AM/FM ALGORITHMS FOR AUTOMATIC DETECTION AND PREPARATION OF APPLICATION PLANS

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Throughout the years much focus has been placed on developing AM/FM/GIS software packages and various techniques for data conversion and maximing its quality. Although data is undoubtedly the foundation-stone of an AM/FM/GIS, it is not possible to judge the success of the whole system by its data quality and design. The eventual success of the system will be measured with its ease of use and presentation through applications. In competitive business environment, software developers face the urgent need to automate engineering, administrative and public relations activities in order to make the system easy and user-friendly. One of the most time consuming and much care needed applications or activities at municipalities and similar organizations is the preparation of application plans showing size and boundaries of a parcel and/or boundaries of building areas. This paper examines how these activities are being carried out at above mentioned organizations in Turkey, and possible mathematical problems to be faced when developing AM/FM algorithms related to this.

1.   INTRODUCTION

Computer Aided Design and Drafting (CADD) technology is a system that supports computer aided mapping. Automated Mapping / Facility Management (AM/FM) systems are CADD based systems, and define relationships among utility system components. Together with the utility system's attribute data stored in a separate data table, it is possible to model and analyze a utility system's operation. Geographic Information System (GIS) is similar to CADD and AM/FM in that it references graphic data elements to a geographic coordinate system and, similar to AM/FM systems, stores attribute data associated with the spatial data.

GIS differs from CADD and AM/FM in that the spatial relationships among all data elements are defined. GIS is best suited for the analysis of geographic data. Analysis, management and organization of all kinds of spatial data forms are the subject of GIS [Korte,1997].

All these systems are not contrary to each other. On the contrary; CADD, AM/FM and GIS systems are components to one another.

Throughout the years; various data processing techniques, CADD or AM/FM algorithms and many software packages were developed. Much focus on these developments has been placed on automation of engineering, administrative and public relation activities.

Preparation of plan of building boundaries within a parcel is one of the most time consuming and much care needed engineering work of the municipalities. Some programs in Turkey and elsewhere exist to deal with these kind of activities. Interactive usage is their common peculiarity. That means, it is necessary to run the programme step by step. At each step, one or some principles of buildings and parcels are to be introduced to system. While doing this, at the same time, user should judge and analyze the building settlement situation that comes into the open. Thus, these programmes needs user support for this progress.

Another approach to solve this kind of problem is to create suitable algorithms and databases which cover all these steps in one action. This kind of fully automated systems requires detailed analysis and questioning algorithms.

2.   SOFTWARE DEVELOPMENT

A computer programme (PLAN_PLOT) was developed. This programme prepares plan of building boundaries within a parcel or a block suitable for zoning application, and it carries out this task in fully automated manner. Algorithms of the programme have been developed in such a way that boundaries of building within a given parcel are automatically drawn. Figure1 shows a sample output of the programme run in this respect. This program's run is also designed interactively, but it only requires parcel numbers for interactive data entry. Rest of the data such as parcel geometry, building and zoning principle, etc. needed for plotting are obtained automatically from a database that should be created at once.
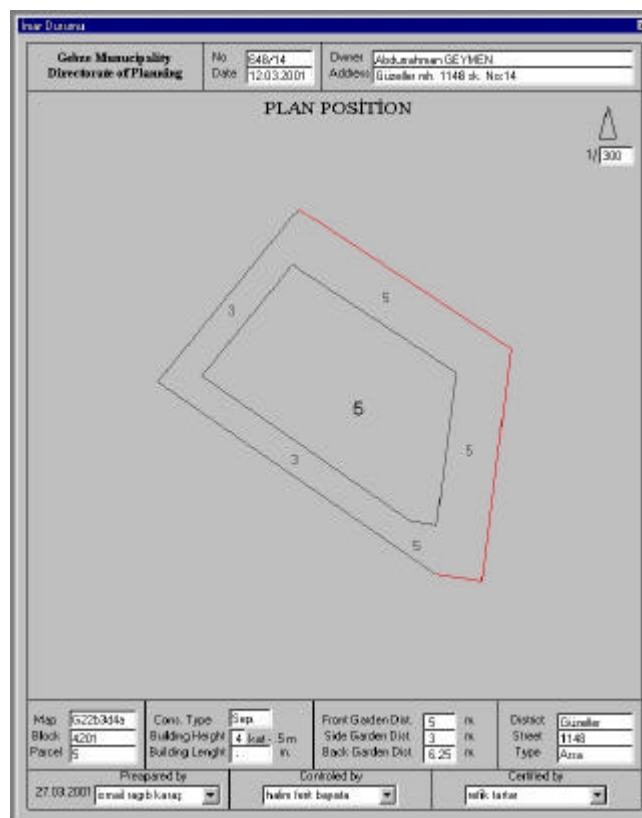

Figure 1: Sample output of the programme PLAN_PLOT

This database consist of two kinds of table (Fig. 2). One of these tables consists of parcel numbers and coordinates of corner points, and the other one consists of parcel numbers, building and parcel principles respectively.
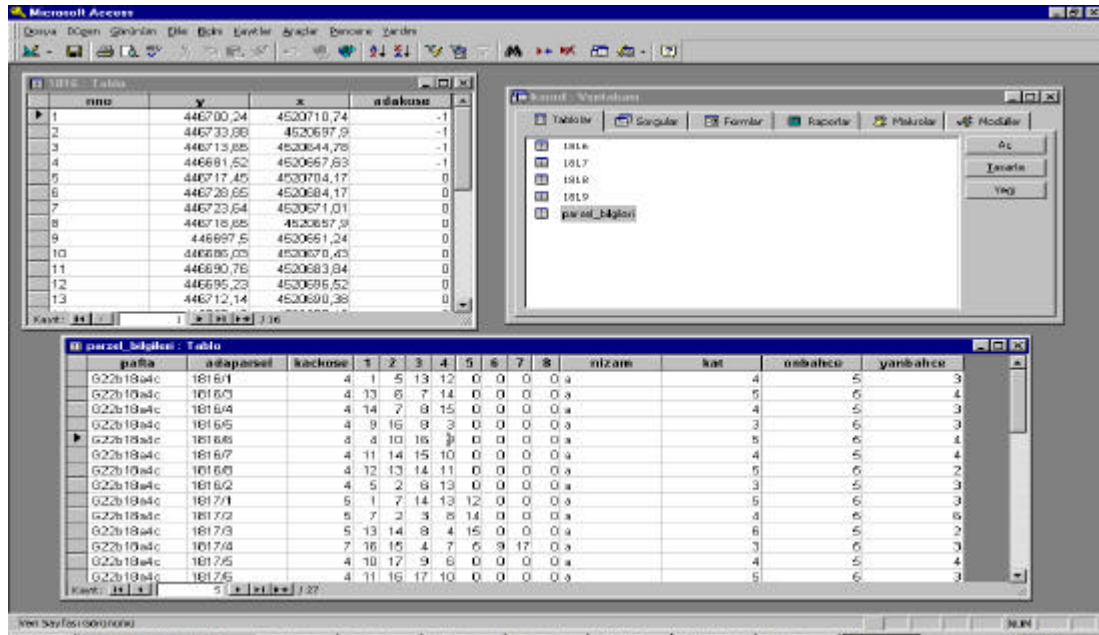

Figure 2: Database formats

Data entry to these tables can be done manually or automatically. Details for automatic data entry process is given in *Baz and Karas* [2001]. Figure 3 shows sample interfaces for manual data entry. Building and parcel principles such as type, storey, front-back-side garden distances, etc. of building may be the same for some blocks. The PLAN_PLOT notices this fact, and requires only the block numbers which are to be assigned with the same principles. As for the graphical data entry, map, block and parcel numbers, coordinates of corner points are stored manually as shown in Figure 3.
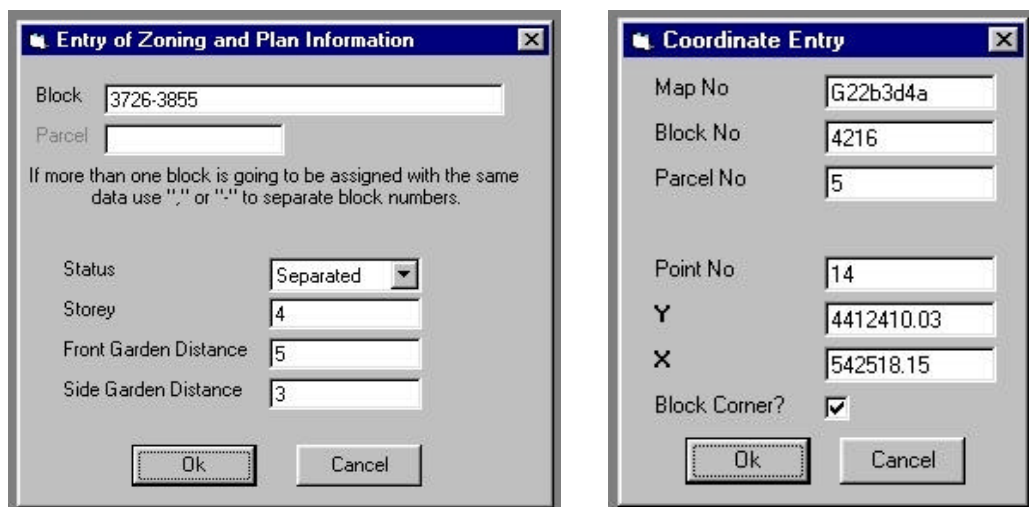

Figure 3: Manuel data entry and interfaces for them

Data editing can be done on these tables directly as well as interactively. Interactive editing is carried out on screen out put. With this editing, all changes are automatically put in action and stored in related data base tables.

3.   ALGORITHMS

Following are some of the algorithms developed for the programme PLAN_PLOT.

3.1   Algorithm For Parcel Drawing Settlement For a Given Scale

This algorithm was developed for settling a parcel drawing in the middle of plotting area with a changeable scale.

Assuming that parcel to be plotted (Fig. 4) has corner points 1,2,3,4,5, and point 1 has the smallest Y-coordinate, point 4 has the biggest Y-coordinate, point 5 has the smallest X-coordinate, point 2 has the biggest X-coordinate, and
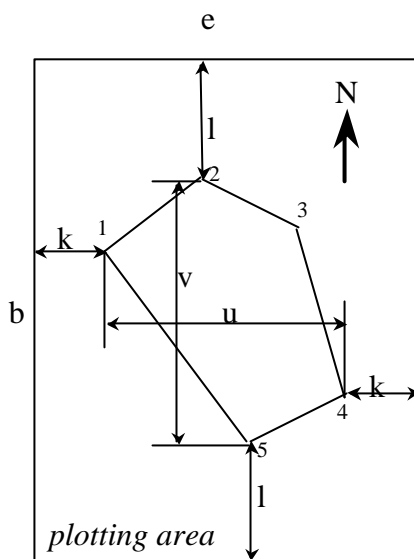

Figure 4: Parcel drawing
settlement for a given scale

e = width of the plotting area * scale
b = length of the plotting area * scale
Y_n , X_n = are mapping coordinates
Y'_n , X'_n = screen coordinates

Then   following   algorithms   can   be written.

$u=Y_4-Y_1$, $v=X_2-X_5$
$k=(e-u)/2$, $l=(b-v)/2$

,and

$Y'_n=[Y_n-(Y_1-k)] / scale$
$X'_n=[X_n-(X_5-l)] / scale$

3.2   Algorithms For Defining Parcel Lines

3.2.1   Definition of Interval Parcel Lines

In this situation, a parcel has three sorts of line positioning. That can be front, back and side line positioning. This algorithm was developed to find out these positionings, and the followings are the procedure to do this.

1. Corner point of a block in which a parcel exists are obtained from the data base.
2. Line equations of the block are formed.

3. Parcel corner points which prove these equations correct are defined.
4. Line or lines connecting these points which are immediately following one another are accepted as front line or lines of the parcel (Fig. 5).

A(p,k)

C

D

B(u,t)

$(y-k) / (k-t) = (x-p) / (p-u)$ ise;

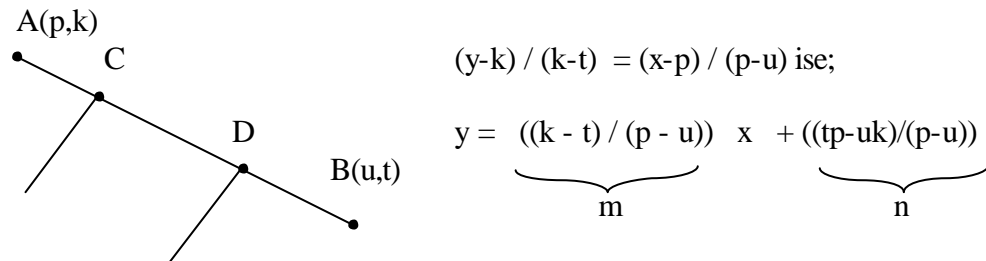$y = ((k - t) / (p - u)) \; x \; + ((tp-uk)/(p-u))$

m   n

Figure 5: Determination of front lines of a parcel

5. Lines connecting remaining parcel points are accepted as back and side lines of the parcel.
6. Bearing angle between lines which are formed by connecting any two of these points immediately following one another are determined.
7. Points with two smallest bearing angles are accepted as turning points from a side line to a back line and vice-versa.
8. Line or lines between these two points are accepted as back lines, and the others as side lines (Fig. 6)

C

b   a

A

a

c   B

$s = (a+b+c) / 2$

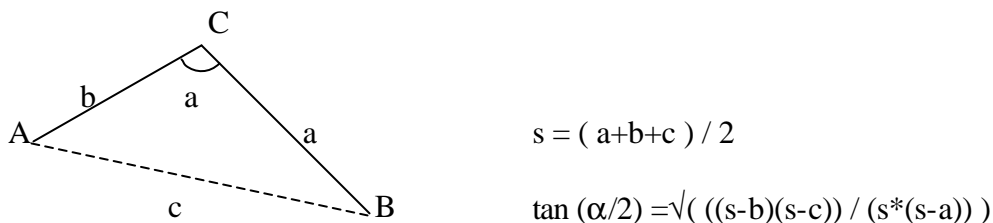$\tan (\alpha/2) = \sqrt{(((s-b)(s-c)) / (s*(s-a)))}$

Figure 6: Determining back lines of a parcel

3.2.2 Definition of Corner Parcel Lines

In this situation a parcel has two line positioning. Those are front and side line positioning. This algorithm was developed to find out these positionings, and the followings are the procedure to do this.
1. First four steps of the previous procedure are applied, and front lines of the parcel are determined.
2. Bearing angles between the first and the last front lines are determined.
3. If magnitude of a bearing angle is found to be less than 120º, then parcel is accepted as one of the corner parcels of the block. (Fig. 7)
4. Fifth step of the previous procedure is applied.
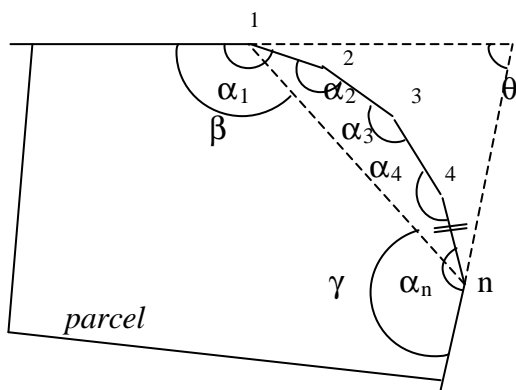
Sum of inner angles of
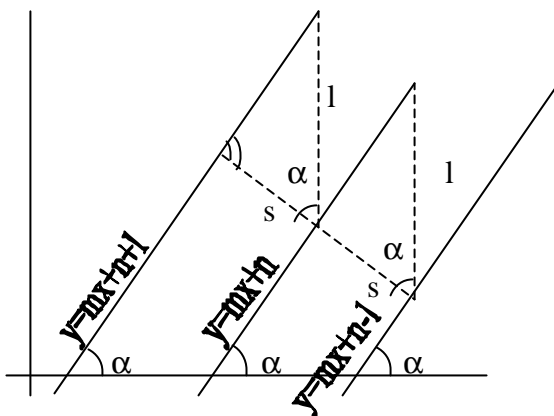polygon$(1,2,3,4,…n) = (n-2)*180°$

$\theta = \beta+\gamma-180°$

$$\beta+\gamma = \sum_{1}^{n}\alpha - (n-2)*180°$$

$$\theta = \sum_{1}^{n}\alpha - (n-1)*180°$$

Figure 7: Definition of corner parcel

3.3   Algorithm For Formation of Parallels to Parcel Lines At a Given Distance

If building approaching distance to parcel lines given, then this algorithm determines and draws parallels to the parcel lines at these distances (Fig. 8)

(a)

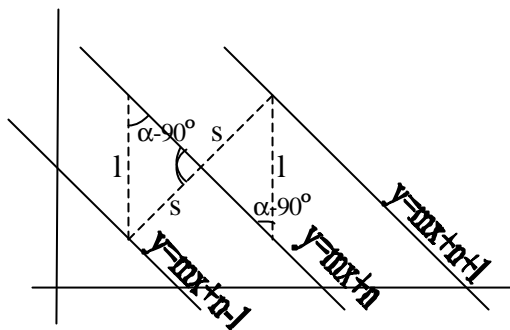<u>First case:</u> $m>0$ ($\alpha<90°$)

s = approaching distance

$l=s/(\cos \alpha)$; $\alpha=\mathrm{arctg}(m)$

$y=mx+n$

and

$y=mx+n\pm(s/(\cos(\mathrm{arctg}\ m)))$

(b)

<u>Second case:</u> $m<0$ ($\alpha>90°$)

$l=s / (\sin (\alpha-100^{g}))$

$\sin (\alpha-100^{g}) = -\cos \alpha$

$y=-mx+n$

and

$y=-mx+n\pm(-s/(\cos(\mathrm{arctg}\ m)))$

Figure 8: Formation of parallels to parcel lines at a given distance

3.4   Algorithm For Determining Corner Points of a Building Drawing

This algorithm determines corner points of a building drawing. These points are obtained by determination of cutting points of the immediately following parallel lines described above. If $y = m_1x + n_1$ and $y = m_2x + n_2$ represents equations of two lines then coordinates of cutting points of these equations can be determined via the following equations.

$$y = ((n_2-n_1) / (m_1-m_2))\ m_1 + n_1 \qquad , \qquad x = ((n_2-n_1) / (m_1-m_2))$$

While doing this, some problems may occur during combining of these lines. Small triangles, as seen in Figure 9, may appear on drawings depending on shape of parcels.

At this situation, points causing this kind of problems are eliminated by deleting these triangles. For this, cutting points of parallel lines are determinated, and then, distances from line end points to cutting points are added together. If total distance value found is greater than the line length, it is accepted that no problem exist. But, f total distance value found is equal to the line length, it is accepted that there is a problem at that corner of the drawing. In this case, line points causing the problem are eliminated, and the cutting point related to them is accepted as the line's end point instead of them.

No problem case:
$|1P_a| + |P_a2| > |12|$

Problem case:
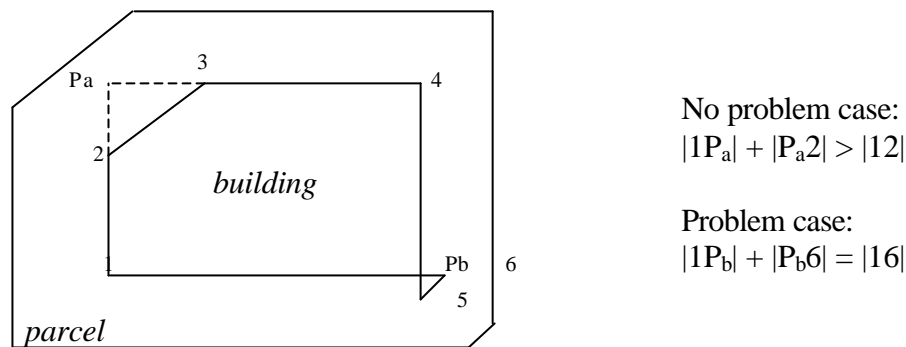$|1P_b| + |P_b6| = |16|$

Figure 9: Determining corner points of a building drawing

4.   CONCLUSIONS

Preparation of plans of building boundaries within a parcel in a fully automated manner necessitates creation of carefully designed algorithms and databases. It is shown in this paper work that once these designs are completed, this most time consuming and much care needed engineering work turns out to be a simple job.

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