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Technical Note

Numeric representation of the surface from the coordinates collected by topographic GPS receiver

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Abstract

With the sanction of the Law number 10.267 for the use of georeferencing in topographic applications, which seeks to establish the technical precepts applicable to services of land surveying, aiming the characterization and georeferencing of rural properties through topographic survey, and posterior certification by the INCRA, the new law of georeferencing has as its main objective to standardize the studies of land surveying. According to the new law, the coordinates to be used for this goal are expressed only in the planimetric form, considering as valuables the plan-rectangular coordinates X and Y, that is, its longitude and latitude, discarding the coordinate Z, altitude. The present study found the possibility of using this coordinate Z, the altitude acquired without extra efforts in georeferencing surveys, for a possible new digital model and consequent edition of new planialtimetric charts, especially for regions where such charts are only available in small scales.

Keywords: Topography, Georeferencing, Planialtimetry and GPS.

Representacíon numérica de la superficie a partir de las coordinadas recogidas por receptor gps topográfico

Resumen

Con la aprobación de la Ley 10.267 para el uso de georeferenciación en aplicaciones de topografía que tiene por objeto establecer las disposiciones técnicas aplicables a la agrimensura objetivando a la caracterización y l georeferenciación de las propiedades rurales a través de levantamiento topográfico y posterior certificación junto al INCRA, la nueva ley de georeferenciación tiene como principal objetivo estandarizar los trabajos de agrimensura. De acuerdo con la nueva ley, las coordenadas que serán utilizadas para este fin están expresas solamente en la forma planimétrica teniendo como objeto de valor solamente las coordenadas plano-retangulares X e Y, es decir, su longitud y latitud descartando la coordenada Z, altitud. Este estudio constató la posibilidad de utilización de esta coordenada Z, la altitud adquirida sin esfuerzos adicionales en levantamientos georreferenciados para su uso en un posible nuevo modelo digital y la consiguiente emisión de nuevas cartas planialtimetricas, especialmente para las regiones en que estas cartas solamente están disponibles en pequeñas escalas.

Palabras clave: Topografía, georeferenciación, mapas topográficos, GPS.

Representação numérica de superfície a partir das coordenadas coletadas por receptor GPS topográfico

Resumo

Com a aprovação da Lei 10.267 para o uso de georreferenciamento aplicações topográficas que tem como objetivo estabelecer as disposições técnicas para o levantamento com o objetivo de caracterizar

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l georreferenciamento de imóveis rurais por meio de levantamento e posterior certificação pelo INCRA, georreferenciamento principal objetivo da nova lei é padronizar o trabalho de levantamento. De acordo com a nova lei, as coordenadas que serão utilizados para esta finalidade são expressos apenas na forma planimétrica tendo como valiosos apenas coordena-Retangulares planos X e Y, ou seja, latitude e longitude descartando a coordenada Z, altitude . Este estudo confirmou a possibilidade de utilizar essa coordenada Z, altitude adquiridos sem esforços adicionais levantamentos georreferenciados para uso em um possível novo modelo digital e, portanto, planialtimetricas emissão de novos cartões, especialmente para as regiões em que estes cartões só estão disponíveis em pequenas escalas.

Palavras chave: topografia, georreferenciamento, mapas topográficos, GPS.

Introduction

Cartography, according to PEZZOTI et al (1995), came up from the necessity of men to know with greater detail the world they lived in, and document it, in order to transmit this knowledge to other members of their group; it can also be defined as the science, the technique and the art of special representation of changes in natural and society phenomena throughout time.

The development of methodologies for updating Topographic Charts becomes essential, being necessary to organize what are the best methodologies to be employed in order that such results can present themselves within the quality standards required by different scales, regarding geometric precision and informative content (CARVALHO, 2013).

The GPS system (Global Positioning System) has proven, in the past few years, that it is an effective technique of positioning, providing the obtaining of coordinates with precision, mainly the geographic coordinates of latitude and longitude (SEGANTINI., 1999).

According to NEWCOMER and ASCE (1990), some aspects have highlighted the GPS in relation to other conventional methods of land surveying, however, it is important to point out the three-dimensional work, allowing high precision of measures, and not requiring intervisibility between spots, a factor that is required among the conventional topographic equipments.

The GPS, or NAVSTAR – GPS (Navigation Satellite with Time and Ranging), is a system of radio-navigation developed by the Defense Department of the United States of America – DoD (Department of Defense), with the intent of being the main navigation system of the American military force. It resulted from the merging of two programs financed by the North American Government for developing a navigation system of global scope (MONICO., 2000).

The GPS was declared operational on April 27th of 1995. At that time, there was a total of 25 satellites and, according to the policy of the president of the United States, in the same period, it was said that it was possible that the use of GPS by civilians would be available in the following decade, which really happened. In this policy, it was also assured the continuity of GPS service globally, without the charging of direct fees. Another important aspect was the decision to develop and implement the extension of GPS, so it could be used as a pattern for transport systems, american or international MONICO (2000).

Similar to the GPS, the GLONASS (Global Navigation Satellite System) was conceived to provide a 3D positioning and speed, as well as information about weather, or whatever climatic conditions, on local, regional and global levels. This system was also conceived in the early 1970s, in former USSR (Soviet Union's Scientific Production Association of Applied Mechanics), and is currently developed and operated by the Russian Federation Space Forces. Like the GPS, the GLONASS is a military system, but there were several statements made by the governments offering the system for civilian use (MONICO, 2008).

The periodicity of the satellites in relation to a certain spot on Earth is of 24 hours, with a 4 minutes decrease each day; some of those satellites can be seen more than once during these 24 hours, always maintaining the 4 minutes advance each day. In relation to the number of satellites, we can say that the GPS is updated constantly, being able to, at any moment, increase or decrease the number of satellites in operation; it is noteworthy that, presently, there is a total of 31 satellites in operation, increasing their precision each day (RODRIGUES, 2014).

The use of GPS receivers without the knowledge of its limitations or classifications can lead the operator to collect positions with low precision (TRAGUETA., 2008).

The precision is directly linked to the way of acquisition, data correction and the superficial and physical information collected, as well as its representation (ISHIKAWA, 2007).

According to AMORIN (2004), the term precision is the level of referencing with which a magnitude is measured. In other words, it means when the values of a series are measured several times and the results of these operations are close very close to one another. Normally the precision is expressed in terms of standard deviation or variance. As for the accuracy, there are different types and concepts, among them we highlight the positional and geometric accuracy, result of the measure of how a data differ spatially (in terms of absolute position, relative form) from those taken as reference.

With the advance of GPS on obtaining geographic coordinates over any position on Earth, it was established in Brazil, on August 28th of 2001, the Law number 10.267/2001, which, among other concerns, deals with the georeferencing of rural properties. This law demands that the bordering vertices of rural properties be georeferenced to the Brazilian Geodetic System (SGB), in the cases of dismemberment, parceling, ownership change, allotment, rectification of areas, besides other activities involving the property (FRANÇA, 2010).

In function of this current legislation (Law number 10.267/2001 and ordinance INCRA/P/Nº 954 of 2002), the rules established by this norm have as reference the determination for each coordinate pair, with positional precision better than 0.5m. It is understood by positional precis0GPS and topographic softwares, both for data surveying and processing and elaboration of maps and floor plans, is common and substitutes more and more the conventional topographic practices in field, the development of spreadsheets and the manual drawing, resulting in material of excelent quality and reliability, apart from the considerable gain of time, generating the opportunity of making numerical modeling from these coordinates.

The Digital Terrain Model or MNT is the mathematic-computational representation of the distribution of a spatial phenomenon that occurs on a region of land surface. Relief data, geological information, depth survey of the sea or a river, meteorological information and geophysical and geochemical data are typical examples of phenomena represented by a MNT. Among some of the uses of MNT, Felgueiras (1999) cites: data storage of altimetry for generating topographic maps, analyses of cutting and backfill for road and dam projects, elaboration of declivity maps and display for support and analysis of geomorphology and erodibility, three-dimensional presentation (in combination with other variables).

The relief characterization of a micro basin is the fundamental basis for the design of sustainable management of land in areas with similar characteristics; the knowledge of the landscape heterogeneity is also important for developing schemes of soil samples and defining management practices (SANTOS., 2002).

The caution at choosing spots and the quantity of sampled data are directly related to the quality of the final product of an application over the model. For applications where it is required a higher level of realism, the quantity of sampled spots, as well as the caution at choosing these spots, that is, the data quality, are decisive (FELGUEIRAS., 1999).

Within the context of position collection with topographic GPS receivers, the position provided refers to the longitude, latitude and altitude; the present study was developed with the objective of finding the digital terrain model generated based on the coordinates collected by a GPS receiver, visually comparing the land deformity through the contour lines generated mathematically with the contour lines from the cadastral map of São Paulo State.

Material e Methods

4.1 Study area

The study area, as showed in Figure 1, is located between the cities of Lençóis Paulista and Pratânea, São Paulo State, approximately 20 km from the downtown of Lençóis Paulista city, having its central position defined by the plan-rectangular coordinates, system UTM 733,581.9002m 7,477,179.9294m with an average altitude of 725 meters.

4.2 Used equipment and software

PATHFINDER TRIMBLE GPS receiver, PRÓ XR model, L1 carrier and code C/A, 12 channels. RECON data collector.

TOPOEVN easy 6.0 CAD.

Autodesk Map 2004.

GPS Pathfinder Office 3.0

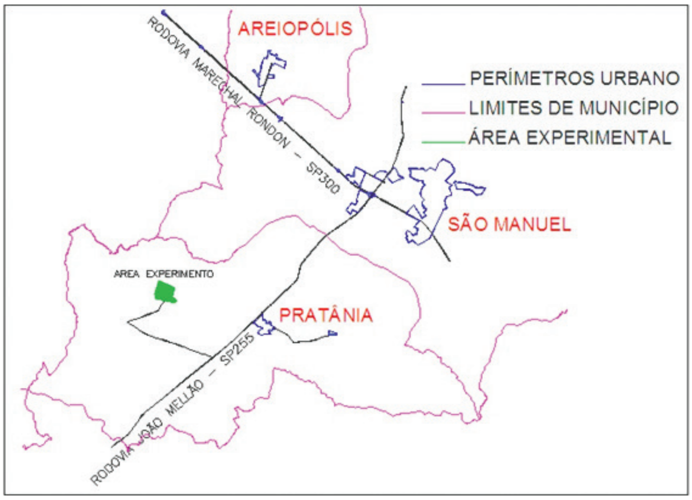

**Figura edited in portuguese by the author.*

(Urban area | County boundaries | Experimental area | Marechal Rondon Highway | João Mellão Highway)

Figure 1. Location of the area

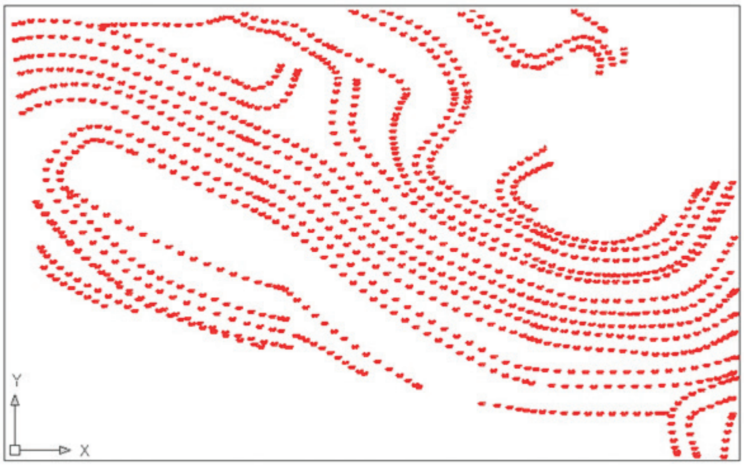

Figure 2. Image of the spots collected in field

4.3 Data Collection and numerical modeling of the surface

For the collection of the sampled data in field we used a topographic GPS receiver and with the receiver shifting kinematically within the area, collecting position data each 5 seconds. During its shift throughout the area, the operator of the GPS receiver went through all relief deformities of the land so that the position samples were reliable on its altimetry representation.

In Figure 2, we observe the spots sampled in field.

After the spots in the field were collected, we used the software *TOPOEVN*6.0 for the numerical modeling of the surface area.

Each sampled spot in field, according to Figure 2, contains the coordinates X, Y and Z, that is, Latitude, Longitude and Altitude; with this data in hand in a mathematical way, so it is possible to model it, it is necessary that each sampled spot be triangulated with two other spots. This triangulation can be more easily understood by observing Figure 3, where each sampled spot is connected to other, forming a single figure, that is, a triangle.

With the triangulation of the spots collected in field, the *TOPOEVN* software, statistically and mathematically interprets the areas not sampled, generating, so, levels of lines that together represent the terrain modeling through its representation; this modeling is represented by contour lines, which, equidistant to one another, can represent the land surface.

Results and Discussion

After the mathematical triangulation of the spots, the software calculated the altitude differences between each sampled spot and generated geometrically contour lines accompanied by its quota. In Figure 4 we can observe the level lines generated by the mathematical modeling.

As seen in Figure 4, the level lines can represent through its outline the model of the local surface. In order to compare the surface model generated based on the sampled spots in field with the topographic GPS receiver, we used a cadastral map of São Paulo State. Such registers are scaled at 1:10.000, and its altimetric representation has equidistant curves at every 5 meters, vertically, as seen in Figure 5.

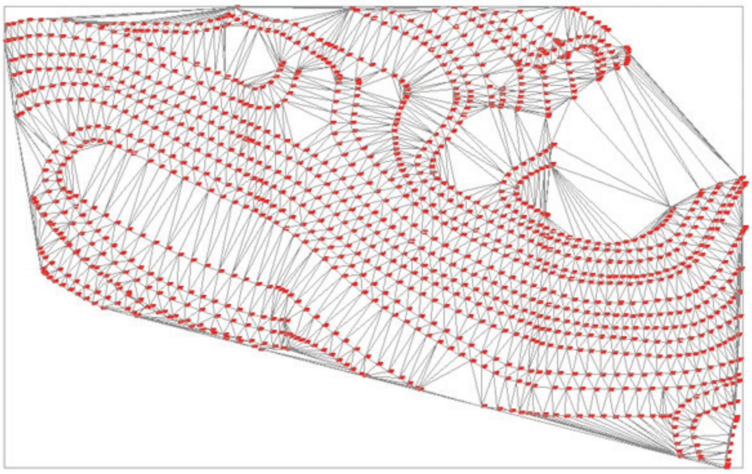

Figure 3. Triangulation of the spots collected in field

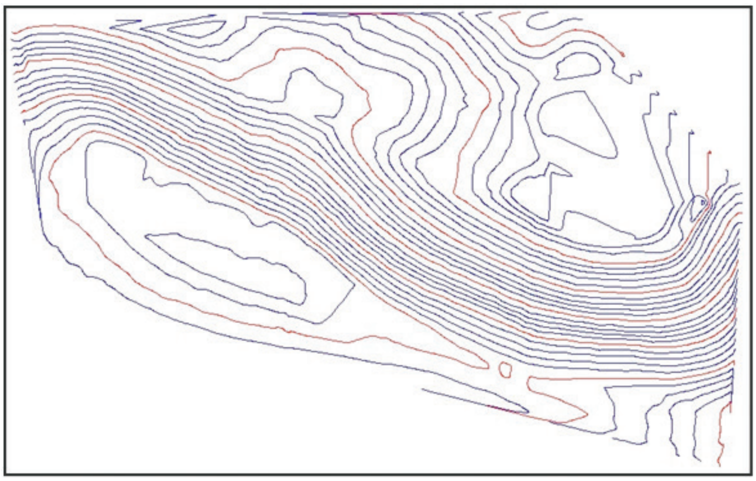

Figure 4. Contour lines generated by numerical modeling of surface

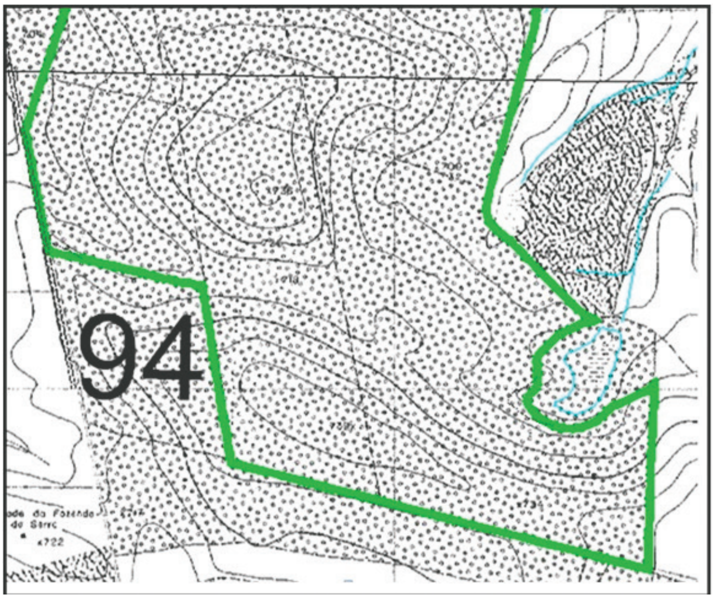

Figure 5. Altimetric representation of the cadastral map

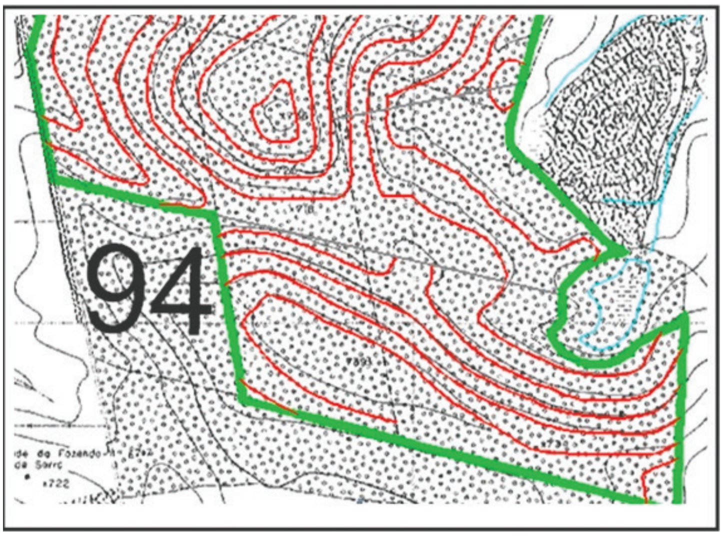

Figura 6. Numerical Modeling of the Surface overlapped to the curves of the cadastral map

In Figure 5, the green-colored line represents the perimeter of the studied lot and the number 94 is the name given to the studied lot. The form used for the altimetric representation of the terrain is through the representation by contour lines equidistant to each other. In Figure 6, the red-colored lines represent the modeling generated based on this study and, at the background, the altimetric representation of the cadastral map. We can observe that the curves of the cadastral map have similar outline to the one generated by the spots collected by the GPS, which shows the quality of the collected spots for this finality, that is, the modeling of the surface. Considering that the curves of the cadastral map have great precision and, for presenting a similar understanding of the relief in both models, the methodology used in this study can provide the basis to new studies, when the aim is the study of the relief.

Conclusions

Considering that the numerical modeling of the terrain is mostly aimed to illustrate the local relief of a certain area and, based upon the representation through level lines, and considering as basis for this comparison the contour lines of the cadastral maps, the present study demonstrated the overlapping of the outlines of two representations, both on the modeling generated by coordinates obtained by the GPS receiver as for the modeling represented by the curves of the cadastral map. Therefore, when the purpose is to generate numerical models of surface, the use of coordinates obtained by GPS receivers can replace conventional methods for obtaining and generating such maps.

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