf> algorithm (Tarboton, 1997) for the representation and calculation of flow direction and on the stability index (SI) from the SINMAP model. The stability index (SI) is defined as the probability that a location is stable (FS > 1) assuming uniform probability distributions of the uncertain geophysical parameters (Pack et al., 1998).

TERRAIN STABILITY MODEL

The MLIP method is based on the D<inf>f</inf> algorithm (Tarboton, 1997) for the representation and calculation of flow direction and on the stability index (SI) from the SINMAP model. The stability index (SI) is defined as the probability that a location is stable (FS > 1) assuming uniform probability distributions of the uncertain geophysical parameters (Pack et al., 1998).

ALGORITHM FOR CALCULATION MLIP

MINIMUM DOWNSLOPE FUNCTION

Grid cell with lowest value at or downslope of each grid cell

MINIMUM UPSLOPE FUNCTION

Grid cell with lowest value at or upslope of each grid cell

SI

Flow Direction

MLIP

Most Likely Initiation Points (MLIP) are where

SI<sub>ups</sub> = SI<sub>down</sub> = SI < threshold
**RESULTS**

<table>
<thead>
<tr>
<th>Grid resolution (m)</th>
<th>50</th>
<th>20</th>
<th>10</th>
<th>5</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLIP SI 0-0.2</td>
<td>5.23</td>
<td>1.83</td>
<td><strong>3.81</strong></td>
<td>2.97</td>
<td>2.57</td>
</tr>
<tr>
<td>MLIP SI 0-0.5</td>
<td>3.19</td>
<td>1.91</td>
<td><strong>3.66</strong></td>
<td>2.93</td>
<td>2.57</td>
</tr>
<tr>
<td>MLIP SI 0-1</td>
<td>1.53</td>
<td>1.42</td>
<td><strong>3.53</strong></td>
<td>2.91</td>
<td>2.57</td>
</tr>
<tr>
<td>MLIP SI 0-infinite</td>
<td>1.46</td>
<td>1.38</td>
<td><strong>3.51</strong></td>
<td>2.91</td>
<td>2.56</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

**A.** The Most Likely Initiation Point (MLIP) method is suggested as a new way to evaluate terrain stability models when mapped landslide area includes runout zones.

**B.** The higher density ratio for the MLIP approach than from categories developed from the SI grid alone, validates the potential of the MLIP method.

**FUTURE WORK**

**A.** Map landslide runout area from MLIP trigger points.

**B.** Investigate “scale effect” with increasing resolution of DTM.

**METHODOLOGY**

(i) Digital Terrain Model (DTM) computed from LIDAR points at multiple resolutions: 50m, 20m, 10m, 5m, and 2m.

(ii) Terrain stability index, SI, computed for each resolution DTM from SINMAP using default parameters.

(iii) MLIP grids evaluated for each DTM resolution SI grid for a range of threshold SI values.

(iv) A range of thresholds applied to SI grid for each DTM resolution to categorize terrain instability.

The quality of the SI map is evaluated by comparing the density of MLIP points within and outside observed landslide area.

\[
\text{Density Ratio} = \frac{P_{\text{landslide}}}{P_{\text{basin}}}
\]

P_{\text{landslide}} and P_{\text{basin}} are the number of cells within the landslide area and within the basin as a whole, mapped by the approach. When used with SI these are grid cells less than a SI threshold. When used with MLIP these are grid cells identified by the MLIP upslope and downslope criteria and less than a SI threshold. Threshold ranges are given at the left of the table below.

**SLOPE “SCALE EFFECT” PROBLEM**

Computed slope is more variable with higher values for a smaller DTM grid resolution.

**ACKNOWLEDGEMENTS**

The authors are grateful to “Servizio Territorio Montano e Manutenzione” (Direzione Centrale Risorse Agricole, Naturali, Forestali e Montane) of Friuli Venezia Giulia Region for the collaboration in field surveys and furnishing of lidar and aerial photograph database. We thank Michela Din and Luca Bincoletto that provided critical support during field work and data collect. Tarolli also acknowledges the contribution of Giancarlo Dalla Fontana and Marco Borga during the prework discussion, and the support of Ing. Alde Gini Foundation on the scholarship period at Utah State University.

**REFERENCES**


