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Rectification of management zones considering moda and median as a criterion for reclassification of pixels

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Abstract. *Management zones (MZ) make economically viable the application of precision agriculture techniques by dividing the production areas according to the homogeneity of its productive characteristics. The divisions are conducted through empirical techniques or cluster analysis, and, in some cases, the MZ are difficult to be delimited due to isolated cells or patches within sub-regions. The objective of this study was to apply computational techniques that provide smoothing of MZ, so as to become viable operationally. Data physical soil properties and soybean yields were collected in 40 sampling points, being selected elevation and soil resistance to penetration (SRP) for the definition of MZ, because presenting spatial correlation with the normalized average yield. The software SDUM (Software for Definition of Management Zones) was used to perform descriptive statistical analysis, spatial correlation between attributes, data interpolation (inverse distance), and definition of MZ with two, three, four and five classes by clustering method Fuzzy C-Means. The MZ were generated with pixel size of 5x5 m, resulting in non-contiguous classes with patches or isolated cells, especially in maps with four or five classes. The reclassification process was carried out considering its close neighbors (3x3 and 5x5 pixels), making use mode and median statistics. It observed that the rectification of ZM through the implemented computational function was able to provide settings that facilitate the implementation of the AP and, in this study, the median statistic with 5x5 mask was the rectification method which demonstrated better results.*

Keywords. *clusters, precision agriculture, smoothness.*

Introduction

The division of agricultural areas into smaller homogeneous units, known as management zones (MZ), is a good alternative for the implementation of precision agriculture (PA). In this manner, the application of agricultural input is performed with constant rate within the MZ, and variable among them, which results in cost reduction, enabling the application PA. In order to define a MZ, that is, a portion of field that is more closely similar, several approaches have been developed. The divisions are carried out through empirical or clustering techniques, and several researchers (Tagarakis et al., 2013; and Rodrigues Jr. et al., 2011) have found satisfactory results for cluster analysis procedures that define MZ. However, in some cases, the generation process causes small isolated fields to be defined within a class, hindering the operation at a variable rate between them, since the purpose is to use mechanized assembly systems with a fixed application rate within each MZ. In this manner, it is important to use any tool capable of analyzing each pixel and its neighbors and, where necessary, change their classification. Thus, this study aimed to develop and apply computational techniques using mode and median in order to rectify and, in this manner, smooth the MZ, making them more viable from an operational point of view.

Methodology

Data collection was based on an irregular sampling grid of one experimental field located in rural field of the municipality of Céu Azul (25º06'32'' S and 53º49'55'' W), located in the western region of the state of Paraná, Brazil. The field has been cultivated under no-tillage system for over 10 years with rotation of soybean/corn for commercial purposes. Measure approximately 15.5 ha and 40 point samplings were set. Only stable attributes and, therefore, recommended for studying the definition of MZ were collected and analyzed, as percentage of sand, clay and silt, acidity, elevation, soil resistance to penetration (SRP) 0-10 cm, 10-20 cm and 20-30 cm depth in 2013 and 2014 and soybean yield in three crops (2012/2013 , 2013/2014 and 2014/2015). The data of all yields were normalized by means of amplitude to transform the value found at each point sampling into a normalized value. The SDUM software was used for defining management units (Bazzi et al., 2013) in order to carry out the descriptive statistical analysis of sample data and interpolation data by inverse distance, considering the data of ten neighbors nearest the pixel to be estimated, as well as 5×5 m pixels. The aforementioned software was also used to perform the spatial correlation analysis between attributes using a spatial correlation matrix (Bazzi et al., 2013), calculated by Moran's bivariate spatial autocorrelation statistic, which aimed to select layers to generate the MZ. Once variables (attributes) were selected, maps with two, three, four, and five classes were defined using Fuzzy C-Means Clustering algorithm.

In order to solve the issue of having very small MZ, a computational function was implemented directly in the database PostgreSQL using the procedural language PL/pgSQL, which is able to analyze each pixel behavior in relation to their neighboring using median and mode; if necessary, reclassify them into a different class. In order to reclassify each pixel, up to eight neighboring pixels were taken into account to 3×3 mask or up to twenty-four pixels to 5×5 mask, always excluding the pixel value that was being reclassified. In this manner, all generated maps were submitted to the rectification process five times, using four methods defined for this study, namely, 3×3 and 5×5 median and 3×3 and 5×5 mode. In order to identify how smoothed MZ were after rectification a smoothness index was used, which is the result of frequency variations of classes in the thematic map in horizontal, vertical, and diagonal directions, pixel by pixel.

Results and discussion

The sample data of elevation and SRP 0-10 cm depth in 2013 showed spatial correlation with the normalized average yield, and so were the attributes used to define MZ in this study. Regardless the number of classes, the MZ generated were visually independent, only some spots and irregularities on the edges, but the quality of the generated maps worsened as the number of classes increased (Figure 1). The smoothing of maps in the first rectification was more obvious from the visual inspection of the effect of the four methods defined for this study (3×3 median, 5×5 median, 3×3 mode, and 5×5 mode) in the thematic maps (Figure 1) obtained after the first and fifth rectification. When field was divided into four and five classes some differences were found, although only 5×5 median removed all the spots and stray pixels over five rectifications.

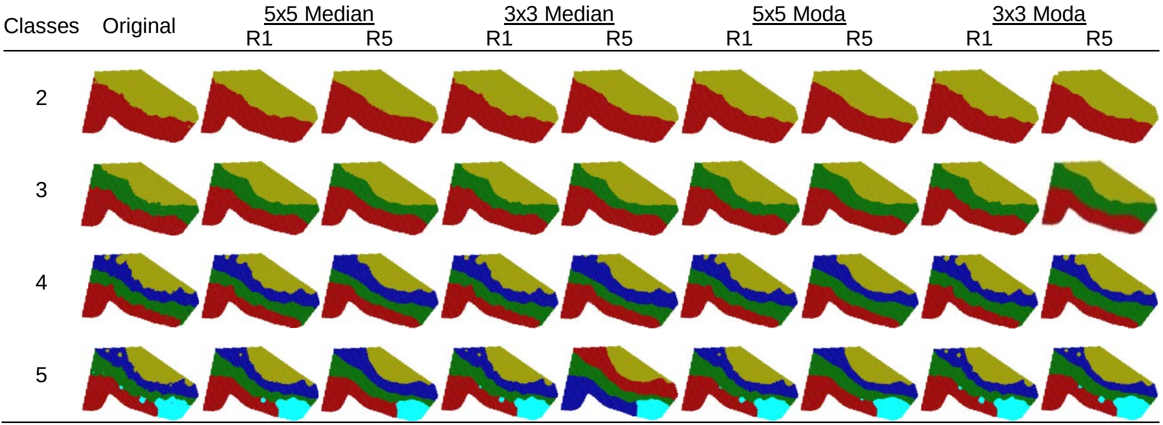

Fig 1 Original and rectified maps using the methods studied

It became evident from graphics of Figure 2 that the smoothness index showed greater variation in the first rectification, and that the index increased proportionally as the number of rectifications increased. It was also possible to identify that rectification methods using 5×5 mask always provide higher total smoothing, and it is more significant when the number of classes increased. The smoothness index showed a similar behavior in relation to all methods used in maps with two and three classes. In case of maps with four and five classes, the 3×3 median method followed the same variation of 5×5 mask methods. On the other hand, 3×3 mode showed lower variation.

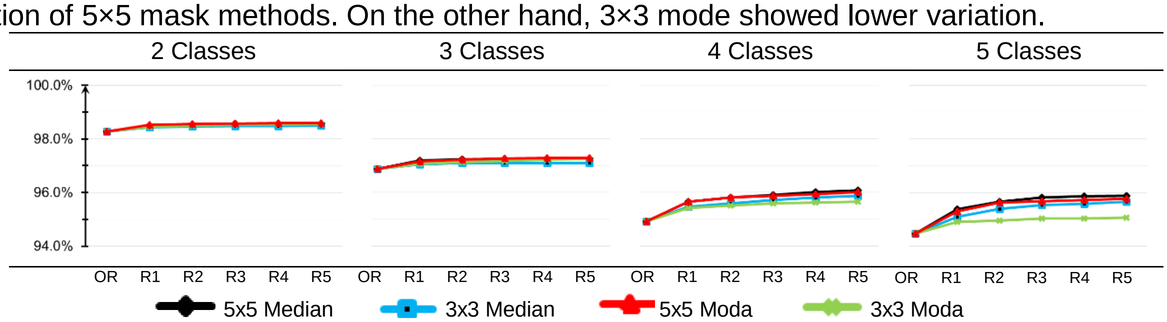

Fig 2 Smoothness index total increase after each rectification

Conclusion

It was found that each time the function was applied, the edges were smoothed and the patches reduced, and after the fifth rectification the patches were generally removed. Thus, the application of computational function of pixels reclassification enabled map changes that facilitate the application of MZ. In this study, the median statistic with 5x5 mask was the rectification method which demonstrated better results.

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