Cobble Cam: Grain-Size Analysis of Sand-to-Cobble from Digital Photographs

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ABSTRACT

Here we report on our efforts to apply the autocorrelation techniques of Rubin (2004) to measure grain-size of fluvial and coastal gravel bars using digital photographs. Digital photos were obtained from approximately 1 m above the ground surface of granule- to cobble-sized sediment. Physical measurements of the intermediate and long dimensions of clasts in the field closely resembled the short and long axes, respectively, measured from the digital photos on a computer. Calibration curves for the autocorrelation technique were generated from a series of the best-sorted samples in the digital photographs. Optimal results occurred when the analyses were discontinued at an autocorrelation threshold of 0.25, for which r-square between the actual grain size and the autocorrelation estimate of grain size was 0.94 and the r.m.s. error was 0.3 phi-units. We also evaluated the effects of wet/dry conditions and illumination on these results. Replicate photos were obtained of dry gravel and the same gravel that was wet artificially. The mean difference in the estimated grain-size from the wet and dry conditions was 4%. Patchy wetness, however, introduced an error on the same length scale of the patchiness. Illumination variability also introduced error (up to 10%) shown by repeat photographs at a single station over the course of a day. These illumination effects can be minimized by the use of shades and a camera flash, although these additional pieces of field equipment may introduce further complications.

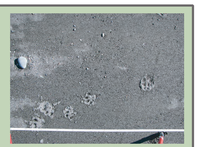
I. Research Question

Can we characterize the variations in grain size of coastal and fluvial landforms quickly and at low cost?

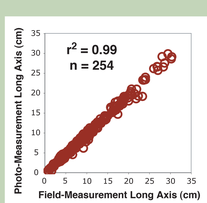
II. Photographic Methods

There are numerous techniques and considerations when sampling coarse sediments (e.g., see References). Photographs can provide grain size samples, although the following characteristics:

(1) Surface Sample (no subsurface)
(2) Planar Sample (not volumetric)
(3) Potential for Bias (imbricated, shadowing, ...)
(4) Limited Resolution
(5) No Physical Sample



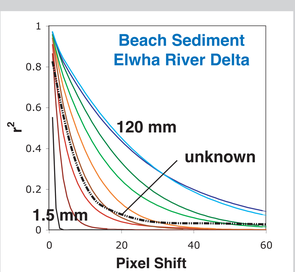
The general technique of photographic methods is to obtain an image with limited distortion and with known spatial scale from which grains can be measured. Here we examine the applicability of the Rubin (2004) autocorrelation tehcnique to sand-to-cobble sediment using a tripod-mounted camera.

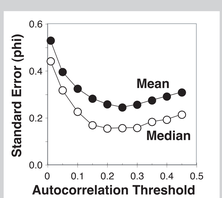


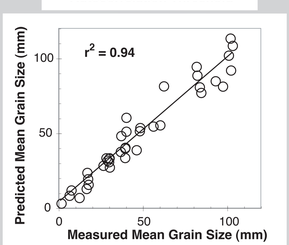
Grain size measurements from the field and photos may compare well.

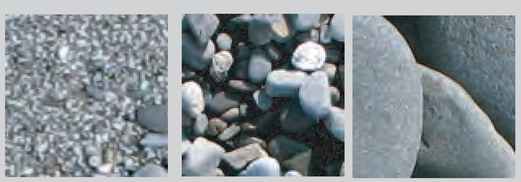
III. Autocorrelation Technique

The Rubin (2004) method is relatively simple. It is based on the observation that the corrrelations between pixels on any sediment photo will decrease with increasing distance (or "pixel shifts"). The rate of decrease in correlation will be related to the grain sizes, shapes and colors in the image and other effects such as lighting. Clippings of photos (below) show examples of these relations. A series of autocorrelation curves are shown for beach sediment (at right). A monotonic relation between grain size and the correlation coeficient is shown.







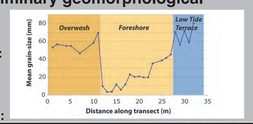


A series of autocorrelation are then chosen to become the calibration curves, then a photo with unknown grain size is evaluated by best fitting through the calibration curves. The technique is optimized by minimizing error between measured grain size (above).

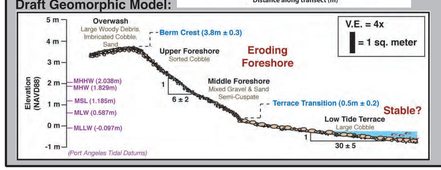
IV. Application to Elwha River

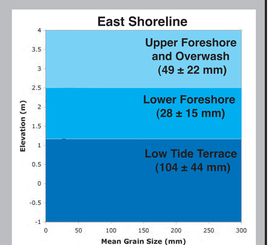
We are testing the Cobble Cam method at the Elwha River (833 km^2) of Washington with the goal of evaluating the effects of the pending dam removal on sediment flux and geomorphic change. Preliminary results are encouraging. For example, beach grain size mapping is revealing a relations with elevation, which has been integrated into a preliminary geomorphological model.

Example Profile:



Draft Geomorphic Model:



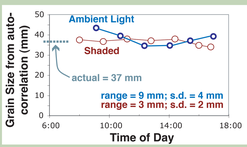


"Stitched" cobble cam photos from a beach profile.

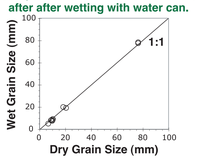
V. Pending Issues

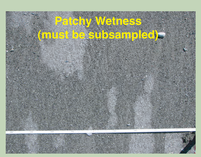
This is a work in progress, and a number of issues remain pending. For example, it has been found that illumination has an effect on the output. Although the results of the analysis are remarkaby similar for wet and dry conditions, patchy wetness can induce significant errors on the scale of the patchiness. Unresolved issues include how to synthesize results from images with clear bimodal distributions and algal/crustacean growth.

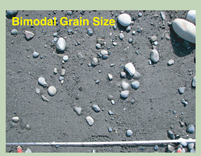
The effect of iullination on autocorerelation results. Identical site resampled during sunny day in both ambient light and shaded with an umbrella:



Comparison of identical sites before after after wetting with water can.







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