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Using computer tomography to visualise and quantify macropores in intact soils, the issue of thresholding

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Soils with strong texture contrast between surface and B horizons, called duplex soils in Australia, dominate the agricultural zone of western and southern Australia. The texture of the A and E horizons is usually coarse (sand, loamy sand, sandy loam) and the B horizon is often much finer (clay, clay loam). These horizons are inimical to root proliferation. The A and E horizons have a low water holding capacity. The B horizons (especially at the E horizon contact) are non pedal and have high strength and bulk densities in excess of 2 g.cm$^{-3}_{.}$Native perennial vegetation e.g. Acacias, Eucalypts, Proteaceae, have created biopores that have been observed to extend many meters through the profile. These macropores not only provide pathways through soil otherwise impenetrable by many plants but also improve exposure to preferential flows of oxygen, water and nutrients. Understanding pore distribution is fundamental to understanding how roots proliferate in these soils more particularly whether they are utilising a pre-existing network or creating a network themselves. Pore characteristics required to predict root growth in duplex soils are pore distribution, orientation, length and connectivity. Measurements of these pore characteristics can only be made if the three dimensional (3D) structure of the pores is known. Computer tomography (CT) analysis has proven to be a powerful tool in soil science insofar as it enables non-invasive and non-destructive analysis of the internal structure and texture of samples

by mapping the density distribution at high resolution in three dimensions. There is a need to identify, reconstruct and visualise the 3D networks of macropores. Thresholding the images from the CT scans is the step that most influences the rest of the 3D measurements from the image segmentation. During this process, binary images are constructed by assigning the pores one value and pixels representing the background or soil matrix another value (generally these values are 0 and 1). The thresholding operation is complicated by various factors. The lack of objective measures to assess the performance of various thresholding algorithms, and the difficulty of extensive testing in a task-oriented environment are major handicaps. In this study, a thresholding method developed by Oh and Lindquist (1999) that utilized the spatial covariance of the image in conjunction with indicator kriging to determine object edges, was tested to determine macroporosity in 16 bit X-ray absorption images obtained from X-ray scans of intact cores of duplex soils. The method is local and here we test the hypothesis that it guarantees smoothness in the threshold surface.

Oh, W., Lindquist, B., 1999. Image thresholding by Indicator Kriging. IEEE transactions on patters analysis and machine intelligence 21, 590-602.