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# A visual basic program for ridge axis picking on DEM data using the profile-recognition and polygon-breaking algorithm ☆

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**Abstract**

For many scientists working with digital topographic data, extracting lineaments or linear features is an important step in structuring and analyzing raw data. A ridge axis, which represents the top a mountain ridge, is one of the most important topographic features used in a wide variety of applications. Algorithms and software for automating the extraction of ridges or ridge axes from DEMs are, however, still not easily available or not widely acceptable. In this paper, we present a user-friendly Visual Basic program that automates the extraction of the ridge axis system from DEM data, based on the profile-recognition and polygon-breaking algorithm (PPA). An important feature of PPA is that it takes a global approach, as opposed to the local neighborhood operators used in many other algorithms. Each segment detected by PPA considers not only relations with contiguous neighboring grid points, but also strives to preserve the continuity of the global trend. This is an attempt to simulate human operators, who always factor in the overall trend of the lineament before delineating its local parts. PPA starts by connecting all points in a neighborhood that can possibly lie on the ridge axis, thus forming a belt of polygons in the first step. Next, a polygon breaking process eliminates unwanted segments according to the assumption that a ridge segment cannot be the side of any closed polygon, and that the result should be a purely dendritic line pattern. Finally, a branch-reduction process is executed to eliminate all parallel false ridges that remained due to the conservative approach taken in the first step. Results indicate that PPA is reasonably successful in picking out ridges that would have been identified manually by experts. In addition to providing a detailed user interface for executing PPA, several modifications were made to significantly improve the computational efficiency of PPA, as compared to the original version published in 1998. The source codes are provided for free download on the website listed above.



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## 1. Introduction

Linear features that can be extracted from DEMs, satellite images or aerial photographs often provide useful information for scientists. Manual extraction of such features is labor-intensive and subject to

☆Code available at URL: http://ycc.dwu.edu.tw/Research/RidgePicker.htm.

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variations in individual expertise and conceptions. With the availability of computers to scientists everywhere, automating the extraction of lineament features is being studied intensively by scientists to promote consistent and standardized lineament detection methods (Koike et al., 1995; Knapperts-busch, 1998; Mugglestone and Renshaw, 1998; Casas et al., 2000; Costa and Starkey, 2001; Székely and Karátson, 2004).

Although most extraction algorithms profess to be widely applicable and often suggested as the standard, they have, in reality, remained ad-hoc, idiosyncratic methods limited by the context for which they were first designed. Consequently, most researchers still tend to design their own lineament extraction algorithms. One of the reasons for the lack of an acceptable standard is that the lineament concept is too diffuse to have a generic solution. There are several kinds of lineaments that scientists have to identify and deal with individually: ridges, valleys, fault lines, water-land boundary, vegetation zone boundaries, soil-type changes, and many others. Each one of them is modeled differently. Even after lineament segments are identified and extracted, connecting them together into one *Gestalt* whole to maintain the global trend is a difficult task. For example, a ridge or drainage system tends to be dendritic; on the other hand, a shoreline should not have any branches. Even in these two cases, when the concept can be clearly stated, the process of axis thinning (Choy et al., 1995) and segment connecting (Lu and Cheng, 1990; Raghavan et al., 1995) are still too complicated to have a universal solution.

To address the heterogeneity in lineament detection, the authors of this paper suggest beginning from scratch with a simple model that can be applied to diverse lineament types. In this paper, the ridge axis is chosen as a simplified, geometric abstraction for all observable linear topographic features. By simplifying the problem thus, all the attention can be paid to the problems of axis thinning and lineament continuity. As many researchers have mentioned (Chorowicz et al., 1992; Band, 1986; Tarboton et al., 1991), both DEM resolution and production errors cause many of the problems for automated feature recognition algorithms. Such problems are minimized in manual feature detection, because of the human ability to overrule local inconsistencies in favor of the overall observable trend. Clear preference for preserving the global trend preempts false truncations and fragmented lineaments during manual extraction of lineaments. The algorithm for detecting the ridge axis, discussed in this paper, is inspired by the human focus on maintaining the global linear trend.

The original ridge axis algorithm that this paper seeks to improve was presented in Chang et al. (1998) for dendritic pattern recognition. It was also successfully implemented later as part of the popular open-source GIS-GRASS (Chang and Frigeri, 2002). This ridge axis detection program presented here can simulate the trend awareness that human operators display through its Profile-Recognition algorithm. A polygon-breaking, algorithm is then used to thin down the linear feature without introducing improper truncations. In this paper, the authors extend the previous work, by adopting a visualization based approach to ridge axis detection. This "visualized" approach to the complicated process of polygon-breaking is expected to make the ridge axis detection and extraction easier than the original algorithm proposed by Chang et al. (1998). The algorithm has also been enhanced computationally, to increase the efficiency by as much as ten times in some cases.

## 2. Data preparation

In this paper, the DEM for a small area from Nanto County in Central Taiwan is used for illustrative purposes (Fig. 1a). First, the DEM is read by our program and transformed into a gray-level image. The user can exaggerate the image scale for visualization purposes. Fig. 1b shows an example. The original data set is $100 \times 100$ pixels, with samples on a 40 m grid.

## 3. Profile-recognition

For most lineament extraction processes, target feature recognition based on contiguous neighboring pixels is unavoidable. For example, Chorowicz et al. (1992) proposed a "profile scan" method to recognize ridge, valley and others features in the DEM. Local pixel comparison methods suffer greatly, however, from scale effects. For instance, there is no reason to assume that a ridge top must always be a local maximum. Ridge tops can be relatively flat in many cases, in which case local measures will fail to detect them correctly (Miliaresis and Argialas, 1999). Detection failure can also occur when the DEM resolution is too coarse to capture small ranged variations. To make the ridge axis detection robust against spurious truncations,