Dynamic Visualization of Urban Sprawl Scenarios

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Abstract

Environment and landscape are threatened by urban sprawl. In the United States of America as well as in Germany we can observe that the open space and the green areas around the cities are disappearing. In Germany, every day more than 100 hectares open space are gobbled up for new residential areas or infrastructure. In the USA the change of landscape and the daily loss of open space is similarly dramatic. In the area of Washington D.C. the change from open space into other land use categories occurs at a rate equal to 21 football fields a day. Furthermore, during the last twenty years we can recognize urban sprawl as an increasing phenomenon. In the boom years of the 1980s the growth rate of Washington D.C. was exceeded only by that of Los Angeles. The urban sprawl phenomenon is one of the main issues of spatial planning worldwide. The sprawling development is reshaping the face of cities and metropolitan areas. Suburbanization becomes a big problem. The disappearance of open space and green areas is affecting the regions' environment, economy and quality of life. Growth control seems to be one of the most important tasks in urban development for the near future. It is necessary to inform the public and the citizens that the unsupervised converting of the open space and the green areas is creating to a big problem with a lot of unwanted consequences for the society. There is also a need to push forward political discussions and strategies to reduce the rate of change landscape.

This paper gives an introduction to the urban sprawl discussion in the USA and in Germany. Different visualizations methods of urban sprawl will be given by using sophisticated GIS tools. New methods of graphic-based computer simulations which can enhance the awareness of the urban sprawl problem will be presented by examples.

1 The Urban Sprawl Problem

The diverging terms used in the U.S. and in Germany shall briefly be introduced before defining "urban sprawl" as it is used in this paper since no commonly accepted term for development in the area surrounding cities exists.
In the U.S., the development in the area surrounding cities is commonly termed as "urban sprawl": It is a problem, that affects urban, suburban, and rural communities. The results of sprawl range from the loss of farmland to the decay of older urban centers. Simple definitions are hard to come by, because there is no clear-cut distinction between sprawl and suburbanization. It is hard to say exactly where sprawl begins and ends.
There is no universal definition for the development in suburban areas surrounding German cities. The most commonly used terms are "dispersed settlement" and "surface consumption". Strategies with which one hopes to counteract the further spread of cities are termed "sustainable urban development" and do not constitute a separate research category. The term "urban sprawl" is used in the following to categorize the processes of
suburbanization in the U.S. as well as in Germany. It is understood as follows: Sprawl is dispersed and low-density development outside of compact urban and village centers along highways and in rural countryside. Because of the low density of these settlements, cars are necessary in order to move. One of the most negative consequences of sprawl is the loss of land.

The onset of industrialization radically changed the makeup of cities. Formerly compact cities spread into open space, so that today the suburbanization of living and working comprises the greater part of modern city development. Societies fascination with the automobile together with growing individual income brought about the first highpoints of this development in the 1960's in Germany, comparable to the development in the U.S. 40 years earlier. A standstill has not been reached, rather cities continue to spread.

By using empirical studies we can postulate the following four phases based on a model of regular development of cities:

- Urbanization: strong population increase in the core city
- Suburbanization: relative stronger population increase in the ring
- Deurbanization: population decrease in the entire area
- Reurbanization: relative population increase in the core city

It is as yet not empirically proven whether the phase of reurbanization will actually take place, especially the growth of the core city while the population of the ring declines. In the U.S. the phase of deurbanization led to urban sprawl. In Germany, cities are still categorized as being in the phase of deurbanization with a continual population shift towards rural areas.

The result of this development in Germany is still uncertain. Will deurbanization lead to urban sprawl, or is there a chance for a reurbanization in the sense of decentralized concentration? Will urban developers agree on a combination of dispersed settlement and interaction within concise areas? Prerequisite for this development would be an open discussion in which the cultural heritage of the "European City" is set against the necessities of today's society, the "City of a Second Modernity".

An important key to the understanding of urban sprawl is mobility - understood as the freedom of movement on the one hand and actually carried-out movement on the other. Mobility is defined by four factors: activity, route travelled, duration and distance. The amount of time spent per day on the move (1 hour) as well as the number of routes travelled and activities carried out has remained constant over the past 30-40 years. The only variable which has changed is that of distance. Due to the fact that the automobile became accessible for broad segments of the population and thus has turned into the mass transportation vehicle of choice, the variable of distance has doubled if not tripled. This formed the basis for the shift of urban activities to the surrounding area.

The relationship towards mobility, especially the choice of transportation is considered to be a dominant factor in the development of urban sprawl.
Fig. 1: The urban sprawl problem in a case study of Stuttgart and surrounding area.

2 Dynamic Visualization of Urban Sprawl Scenarios

The discussion of urban sprawl is decidedly different in Germany from the USA. The public in general has not recognized the implications of wide-spread settlement yet, and so discussions are held almost exclusively on a professional level. These discussions are characteristically flat and factual, strongly dissenting points of view are not represented. In the U.S. the discussion is by far more controversial and broader due to the fact that the population is directly confronted with the effects of a more wide-spread urban sprawl and thus is more sensitive to the topic. Diverging points of view are propagated specifically by special interest groups.

The basis of effective communication and successfully spreading information to a broad segment of the population is, apart from purely textual information, above all visual communication. An educated public as the prerequisite of participation in the planning process demands possibilities with which to visualize future development and planning.

The traditional media of information and visualization of planning are printed matter, maps, slide projections, perspective and axonometric drawing as well as model studies, endoscopic imagery and photo-montage.

Since the increasing spread of the computer beyond the workplace, this medium is more and more effectively utilizable due to its manifold possibilities to transcend traditional
patterns. The development of new methods of information and visualization is a dynamic sector, the ability to convince grows in importance in lieu of global competition. Information and visualization can be presented in many ways with the aid of programs for CAD, GIS, photo-manipulation, simulation and animation. The World Wide Web (www) is a medium predestined for making information in digital form accessible to a large number of people.

![Fig. 2: Observing the land use change in comparison.](image)

Specifically of interest in the course of this paper is the question of the methods of information and visualization used in the discussion of urban sprawl. Some examples are presented in the enclosed figures and images. Only screenshots of the dynamic visualization of the urban sprawl processes can be given here because of the static print medium.
3 The Future Role of Generic Algorithms

The creation of urban design is a process subject to numerous influences. Plans drawn up by urban planners are extracts related to given scales whereby, depending on the selected or prescribed degree of accuracy, abstractions of the desired and planned reality are drawn, thus creating blurs. For a given degree of detail, external influences such as topography, existing buildings, green areas and geographical orientation may be included in the overall design in exactly the same way as architectural data, the desired density of building, or spatial distributions. Sometimes the designs simply contain a hierarchical road network, and other times they show a complete estate depicting the individual houses down to the last detail. Degrees of detail not embraced by the given scales are not included in the architects overall plans.

This is particularly evident with historical urban structures which have evolved over the centuries. The interrelationship between these conglomerates are so complex that it is difficult to discern any laws of growth. The growth of the urban population is similar in form and shape to that found in animate and inanimate nature, so that aerial photographs of these settlements bring to mind colonisation by plant populations or cell formations.

A research project sponsored by the DFG (Deutsche Forschungsgemeinschaft) is addressing the creative use of computers to simulate the processes of growth of urban structures. The aim is to identify the apparently unplannable processes of urban growth, and to express them in terms of algorithms (recurring processes of computation). These laws of growth can be applied in a virtual-reality environment, thus enabling this phenomenon to be simulated on the computer. Using this technique it is possible to proceed beyond three-dimensional visualisation and, by programming the laws, standards and legal acts of a virtual world, to model the development of urban structures and to observe their behaviour.
In this way, it is possible to "breed" towns as in a test-tube. One element of current research is, in fact, to achieve the, so to speak, evolutionary and genetic "cross-breeding" of urban development modules and their algorithms. In view of the similarity between organic structures and growth in urban development this idea would appear to be an obvious step.

A limited number of selected parameters, including the growth of the buildings, geographical orientation and the topography, are introduced into the virtual environment known as the "village generator". The virtual buildings are created by generators which pass through the virtual world checking the attractiveness of the location in line with prescribed environmental factors. A sort of communal "social" behaviour is programmed amongst the virtual house-builders to enable them to change their direction depending on their proximity to their neighbours. This so-called "swarm behaviour" is a natural phenomenon copied from the behaviour of flocks of birds and swarms of insects. Once the prescribed conditions have been met, the generator produces a building. Because these generators are all interactive this comparatively simple programming results in very harmonious and natural paths of movement which would otherwise have been impossible to precalculate with this clarity. The resulting forms are organic in the architectural theoretical sense of the term, meaning that they have developed from the inside to the outside.

Despite the fact that the programmed modes of behaviour are not directly derived from urban developmental experience, the results display close similarity to the existing structures found in real urban sprawl situations.

Fig. 4: Simulation of the urban sprawl by using generic algorithms.

References


Expanding the Boundaries of GIS – Making the Transition to Small Urban Scale Projects

John K. NICHOLSON

1 Introduction

Computerized representation of three-dimensional space has an interesting history. The distinction in the terms "GIS" and "CAD" grows more out established professional associations and traditions than unique technical issues related to software design. GIS professionals may argue that the "curvature of the earth" issue is uniquely theirs while the fact remains that engineers and architects have had to deal with the issue on many large projects. (RASTORFER, 2000)

The most important issue for professionals is the simple question: "What can this technology do to improve my effectiveness?" Landscape architects, for example, work on projects that may begin at a regional scale, move on to an urban or neighborhood scale, and then finish with working drawings at site scale. At a regional scale, work may consist of transportation studies, environmental suitability, view shed analysis, slope/orientation, social and demographic studies, etc. At the site scale, work may entail sun/shade analysis, construction details, fly-through/walk-through, grading/site sensitivity, section/profile/elevation, and detailed design/materials selection. While it would be more efficient if all of this could be done within one software environment, professionals generally must begin in the GIS world and finish in the CAD world.

This paper will look at an example of a proposed park located in Logan, Utah USA as a starting point for a discussion on making the transition from "GIS scale" to "CAD scale". The Garff Garden Park proposal was a collaborative design by Prof. Caroline Lavoie of Utah State University and the author.

2 Technical Process

The availability of computer compatible data increases every year. For design and planning professionals, two of the most important information sources are topography and aerial photography. Topography is generally found either in the form of contour lines or in an evenly spaced grid of spot elevations (digital elevation model). The example showed in this paper uses contour lines as a starting point however it is a simple matter to convert elevation grids (DEMs) into contours using the tools available in most GIS software packages.
As illustrated in Figures 1–2, starting a project in “GIS mode” offers design professionals a great advantage in that multiple layers of information may already be geo-referenced. Once a rectangular “clipping frame” is created, it can be use repeatedly to focus in on a particular site. Figures 1–2 show an example where both contours and photography are cropped for the Garff Garden site in Logan Utah. The clipped contours (in shape file format) are then converted into AutoCAD format (dxf); in this case using ESRI’s “ShapeDXF Utility”. Adobe Photoshop was then used to both brighten and add contrast to the photography.
With both topography (dxf file) and aerial photography (jpeg file) the information was then transferred to 3D Studio VIS. Figure 3 shows the result of importing the dxf file, using the “terrain” operation, and specifying a layered surface. It should be noted that the goal is to create an accurate working model as opposed to a highly realistic model. While the option to display a graded surface is perhaps more realistic, the “layer cake” option gives the designer a direct link back to the original 2 ft. contour interval base information.

Figures 4–5 show the process of including detailed design work including hand drawn elements on top of the bitmap photographs. (Note in both Figures the hand drawn trees on the ground plane.) Merging 3D design elements with the topographic information and aerial photography gives the designer/planner a dynamic virtual environment that allows various kinds of analysis.

3 Design Process and Analysis

As soon as the 3D model is complete the designer is free to visually explore the site using the dynamic camera tools. It is at this point that the real advantages of 3D design come into play. Fig. 6 illustrates some of the most important types of analysis which are facilitated by the 3D modeling process.
“Construction details” in this context refers to the up front, very “loose” design mode, simply looking at how elements are put together. (This is not to be confused with “construction documents” which come at the very end of the design process to communicate with the construction contractors.) The 3D Studio VIZ software can be used in a very powerful way by establishing a “clipping plane” for a given camera. In this way, section and profiles can be cut in a very spontaneous and interactive way to reveal areas of the design that need further detailing. Figure 7 shows a rough, hand drawn detail, quickly made on top of section created in this manner.

A “Sun/Shade” study is a very powerful kind of analysis that is a natural extension of the 3D modeling process. Design professionals can now perform a number of accurate and detailed analyses:

- Zoning of plant materials based on seasonal variations in sunlight, filtered sun, and full shade.
- Strategic location of trees and/or windows to handle, for example, the overheating affects of late afternoon sun. (Fig. 8) (NICHOLSON, 1999)
- Detail parking lot analysis looking at the affects of orientation, tree spacing, and median width. (Fig. 9) (NICHOLSON, 1999)

A “fly-through” or “walk-through” offers the designer the ability to experience the design in a realistic way before the project is built. Again, this can take the form of a structured and comprehensive analysis:

- What is the view from the second story window of the adjoining restaurant?
- How does the design progressively reveal itself to a passing motorist?

Terrain analysis using sections and profiles gives the designer important information to set elevations and slope of walkways and to establish logical placement of retaining walls. Using the “clipping plane” method described earlier, 10 – 20 sections could be produced in a matter of minutes. At an even earlier step of the planning phase, the design sensitivity to existing terrain is facilitated by exploring the site in an interactive mode capitalizing on the ability to simultaneously look at plan, section, profile and perspective.
Detail design and materials selection becomes more of an issue as the scale begins to focus on small details. Using bitmapped images to “paste” on 3D forms, lets the designer look at issues of color, texture, and form. (Fig. 10) Subtle color differences in plant materials or other design elements can be accurately modeled if care is taken in the photographic process. Fig. 11 shows that a combination of digital and hand graphics can be merged into a single rendering as an effective way to communicate with the public.

Fig. 10: Color, texture, form  
Fig. 11: Combination (LAVOIE, 2001)

4 Conclusion

The progression of figures in this paper (Figures 1 – 11) is perhaps most indicative of a design process offering a seamless transition from “GIS” to “CAD”. A key factor in this transition is the utilization of "smart" drawings. GIS software providers were pioneers in the idea that elements in a drawing need to be tied to "attributes", essentially linking these elements to a database. (Lines might be defined as roads or streams, polygons as property boundaries or lakes.) Ironically, it has taken architects and landscape architects longer to begin utilizing "smart" drawings. The reason for this is that these designers have always been operating in a 3D environment with a long tradition of providing plans, sections, profiles, elevations, obliques, and perspectives. Geographers on the other hand have a long tradition of "flat" maps. Since computer hardware and software has only recently been able to work efficiently in a 3D environment this means that designers have had to wait longer to reap all of the potential advantages. The first attempts to computerize "drafting" were simply a replication of what was essentially a hand craft.

We are now in an era when the design professions can begin to fully utilize the powerful analysis tools that are available in the 3D design environment. (Both GIS and CAD) It means, however, that the design process must in its earliest stages begin in this 3D environment to reap all of its potential advantages. It also means that designers should be encouraged to begin projects with base information that is already geo-referenced and compatible with existing GIS applications.
5 Literature


1. Introduction and Perspective

With the new terminology “Precision Agriculture” and “Site Specific Crop Management”, and “Site Specific Crop Production” etc., a new philosophy of crop production in German agriculture has been introduced. What sets precision farming apart from traditional crop production is the intensive and extensive use of information about the specific site and the condition of the crop. The use of still evolving, new technologies in Site Specific Crop Management will enable the farmer to deal specifically with the differences of the sites and of the crop within the fields (arable area or grassland) using a variable rate of agronomic inputs.

Precision Agriculture implies first, extensive data capturing, data gathering, data management and processing of complex data. Because of the spatial components of all of these data, the use of Geographical Information Systems (GIS) is called for. The precise monitoring of soil and crop variability plays a key factor in site specific crop production. Different remote sensing sources, such as airborne scanners and satellite imageries, are being used as well as modern ground based capturing techniques and new mapping devices which record soil conditions and other factors for productivity. Because of the huge amount and complexity of spatial data which needs to be captured and managed in the agricultural field, mobile GIS systems are very well suited for this task.

Today there are lightweight and portable mobile units available for GPS assisted soil sampling. These new GPS units have by far more functions than a classical GPS receiver. Because of their ability to handle and manage spatial data, according to GOODSHILD & KEMP (1990) definition, they could be called (mobile) Geographic Information Systems (GIS). The same role which navigation systems are increasingly playing for car and truck drivers, is being taken on by GPS modules combined with Personal Digital Assistant’s (PDA) and specific software.

The farmer is also able to use mobile GIS to implement his strategic and operative input decisions in the field. Combined with GPS, mobile GIS offers the opportunity to react to variations in the conditions of the soil and the crop with spatially precise fertilizing and
crop protection even for small areas within the fields. This opens up the opportunity for a new dimension of preciseness in agriculture and provides new options for solving the classic conflict between ecology and economy.

2 Mobile GIS Application in Agricultural Practice

In precision farming, mobile GIS offers a wide range of application in data capturing and field surveying (digitizing field perimeters, crop monitoring and soil sampling). However, mobile GIS units are also helpful in implementing the input decisions in the field using variable and spatially precise doses of fertilizers or pesticides.

2.1 Mobile GIS for Data Capturing in the Field

Before the work in field, GIS is being used to prepare specific soil samplings or crop monitoring in the office. In order to prepare the field work, the locations for taking samples are marked on a GIS map. The selection of necessary field samples are driven by analysis of existing data, such as remote sensing information, maps of crop productivity and soil maps. This analysis is done using image classifications and other GIS-analysis. The results are mapped as thematic maps with field perimeters. The farmer or his consultant will then evaluate the results of the GIS-analysis and select points for the sampling (“Bonitur”). The points for the samples are used as reference points in a database sheet. The fields of the database will vary depending on the specific goals of the task. With the help of this link in the database to a spatial point in the GIS map, the database can be updated in the field.

This option is, for example, offered by the GIS “Field Notes”, “Field Notes”, installed on a Pentop computer can, while using the operating system “WINDOWS”, offer the user in the agricultural field the necessary mobility and flexibility needed for data capturing. Using a serial interface link to a GPS-unit, standard GPS-protocols (i.e., NMEA 183) can be sent to the GIS. The display of the Pentop computer will show the new location (of the GPS antenna) newly every second. This gives easy and precise orientation in the field. The points for taking samples can be found quickly and easily in the field. However, the combination of a Pentop computer and a GPS-unit (i.e., Ag Leader) is best installed on a car, and is less comfortable when walking in the field. We cannot drive with a vehicle to the necessary locations during all periods of vegetation growth to take samples for crop monitoring. If vehicle access is not possible, the locations for samples have to be reached by foot in order to prevent damage by driving, especially after a certain height of the crops. In this case, the GPS, the GPS-antenna, the batteries and the Pentop computer have to be carried in a backpack, which is tough on longer walks.

In the meantime, low-cost, handy and robust GPS units, originated for use in outdoor
recreation and tracking, are available on the market. These have easy to use functions for navigation which allow point location for taking samples (“Boniturpunkte”) with an overall satisfactory precision. For the purpose of soil sampling for precision farming, among others, the series of small GPS units called ETREX by the American company GARMIN can be named. The units are as small as mobile phones. They allow the display of lines and points in 4 gray scale quality. The point display option enables full labeling functions. The GIS maps, which have been prepared in the office to assist the field work, can be transferred, without much effort, to be displayed as lines and points. GPS units, such as the ETREX series, are quite useful for navigating in the field and limit the need to carry heavy equipment. However, this type of GPS is not useable for GIS-links to a database and for updating these in the field. In order to use the strength of mobility and navigation for the purpose of mapping crop monitoring samples, they have to be linked with a data capturing device. Using a Personal Digital Assistants PDA would enable the digitizing of handwritten notes in the field. Back in the office, the digital notes saved on the PDA can be copied to the database. This additional work is also a additional potential source of mistakes.

There are now however even more technical possibilities for the needs of crop monitoring in the field. PDA’s are now available that come with a additional GPS unit. Before the actual field trip, the basic GIS point data of the samples can be transferred to these mobile units using their already available powerful GIS software running under Windows CE. In the field, the GPS unit is then shown on top of the actual location of the user, displaying a point symbol or coordinates which are shown on the display of the handheld. This technical set up enables finding the necessary points for taking samples and the direct and safe update of the database.

Additionally, wireless connections to the office are also possible. Using the internet, the data of the field samples can be transferred to the server of one’s own office or to a provider such as TeleGIS. This way the data can also be transferred directly online worldwide. The update of the database and the evaluation can be started by a third party while the field data collection is still going on. Also, the other direction of data transfer is possible today. Using wireless connections, one can load down data and maps from the server while in the field. The products ArcPad and ArcIMS by ESRI are examples of this type of mobile GIS functions needed in precision farming.

2.2 Using Mobile GIS to Implement Input Decisions in the Field

After the interpretation of the soil or the crop samples in special laboratories, the results, in terms of the status and the potential of specific management zones, will be discussed with the farmer or his manager. Site specific crop management means decisions for each management zone are based on economic and ecologically sound agronomic input. This input decision is then digitized on a GIS map and then transferred to the GPS extended PDA’s.
For practical reasons, only three levels of intensity (high, middle, low) should be selected for the tractor driver when manually operating the devices. Furthermore, the number of sites within a field should be limited in terms of their minimum size. Even though the small PDAs already have color displays, depending on angle and the intensity of the sunlight, the displays are often hard to read. This can be irritating for the tractor driver.

The PDAs having the application map with the input decisions should be mounted on the tractor where the driver can read them easily. As soon as he enters a management zone, the driver manually operates the pressure of a sprayer or he changes the speed of the tractor according to the fertilizer input for this type of zone as called for by the color of the map in the display. This manually implemented approach calls for a higher level of concentration from the tractor driver than has been the case until now. Not every driver will accept this. There is however the possibility to automate this procedure. The input map has to be programmed geobased and transferred to the mobile GIS. The PDA could communicate with the computer of the pressure driven sprayer. The PDA would alter the signal according to the geographical position of the tractor. The first commercial solutions are now being offered on the market.

For applying site specific crop production without the expensive investment of the full automatic process, one has to watch the display during driving and operate the sprayer manually. A compromise between expensive investment in automation and stressful concentration during the application can be found, again, using navigation systems which are offered for outdoor sports. Using GPSMap 176 (Portable Marine Navigation Chartplotter) by GARMIN, which has been developed to navigate sailboats, helpful assisting systems for the driver of the tractor can be implemented without much effort. The advantage of this robust device with nearly mobile GIS functions, is its comparably large and against reflection optimized display (16 colors 3,8″ diagonal, 320 x 240 FSTN-display), a fast processor and extended opportunities for data import. With additional software, shape files can be imported or captured and data (tracks, crossings etc.) can exported into GIS systems.

The following figure shows how an application map, as prepared on a GIS, is viewed by the tractor driver on the display of a GPS map, showing routes and the cross sections. Spatial price dose rate prescription are calculated in the office and coded with a label on a map as shown in figure 1. All this calculation is spatially calculated for the driving corridors of the tractor. All the results of the different GIS analysis like the intensity of growth map driven by classifying remote sensing information, maps with the result of the soil samples, and the productivity maps are evaluated for the application input maps.

While entering the field the tractor driver is opening the specific file according to the actual ground point (“Wegepunkt”). As long as he drives within the same management zone, or within two ground points, the relevant information on the dose rate is projected.
Coming to the next changing point a acoustic signal informs the tractor driver to change the settings for regulation of the sprayer pressure or to change the driving speed. The new dose rate prescription is indicate by the code of the label. „13—70”, i.e. means that the driver is in management zone (“Wegepunkt”) 13 and he should apply 70 kg/ha of a agronomic input.

3. **Summary**

Precision Farming aims to react to spatial differences and differences in crop growth in applying ecological and economic factors. Precision Farming relies therefore on four principal new technologies: that are available today.
1) Navigation systems for capturing the crop and soil condition spatially correctly as well as for applying and documenting measurements from sowing to harvesting,
2) Powerful and cost effective information technology for the objective capturing of plant and soil conditions.
3) Variable Rate Technology for applying crop production measurements
4) and finally Geo-Information-Systems (GIS), for managing all procedures from data retrieving of the conditions to implementing all production measurements, analyzed with specific spatial information and combined with technologies for agronomic input, as well as for other all controlling and documentation.

In order to have punctual and well-informed decisions to prevent undesirable impact on the ecosystem soil that are also cost effective, it must be possible to gain the basic information completely, punctually and cost effectively. In precision farming, mobile GIS will therefore play a major role.

4. Bibliography

Using GIS for Visualization of the Changing Landscape of the Brown Coal Mining Areas at the International Building Exhibition (IBA) Fuerst Pueckler Land

Erich BUHMANN

1 Changing Landscapes: From Fuerst Pueckler to Brown Coal Mining to Waterfront Parks

Today, the Cottbus region south of Berlin is dominated by 24 open, large-scale, brown coal mining areas. As described by STEINITZ, this region once very looked very different. In the early 19th century, Prince Hermann von Pueckler-Muskau (1785-1871) laid out a huge landscape park on his estates at muskau, now divided by the German-Polish border. His extravagant devotion to landscape as art, and a disregard of practicalities resulted in the forced sale of the beautifully embellished Muskau in 1846. He retired to his smaller property at Branitz, near Cottbus, and began work there, creating more English inspired gardens and the famous pyramid tomb. The landscape park at Branitz has survived the 20th century in surprisingly good condition. The portion of the Muskau park extending into Poland has been completely neglected since 1945, although some improvements are on the way.

The region surrounding the two landscape parks has suffered major devastation and related pollution problems resulting from extensive open cast lignite mining and industrial development. With the demise of mining and heavy industry, economic conditions in the region have deteriorated, resulting in very high levels of unemployment. Although efforts at reclamation and economic stimulation have been made, the problem is enormous. Twenty-four large-scale brown coal mines have been closed for active mining since 1990, with only two mines still being kept active. A region of approximately 70 km by 100 km of vast inaccessible mines will be transformed into a chain of lakes with waterfronts.

In order to cope with this world’s largest „construction area“, the International „Bauausstellung“ IBA Fuerst Pueckler Land has been founded. According „Bauausstellung“ projects have been known in Germany for 100 years. For an initial period of 10 years the IBA-Fuerst-Pueckler-Land will guide this process as steward of the land and communicate this dramatic landscape change.
Fig. 1: Changing Landscape: The area of the Klettwitz Cast Mining Fields in historical maps of 1847 and 1920, compared with the aerial photograph of 1999
2 Objectives

In order to communicate the huge dimension and the high-speed process of a dramatically changing environment, we have chosen to look into GIS-based technologies to virtually simulate this process. In classical landscape simulation, there is usually a design proposal for construction which needs to be visually accessed. If our visual assessment shows deficits, the design may be improved or it may not be build. In the case of the reclamation of our open brown coal mines, we know that as soon as the pumps, which are lowering the groundwater table to make mining possible, are stopped, the water will rise fast. There is not much to doubt the “water coming”.

Our goals could be therefore described as

- Making the forever-lost historical landscape before the coal mining experiential
- Making the soon-to-be forever-lost open coal mining landscape experiential (as soon as the water is rising, one cannot access these areas anymore)
- Helping to focus on the beauty of the process of this changing landscape, instead of focusing on the “final restored landscape”
- Helping to simulate alternative ways of re-cultivation (Land Art, succession...)

We are in the process of building the first virtual landscapes. The visitors shall be invited to travel through time and interactively move within the model, look closer here or there and compare different scenarios. In this paper, we include first images of the large-scale Klettwitz Cast Mining Fields, nearby the city of Finsterwalde. The brown coal mine extends, with two adjusting fields, over an area of 10,000 hectares. All the renderings have been processed by Matthias Jähne. During the years of 2000 till 2002, a series of studies for the IBA Fuerst Pueckler Land had been co-supervised by Matthias Pietsch. All the excellent raw data, such as the digital terrain model, the historical maps, the satellite and aerial photography have been supplied by the LMBV.

3 Level of Detail

As several of the contributions for these proceedings have also discussed: As we look closer, we do leave the world of GIS and move into applying other imaging and VR software products. This cannot be a smooth operation in a virtual walk. Therefore we will try to stay as long as possible within the GIS World. At the moment, we are using primary the ERDAS Imagine Virtual GIS software palette.

We have been supplied with very detailed digital elevation point data driven by a very high resolution airborne scanner. On top of this, we drape a satellite image for large scale views or a high resolution aerial photography for closer looks. From images as in Fig. 2, we can derive some answers about integration of “draped” DGM and rendered DGM.
Fig. 2:  DGM driven by a airborne scanner, looking from 4500 meters above, vertical exaggeration X 4, area covered approximated: 10 x 5 km

Fig. 3:  Same view with a draped satellite image
Fig. 4:  Coming closer: DGM draped with the aerial photography, looking from 500 meters above, vertical exaggeration X 3, area covered approximated: 5 x 6 km

Fig. 5:  Approximately eye level: DGM with textures by World Construction Set (WCS), looking from 30 meters above, vertical exaggeration X 2, area covered approximated: 2,5 x 3,5 km
4 Moving Through Time and Terrain

Fig. 6: Moving through time: The close-up of the WCS rendering shows the flooding during the years 1999 till 2014.
Using high resolution aerial photography on a high resolution elevation model creates „Geospecific“ textures that are very realistic. The top image in Figure 6. has the quality of an on-site photograph. With the help of a Flight Path Editor as offers by ERDAS Imagine, one can nearly take a virtual walk interactively. In order to enhance the spatial experience, this reality-like image must be projected as a stereo image.

In order to create travel in time, such as the flooding process presented in Figure 6., one has to create „Geotypical“ textures. The texture images in Figure 6. were created with World Construction Set (WCS).

WCS and similar packages also allow the creation of flight paths. However, the rendering time on this level of detail is still enormous, so that virtual walks with this type of software are not yet realistic.

Fig. 7: Moving through terrain: The Flight Path Editor of ERDAS Imagine as a first step for walking virtual through GIS-driven landscapes
5 First Conclusions

The technical effort for preparing an (interactive) virtual GIS environment is still immense. None-the-less, we are somewhat less pessimistic than Lange in his conclusion in these proceedings: "... there is no doubt that visualization technology will make considerable progress in the near future. The question is whether landscape architecture and planning will take advantage of the opportunities these technologies are offering. ...” We are sure that our profession will continue to take this opportunity! And we are just assure that we are working in the spirit of Fuerst Pueckler while using todays technology.

References


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