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METHODS OF USE TWO-DIMENSIONAL CAD APPLICATION ENVIRONMENT OF MINING DIGITAL MAPS TO GENERATE THREE-DIMENSIONAL MODELING OF THE GEOLOGICAL SURFACE LAYER

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Abstract

The article focuses on selected issues related to creating documentation of cartographic departments of geological surveying of mines. It highlights the problem of creating three-dimensional models from flat digital maps. This article presents a new solution to this problem based on the *AutoCAD* platform. The visual lisp environment has enabled to build *MapDraw* package, which uses non-explicit object attributes so that it has become possible to obtain additional information necessary to carry out the transformation of flat digital map to a fully qualified three-dimensional model. The base of these solutions is studies on the generalization of mining maps *MapDraw* environment published in the D. Biegun dissertation.

The article presents the methodology of obtaining the required information from the flat digital map using a group of procedures called *'Mini GIS'*. Step by step we present the method of creating TIN surface obtained from the raw data and a tool for optimizing the resulting surface. Then, the tools available to use the model to create profiles and generate contour formed on the surface are presented. The program enables users to smooth the resulting contours using for this purpose an original algorithm in conjunction with third-degree polynomial approximation. Thanks to these forms of handling course of generated contour it is very simplistic. Additionally, we present various automatic and manual methods of labeling contours, the use of surface gradient fill to improve the effect of 3D visualization. The developed methodology to generate contours allowed us to implement in an overlay of *MapDraw AutoCAD* one of the typical functions for *GIS* programs without using advanced mechanisms offered by, for example, *AutoCAD Civil*. This solution enhances both the comfort, quality and the possibility of obtaining new information from the map resources with minimal effort from the user's side.

METODY WYKORZYSTANIA ŚRODOWISKA APLIKACYJNEGO CAD DWUWYMIAROWYCH GÓRNICZYCH MAP CYFROWYCH DO TRÓJWYMIAROWEGO MODELOWANIA POWIERZCHNI GEOLOGICZNYCH

Słowa kluczowe: kartografia górnicza, Systemy GIS, Systemy CAD, interpolacja danych przestrzennych

Abstrakt

Artykuł porusza wybrane zagadnienia związane z tworzeniem dokumentacji kartograficznej w działach mierniczo-geologicznych kopalni. Zwrócono w nim uwagę na problem tworzenia trójwymiarowych modeli z płaskich map cyfrowych. W niniejszym artykule zaprezentowano nowe rozwiązanie tego problemu bazujące na platformie AutoCAD. Środowisko *visual lisp* pozwoliło na zbudowanie pakietu MapDraw, który wykorzystuje atrybuty niejawne obiektów, dzięki czemu możliwe stało się pozyskanie dodatkowych informacji niezbędnych do przeprowadzenia transformacji płaskiej mapy cyfrowej do w pełni kwalifikowanego modelu trójwymiarowego. Bazą rozwiązania są badania nad generalizacją mapy górniczej w środowisku MapDraw, opublikowane w dysertacji D. Bieguna.

Artykuł przedstawia metodologię pozyskiwania wymaganych informacji z płaskiej mapy cyfrowej z wykorzystaniem grupy procedur o nazwie „Mini GIS". W kolejnych krokach prezentowana jest metoda tworzenia powierzchni TIN z uzyskanych danych pierwotnych oraz narzędzie do optymalizacji uzyskanej powierzchni. Następnie prezentowane są narzędzia wykorzystujące powstały model do tworzenia profili oraz generowania warstwic na powstałej powierzchni. Program pozwala na wygładzanie powstałych warstwic wykorzystując do tego celu autorski algorytm w połączeniu z aproksymacją wielomianem trzeciego stopnia. Dzięki tym zabiegom przebieg powstałych warstwic jest bardzo naturalny. Dodatkowo zaprezentowano różnorakie metody etykietowania warstwic automatyczne i manualne oraz wykorzystanie gradientowego wypełnienia powierzchni w celu poprawy efektu wizualizacji 3D. Opracowana metodyka generowania warstwic pozwoliła w środowisku nakładki MapDraw programu AutoCAD na implementację jednej z typowych funkcji dla programów GIS bez wykorzystywania zaawansowanych mechanizmów jakie oferuje na przykład AutoCAD Civil. Prezentowane rozwiązanie zwiększa zarówno komfort, jakość jak i możliwości pozyskiwania nowych informacji z zasobu mapowego przy minimalnym nakładzie pracy ze strony użytkownika.

INTRODUCTION

Computer systems which build and operate digital mining maps use the latest computer support technologies of designing (CAD). These systems enable users to implement the non-explicit object and enhance the representation of data into a three-dimensional model (apart from two-dimensional cartographic visualization directed to analog reproduction).

In geological-surveying mine departments various tasks connected with creating cartographic documentation are divided and transferred to different mine departments. A geological department prepares geological data concerning e.g. the noun ledge isolines, mineral deposits or drawing other surfaces based on geodetic data gathered by a surveying department.

Originally, many years ago, geological departments drew the isolines manually. Then, the programming system desktop started to be used which enabled us to draw the isolines. This type of tasks was generally performed by *GIS* systems and specific software created for geology and mining industry. Nowadays, for this purpose, Polish mines use *SURFER* program by *Golden Software*. KGHM Company uses *GIS* programming system called *Geomedia* by *Intergraph* [1]. There is also free software *SGeMS* which may be used to calculate spatial distribution of methane, for example, in the mining panel designed to exploitation. [2]

In the article below, we would like to present a new solution to the problem which was created based on the *MapDraw* environment. The solution is based on the studies on the generalization of maps mining *MapDraw* environment published in the D. Biegun dissertation. [3]

The article concentrates on the importance and usability of attaching non-explicit additional and descriptive (text) attributes to geometrical elements. Due to such an attitude, it is possible to solve problems which normally are difficult to perform or they are so

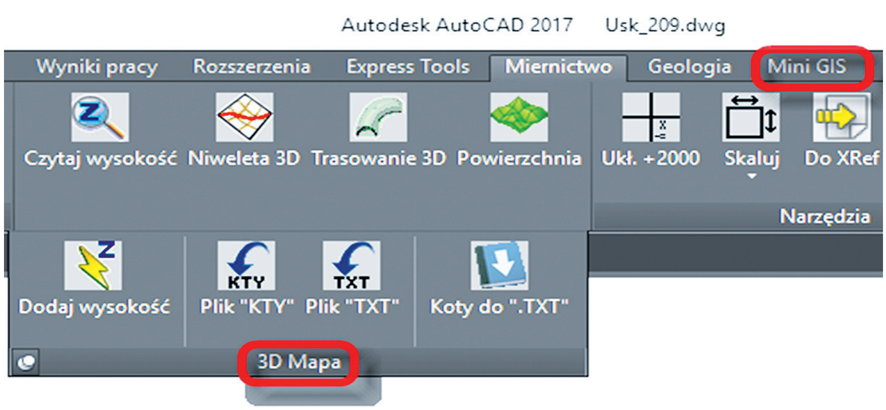


Fig. 1. The menu of MapDraw 3D Mapa with the option MiniGIS
Rys. 1. Menu pakietu MapDraw paletą 3D Mapa z opcją MiniGIS

labor-consuming in implementation that they become unprofitable. A good example is the problem of profiles of the mining ledge. Information about the position of the sidewall (coordinates X, Y) was used to plot, and Z-coordinate were registered as an additional attribute in the map objects. As a result of such an operation it was possible to design software which automatically generated a profile of mining pits directly from a digital mining map. The data gathered in this way are highly useful for the mining entrepreneur. But the problem of completing the profile with geological data, and consequently, the profile of a ceiling and a floor of a ledge between pits, still exists. Because of this problem, it has become necessary to work out a solution of that issue.

THE USE OF ADDITIONAL ATTRIBUTES TO MODELING (MINI-GIS)

Additional data attributed to objects may be used to perform the process of modeling the location of the ledge [4]. The chosen issues implemented in the package are initiated from the menu in the fold *3D Mapa* and *Mini-GIS* [Fig. 1].

The data analysis requires downloading specific information from the picture database. To achieve this, a part of the ledge [Fig. 2] which includes the information about the positioning of the ledge is chosen. Then the required information is downloaded and transformed by the procedures implemented in the package [Fig. 3].

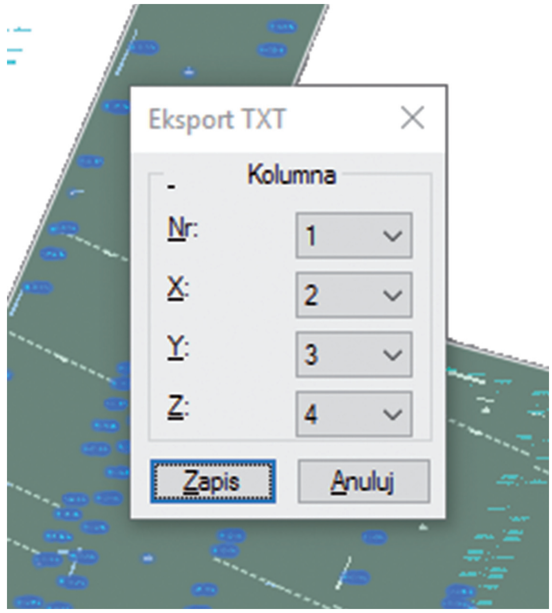


Fig. 3. Choosing the format of the data
Rys. 3. Wybór formatu danych

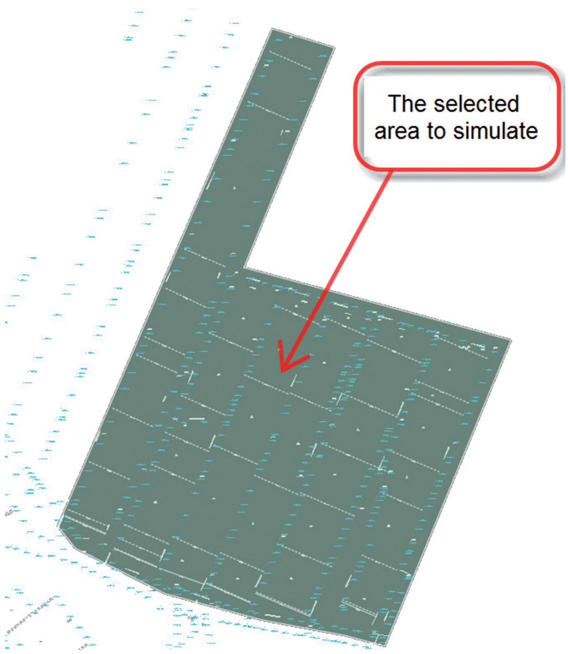


Fig. 2. A chosen part of the ledge
Rys. 2. Wybrany fragment pokładu

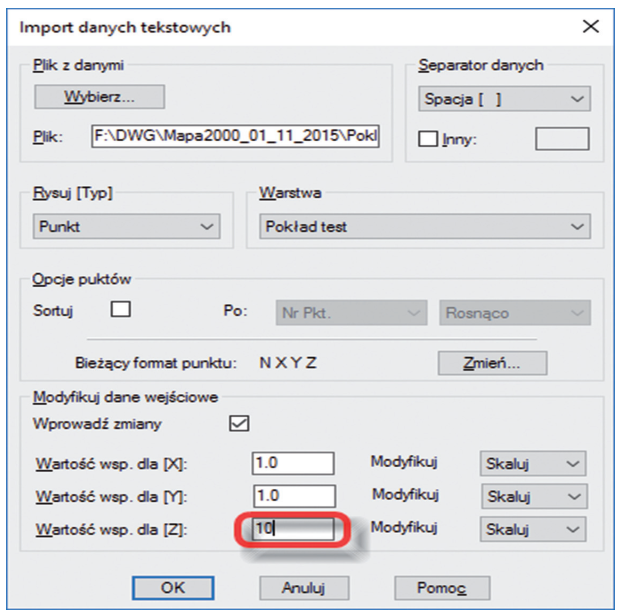
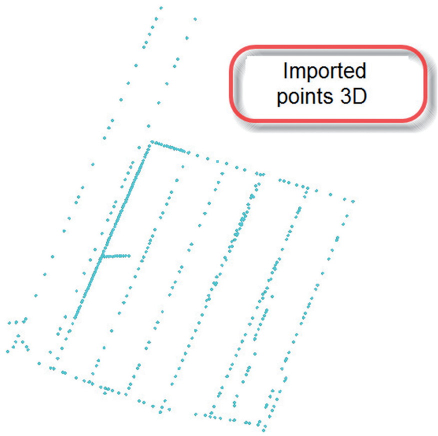


Fig. 4. The window of text data import Rescaling x 10
Rys. 4. Okno importu danych tekstowych Wysokość przeskalowana x 10



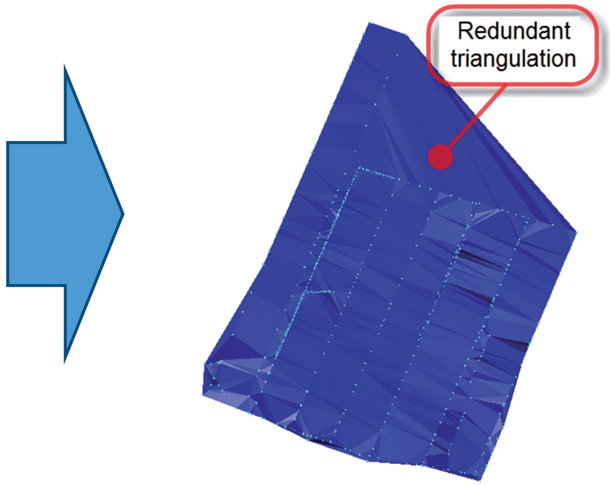


Fig. 5. Graphic representation of text data
Rys. 5. Graficzna reprezentacja danych

Fig. 6. 'Raw' TIN surface
Rys. 6. „Surowa" powierzchnia TIN

The next steps are to set the format of the recording and the place of the saved and downloaded information. In order to get a better visualization of the surface positioning, for the use of this publication, it has been decided to rescale the elevations ten times bigger [Fig. 4].

It enables us to expose the positioning of the ledge in a chosen part. To create the surface a triangulation algorithm presented by Evgeniy Elpanov [5] has been used. It applies a simple iterative algorithm based on a structure of a super-triangle, which was presented in a diploma dissertation of I. N. Ponamarev (И.Н. Понамарѐв) under the supervision of Professor A. V. Skvortsov (А. В. Скворцов) [6]. In its assumed that the program was created to operate with enormous groups of points. When choosing a cloud of points and its transforming,

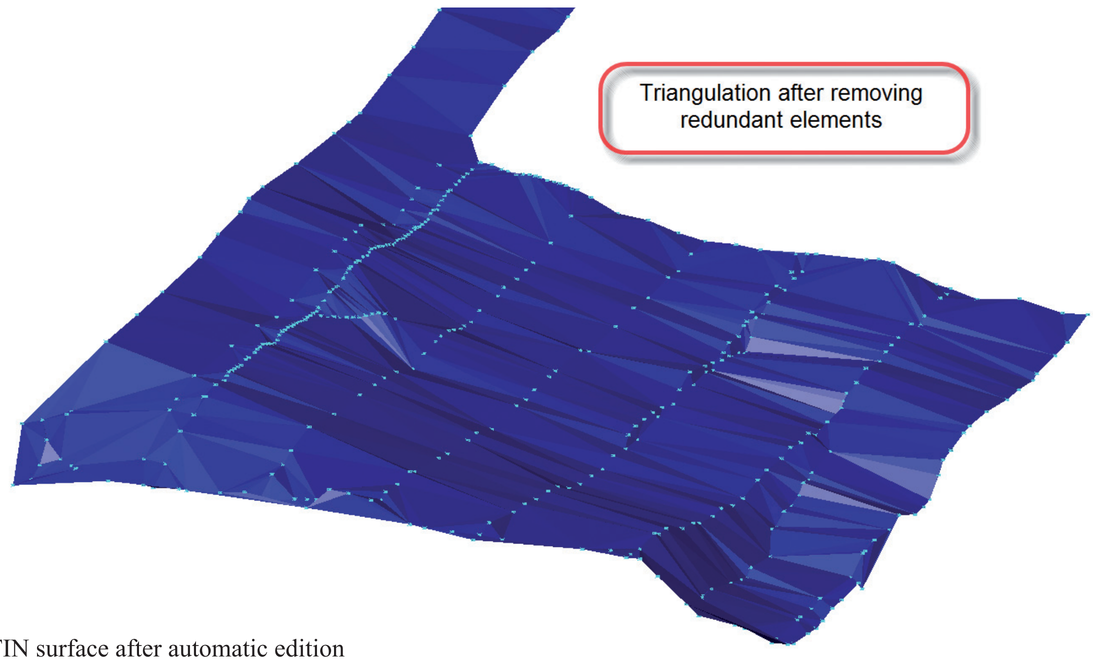


Fig. 7. TIN surface after automatic edition
Rys. 7. Powierzchnia TIN po automatycznej edycji

primitives of triangles are generated in the picture in the form of objects *3DFACE* type. The triangulation of the chosen points [Fig. 5] allows the creation of TIN surface [Fig. 6].

The next procedure enables to remove excessive triangulation from an irregular grid. In consequence we get a required positioning of a highlighted part of a ledge.

This procedure was described in ‘Efficient generation of simple polygons for characterizing the shape of a set of points in the plane’. Its algorithm is based on Delaunay’s group of point triangulation [7]. TIN surface contains information which at the same time allows the analysis of this in order to calculate elevation view of any edge on that surface. As a result of the intersection of the projection and TIN surface, it is possible to set the positioning of a surface profile under the curve. In order to achieve that, drawing any curve, which is an edge of the projection, is sufficient [Fig. 8].

Afterwards, the program sets positioning of the curve in the projection on the TIN surface. As a result, we get a precise course in the form of 3D lines for an examined surface [Fig. 9]. At the same time, it is a surface grade line for the chosen edge.

It is possible to show the course of the grade line in the form of a profile generated by the following procedure implemented in the package [Fig. 10].

The analysis of the course of the leveling may be used for different purpose. It is possible to define potential places of formed water reservoirs, for example. The data profile may be used to design cutting out the parcel or the course of an excavation. It is worth mentioning that the whole procedure may have various usage connected with mining issues, but it may also be applied to work out case studies concerning surface area.

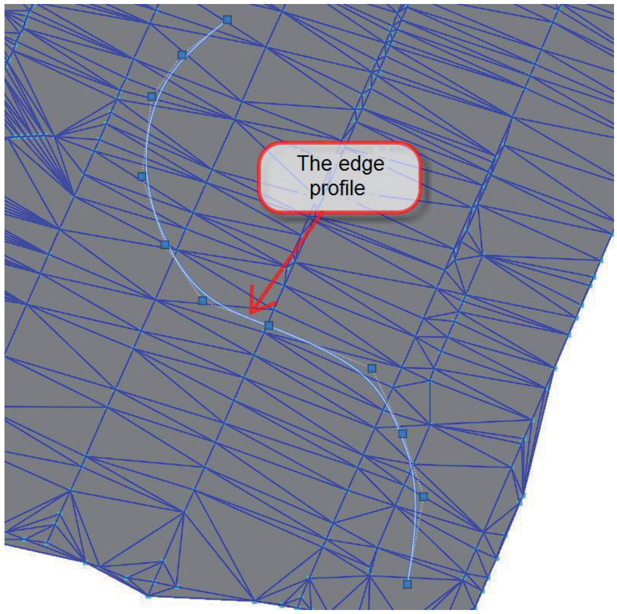


Fig. 8. Setting the positioning of a profile
Rys. 8. Wyznaczanie przebiegu profilu

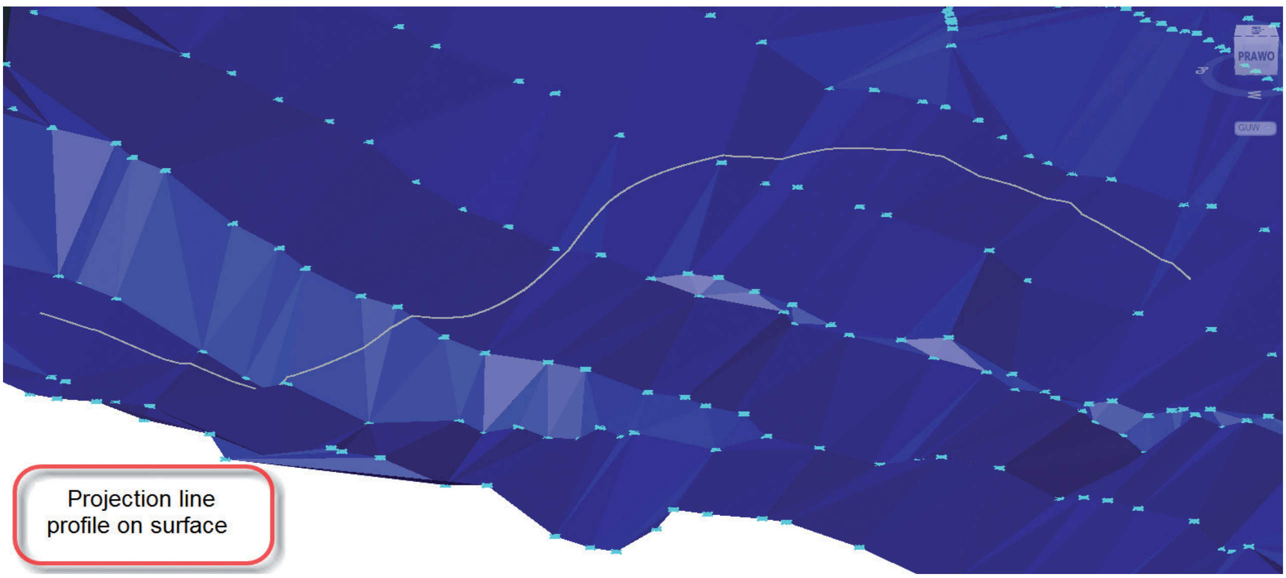


Fig. 9. The course of a profile lines
Rys. 9. Przebieg linii profilu

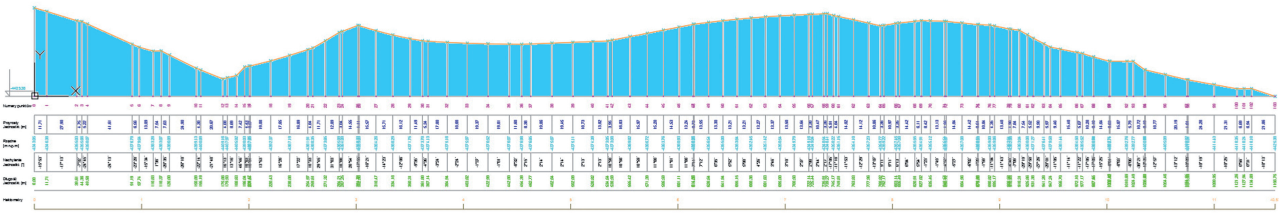


Fig. 10. The graph of a profile displayed on a flat surface
Rys. 10. Przebieg profilu w rozwinięciu na płaszczyźnie

The TIN surface is also used to create a contour map. Using the surface, model contours are generated. Additionally, the contours are smoothened, which allows more natural visualization of the course of the examined surface. After entering required parameters [Fig. 11] the application generates the course of 3D contours. If we apply smoothening of contours, we get flat lines close to the surface. If we do not want to smoothen the contours, they are exactly on the TIN surface.

The method of smoothening contours is based on the process of adding vertexes to curves in the places of their bending. The algorithm analyses the radius of the curve in correlation with the length of the line segment prescribed to them. If the ratio of the length from the curve is appropriate, additional vertexes are calculated. The approximation of the curve is calculated up to the point of achieving limit values of parameters assessed in the program. Due to such an approach,

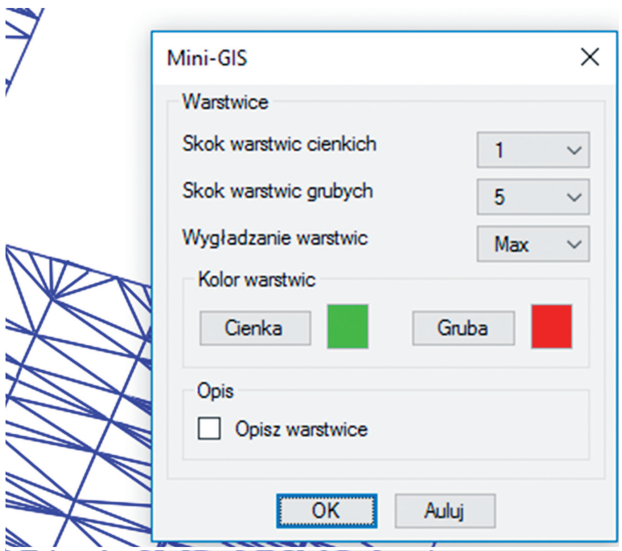


Fig. 11. Parametres of generating contours
Rys. 11. Parametry generowania warstwic

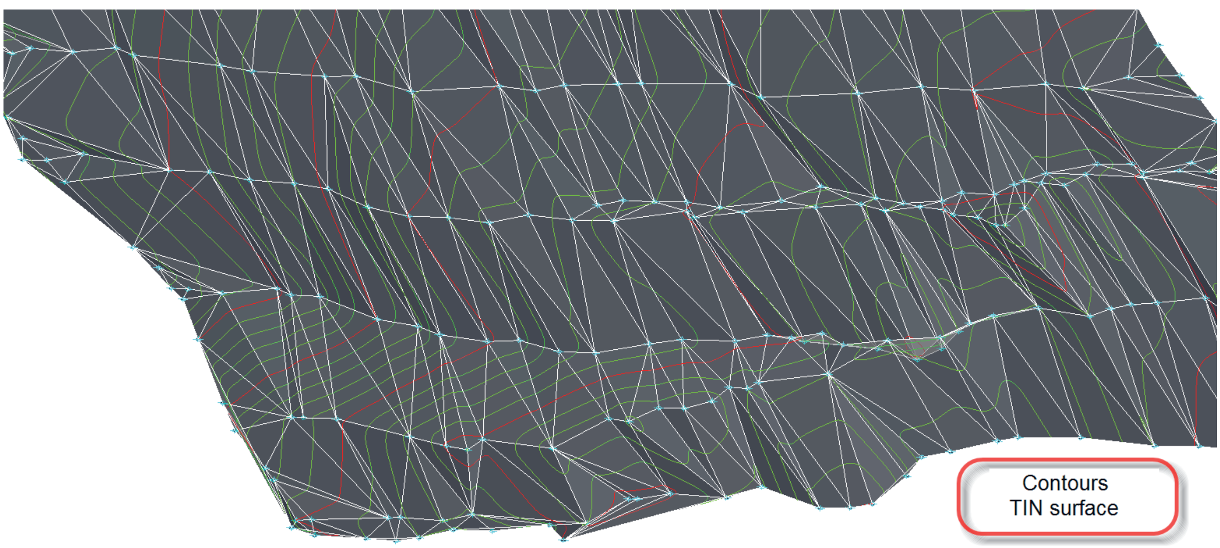


Fig. 12. Contours after smoothening process
Rys. 12. Warstwice po wygładzeniu

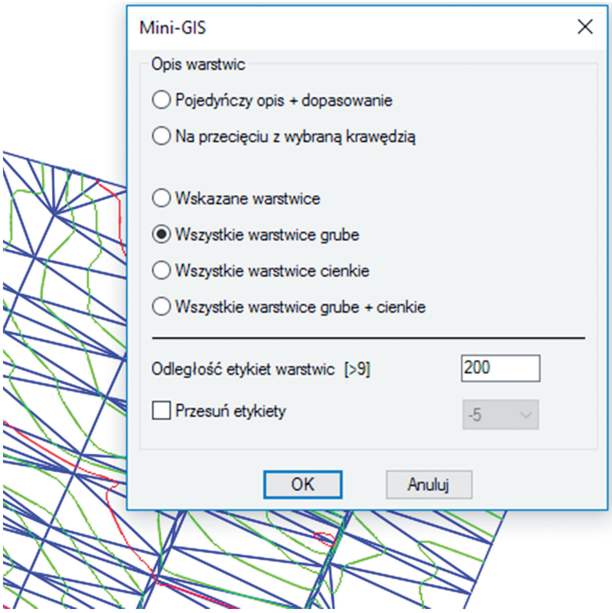


Fig. 13. Methods of labeling contours
Rys. 13. Metody etykietowania warstwic

vertexes are added only in the places which demand to be condensed. In order to get a better effect, additional smoothening of curvatures is applied (using the means of interpolation with the help of third-degree polynomial approximation – the function inbuilt in *AutoCAD* system)

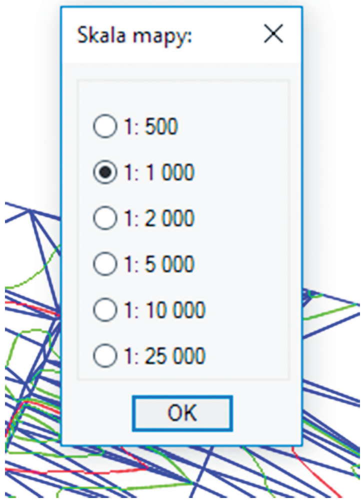


Fig. 14. Adjusting labels to map scale
Rys. 14. Dopasowanie etykiet do skali mapy

After smoothening, we get a map of contours positioning for analyzed surface [Fig. 12]:

The application offers possibility to add labels to generated objects. There are several methods implemented [Fig. 13] which present automatic labeling of main contours. After entering the demanded parameters and setting the map scale [Fig. 14], the application adds labels automatically in accordance with the descent of TIN surface.

Fig. 15. Labels of main contours generated automatically
Rys. 15. Etykiety warstwic głównych wygenerowane automatycznie

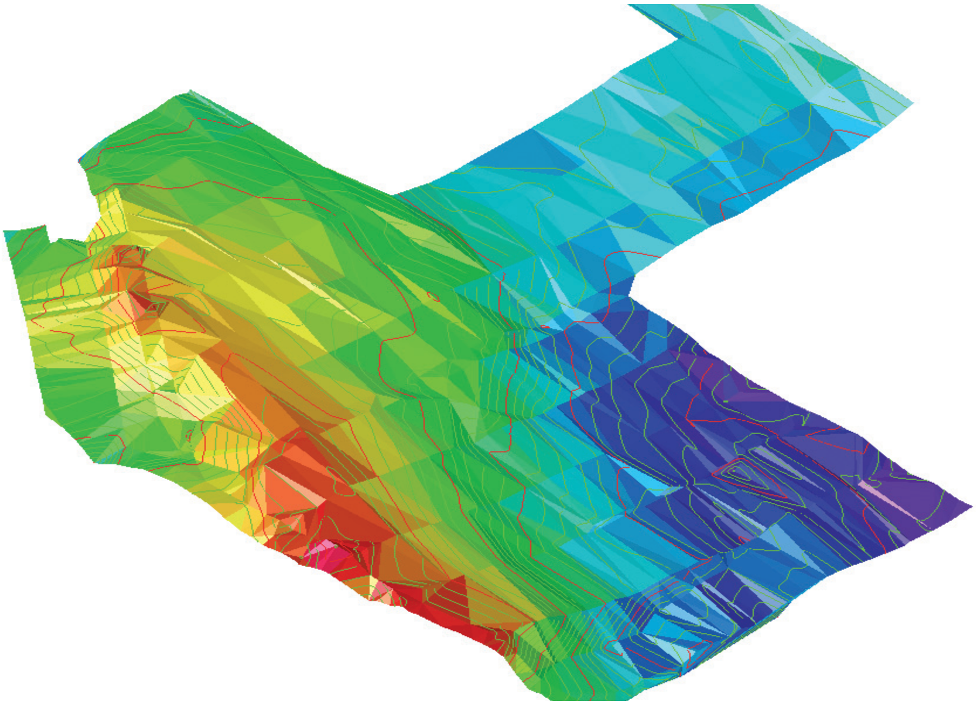


Fig. 16. An RGB gradient model
Rys. 16. Model gradientowy RGB

Owing to the program, we get a generated TIN surface with contours and labels which include the descent of the surface [Fig. 15].

Adding gradient of the TIN surface [Fig. 16] additionally allows getting a more plastic form of visualization.

The elaborated form of visualisation of a ledge surface map considerably enhances cognitive values of a digital map in comparison to its 2D version. It is a priority [8] in the development of cartographic maps for mining industry. More plastic spatial data makes the spatial information easier to perceive for the personnel of a mine.

SUMMARY

The presented method of generating contours allows the implementation of one of typical functions of *GIS* program in *MapDraw* environment of *AutoCAD* program. This new approach to mining maps allowed the integration of the work of two technological departments of KWK 'Piast' mine. The solution improved both comfort and possibilities to obtain new information from the map resources with minimal effort and labor from the user's side. Requirements of the package are optimized in such a way that it may be activated in low efficient computers with a basic version of *AutoCAD*. The *MapDraw* platform is adjusted to current information solutions applied in the latest applications considering principles of ergonomics of modern interface.

It must be emphasized that the worked-out solution is a complete one contrary to other half measures used in Polish mining industry. The formulated interpolation algorithm makes the user independent from buying foreign software. For example, in *GeoLISP* [9] system *Surfer* software was initially used, nowadays more expensive *AutoCAD MAP* software which contains interpolation modules of TIN surface is used.

It is also worth mentioning that the presented technology does not limit its use to mining map environment. It may also be used for any kind of maps when the interpolation of data is necessary. A good example is a *K-1* overlay which has been already equipped with isoline interpolation module. Information included in the picture database is enhanced with descriptive data operated by dedicated tools. It enables both publishing the data of a module in the form of a map and carrying out various analysis.

BIBLIOGRAPHY

[1] Kosydor P., Krawczyk A. „Wdrożenie w KGHM „Polska Miedź" S.A. Systemu Informacji o Terenie", Sympozja i Konferencje, nr 74, XVIII Szkoła Eksploatacji Podziemnej, Wydawnictwo IGSMiE PAN, 2009.

[2] Badura H., Zawadzki J., Fabijańczyk P.: „Kriging blokowy oraz metody GIS w geostatystycznym szacowaniu metanonośności w kopalniach węgla kamiennego", Roczniki Geomatyki Tom X, zeszyt 3(53), Warszawa 2012

[3] Biegun D. „Dynamiczne generowanie wieloskalowych map górniczych w środowisku AutoCAD". Praca doktorska, niepublikowana, AGH WGGiIŚ, Kraków 2014

[4] Smith J., Gesner R.: „Autolisp czyli programowanie AutoCADa" Wydawnictwo HELION Warszawa 1995

[5] Levcopoulos C., Krznaric D. Quasi-greedy triangulations approximating the minimum weight triangulation // Tech. Rep. N. LU-CS-TR. Dept. of Computer Science, Lund University, Sweden. 1995. P. 95–155.

[6] Скворцов А.В. Алгоритмы построения и анализа триангуляции / А.В. Скворцов, Н.С. Мирза. — Томск: Изд-во Том. ун-та, 2006. – 168 с.

[7] Duckham M., Kulik L.,, Worboys M., Galton A.: „Efficient generation of simple polygons for characterizing the shape of a set of points in the plane." Journal Pattern Recognition Volume 41 Issue 10, October, 2008 pp. 3224–3236 Elsevier Science Inc. New York, NY, USA

[8] Krzywicka-Blum E.: „Usable functions of modern maps" Geoinformatica Polonica. Volume 11, Issue , pp. 27–36, ISSN (Print) 1642-2511, DOI: 10.2478/v10300-012-0003-4, July 2013

[9] Pomykoł M., Poniewiera M. „Numeryczne projektowanie w geodezji górniczej" Wydawnictwo Politechniki Śląskiej. Gliwice, 2009.