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Comment on "Global search algorithm for nondispersive flow path extraction" by Kyungrock Paik

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[1] *Paik* [2008] presents a new algorithm for the extraction of surface flow paths from gridded elevation data, arguing that "significant improvement over the limitation of D8 and D8-LTD [methods] can be achieved using a new and simple idea without introducing any model parameter" [*Paik*, 2008, paragraph 9]. However, all *Paik*'s [2008] arguments against *Orlandini et al.*'s [2003] D8-LTD method can be shown to be unsubstantial merely on the basis of geometrical considerations. The purpose of the present comment is to point out that (1) an analytical background to support the decision to set the dampening factor λ equal to 1 in the D8-LTD method does exist and (2) results obtained from incorrect implementations of the D8-LTD method are used in the investigation of *Paik* [2008]. Further considerations on *Paik*'s [2008] analysis of the D8-LTD method are also provided.

[2] In the work by *Orlandini et al.* [2003, paragraph 17] one can read that "the D8-LTD method with λ = 1 is advocated and it can be referred to as the D8-LTD method when no specification for λ is made." *Paik* [2008, paragraphs 8 and 27] acknowledges that λ = 1 in the D8-LTD method, but argues that "there is no analytical background to support the decision of the value of the dampening factor [λ]." However, as expressed by *Orlandini et al.* [2003, paragraph 9] and exemplified below, this analytical background does exist. The analytical basis for the formulation of the D8-LTD method with λ = 1 can easily be illustrated by considering a portion of a sloping plane such as that shown in Figure 1. From cell 1, the steepest flow direction may be approximated by the cardinal direction 12 (i.e., from 1 to 2) or by the diagonal direction 1A. The former is selected since the local transverse deviation $\overline{2B}$ is less than the local transverse deviation $\overline{AC}$. From cell 2, the steepest flow direction may be approximated by the cardinal direction 23 or by the diagonal direction 2D. Once again, the former is selected since the cumulative transverse deviation $\overline{3E} = |-\overline{3F} - \overline{2B}|$ is less than the cumulative transverse deviation $\overline{DG} = |\overline{DH} - \overline{2B}|$. From cell 3, the steepest flow direction may be approximated by the cardinal direction 3I or by the diagonal direction 34. In this case, the latter is selected since the cumulative transverse deviation $\overline{4J} = |\overline{4K} - \overline{3E}|$ is less than the cumulative transverse deviation $\overline{IL} = |-\overline{IM} - \overline{3E}|$. Likewise, from cell 4, the flow path extends toward cell 5 since $\overline{5N} = |-\overline{5O} + \overline{4J}|$ is less than $\overline{PQ} = |\overline{PR} + \overline{4J}|$, and from cell 5, the flow path extends toward cell 6 since $0 = |-\overline{6S} + \overline{5N}|$ is less than $\overline{TU} = |\overline{TV} + \overline{5N}|$. In the work of *Orlandini et al.* [2003], the idea of minimizing the cumulative transverse deviation along flow paths is mathematically formalized and experimentally verified for the sloping plane and more complex draining surfaces. The dampening factor λ is used to study the transition from local (λ = 0) to path-based (λ = 1) methods. A more recent analysis of the D8-LTD method (with λ = 1) is reported by *Orlandini and Moretti* [2009].

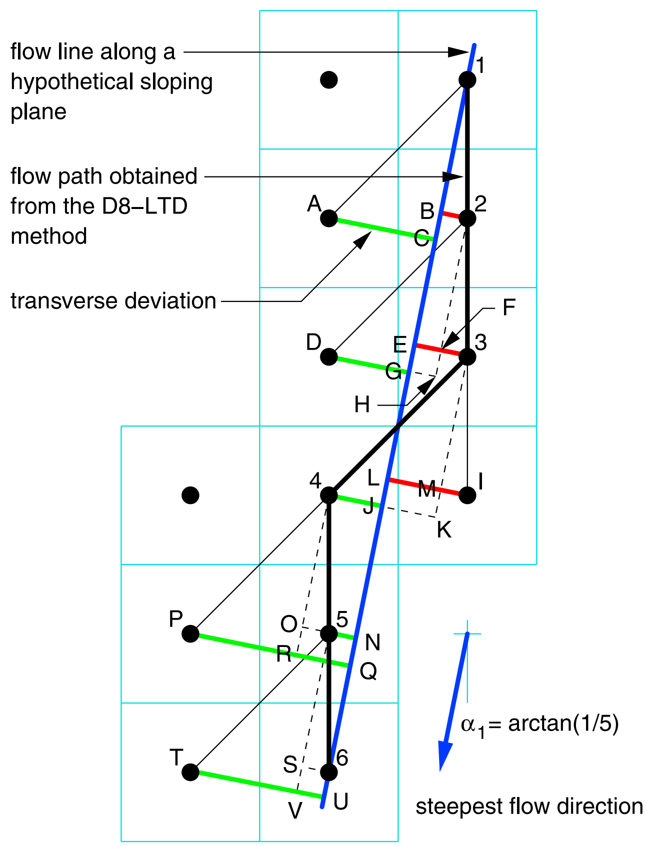

Figure 1. Sketch of the analytical basis for the formulation of the D8-LTD method with λ = 1. The flow line is shown in blue, the flow path is shown in black, positive transverse deviations are shown in green, and negative transverse deviations are shown in red.

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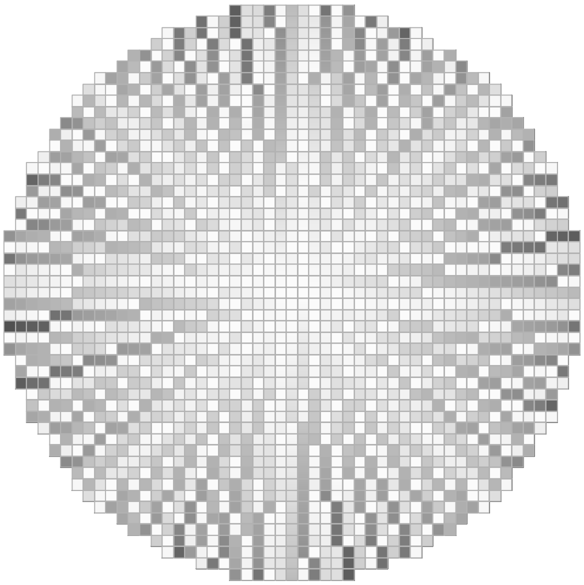

Figure 2. Drainage areas resulting from the application of the D8-LTD method to an outward-draining circular cone which is represented by imposing the same planar position for the center of the uppermost grid cell and the cone apex. These drainage areas are insensitive to cone aperture variations. Shades represent the number of drained cells, with values ranging from 0 (no shade) to 34 (darkest shade).

[3] *Paik* [2008, paragraph 36] uses the cumulative lateral deviation as an evaluation metric. He states that his "GD8 [algorithm] yields the least cumulative lateral deviation among algorithms compared." He also specifies that the D8-LTD algorithm "generates a larger deviation [than the GD8 algorithm] for cones, where the terrains are more complex than the plane." *Paik*'s [2008, paragraphs 34 and 35] cumulative lateral deviation is as meaningful as *Orlandini et al.*'s [2003, paragraphs 7 and 8] cumulative transverse deviation. However, incorrect implementations of the D8-LTD method are used in the investigation of *Paik* [2008]. *Paik*'s [2008] Figure 5d shows drainage areas resulting from an incorrect implementation of the D8-LTD method to the outward-draining circular cone. These drainage areas are manifestly inconsistent with the flow paths shown by *Paik*'s [2008] Figure 4f. Drainage areas resulting from the D8-LTD method are shown in Figure 2. Moreover, *Paik*'s [2008] Figure 6e shows flow paths resulting from an incorrect implementation of the D8-LTD method to the inward-draining circular cone. Flow paths resulting from the D8-LTD method are shown in Figure 3. Similar flow paths are shown in Figure 2k of *Orlandini et al.* [2003], where a spherical crater is considered. These flow paths display point symmetry. Hence, *Paik*'s [2008, caption of Figure 6] statement that "the global pattern obtained by D8-LTD [method] in the inward cone is deviated from the ideal symmetric pattern" is incorrect. In addition, cumulative lateral deviations reported in Table 1 of *Paik* [2008] are, at least in part, computed by using flow paths resulting from incorrect implementations of the D8-LTD method.

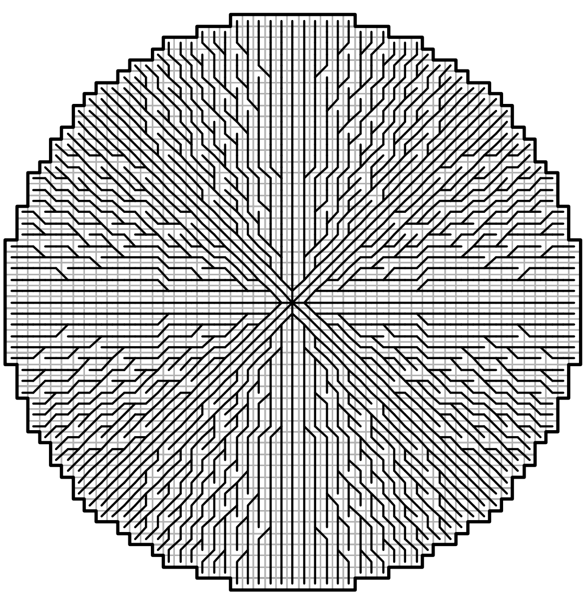

Figure 3. Flow paths resulting from the application of the D8-LTD method to an inward-draining circular cone which is represented by imposing the same planar position for the center of the lowest grid cell and the cone bottom vertex. These flow paths are insensitive to cone aperture variations.

[4] Further considerations on *Paik*'s [2008] analysis of the D8-LTD method are provided below. *Paik*'s [2008] Figure 4f illustrates the application of the D8-LTD method to an outward-draining circular cone which is represented by imposing the same planar position for the center of the uppermost grid cell and the cone apex. Unlike other single flow direction methods, the D8-LTD method determines a flow path originating at the cone apex that does not entirely extend along one of the eight possible cardinal or diagonal directions. This is due to the combination of two geometrical facts. The first is that triangular facets shown in Figure 1 of *Orlandini et al.* [2003] are used to approximate the draining surface. The eight triangular facets formed around the cone apex are shown in Figure 4. It can be verified that (1) each of these facets provides the same maximum slope, (2) facet ABC is selected simply because it is the one that is

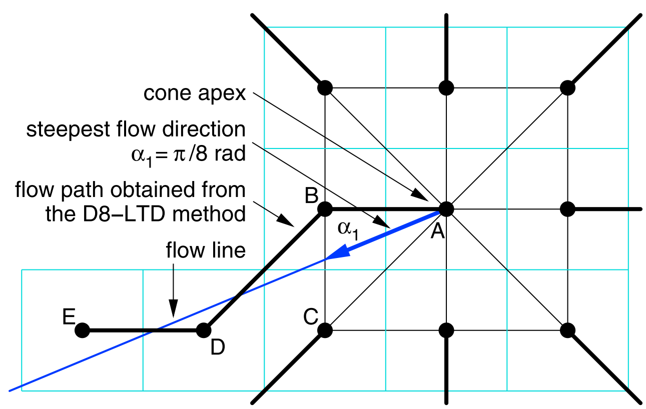

Figure 4. Sketch of the flow paths resulting from the application of the D8-LTD method to an outward-draining circular cone which is represented by imposing the same planar position for the center of the uppermost grid cell and the cone apex, with emphasis on flow paths in the neighborhood around the cone apex.

processed first, and (3) the maximum slope along facet ABC occurs in the direction bisecting the facet angle at the cone apex ($\widehat{BAC}$). The second geometrical fact is that a nonlocal (path based) analysis is performed (Figure 1). As shown in Figure 4, this implies that the steepest flow direction selected at the cone apex (A) determines the direction of the flow line around which the generated flow path (ABDE) zigzags. Because of this description of the flow path originating at the cone apex, a point symmetrical description of the outward-draining circular cone's flow paths cannot be provided. One can, however, note that the obtained flow paths zigzag along radial flow lines and, within the limitations inherent to the use of gridded elevation data, provide a plausible description of the drainage process. Point asymmetrical flow paths occur around the cone apex and consistently extend downslope. The FORTRAN code implementing the D8-LTD method is available as expressed in the work of *Orlandini et al.* [2003, section 5].

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