

Automatization of Electromagnetic Field Level Measurement in Broadcasting using GIS-MW Software

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Abstract – This paper presents a principle of automatization of electromagnetic field level measurement in broadcasting based on use of specialized GIS software package GIS-MW. This software package, developed in Laboratory for Microwave Technique and Satellite Television at Faculty of Electronic Engineering Niš, enables automatic measurements of EM field level, measurement results storage in space-relational database and their appropriate presentation in georeferenced space.

I. INTRODUCTION

For work analysis and development of actual microwave systems, it is very important to strictly determine covering zones of their transmitters. If this is done successfully, EM field level measurements will be done in large number of different locations, especially in urban area. These measurements enable modeling of EM waves propagation using some empiric or neural model to improve broadcasting systems analysis [1,2]. These measurements should be correct and they should be finished for a certain period of time in the large number of locations. These requirements are not easily realized if the measurements are done manually, if the standard geographic maps are used and if the measurements results are saved as usual file.

Recently, majority of measurement systems have been automated and controlled by the computer while space-relational databases have been used for results storage and their representation. This improving has many benefits. Automation of measurement systems can give ability of using the large number of mathematical functions with measurement data, generation professional reports, synchronization of instruments and big speed of measurement process and many others benefits. Automated measurement place need less engineer time, which induces both effectiveness increasing and measurement cost decreasing. Use of space-relational database minimizes development time of application, increments level of data updating, the new information requirements are easily accepted and unification of reports and of data is enabled.

The problem of automatization of EM field level measurement is analyzed by two approaches concurrently: approach of maximal automation of measurement place

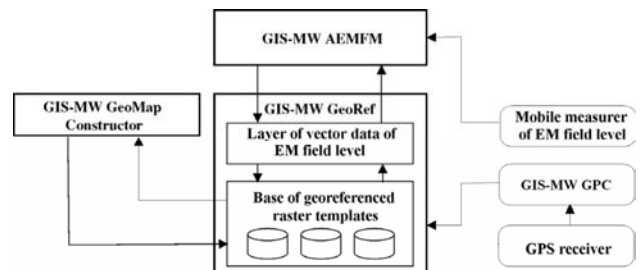


Fig. 1. Special GIS software package for automatization of EM field level measurement

(vertical automation) and approach of space automation (horizontal automation) with software support of specialize GIS (Geographic Information System) application which is named GIS-MW (Fig. 1) [3-6]. This GIS-MW software, which is presented in this paper, is improved version of previous GIS application [7].

Automation of measurement place is done by connecting notebook computer with removable manually EM field level measure equipment. Managing of measurement procedure and processing of measurement results are controlled entirely by software, which is executed by notebook computer. Ability of software package to strictly determine both measured signal level by GPS receiver and accurate geographic location of measurement place has enabled that this software has become one specialize GIS application.

GIS-MW software package for automatization of EM field level measurement, developed in Laboratory for Microwave Technique and Satellite Television in Electronic Faculty in Niš, is unique measuring system which consists of relational information system and different geographic data, as many geographic information systems. This application has been developed with maximal exploitation of processor power and integrated memory for effective processing large amount of complex type data, which is, in this case, elements of digital maps (bitmap pictures) obtained by scanning of geographic maps of measurement place and data obtained by mobile measure equipment of EM field level. Digital maps represent template in which accurate location of measurement place is determined by technique of signal processing from GPS device. Both location and level of measured signal are stored in local database and they are basis for latter graphical display of signals levels from different geographic locations.

Measuring equipment consists of notebook Pentium IV (2.5 GHz, 512 MB RAM) in which GIS MW software package is executed, GPS device Garmin 35PC, and mobile measure equipment of electromagnetic field Sperry RF-3200. First

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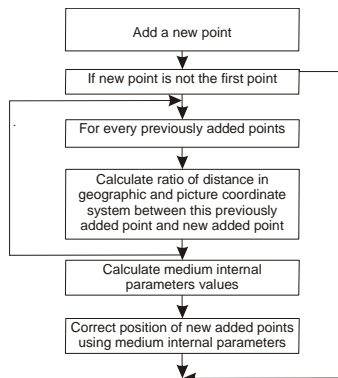


Fig. 2 Algorithm for correction of geographic point position

measurements, performed in wider area of city Niš, are used for testing of currently version of software systems.

II. GIS-MW SOFTWARE PACKAGE PARTS

GIS-MW software package for automatized measurement of EM field level consists of four modules cooperating. First module is used for preparing georeferenced templates (*GIS-MW GeoMap Constructor*), second module is used for managing georeferenced system and for positioning in it (*GIS-MW GeoRef*) and the third module is used for data acquisition from field measure equipment and GPS device and their storage in database and their representing in the proper way in georeferenced space (*GIS-MW AEMFM*) (Fig. 1). Accuracy of position of measured geographic points is very important for GIS-MW software package whose previous version is improved with module GIS-MW GPC (Geographic Points Correction). This module corrects points positions and it increases accuracy of GIS-MW software package. In the first phase, different components have been developed almost entirely independently and they have been integrated in the second phase.

A. GIS-MW GPC (Geographic Points Corrector)

Accuracy of position of geographic points obtained by GPS device determines accuracy of whole *GIS-MW* software package. This accuracy depends of measuring device accuracy but it is not greater than it. To decrease overall system error, this program owns special statistic processing which is based on relationship between measured points in one area (Fig. 2). This module, for every two measured points, calculates ratio of distance between these two points in picture coordinate system and distance between these two points in geographic coordinate system and it minimizes overall error using medium value of pixel per meter. In that way, values of medium internal parameters are calculated and points coordinates correction is done using these values. Both accuracy of transformation of geographic coordinate system into picture coordinate system and accuracy of EM field measuring and representing of measuring results increase.

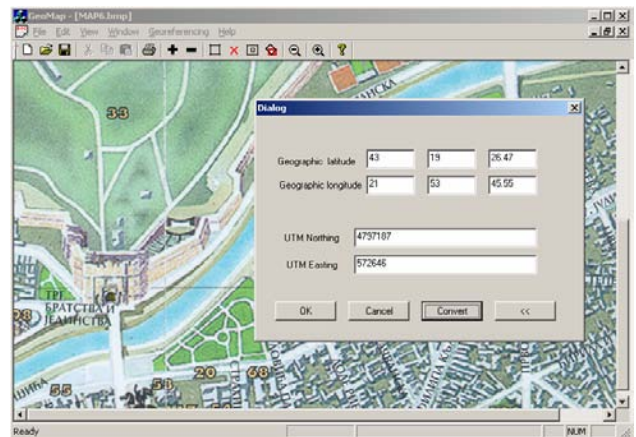


Fig. 3. Input parameters of essential points using GIS-MW GeoMap constructor module

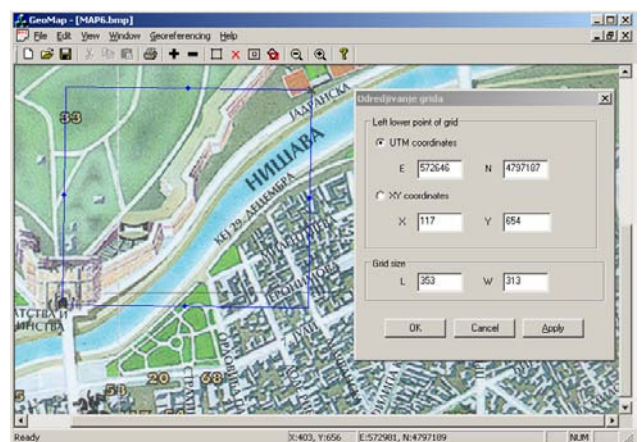


Fig. 4. Definition of UTM cells in software module GIS-MW GeoMap constructor

B. GIS-MW GeoMap Constructor

The principle of operating of this software module is based on transformation digital geographic maps into 2-dimensions bitmaps, which are projected by *Universal Transverse Mercator (UTM)* projection (term *Gaus-Krugerova* projection is used in German literature).

UTM projection defines position of every point at the surface of Earth on the basis of *Easting* and *Northing*, which are equivalent of geographic longitude and latitude [8]. *Northing* is distance of equator in meters, and *Easting* is distance of Central meridian in meters. Entire Earth surface is divided into 60 zones, each covers 6 degrees of geographic longitude and 8 degrees of geographic latitude with same exceptions. Central meridian, defined for every UTM zone, whose *Easting* is known and it is used for calculating *Easting* distance inside the zone. Transformation formula involves specialize *scale* factor which is the same for every zone (0,9996) at the Central meridian. Our country is in 33T zone where there are not system deviations.

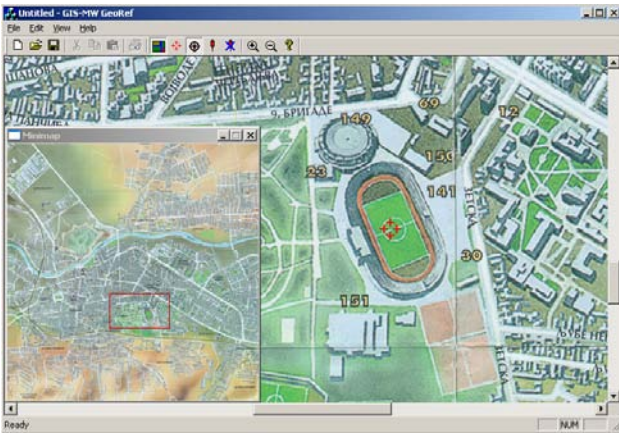


Fig. 5. Defining accurate position of selected geographic point using GIS-Mw GeoRef module

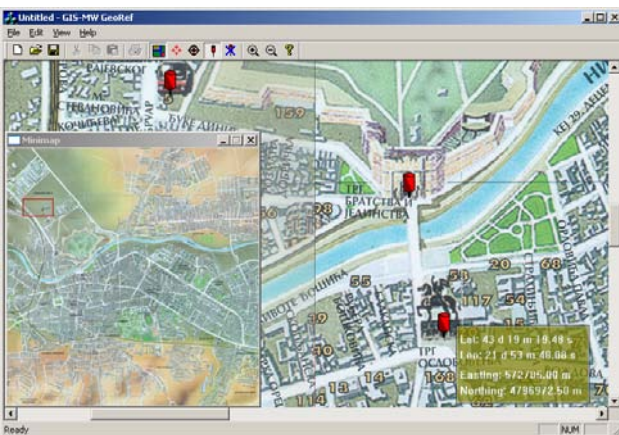


Fig. 6. Positioning of references points in GIS-MW GeoRef module

Digital maps (previously digitized by process of scanning or by some other way), where relevant points are assigned, represent input in this program. Output from program is group of maps, transformed into UTM orthogonal system. These maps make base of raster template of GIS-MW software package. Every raster template is mosaic group of UTM cells, which are 2-dimensional bitmap with equal resolution. Geographic coordinates of relevant points are input value in transformation formula and coordinates of other points in the map are determined by using them. Coordinates of relevant points are obtained by measuring geographic longitude and latitude by GPS device in different location of original map. The system error decreases using GIS-MW GPC module. Input digital map consists of pixels which position is defined in two coordinate systems:

- 1) *Picture coordinate system* – each pixel is defined by sorted couple of (x,y) coordinates.
- 2) *Geographic coordinate system* – each pixel is defined by geographic longitude and latitude in geographic map.

Operating with *GIS-MW GeoMap Constructor* module starts with labeling essential points in map, which should be transformed, and input their measuring values of geographic longitude and latitude (Fig. 3). These input parameters determine both internal transformation parameters and system accuracy, and GIS-MW GPC module is used to minimize transformation error. After that, the area, which should be

transformed in one UTM cell, is denoted. Using suitable options in module, user can define resolution, width and length in pixels of UTM bitmap in which denoted area will be translate (Fig. 4). Transformation process involves processing started picture, which is named as orto-rectification process. This processing should eliminate both effect of picture distortion and rotation and some others noises which can occur during process of scanning and other way digitalizing of digital map.

After transformation, orto-rectificated picture is retrieved in UTM system. This picture is one element of collective pictures group, which represents georeferenced system, and after such editing, it should be treated by different processes.

C. *GIS-MW GeoRef*

GIS-MW GeoRef software module is used for managing georeferenced system of previously prepared geographic maps and for positioning in this system. This module uses group of two-dimensional raster pictures (i.e. bitmapped templates) which form unique electronic map with suitable interface for diapason of operations. This diapason of operations involves: manual (fine) scrolling throughout georeferenced space, system of fast scrolling using minimap, determining accurate position of selected geographic point (Fig. 5), reading position by input suitable geographic longitude and latitude and setting up adequate referenced points in georeferenced space (GIS markers) to enable easier performing same spacing operations (Fig. 6). This module manages superiors layer, composed of vector data which concern measuring of electromagnetic field and which are represented in georeferenced coordinate system. Positioning can be guided by information, which GPS receiver transmits.

D. *GIS-MW AEMFM (Automatic EM Field Measurement)*

GIS-MW AEMFM is module for automatic measurement of electromagnetic field level and for storing measurement results in vector layer of GIS software package. Also, this module must represent measurement results in georeferenced space using isofield lines in city map. Module manages mobile measurer of EM field level and it cooperates with *GIS-MW GeoRef* to get information about current position.

This vector layer is advanced layer, which is above level of geographic maps. In this case, vector layer consists of information concerning EM field level and place in the geographic map where this level has been measured. Using mobile measuring device of electromagnetic field, value of EM field is determined in the current position and GPS device gives information about current geographic coordinates. These measurement results are sent to notebook computer, GIS-MW GPC module corrects their position accuracy and they are written in database. During writing, geographic coordinates are translated into picture coordinates, and EM field zone, where measured EM field belongs, is determined. When the measurements are done, results are represented and isofield lines for this measuring area are drawn (Fig. 7).

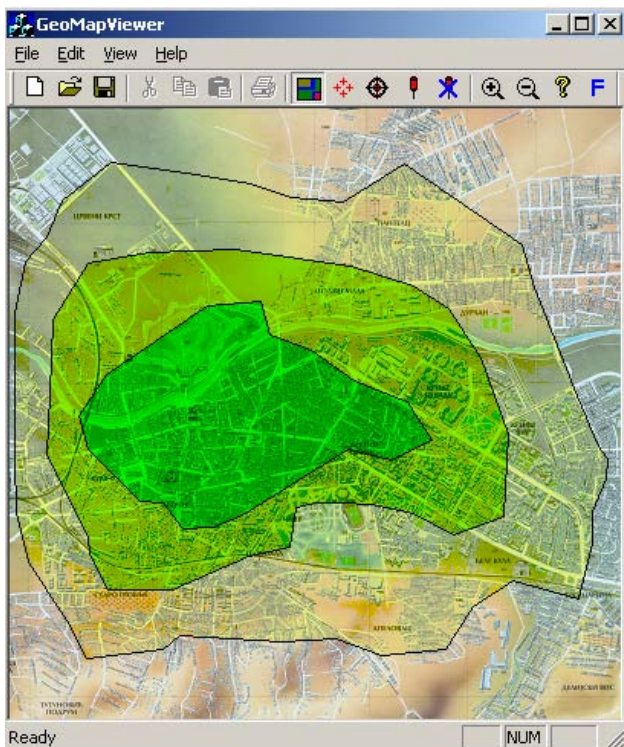


Fig. 7. Representing measurement results for total area of city Niš

III. INTEGRATED GIS-MW SOFTWARE PACKAGE FOR EM FIELD MEASUREMENT

The integration of *GIS-MW GeoMap Constructor*, *GIS-MW GeoRef* and *GIS-MW AEMFM* modules gets GIS-MW software package, which enables automatization of EM field level measurement in broadcasting (Fig. 1). Links between particular modules are direction of data exchange between software modules in the same time. Particular components are clearly isolated to see their roles in system. Central part of system is module *GeoRef* which manages georeferenced template, which is one of more complex problem. Communication with user and editing of digital maps are established by module *GeoMap Constructor*. Collection of data from measuring instruments and their final processing and storing are done by *AEMFM* module. Also, *GIS-MW GPC* module is very important because it determines accuracy of whole system.

Each components of the system can work relatively independently. The current reached version of *GeoMap Constructor* module can process digital picture and it can be enlarged with new functions. *GeoRef* module depends of previous module, but it can be enlarged with specific function for operating with *GeoTiff* formats picture which enable maps in different projections and which are useful instrument for exchanging information between independent GIS packages.

AEMFM module collects data and processes data transmission.

IV. CONCLUSION

For analysis of transmitter operating in modern broadcasting systems, it is necessarily to do accurate measurements of EM field level in the large number of different locations and then to process these results effectively. Manual measurement needs a lot of time, errors can occur and preparing measurement results for processing is difficult. Automation of these measurements can reduce remarkably these problems and it can make analysis of broadcasting systems very fast and effective. Automated system for EM field level measurement, which is presented in this paper, introduces space component in data processing (space automation) by combining measurement results and space-geographic data. In this way, this system becomes one powerful geographic information system with many advantages. Characteristic of this system is its mobile. Also, it can be enlarged with many automated mobile measuring units, which can do data transmission by *wireless* link into *mainframe* computer in control room where data should be processed. Rate and quality of processing of measurement data get better and they make analysis more effective. Entire system can be serviced by several people, which may not have some computer knowledge, although they should have knowledge from their specific domain.

System precision and accuracy depend on measurement equipment quality because information, which is obtained by these instruments, is the majority source of data for this automated measurement system.

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