The development of SOLICON 2 - Classification of Soil Structural Condition using Horizontal Image Analysis

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The purpose of this work is to develop a technique for standard quantitative soil structural assessment using horizontal image analysis. The SOLICON (Moran *et al.,* 1989a*)* soil structure evaluation system has been developed further to enable horizontal soil sections to be analysed and classified. Using this new system, SOLICON 2, images of soil collected from the field can be measured and classified in relation to a library of structures.

This computer aided system involves the collection, processing, analysis and classification of images that represent the field condition of the soil pore structure in specific horizons. There are four major steps involved:

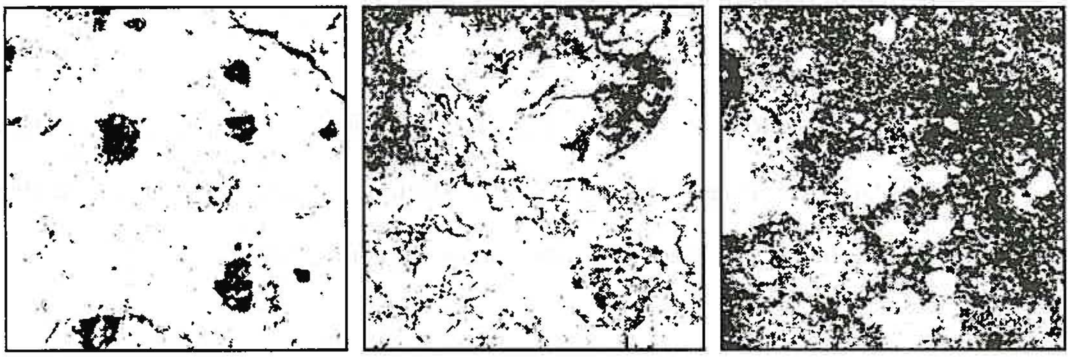
1. Visualising the pore network

There is a variety of dying and staining methods available to highlight and expose the soil pore network. The resin impregnation technique (developed by Moran *et al., 1989b)* was found to be the best for highlighting soil macropores. Other cheaper and simpler techniques have been used (e.g. paint) but the images do not depict the structure so well. Samples taken at two depths under a wide variety of management regimes were impregnated using a polyester resin with a UV dye. The samples were hand-ground to expose a single section of the horizontal structure. The samples collected are approximately 300 × 300 mm wide × 100 mm deep to enable horizontal images of 200 mm square to be captured. This size was chosen because it is large enough to be related to the size of the root mass from a single growing plant. It is also a size from which one photograph will give the convenient resolution of 0.1 mm per pixel.

2. Obtaining a binary image

Photographs are taken of the exposed soil structure surface under UV lights to obtain the best contrast between pores and solid soil. These photographs are simply scanned into a computer to obtain a digital image. Alternatively a digital camera could be used to capture images directly to disc but the current resolution is poor. The digital image must be made binary (black and white) by using a technique called segmentation. The image segmentation procedure is standardised so that all images are treated equally.

A *B* *C*



These three digital binary images, A, B and C were segmented using a standard colour segmentation. Each image represents 200 × 200 mm of soil. Pixel resolution is 0.1 mm. Black pixels represent pores.

3. Image analysis

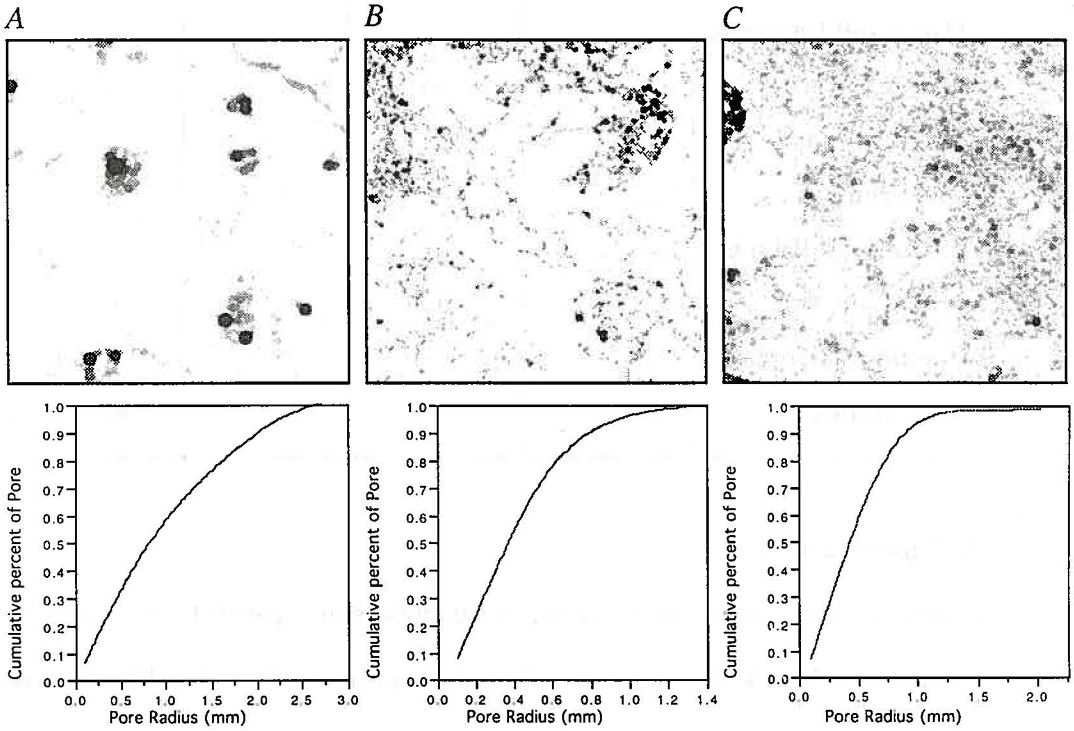
This involves the measurement of structural attributes from the images. The measurements used for horizontal analysis are outlined below:

Porosity: measures the volume proportion of pores per unit soil.

Surface area: measures the boundary area of the pore and solid interface per unit volume of soil.

Solid star area: measures the equivalent diameter of the size of solid area (white) that can be measured in eight directions from each solid pixel. The mean solid star area gives an average size estimate of soil aggregates.

Pore sieve: measures the equivalent diameter of octagons that fit inside the pore space. The mean gives an average size of pores. The distribution of the pore sieve relates to the pore size distribution



These three images and graphs represent the pore sieve distribution the estimated pore size distribution of the images A, B and C.

Minimum intra-solid distance transform: is the shortest distance from any solid pixel to the nearest pore pixel, this represents the distance that air or solutes must travel to infiltrate the soil. From this transformation two other important measurements can be made.

Anaerobic risk: is the proportion of the soil that is pore or within 3 mm of a pore and hence the best environment for roots (in a heavy cracking clay).

Rooting potential: is the proportion of the soil that is within 3 mm of a pore and hence the best environment for root growth (in a heavy cracking clay).

Pore Genus: is the connectivity of the pore phase. The larger the genus the more connected "pore loops" exist in the image.

This Table show the attributes measured for the three images A, B, C.

Structure attributes	Units	*A*	*B*	*C*
Porosity	mm mm^{-3}	0.0762	0.166	0.394
Surface area	$mm^2 mm^{-3}$	0.235	0.840	1.61
Mean solid star area (equiv. diameter)	mm	36.9	15.8	7.42
Mean min. pore sieve radius	mm	0.968	0.426	0.494
Intra-solid distance	mm	2.25	1.27	0.61
Anaerobic Risk	%	0.21	0	0
Rooting Potential	%	74.7	92.5	99
Pore Genus		45	347	890

4. Classification

Fuzzy classification gives the degree of membership (from 0 to 1) of each image to a class. Classes may be defined to suit the purpose, by using the structure attributes.

Two simple classes are shown for A, B and C.

Image Membership	Poor	Fair	Good
A	0.47	0.27	0.15
B	0.09	0.82	0.09
C	0.08	0.15	0.76

This system has been successfully applied to field trial images to distinguish management treatments. Horizontal structural attributes measured using image analysis can be used to classify the soil structural condition. This will enable soil scientists to quantitatively allocate soil to agronomically relevant structural classes.

Presently a library of 180 images representing the variety of structures that exist in cotton growing areas of NSW and QLD is being collated. From this library structural classes can be created and used for practical applications.

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REFERENCES:

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