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LETTERS TO THE EDITOR

Comment on "Hillslope Topography From Unconstrained Photographs" by A. M. Heimsath and Hany Farid

A paper recently published in Mathematical Geology raises some concerns, which need to be expressed. The paper is entitled "Hillslope topography from unconstrained photographs" by Heimsath and Farid (2002) and presents a "simple methodology to extract the high resolution 3-dimensional topographic surface from photographs taken with a hand-held camera with no constraints imposed on the camera positions or field survey."

The implication from the abstract is that extracting spatial data from ground-based photography is a new development. Unfortunately, this prompted a BBC reporter here in the UK to publish an article on the web (Anon, 2002), apparently based on a web news item from Heimsath and Farid's own institution, which did not even mention photogrammetry, the science associated with extracting spatial data from photographs that has evolved over 150 years! During the same period these techniques have spawned an industry that has provided most of the world's large scale mapping and, as websites of the Remote Sensing and Photogrammetry Society's (www.rspsoc.org) and the American Society of Photogrammetry and Remote Sensing (www.asprs.org) suggest, so much more!

In fairness to the authors, the science of photogrammetry is referred to and relevant work involving photogrammetric methods is acknowledged in the paper, which was available freely over the Internet. However, from the Introduction and Discussion it would seem that the authors are convinced that photogrammetry imposes "high degrees of constraints upon the positions of the cameras," and that "precisely located control points" and "application specific third-party software" are required, and they go on to argue that their solution is an improvement.

Firstly, it is important to state that in modern photogrammetry there is huge flexibility in both the position and orientation of the camera and indeed the type of camera that can be used. The key condition is that in order to extract three-dimensional (3D) coordinates, the feature required must appear on a minimum of two photographs. It is important to maintain some general geometric relationships between the camera positions and the object, which are embodied in

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the base/height ratio (see any textbook on photogrammetry, Mikhail, Bethel, and McGlone, 2001, p.28; Slama, 1980, p. 952; Wolf, 1974, p. 66). This is also an issue that would be of some importance to the approach developed in the paper, although sadly this aspect is not examined. It is also not essential to use precisely located photo-control points to carry out photogrammetry, although there are many advantages from doing so. Most significantly for process-based studies, photo-control defines an appropriate datum in which elevation changes are related to the local vertical and allows meaningful spatial comparison in multi-epoch surveys.

There are also some problems with the theoretical aspects of the development. The authors assume a perfect pinhole camera—as do photogrammetrists. From this assumption the well-known and fundamental collinearity equations are developed. However, the authors do not consider the impact of camera geometry and lens distortion in their mathematical model, which is important for measurements derived from any camera not designed for photogrammetry. This is an area where photogrammetrists have made major contributions (Fraser, 1997; Kenefick, Gyer, and Harp, 1972, p 1118; Slama, 1980, p. 480), to the extent that the mathematical models used to compensate for a whole array of systematic effects associated with modern sensors have become broadly accepted. Such models and appropriate photo-control points can assist in the camera calibration process, essential if 35 mm imagery is used. Another key limitation of the new approach is the whole principle of the "paraperspective" projection. Why use a nonrigorous model when a rigorous solution is clearly in the public domain? (i.e., collinearity). The "paraperspective" model may be appropriate for the machine vision community where camera to object distances are typically less than a few meters, but at the process-based scale this model is surely not accurate enough, particularly if there is a wide depth of interest in the object space. This limitation is clearly responsible for the "subduing" effect on the measured topography and for the mean elevation errors, which most photogrammetrists would consider to be rather large considering the photo scale (again not mentioned).

The authors make the point that photogrammetry applied to past landform studies has relied upon third-party software. Why is this such a limitation? Did the authors write their whole paper in a basic ASCII editor such as Microsoft® "notepad" or did they use a more comprehensive word processing package such as Microsoft® Word? The cost of proprietary photogrammetric software packages capable of extracting digital elevation models (DEMs) consisting of many thousands of points automatically and then generating orthophotographs has never been cheaper. They are often directly available to university researchers through generous academic licensing agreements and generally easy to use. If direct access to such functionality proves difficult, why not contact and collaborate with researchers engaged with photogrammetric research? From our experience, this can be a "win-win" situation for all concerned!

In summary, it is somewhat surprising that the referees selected to assess, review, and improve this particular paper did not identify these weaknesses on this occasion. Of perhaps greater concern is that the article may encourage geographers and earth scientists to use the techniques offered freely and which many would classify as being photogrammetric. Poor results will inevitably be obtained and this may discourage a whole new generation from benefiting from 150 years of scientific evolution in photogrammetry.

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