

2006-257: TEACHING GIS WITH INTERGRAPH'S GEOMEDIA IN A CIVIL ENGINEERING TECHNOLOGY PROGRAM

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Abstract

At the Pennsylvania College of Technology, we feel that the tools of project design and management, such as Geographic Information Systems (GIS), should be taught along with the more usual subjects in a Civil Engineering Technology curriculum. With an NSF(ILI) grant, Pennsylvania College of Technology purchased the Intergraph MGE software suite for use in studying and teaching the capabilities of Geographic Information Systems (GIS) to Civil Engineering and Surveying students in our ABET(TAC) accredited Associate's and Bachelor's programs. After a number of years of MGE use, we decided to upgrade to GeoMedia without changing the problems to which it will be applied by Civil and Surveying students. Our first use in instruction is in our Bachelor's program senior (fourth year) course [4]. Most students in that program have been exposed to Intergraph's MGE through an already constructed GIS using elements of the Knoxville, TN municipal database. We had previously used those data with MGE [4] for all civil engineering and surveying students' education [2 and 3].

This article discusses the utility of the software when “reviewing” tasks previously accomplished using MGE and now executed with Intergraph’s GeoMedia. Concepts such as scale (representative fraction and engineering), true (as opposed to projection) azimuth, and point/line scale as applied to GeoMedia are discussed as they apply to these projects.

In addition, students in the senior course (CET 414) must construct a GeoMedia work space from the coordinate system definition to spatial and attribute queries for features they will define for a vertical construction project. Students then use the results of queries to estimate concrete requirements, sheetrock and paint/primer requirements for the proposed structure.

Introduction

At the Pennsylvania College of Technology, we feel that the tools of project design and management, such as Geographic Information Systems (GIS), should be taught along with the more usual subjects in a Civil Engineering Technology curriculum. Our portfolio includes associate’s degrees in both Civil Engineering Technology (CT) and Surveying Technology (SUT) and a bachelor’s program in Civil Engineering Technology with emphasis in Surveying (BCT), all ABET (TAC) accredited. The use of GIS is taught to students in all degree programs. A more advanced course in Land Use/Information is part of the BCT program.

With an NSF (ILI) grant, Pennsylvania College of Technology purchased the Intergraph MGE software suite to teach the capabilities of Geographic Information System (GIS) to Civil Engineering and Surveying students. After a number of years of MGE use, we decided to

upgrade to GeoMedia and teach the same applications to Civil and Surveying students. Our first use in instruction is in a Bachelor's program senior (fourth year) course [4] where we plan not to change what we teach despite the software change.

This article is not a software review. We teach the elements of GIS to all our civil engineering technology and surveying students so that they understand its use in their professional practice. Like both AutoDesk's ACAD and Bentley's MicroStation CAD software, the object of the instruction is not to produce drafters and GIS specialists, it is to teach our students the use of the tools of modern civil engineering professional practice. To that end, we think a working knowledge of these tools is part of their education.

Most students in that program have been exposed to Intergraph's MGE through use of an already constructed GIS using elements of the Knoxville, TN municipal database. We had previously used that with MGE [4] for all civil engineering and surveying students' education (Sprinsky, [2 and 3]).

The problems students encountered when doing a "review" of tasks previously accomplished using MGE and now executed with Intergraph's GeoMedia are of interest to our faculty. Concepts such as scale (representative fraction (RF) and engineering), true (as opposed to projection) azimuth, and point/line scale are a part of the course's curriculum. How these ideas are applied to GeoMedia is also of interest.

In addition, students in this senior course must construct a GeoMedia work space. From the coordinate system definition to spatial and attribute queries for features they will later define for a vertical construction project. Students must then use the results of their queries to estimate concrete requirements as well as sheetrock and paint/primer requirements for the proposed structure. Their success is compared with the same project done in Intergraph's MGE.

What Was Taught and How It Was Applied in GeoMedia

The College Catalog Course Descriptions for the two courses involving GIS instruction are as follows:

CET 122

Topographic Drawing and Cartography

Use of conventional symbols in mapping, the construction of large-scale topographic maps, contours, slopes, features, profiles, photographic and map interpretation. Methods of plotting, use and construction of small scale maps, the Earth's coordinate systems, map projections, enlargement and reduction of maps, map digitizing, geographic information systems, thematic maps, computer applications.

CET 414

Geographic/Land Use Information Systems

Definition of data structures and procedures used in the synthesis of geographic and non geographic data to provide decision makers with options for civil engineering projects upon which to make the best possible choices. Project definition, data organization and capture, and use of query languages to generate options. Computer applications to civil engineering project design.

In CET 122, the first experience of students in both associate's programs and in our baccalaureate program was in an environment where graphics and data base were already made and set up with both positional and attribute data for Knoxville, TN. Starting from an understanding of coordinate systems, particularly the State Plane Coordinate System (SPCS) for the North American Datum of 1983 (NAD83), and an introduction to cartography, students found that GeoMedia was as easy as or easier to use than Intergraph's MGE product. Queries, both spatial and attribute, while formed differently, were equally understandable. The most marked difference was in sequence of use. When faced with a problem involving location of a project and gathering of information about the project area, students must first identify the location and then gather information and compute quantities required to accomplish the project. The GeoMedia software can be used as a tool in that sequence. MGE was a less intuitively useful tool.

The senior students taking CET 414, who had been exposed to MGE more than two years previously but had not used this GIS software since that time, really appreciated the idea that queries could be executed as their thought processes progressed. With MGE, the data base was always being interrogated for attribute data for the geo-referenced features that were being identified. With GeoMedia, students discovered that they could use the previous query results to build upon as the solution of their tasks progressed. This made comprehensible the process of identifying roadways by name and then finding properties adjacent to them.

The only questions the senior students had centered around attribute data location in the database. With some nudging from their instructor and some trial and error efforts, they soon

overcame this uncertainty. Later on, when they made their own data bases for attribute data, the whole process became much more clear and meshed well with class instruction on GIS design.

A teaching point involves the usual chore of going from one enhancement to another. We place emphasis on graphic interoperability and use the .dxf file format as an important concept.

Because one of the options in GeoMedia is for “label display”, students are asked to show the plat numbers using GeoMedia options and .dxf files generated from another program, LI Contour v7.0 (AB Consulting). This program uses coordinates that are derived from the centroid plat file, a part of the MGE exercise previously used to illustrate GIS concepts. In displaying these .dxf files as objects, scale (both RF and engineering) are used, and students see how these scales alter the display of the .dxf file image. Even though improperly displayed by GeoMedia, understanding of engineering scale must be used to superimpose the .dxf file on the layout window before plotting.

A series of exercises that students in all programs perform involve coordinate transformations [5]. The senior course, CET 414, requires students to understand not only SPCS projections and transformations between SPSC zones, but also how installed CAD digitizing systems work.

After demonstrating that they understand the Transverse Mercator (TM) to Lambert Conformal Conic (LCC) zone transformations, senior students do building placement from architectural drawings to CAD coordinates by reading digitizer streams and using the same transformations to predict building corner coordinates for points on the drawing to SPCS coordinates in the CAD.

Four geometric transformations were discussed and used by students. They were the three parameter affine and 6 parameter affine and two Bentley enhancements, the Rigid Body (a

variant of the three parameter affine) and Least Squares transformations (a four parameter affine), [1 and 5]. The metric used in digitizer to SPCS, to decide the “best” transformation was the sum of the squares of the differences between known SPCS (NAD83) coordinates and their values predicted by the transformations. The final choice had to be the smallest sum produced by one of the two Bentley enhancements. Although all the students found the best performer to be the six parameter affine (commonly used in photogrammetric transformations), the Bentley enhancements came in a close second and third and are in common use in civil engineering and land surveying practice.

This senior course requires that students create their own “warehouses” (Access databases) and use them in conjunction with CAD files to produce data that will be used to estimate project costs. When these senior students used MGE previously, they were not required to perform these functions, so that aspect was new to them. The instructor, however, remembers from previous classes the arcane manner in which MGE was manipulated to get such simple data as area and perimeter of an area feature.

After placing and verifying the building outline, students are instructed the read MicroStation (V8) design files directly using GeoMedia, rather than converting them to GeoMedia graphic files and exporting GIS results into CAD formats. The creation of MS Access Database files (Warehouses) and associating them with these design files is easily done, and students recognize the resulting queries as products of attribute data they entered into various warehouses, and GIS computations such as area and perimeter. These query results are later used in MS Excel to

generate quantities of materials that could be used in estimating project costs and managing site storage and construction task phasing.

The instructor does realize the simplicity of using this software as compared to MGE and the comments that follow are his. The initial database (warehouse) setup in GeoMedia was very different from that of MGE and appeared to be much more intuitive and understandable for students tasked to do it. Displaying the Bentley MicroStation design file in GeoMedia generated an understanding of the inherent MicroStation coordinate system, evidenced by their creation of a .csf (coordinate system file) for GeoMedia to use in interpreting the design file. Once this was mastered, association of the database with the graphic was straight forward for them (and considerably easier for the instructor to get across to students than the procedure in MGE). Populating the attribute data that the GIS was unable to generate was also much more straight forward when students learned that clicking on the feature brought up a dialog box that allowed them to key in such attributes as suite name (S_NAME), renter (RENTER_NAME) and project title (PROJECT_NAME). Once the area features were identified and associated with the database, students mastered the Functional Attributes tool in GeoMedia with surprising ease. The syntax of the instruction to the program posed some problems initially but was quickly mastered. Students checked the Geomedia values from coordinates they generated and commented on any differences noted, as part of the report of this graded exercise. These quantities then were output to an Excel file and used to estimate concrete volumes, heating plant sizes, and quantities of cement block, paint/sizing and sheetrock for the proposed building. There was no difficulty in producing GeoMedia computed areas, perimeters, centroids (a graphic representation of the center points of the areas – in this case a circle in each of the first and

second floor suites in the proposed building), orientations, or in deriving SPCS (NAD83) x and y coordinates of those centroids.

Civil Engineering Design and Use of GeoMedia

The use of Intergraph's MGE system was discussed in some detail in [2 and 3]. This discussion will concentrate on our experience with GeoMedia on the same projects. The level of detail in the following description will demonstrate that their use of GeoMedia was considerably more than a "click and drag" for them. For our senior students in CET 414, the first of these exercises was designed to refresh student memories of their MGE experience. They were to locate Ray Mears Boulevard in Knoxville, TN. The data base used was furnished by Intergraph as part of their MGE application. The instructor modified the format so that students could read the data directly into GeoMedia. Figures 1 and 2 show the formation and result of this attribute query. To illustrate the reasons for limiting access authority to change data, students then located plat 9.14, on Ray Mears Boulevard, Figure 3, and changed the owner to their own names and the assessed value to \$1,000,000, Figure 4. Most students understood the ramifications of this step when it came to borrowing against this property, so the emphasis on data security made on class lectures was underlined. Students who remember the steps required in MGE to change attribute data appreciated the ease of making the change in the data in GeoMedia

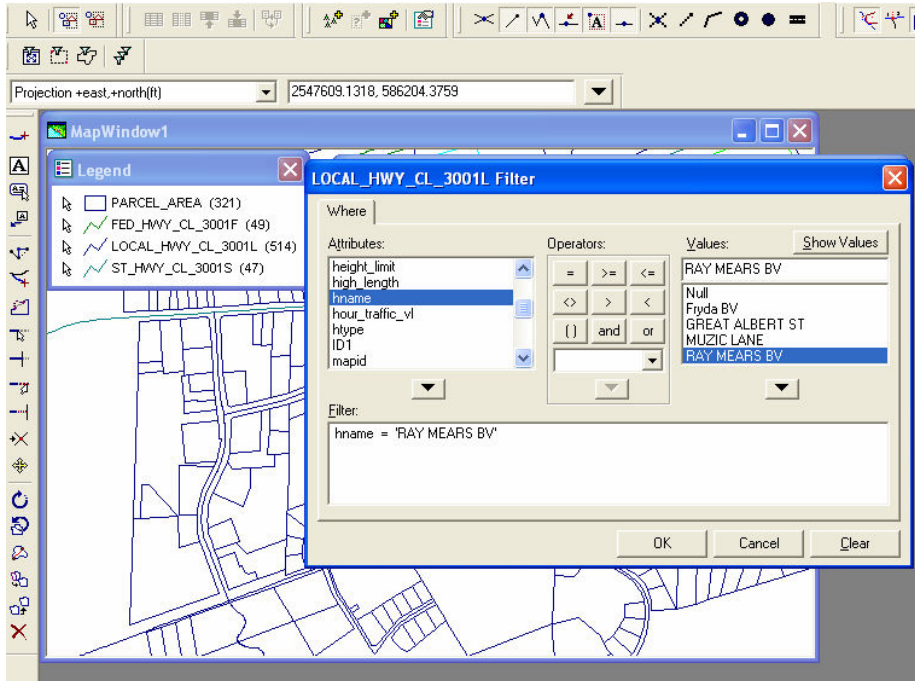


Figure 1. The dialog box for the query to locate RAY MEARS BV with GeoMedia. The display comes from an already constructed database and graphics of Knoxville, TN furnished by Intergraph.

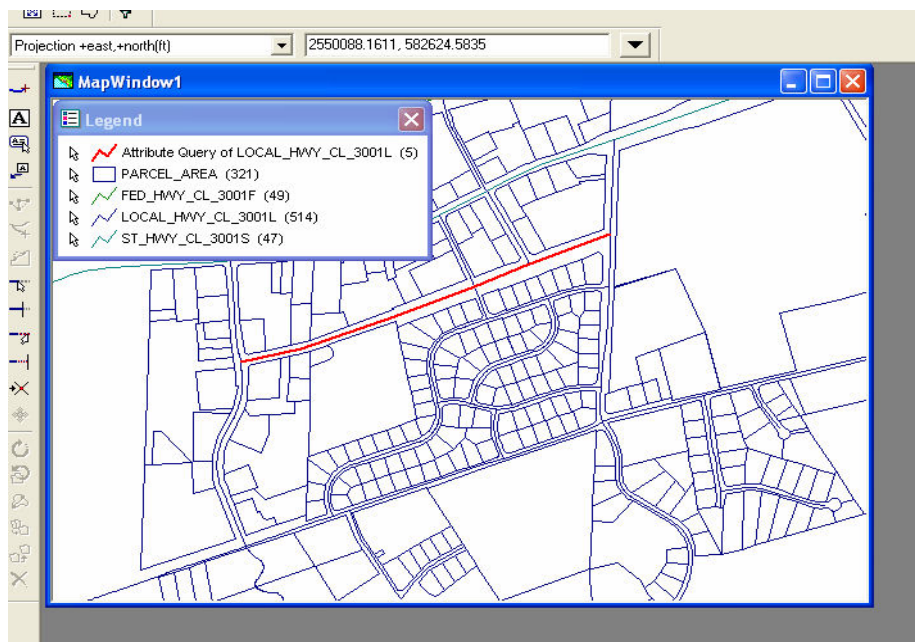


Figure 2. RAY MEARS BV location from query.

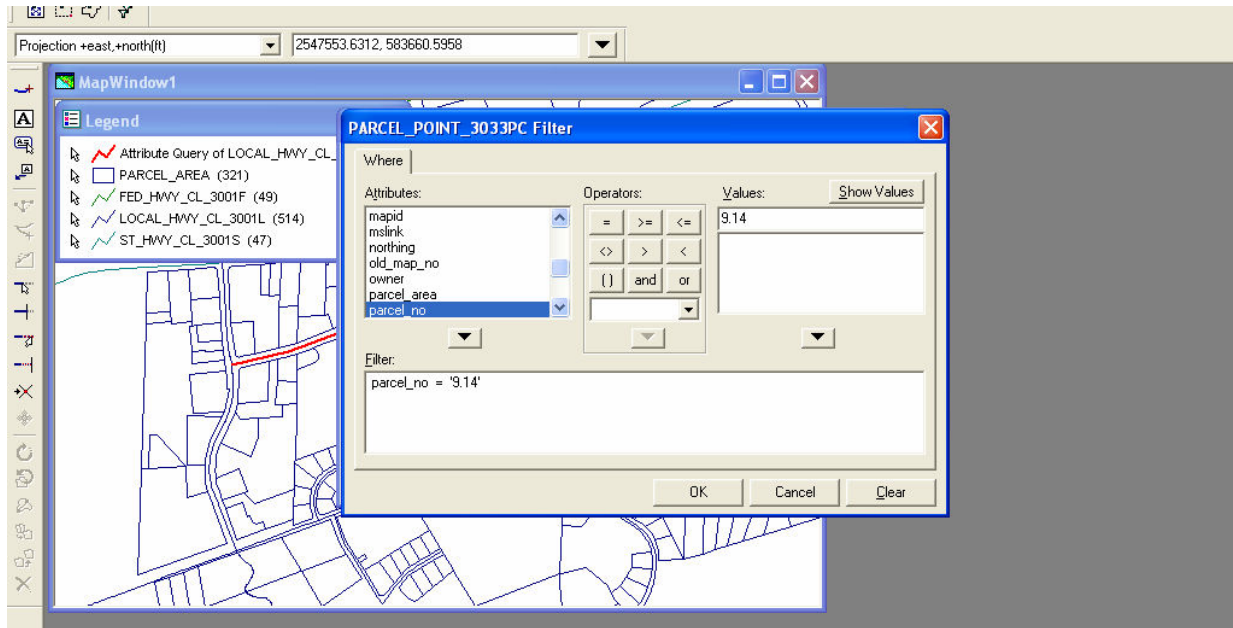


Figure 3. Query to locate plat (parcel no.) 9.14 using GeoMedia.

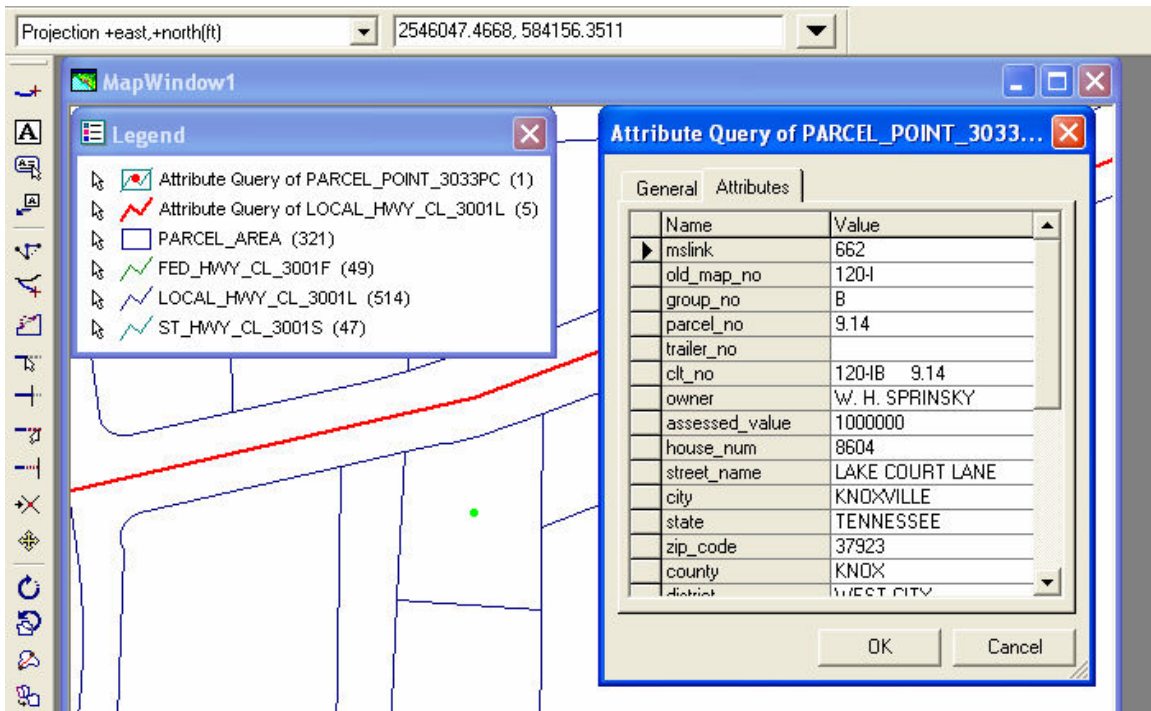


Figure 4. Ownership of parcel modified by author using one of GeoMedia's tools.

Their second GIS exercise was choosing an area for development in the same neighborhood. Its extent was 1.25 acres, “plus or minus.” They repeated the attribute query, now to locate Great Albert Street, see Figure 5. Students then did a spatial query to locate plats within 220 ft of that street (the depth from the centerline required to attain 1.25 acres with a frontage of 250 feet, see [4], see Figure 6. Because of a number of other restrictions, this was only the start of the solution of their task.

In order to illustrate the use of .dxf files generated from other programs, students used Excel to export the centroid coordinates of plats found from their spatial query, see Figure 7. The coordinates were saved in Excel as a csv (comma separated values) file and read into LI Contour, AB Consulting, with the plat number as the Z coordinate of an X,Y,Z coordinate. From LI Contour, a .dxf file was generated which was read into GeoMedia. It was here that other teaching points, primarily about scale (RF and Engineering scale), were reinforced when the .dxf file displaying the plat number as Z had to be navigated into position, see Figure 8. The scale specified by GeoMedia was incorrectly displayed as a decimal, but it wasn't a representative fraction. Analysis of the .dxf file coordinate units (feet from the data base) and units of the display (inches) showed them that this was an inch/foot (engineering) scale, see Figure 8. Again lecture was reinforced by reality.

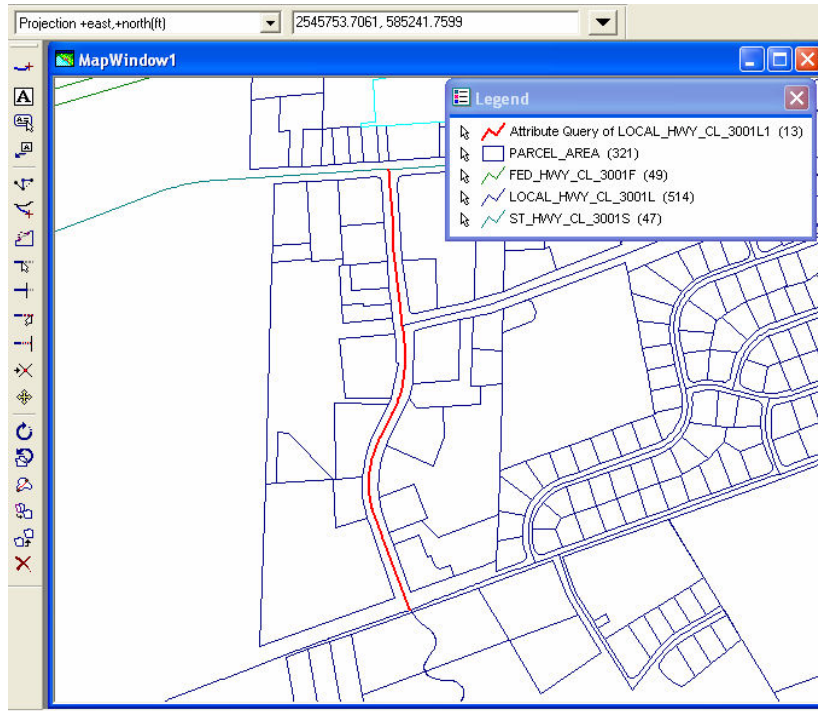


Figure 5. Students use query language to locate GREAT ALBERT ST in GeoMedia.

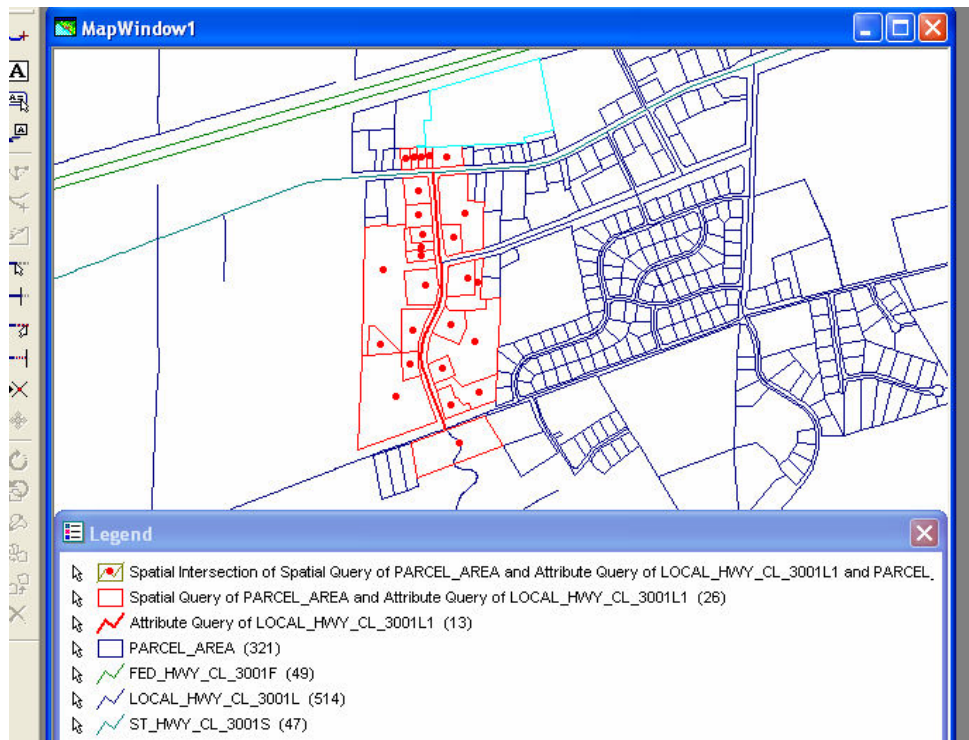


Figure 6. Location of properties suitable for Client's needs. Red dots are centroids of plats within 220 feet of the centerline of GREAT ALBERT ST. This is a spatial query and a spatial intersection for the centroids.

	A	B	C	D	E
	parcel_no	centroid east	centroid north		owner's name
2					
3	4.12	2545665.682	585094.120		CAIN LILLIE MAE
4	4.14	2545516.435	585106.953		CAIN LILLIE MAE
5	4.15	2545447.436	585097.286		CAIN LILLIE MAE SUB LEASE THE FERGUSON REALTY COIN
6	4.16	2545376.854	585098.953		CAIN LILLIE MAE LSD OMEGA ENTPRS INC
7	4.05	2545312.658	585086.086		CAIN LILLIE MAE LSD OMEGA ENTPRS INC
8	9.07	2545820.429	584614.292		SOUTHERN FARM BUREAU ANNUITY INSURANCE CO
9	9.06	2545413.685	584804.539		FIRST TENNESSEE BANK ATTN: CORPORATE TAX DEPT
10	9.24	2545419.851	584597.208		UNIVERSITY REAL ESTATE FUND 10 LTD
11	9.17	2545116.688	584122.461		UNIVERSITY REAL ESTATE SUND 10 LTD
12	9.09	2545457.017	584431.793		SWENSEN-S OF DOWNTOWN WEST INC
13	9.23	2545446.184	584320.377		SEDGLEY RICHARD TR
14	9.10	2545447.683	584244.628		MUSSELMAN BROTHERS % THE H L ERDMAN CORP
15	9.15	2545719.930	584400.794		HOME FEDERAL SAVINGS & LOAN ASSN OF KNOXVILLE
16	9.12	2545477.099	583990.964		MCNEILL INVESTMENT COMPANY INC
17	9.04	2545839.740	584048.611		UNIVERSITY REAL ESTATE FUND 10 LTD LSD FAIRLANE
18	9.22	2545933.342	584009.548		UNIVERSITY REAL ESTATE FUND 10 LTD
19	9.21	2545904.007	583506.886		DOWNTOWN WEST ASSOC LTD
20	9.13	2545704.428	583647.551		BMW & I PARTNERSHIP
21	9.18	2545372.016	583597.300		TGI FRIDAYS INC
22	9.19	2545348.765	583306.553		UNIVERSITY REAL ESTATE FUND 10 LTD LSD DOWNTOWN
23	9.26	2545090.520	583481.301		DOWNTOWN WEST ASSOC LTD LSD TO DONLEVYS OF TN INC
24	9.20	2545226.600	583023.472		UNIVERSITY REAL ESTATE FUND 10 LTD
25	9.27	2545627.178	583272.471		MUSSELMAN MUSSELMAN & TOTTEN INC
26	9.25	2545942.672	583060.640		UNIVERSITY REAL ESTATE FUND 10 LTD
27	9.03	2545698.342	582953.891		WEIGEL LYNN B & WILLIAM B
28	13.01	2545768.923	582624.894		LENOX PLACE REALTY CO % USGI

Figure 7. A MS Excel file from the Figure 6 query showing plat number, centroid coordinates and owner's name.

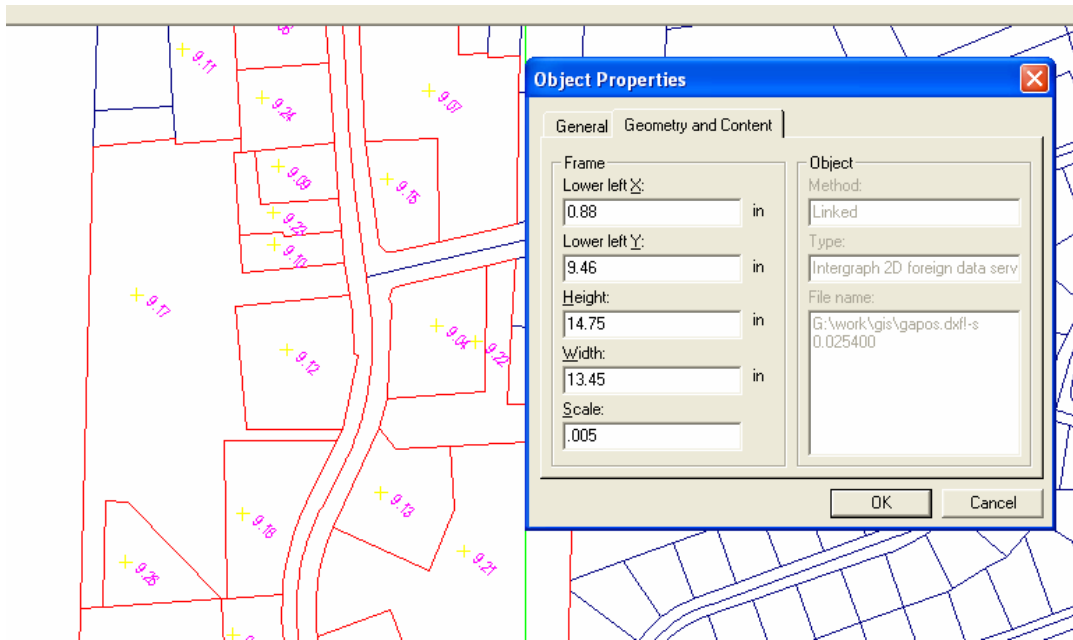


Figure 8. Display of plat numbers from a .dxf file made from Excel file in Figure 7. Note the “Object Properties” box “scale” is actually an improperly displayed engineering (inches per foot) scale.

The senior student experiences were a repeat of their freshman classes in CET 122 with different software. After a more complete treatment of the SPCS (NAD83), the CET 414 students did a series of assignments on coordinate transformation, with the exception of Datum Transformations. The primary vehicle for arbitrary or North American Datum of 1927 (NAD27) coordinate transformation to NAD83 was Bentley's InRoads Rigid Body and Least Squares transformations. They are compared with instructor-written programs which do a 3 parameter affine transformation [5] where the scale is fixed and a 6 parameter affine [1] commonly used in photogrammetry. Exposed to all this theory, students read a digitizer stream directly and use the transformations on an architect's siting of a building to be constructed in the Ray Mears Boulevard location. For liability protection of their employers (the instructor), they are only allowed to use the InRoads products, although the six parameter affine does a much better job as measured by the metric of smallest sum of the squares of the residuals to the "known" coordinates of the plat corners in NAD83 Survey Feet.

The students then used MicroStation files containing the linework of the project building's footprint to create area features for the basement and two upper floors. Figure 9 shows the basement of the project in GeoMedia. While there are a number of ways to enter attribute data, they agreed that the option of mouse clicking on the feature and adding the attribute data directly was an improvement over the query-find-edit-modify MGE routine. Figure 10 shows the dialog box after modification.

Once the project warehouse was populated with suite names, potential renters and other non-spatial data, students let the GIS do the work of finding centroid, area (sq ft) and perimeter for

later use in Excel to predict number of concrete block, volume of concrete, sheets of sheetrock and gallons of paint and sizing required for a cost estimate. Figure 11 is one of the solutions for the basement. Figure 12 shows the graphic display of this work with the label function used.

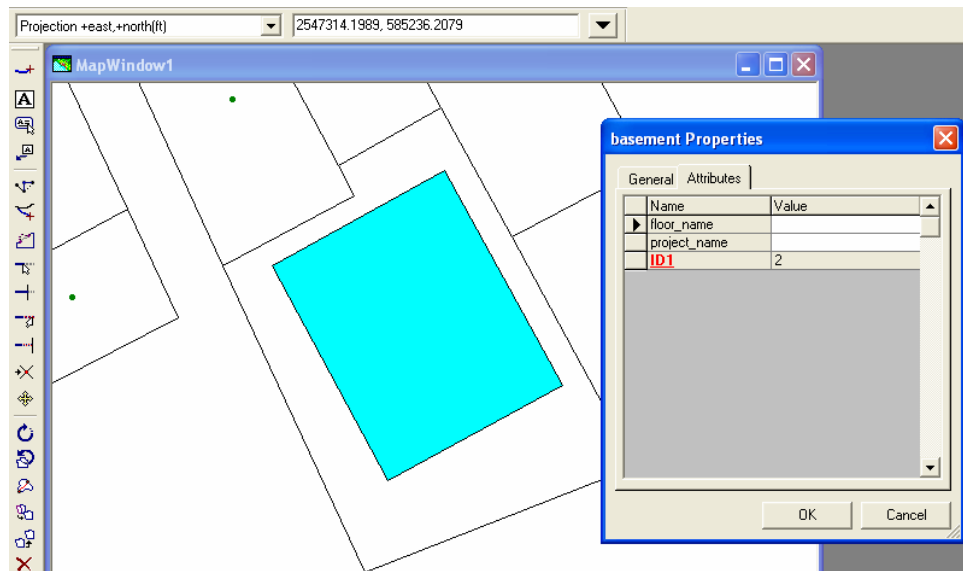


Figure 9. Once NAD83 coordinate transformation is done, students do the linework required to portray the basement of the office building to be constructed and associate it with the data base as a feature, shown in light blue. Using a GeoMedia tool, the software displays the record for this feature, basement (feature name) Properties.

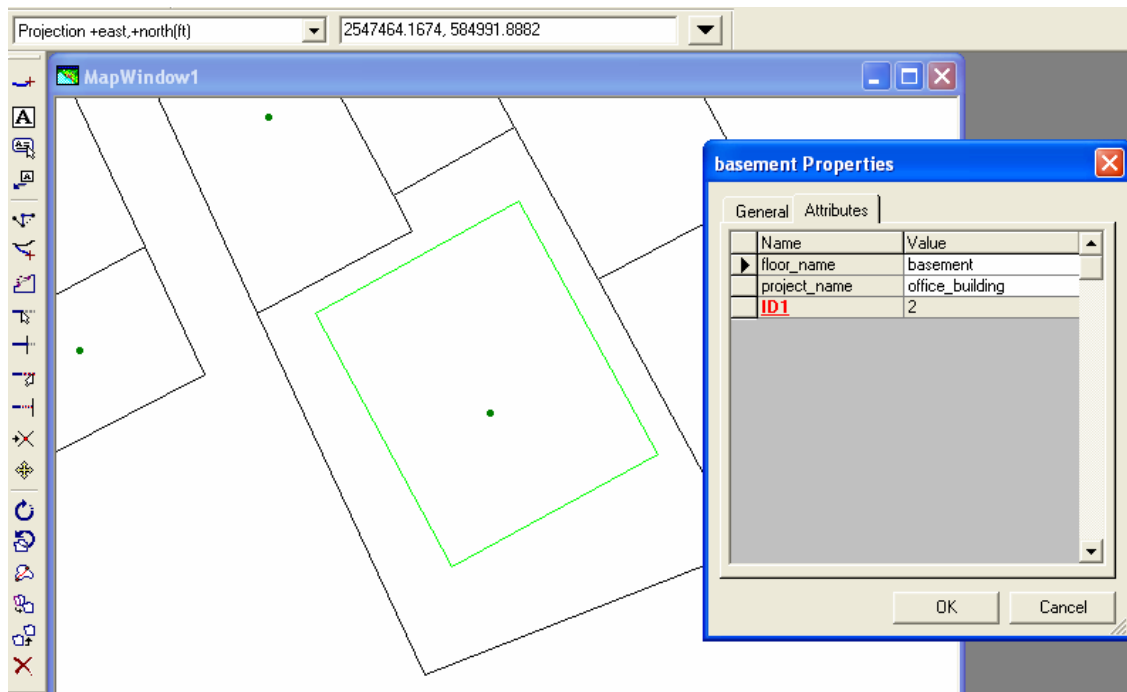


Figure 10. Adding attribute data to complete the database record.

	A	B	C	D	E	F
1	floor_name	project_name	area ft^2	perimeter ft	centroid_x ft	centroid_y ft
2						
3	basement	office_building	32921.2598	729.9098048	2547346.945	585040.2265

	A	B	C	D	E	F	H	I	J	K	L	M	N
1									rounded values				
2	suite	area	perim	volume	heat plt size	dry wall shts	sizing (gal)	paint (gal)	heat plt size	dry wall shts	sizing	paint	
3	c	16500	530	132000	2640000	432	41.48	82.96	2640000	433	42	83	
4	d	16500	530	132000	2640000	432	41.48	82.96	2640000	433	42	83	
5	a	8250	430	66000	1320000	244	23.38	46.76	1320000	244	24	47	
6	b	24750	630	198000	3960000	621	59.58	119.16	3960000	621	60	120	
7					10560000				10560000				

Figure 11. Data are transferred from GeoMedia to Excel for use in computing quantities of construction materials required for this project.

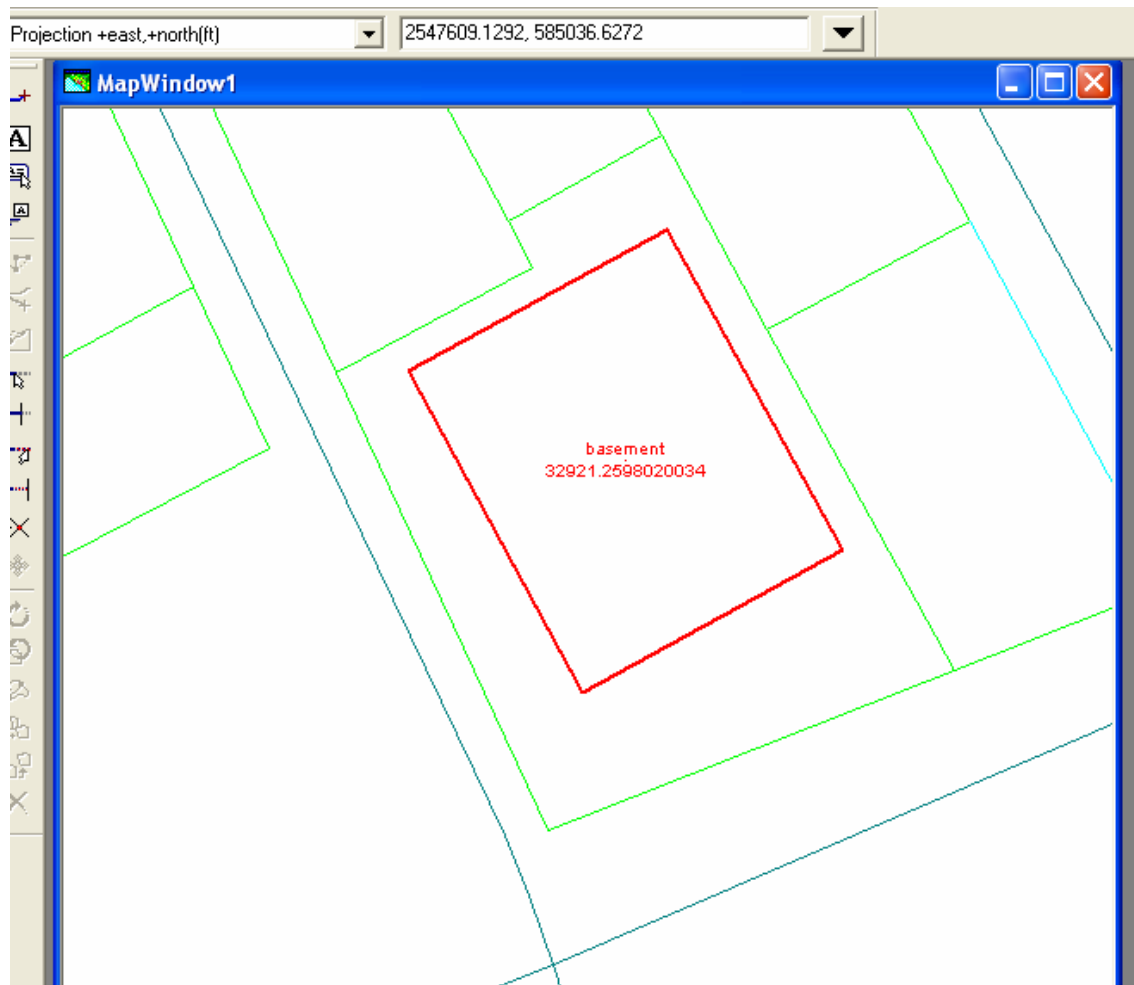


Figure 12. As briefing materials for the client, this graphic shows the location of the office building with respect to the plat and adjoining streets. The GeoMedia labeling option is used to display the floor_name (basement) and the area computed by GeoMedia for the feature shown in Figure 9.

The senior students' final assignment was using the GIS data to estimate construction material requirements for this project, see Figure 11.

Conclusions

The workflow of the GIS applications was much more like the problem solving methods the students employed in other course work, so GeoMedia was considerably easier to use for them than was MGE. The author (instructor) noticed that explanations of how the GIS worked were much more easily accepted by students than comparable experiences with MGE, with their detours into .ULF and .TOP file construction and constant repetition of data base queries.

Although really not much different the two software packages are not equally useable by students. GeoMedia, because it allows students to sequence their solutions more logically, was much more effective in providing solutions to the problems posed.

Because one of the objectives of the instruction was to familiarize students with the capabilities and use of a new tool in Civil Engineering and Surveying, the software use as a part of our instruction was very successful in all our programs. We feel the introduction of GeoMedia into our programs met that objective: to teach our students the use of the tools of modern civil engineering professional practice.

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