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HUMAN GEOGRAPHY WITH GEOGRAPHICAL INFORMATION SYSTEMS

The purpose of this paper is to represent that a GIS in human geography is not only a straightforward tool for generating and spatially analysing maps and graphics, but also is intended to identify certain spatial samples and to form new spatial derivative data for reaching advances in human geography research. Digital maps introduced as a paper map effective alternative made possible by GIS. Once introduced by the authors environmental geography concept is additionally discussed purely of human geography contribution to this field by geographical information systems. Traditional quantitative geography is explained to be a key basic for all following GIS applications in geographic sciences. The conclusion is made this field is highly essential for the further GIS-expansion within human geography. Few examples of original software with respect of city key element extraction are suggested for the urban system analysis.

Keywords: *geographical information system, human geography, environmental geography, quantitative , geography, urban system analysis.*

Сергій Костріков, Катерина Сегіда. ГЕОІНФОРМАЦІЙНІ СИСТЕМИ В СУСПІЛЬНІЙ ГЕОГРАФІЇ. *В статті подаються деякі складові геоінформаційної концепції в сучасній суспільній географії. При цьому геоінформаційна система розглядається не тільки та не стільки в якості інструменту перетворення традиційного картографічного матеріалу в цифровий формат, скільки потужним засобом впровадження новітнього методологічного підходу. Останній на підставі похідних даних і просторового аналізу, здатний вивести суспільну географію на принципово новий рівень досліджень. В цьому аспекті автори знову звертаються до запропонованої в попередній роботі новітньої предметної галузі – інвайронментальної географії. Традиційна математична географія розглядається в статті найсуттєвішою умовою всього різноманіття сучасних ГІС-застосувань. Роботу завершують приклади аналізу урбаністичних соціогеосистем за допомогою авторського програмного забезпечення ГІС.*

Ключові слова: *географічна інформаційна система, соціальна географія, інвайронментальна географія, математична географія, аналіз урбаністичних соціогеосистем*

Сергей Костриков, Екатерина Сегида. ГЕОИНФОРМАЦИОННЫЕ СИСТЕМЫ В СОЦИАЛЬНОЙ ГЕОГРАФИИ. *В статье излагаются некоторые элементы геоинформационной концепции в современной социальной географии. При этом геоинформационная система рассматривается не только и не только и не столько в качестве инструмента преобразование обычного картографического материала в цифровой формат, сколько в качестве средства внедрения обеспечения использования новейшего методологического подхода. Последний на основании обработанных данных и пространственного анализа, способен вывести социальную географию на принципиально новый уровень исследований. В данном аспекте авторы снова обращаются к предложенной ими в предыдущей публикации новейшей предметной области – инвайронментальной географии. Традиционная же математическая география рассматривается в статье ключевым условием всего разнообразия современных ГИС-приложений. Работу завершают примеры анализа урбанистических социогеосистем с помощью авторского программного обеспечения ГИС.*

Ключевые слова: *географическая информационная система, социальная география, инвайронментальная география, математическая география, анализ урбанистических социогеосистем.*

Introduction: GIS initialization in Human Geography through geoinfomation science. For the time being geographical information systems (GIS) have applications in a wide variety of subject areas in Geography and Geology, from mineralogy, oil & gas geology and physical geography to human geography, urban studies, civil engineering, architecture, agriculture, forestry, environmental science, ecology, regional economics, demography, sociology and in many other fields.

New GIS-applications follow in the areas like disaster / catastrophe management, health care, telecommunications, facility management and social / human /environmental monitoring as well as research on advanced geographical problems like classification of processes in different ecosystems and sociogeosystems would be of major advance if the various and distributed information were readily available for effective processing with adequate and highly developed GIS-tools.

Some key scientists in the area state that "the GIS revolution" beginning from the late eighties has changed in our days from "GIS-systems" to "geoinformation science" [1-3]. In that very time geographical information systems have had a historically close relation with regional studies and human geography, since both mentioned fields were to the certain extent developed as quantitative trends in the general geographical science. Nonetheless, despite understandable GIS-benefits in the contemporary human geography and continued rapid increase of its spatial and human / environmental information the resultant data is stored digitally in numerous different software systems, and they use heterogeneous data types and formats. These formats are often defined exclusively according to local necessities and temporary needs of a given project. Moreover, a recurring usage of this data is often impossible due to missing information about the data like the information which is stored, data representation and structure, data quality, the date to which data refers, the scale employed and other factors. All these circumstances normally lead to widely isolated GIS-databases used in the human geography field, if only the relevant basics of the geoinformation science are not involved..

The main research goal of this paper is to represent proceeding from the geoinformation science basics that a GIS in human geography is not only a straightforward tool for generating and spatially analysing maps and graphics, but also (first of all) is intended to identify certain spatial samples (for instance, in urban sociogeosystems) and to form new spatial derivative data for reaching advances in human geography research. The paper authors' ultimate aim is to emphasize, that when the geoinformation approach is used instead of the traditional one quite a few of unsolved tasks are resolved, new results are obtained and new research trends are defined by this connection between human geography and innovative technology.

Geographical answers with digital maps. It is widely accepted that a *digital map* is a crucial basic for GIS, due at least to that fact the enormous variety of them are on the Internet right now, and many these maps not only are a paid service, but they are available for free [4]. Just digital maps represent one of the basic GIS fundamentals that makes the geoinformation science as effective and powerful as it is, and a scientist or a ordinary computer user is really only limited by his / her own imagination.

One of this paper authors once already thoroughly discussed both understanding digital maps, and finding answers with them in his textbook [5]. It was explained then that just with digital maps a GIS becomes an essential tool for both university teaching and applied research. For an advanced user a digital map is even easier to employ than a routine paper map. Comparatively with a paper map of a human geography content a visualizing procedure related to a digital map implies many similar symbols: dots visualize GIS-features such as cities, lines represents features-roads and other linear elements of technogenic infrastructure, polygon areas of a different size outline different census tracks. All features are neatly labeled, and their colors are just as bright as on usual paper maps.

Nonetheless upon all visualizing similarity computer maps have significant advantage just for data storage, that taking into account huge information volumes in human geography can hardly be overvalued. The case is that a digital map takes significantly less space to be stored somewhere, because all its information is kept in a digital format, as a lot of ones and zeros. At that very time a digital map can possesses the same valuable information as a paper map does: where a given factory is as a point GIS-feature, how long the main road is in the area, how many square kilometers the census track occupies and so on.

Finding answers with a digital map in human geography a scientist more often deals with two following classes of questions: *What is it? / Where is it?* And *How far is it?* Answering such kind of human geography questions is one of those issues a GIS with a digital map can do best of all.

In our geoinformation textbook mentioned [5] students learned that a user can think of digital geographical information, the ones and zeros, as being in a pack of layers behind a digital map exposed on a computer screen. All constituents of technogenic infrastructure must be sorted so that to belong to its own layer. Thus all highways must be in one layer, all roads in another one, all governmental institutions in the third layer and so on. To outline the essence of the digital information management we referred in our textbook mentioned above a very informative, from our point of view, visual, which illustrates that digital map layers are really produced of two different kind of information about each GIS-feature – its locational data and its descriptive characteristics. Due to the significance of the mentioned visuals we provide it in this paper too (Fig. 1):

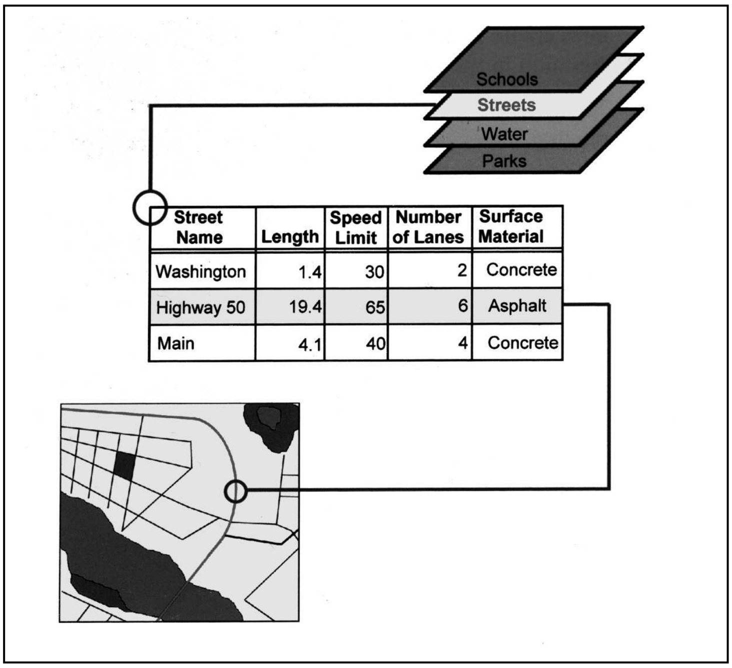

Figure 1. Series of layers with geographical features, attribute table and a resulted 2D map (a figure draft is from [3, P. 28])

Computer files that store locational data allow a user finally to visualize GIS-feature such as, for instance, streets, agricultural fields, buildings, parks and census tracks. Often each file represents just one layer from the series (see the figure above). The description of each GIS-feature is its attribute stored in a relevant attribute table. In this table they are stored in rows and columns. Attributes can be as complicated and numerous as a user would like them to be. 2D digital map is normally actualized as *a theme* (a complex geographical map), while attributes, for example, in a layer of streets can include a street name, its total lengths, the speed limit along this street, road material, route number and other relevant characteristics.

It directly follows from the picture above that with the attribute table there is more to a GIS-feature than simply its shape and location, what can be involved in the human geography research. There are all else that may happen to be known about it. For a country it may include its system of government, population, capital, main import and export, natural and some specific human resources (e.g., highly qualified part of population). Particularly for a road (see Figure 1) it may be speed limit, a number of lanes on it, if it is paved or unpaved, if it is one-way or two-ways and so on. For instance, for the city management there is a great volume of information to be had about any GIS-feature, from a humble length of a sewer pipe to a whole city.

It may be understandable now why digital maps are key issues in urban system modeling nowadays. We touch this item somewhat more in details in another section of this paper.

Transitional research subject: towards Environmental Geography through Human Geography with GIS. This paper authors have introduced the Environmental Geography subject area concept recently [6]. We have traced with examples and proved why two existing contemporary fields – physical and human geography – have to contribute to one united subject area in the future – *Environmental Geography*. We specially emphasized then that one of the most significant peculiarities of this field that just concerns with human-natural interactions is a strong necessity of the modern technological tool involvement in it – a geographical information system. As it was stated in the paper referred: "….just such kind of software may be viewed as a key, which opens for "Orthodox Geography" that desired research subject of the environmental geography" [6, c. 7].

In the paper mentioned we introduced the environmental geography concept both within some peculiarities of its theory, and with few short examples of its applied tasks. It was strongly stressed that spatial laws, trends and fluctuations make the environmental geography subject up. That paper examined briefly some regularities of this new discipline formation, and once again it was underlined environmental geography would describe just *spatial aspects* of interactions between the humans and the natural environment, *what directly corresponds to the GIS-domain.*

According to the trend of geographical science becoming the environmental geography a definite research approach that would unite a strong spatial aspect of environmental researches with the GIS regional applications does directly relate to the domains of both physical and human geography. Since it was accepted that environmental geography draws upon geology, physical geography, geomorphology, hydrology and human geography [6], then providing corresponding information domains by GIS for each from these fields mentioned, let us outline so-called *Transitional Research Subject* of GIS-application in human geography, which moves to the environmental geography core subject.

In this case we are discussing the original approach, which links computer modelling of natural landscape / human society processes with geoinformation technology. If methods of landscape / human society assessment follow from the environmental science / human geography research strategy, they can introduce complex numerical algorithms of system analysis with GIS [7]. Moreover, such methods allow not only generation of the information missing in the initial data sets, but also calculation of various, for example, demographic \ social indexes representing current conditions of the social medium [8]. A research technique like this may facilitate the solution of various problems concerning environment / human interactions, but upon the GIS presence only. Most of only a few existing efficient modelling systems of GIS technique have been elaborated either as inner GIS modules, or as external tools. All these systems, to a greater or lesser degree, employ either deterministic or stochastic approaches. According our environmental geography concept the set of geographical stochastic *environmental / human medium models* are mainly based on calculation of natural / social events and process probabilities, whereas the systems incorporating deterministic simulation models generally must proceed from two following principles. Firstly, it is a representative choice of functional interdependencies and parameters describing interrelations among physical components of geographical landscape and social ones of human medium. Secondly, it is a thorough choice of a solution procedure for differential equations, because the equations describing environmental / human medium systems (sociogeosystems) are featured by a very high order and strong non-linearity. It is evident that both of these somewhat unilateral approaches may distort some important characteristics of the environmental geography research area.

Actually, this paper authors represent an approach capable of minimising mentioned distortions occurred upon geographical research by modelling the appropriate information missing in an initial data set with employment of so-called "transitional research subject", which considers owing to a GIS both natural and human aspects of the environmental domain.

Quantitative Human Geography before and after "the GIS revolution". We have already mentioned M. Goodchild's "the GIS revolution" definition above in this paper. Geographical science has been rapidly changed in Ukraine if compared with traditional Soviet Geography since late eighties, but these alterations just concurred with market laws and rules introductions, accompanying by numerous external impact factors on university education and academic science. Thus some geographical departments of several universities in our country, which had such opportunity, attempted to shift human geography to an applied science. It became possible only due to that fact the soviet human geography once developed "quantitative geography approach", which does serve for the time being as a basic methodology for relevant research even for contemporary Russian geographers [9].

From another side, in world-wide geography even in so-called "pre-GIS period" the quantitative geography subject field was efficiently developed too, what is more – it even more significantly contributed to the human geography area, than to the physical geography ones [10]. Human geography provided even several different types of human geography, including geographical simulation of many phenomenon in social medium [11]. In this paper referred the limitations of modeling research were accepted, while its author tried to prove that models were highly efficient tools to reveal complexities in many situations within social medium. Advanced urban and regional modeling even allowed in that "pure quantitative geography time" (without GIS yet) to develop that data driven computer simulation in information economy and introduce so-called "computational geography" as an innovative academic and educational discipline [12].

K. Yano once wrote that just before "the GIS revolution" quantitative research in human geography had two sides – deductive and inductive, academic and applied –and the GIS revolution just progressed under such circumstances [3].

Some key specialists of the world-wide GIS-community once introduced a point of view, according to which the GIS-revolution that happened in the first half of nineties managed to conduct strong relationship between *geographical information systems* and *spatial analysis* exactly thanks to the "classical" *quantitative geography* [13]. Normally it is not easy to define spatial analysis peculiarities when examining

its relationship with GIS. Well known broad definition of the spatial analysis indicates it to be a general ability to manipulate spatial data into different formats and exact supplementary values as a result. Tools addressing the inherent probabilistic nature of human geography phenomenon patterns and relationships are titled *statistical spatial analysis*, rather than forms of analysis that are purely *deterministic* [14]. This spatial analysis refers to the basic functions for a selective processing of spatial information within defined areas of interest, and for the computation, tabulation or mapping of different basic summary statistics for this information. The deterministic approach is more concerned with research of patterns in spatial data – in particular, in seeking possible relationships between such patterns and other attributes or GIS-features within the study region, and also with the modelling of such relationships for the goals of understanding or predicting [14].

Actually all relevant key publication in the contemporary GIS-modeling-spatial analysis domain illustrate how this spatial analysis and computer simulation within the framework of a certain GIS-shell can be applied to problems in human geography, where the emphasis is done largely but not exclusively on urban activities, land uses, networks, and populations [15-20]. In this area, human interactions with the environmental systems in the form of the planning strategy elaborated in advance always dominates. Hence, simulating models and spatial analyst tools do not always perform exclusively descriptive or predictive tasks, but they always contain some prescriptive or control elements in them [15, 16, 18]. It is worth to remark, that over last several decades, as simulating models in human geographyhave been slowly developed, a common idea appeared that in general sence GIS-models for human geography domain should be predictive in structure but simultaneously imply some wider process of control or planning procedures. Mentioned processes can be expressed as *meta-models*, within which predictive models are employed to explore alternative decisions, that is, to pose "what if" scenarios [21].

In terms of links "classical quantitative geography tasks" to GIS and spatial analysis in human geography domain after "the revolution" mentioned above, it is worth noting that many corresponding models from these first originated some decades ago, but their today statement is thoroughly informed by contemporary GIS-software and by concepts and techniques that are fast coming to represent the geoinformation science. In the aspect mentioned we are introducing further in this paper rather typical example of a routine task solution with spatial analysis tool. What is more, this example of apportion data for non-coterminous polygons is a common and classical type of GIS-application in human geography. We conducted it on the base of ESRI educational software and initial data package issued for university students [22]. The example of such a task completion is like follows.

Quite often a computer user - a human geographer, who is either a manager, or a scientist, while dealing with city attribute information, will not have raw point data, but only aggregate data consisting of various polygons. A relevant example is *census data*, which is totaled for polygon layers from counties down to blocks. Nevertheless, a user necessity may be for much different types of polygon boundaries, namely, administrative areas, for a example, such as *police car beats* (areas served by patrol cars) [22]. We employed an educational project with initial data for the Rochester, New York, Police Department. This county designed its administrative areas to meet police needs and, consequently, car beat boundaries do not always follow census tract boundaries. If you need census data by car beats, you will have to apportion (make approximate splits) each tract's data to two or more car beats. Initially a user has to complete a basic map of car beats and census tracts in the Lake precinct of the Rochester Police Department. After this completion a user will find several cases where car beats contain only portions of tracts (Figure 2).

Apportioning data from one set of polygons to another is a very complicated procedure, that hardly could be made in the quantitative human geography domain before "the GIS-revolution". We have no space in this paper to introduce all steps necessary for its completion, but we shortly touch only basic components of this task algorithm.

In general there are several alternatives for apportioning data [22]. A user can make it by area, length of street network, or the *block centroids population*. The last method is most preferable, because it is one of the most accurate. A user has to assume that the variable being apportioned, in this case the number of people 25 or older who have less than a high school education, is spatially distributed within the census tract proportionally to general population aged 22 or older at the block level. Also a user has to employ in this case *block centroids* instead of *block polygons*, because the blocks are relatively small and can be safely represented by points to make the spatial data processing easier. We are introducing summarized steps of this GIS-project completion further according to the tutorial guide mentioned above [22].

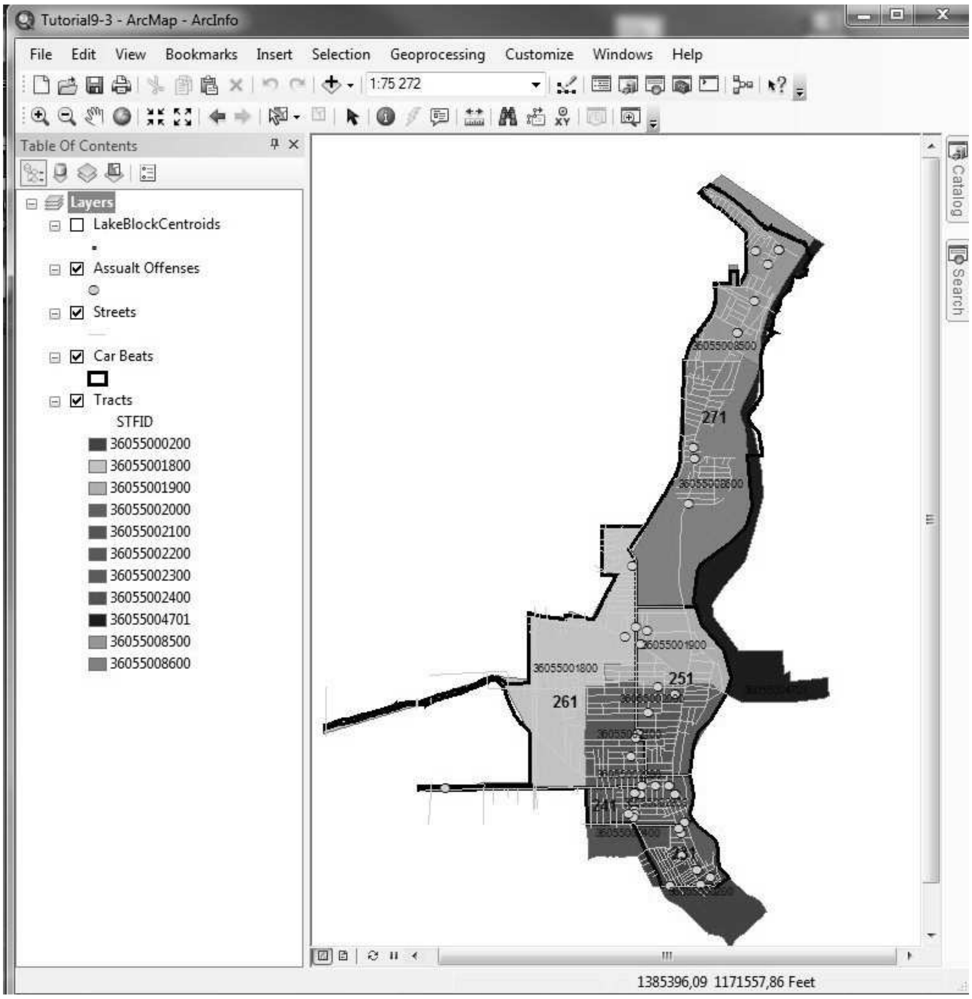

Figure 2. Apportion data for non-coterminous polygons: initial map which includes car beats and census tracks in the Lake precinct of the Rochester Police Department, there are several cases in it, where car beats contain only portions of tracts

In the attribute table for block centroids, we create two new fields: the census tract ID for each block and the sum across age groups for the population of age 22 or older in each block; in the attribute table for block centroids, we sum the field for persons aged 22 or older by tract ID to create a new table; afterwards it is necessary spatially join the tract and car beats layers to create new polygons that each have a tract ID and car beat number; then we have to spatially overlay the joined layer of tracts and car beats onto the block centroids to assign all the tract attributes and car beat attributes to blocks; further we join the table from step 2 to block centroids in order to make the apportionment weight denominator, total population aged 22 or older by tract, available to each block centroid; for each block centroid, we create new fields to store apportionment weight and apportioned under-educated population values, then we calculate these values for the new fields; on the next step we sum the apportionment weights by tract as a check for accuracy (they should sum to 1.0 for each tract), then sum the undereducated population per car beat storing the results in new tables; finally we join the table containing undereducated population by car beat to the car beats layer, then symbolize the data for map resulted display (Figure 3).

From urban digital models to “visible cities” under GIS environment. The quantitative human geography branch was traditionally involved for analysis of urban systems even in the “pre-GIS period” since late sixties of the past century [23]. It is obvious that innovative highly advances in this field had to appear after GIS-opportunities introduction in it, and they did. Even during first several years after “the GIS revolution” the components and processes, when a scientist use GIS for urban system analysis were defined [24]. The procedure normally begins with data input of a set of attributes so that to introduce the structural characteristics such as size, architecture peculiarities and other socio-economic and human geographical properties of each city. Such characteristics are all represented with points, lines and polygons under certain GIS-platform environment.

The concept of the urban system analysis traditionally possesses a number of strong constituents, but perhaps its main one is that it links together all research examining the relationship between city spatial components [23]. In the case of these linkages, a scientist faces two ways to identify these points, lines and polygon. One is to input N-Dim data of realistic linkages to indicate the forms of interaction among one city census tracts (please refer to the previous section of this paper) and among several cities in terms of movements of population, data, goods, money, specific information and so on. Another way is to identify the linkages by calculating the available point data of possible characteristics a given city. Finding a source of point data that describe a city, one can use the data of realistic interaction among city components directly, or he can also take the realistic data as direct flows (for example, coordinated and utilized live collections of airborne LiDAR range data), then calculate the indirect flows by some city models, and then summarize the direct and indirect flows into account together.

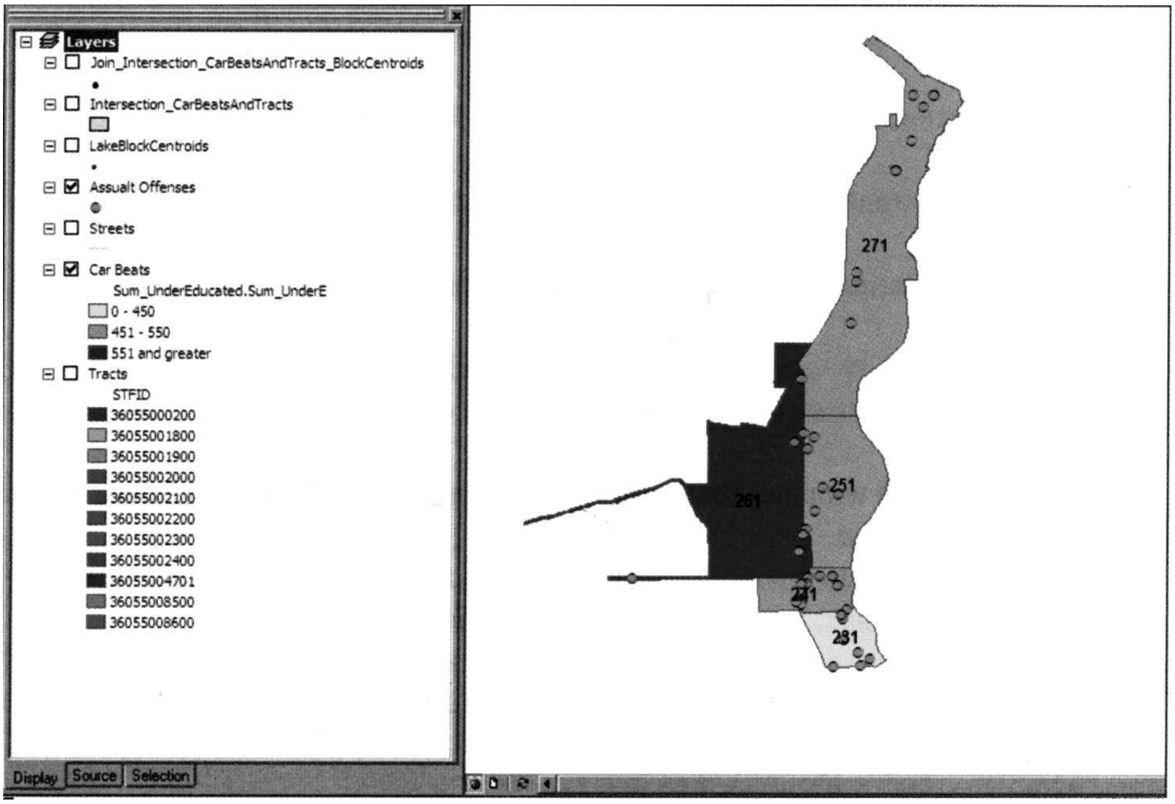

Figure 3. Apportion data for non-coterminous polygons: final map of undereducated population by car beat – a resulted map of GIS-project completion

There are now quite a few ways to obtain accurate locational, height, and appearance data for 3D urban features such as buildings, bridges, roads, sidewalks, pathways, highways and trees [25-. Normally there are geocorrected imagery from aerial photography and satellites at high resolution (down to a meter or less) upon this process. This process produce ground-based close-up images of buildings, groups of buildings and other urban features for their analysis with GIS as elements of an urban system.

One from this paper authors is directly involved in the Three 2N company GIS-technology elaboration (www.Three2N.com), which processes LiDAR data so that to receive from initial LiDAR "point clouds" "a Visible City model" as an output. Point-cloud data volume of laser remote sensing and its derivative urban digital models proceed from the airborne laser range-finding systems, such as LiDAR, which permit an airplane to quickly collect a high-resolution height field for a small / average city in just a few hours, not more. Three 2N Automated Feature Extraction Technology (AFE) allows a user to be able to import, analyze, process and classify LiDAR data. AFE development will result in producing a software technology for: Automatic bare earth identification (*Ground Maker*) based on Airborne LiDAR point cloud data and Automatic building extraction (Urban Building Extractor - UBE). Produced software components will be structured in a way that should allow using them later for extended urban system analysis, and are intended to be used within the existing Three2N software to demonstrate the functionality, performance etc. Three2N UBE software lets a user much more rapidly build up urban databases, than it would be done with manual methods. The current software version is significantly faster, has more capabilities, and has been used to build several unique digital models of a "Visible City". Nonetheless, we had to take into account that LiDAR provides city building heights at the resolution of fewer, than a meter for samples that can be as close as a one meter apart. However, the sides of buildings, especially taller ones, have much less details, although our UBE software finally provides rather effective initial elements for the urban system analysis in general and the city change managing procedure in particular (Figure 4):

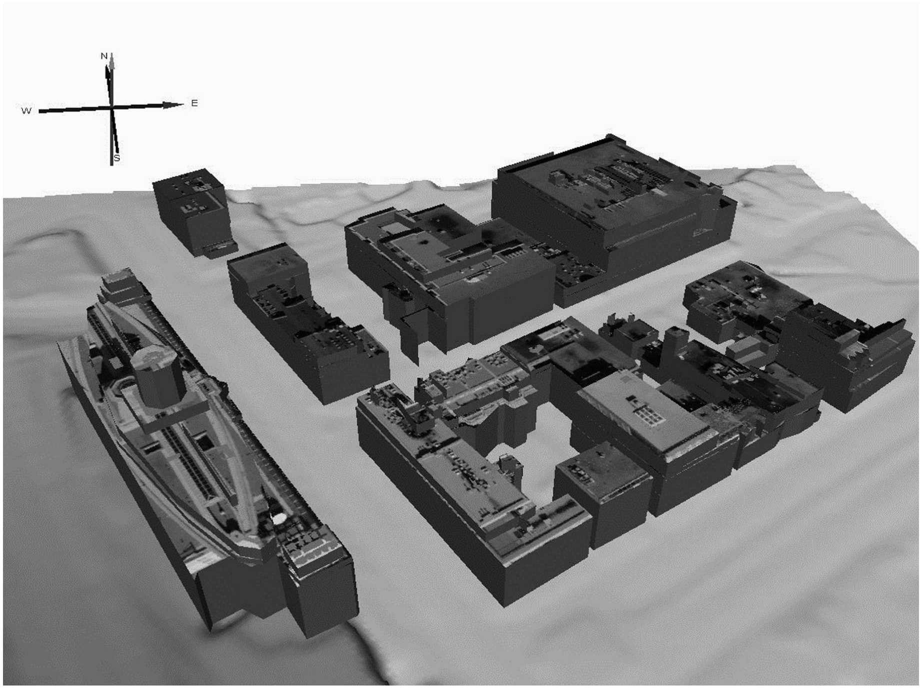

Figure 4. The result of urban data acquisition within Three2N UBE software interface (UI)

Recent advances of our software concerning LiDAR data processing belong to different so-called *real-time applications.* For example, *rotorcraft operations within an urban area* and engaged in urban system analysis are challenged by several unique problems, such as unfamiliar landing and operational areas, brownout landing, low-altitude operational requirements, and off-shore operations. These challenges can only benefit from the availability of detailed, highly precise data, which is collected and processed in real time during the mission. Three2Ns 3D data processing and rendering technologies can provide added capabilities and enhancements for rotorcraft navigation systems in both human navigation and auto-navigation scenarios.

Three2N 3D Geospatial Application Engine is software that provides a set of capabilities to embed 3D data within applications. Similar to game engines in design, it consists of a set of offline media convertors that convert and compress 3D data such as urban terrain, 3D models, imagery, UI definitions, and fonts into binary formats that can be readily deployed to embedded and mobile environments. The latter are able to provide the urban system analysis with real-time data (Fig. 5).

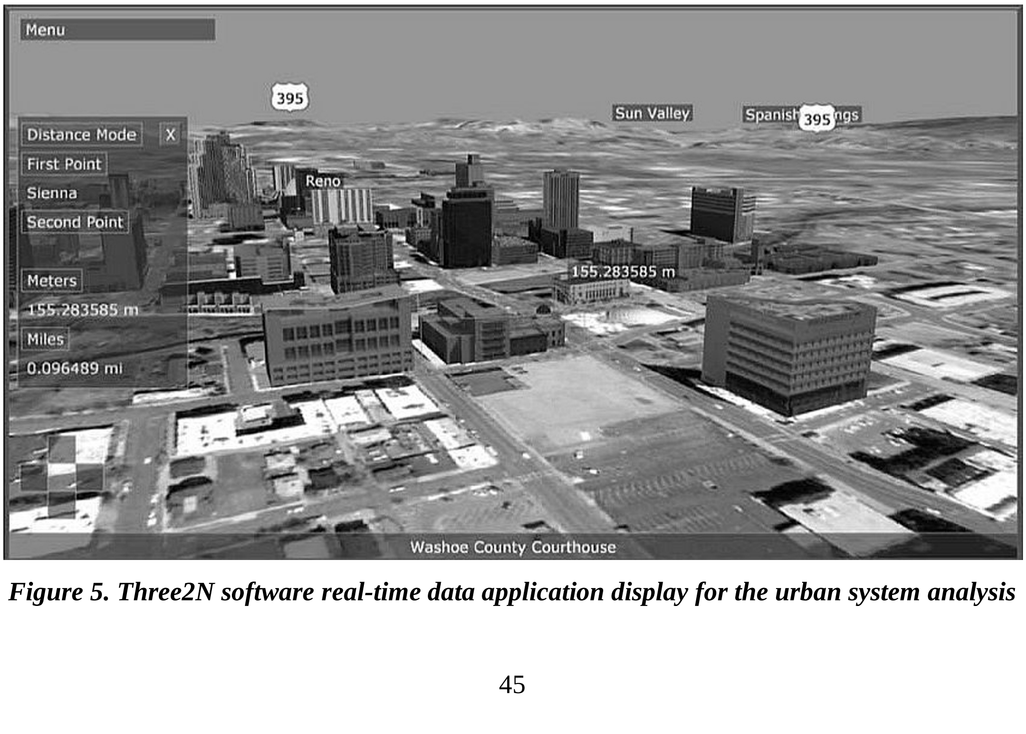

Figure 5. Three2N software real-time data application display for the urban system analysis

Conclusions. This paper authors in their previous advances text have already emphasized that just Human issues must be accepted as the key domain of the novel subject field presented - environmental geography [6]. The latter must employ the social science professionals and some specialists from the humanities fields to solve numerous problems of contemporary humans / environmental interactions, but such an employment can not be definitely done without a geographical information system, which has already obtained nowadays this widely accepted definition as "a Tool-Science Continuum". Contemporary geographical research in general, and an investigation in human geography domain in particular, is *only made possible* by GIS, what is more the geoinformation science introduced a kind of High Technologies revolution in Human Geography. For example, current continuing trends of urbanization, metropolization and globalization – all human geography hot issues – can be made understandable exclusively by GIS. Moreover, a geographical information system, which was yesterday only a tool to convert a paper map into a digital map, becomes a unique methodology today, which will change academic human geography into Applied Human Geography.

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Summary

Sergiy Kostrikov, Kateryna Segida. HUMAN GEOGRAPHY WITH GEOGRAPHICAL INFORMATION SYSTEMS.

The paper purposes is to represent that a GIS in human geography is not only a straightforward tool for generating and spatially analysing maps and graphics, but also is intended to identify certain spatial samples and to form new spatial derivative data for reaching advances in human geography research.

The authors' ultimate goal is to emphasize, that when the GIS-approach is employed in Human Geography instead of the traditional one, then many tasks unsolved and uncompleted yet are resolved and successfully provided.

Digital maps introduced as a paper map effective alternative made possible by GIS. Finding answers with a digital map in human geography a scientist more often deals with two following classes of questions: "What is it? / Where is it?" and "How far is it?" Answering such kind of queries is one of those issues a GIS with a digital map can do best of all.

Once introduced by the authors environmental geography concept is additionally discussed purely of the human geography contribution to this field by geographical information systems. According to this contribution a definite research approach, which combines a strong spatial aspect of environmental researches with the GIS regional applications, directly relates to the domains of both physical and human geography.

Traditional quantitative geography is explained to be a key basic for all following GIS applications in geographic sciences. A corresponding example of a quantitative geography task solution by a GIS – spatial analysis for city management – is provided.

Few examples of original software with respect of city key element extraction are suggested for the urban system analysis.

The conclusion is made: contemporary geographical research is only possible with GIS, and the geoinformation science already introduced the high technologies revolution in Human Geography.

Keywords: geographical information system, human geography, environmental geography, quantitative, geography, urban system analysis.