The Integrated Use of EMME/2 and Arc/Info

- Practice in Lyon County, Minnesota
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Abstract:
Sharing data between GIS software (Arc/Info) and Traffic Demand Modeling Software (EMME/2) has long been an issue of interest to traffic engineers. A literature review and evaluation of current efforts on the data exchange is given in this paper. The authors also developed their own economical method to realize the data transform through Matlab programming. As a practice, a model of the truck flow pattern in Lyon County, Minnesota is developed by the integrated use of Arc/Info, EMME/2, Enif, and the Matlab program. The combined use of these programs overcame the disadvantage of a single software and achieved expected objective. The program is free to anyone who have interests.

Keywords:
Data exchange, EMME/2, Arc/Info, network map

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1. Introduction

Transportation demand modeling is a data-intensive process. It requires a huge amount of information on traffic network data, land use data, population density data to estimate traffic demand and implement the four-step model. Traffic demand software, like EMME/2, has a powerful ability to automate the four-step model for traffic analysis. But often they have a poor graphical interface and the network maps for these software are very difficult to find.

The Geographic Information System (GIS), like Arc/Info, is widely used now in various fields like environment engineering, geography, and forestry. It has a powerful function of creating, managing, analyzing, and displaying the geographic and attribute information in a systematic way. Much effort has been invested in building GIS map databases at city, county and state level in recent years so we can get a digitized map in GIS format easily from the Internet. But the GIS software has very limited function of traffic demand modeling.

Thus, the integrated use of GIS software and traffic demand software will greatly benefit the traffic demand modeling process. Sharing the data of GIS in our traffic demand modeling would greatly ease our work.

As part of our Spring Load Restriction project, we need to estimate the truck flow pattern in Lyon County, Minnesota to evaluate the effect of SLR policy. To achieve this goal, we have to first build up road networks in county and regional levels and generate truck traffic demand, distribution, and assignment on links by using EMME/2 software.

The use of EMME/2 requires a base map in the EMME/2 format. But unfortunately, we do not have a base map of EMME/2 format at a county level. But we can get a digital map in the Arc/Info format because of the wide use of GIS application today.

So sharing data between the Arc/Info and EMME/2 is the critical task to achieve our goal. In this paper, we will focus on exploring different data structure of Arc/Info and EMME/2 and finding an easy way to share data between the two systems. We will finally develop our own method to realize this process by using Matlab programming. The
The integrated use of Arc/Info, EMME/2 and a new EMME/2 supplementary software Enif achieved our goal.

2. Motivation of data exchange between the two software’s.

Arc/Info is a powerful tool for managing spatial information and performing associated computations. They have good database management features and user-friendly graphical data interface. Road maps at state, county, and city levels in the GIS format are easily accessible for research and education. But they offer a limited set of tools for transportation planning.

EMME/2 is a state-of-art graphical software tool for multimodal transportation planning developed by the INRO Company. It is among the most powerful transportation planning software to model transportation network and assign the generated traffic under given conditions.

But EMME/2 also has its major disadvantages. First, it is a DOS based program with a very unfriendly user interface. Its graphical function is very limited. Although it has a strong ability for traffic demand modeling, it is very inconvenient to show its results. One cannot view the network comfortably by just zooming in and out like what we do in Arc/Info. To compensate this shortcoming, the INRO Company recently developed a supplementary software Enif to demonstrate the network of EMME/2. It has a graphical user interface and thus greatly facilitates the use of EMME/2. The second, there is also very limited resources of road maps in EMME/2 format, while GIS map are conveniently accessed.

The idea of integrating GIS and travel demand modeling has been put forward for several years. The ideal solution is to provide a completely unified system capable of performing all the GIS and travel modeling functions within one platform. That means to develop comprehensive software that can perform all the functions of EMME/2 and Arc/Info so that we use GIS to develop transportation networks and to display model results. The idea is good but it is hard to achieve. Some private companies have developed some unified tools like TRANPLAN and TRANSCAD software packages. Although these software’s have developed a fully integrated GIS background to some extent, they are not accepted by the customer as the most powerful transportation planning packages available. Many customers still prefer the use of EMME/2 for it is a very sophisticated software in traffic demand modeling.

From a long time perspective, there will be a software package can take advantages of both Arc/Info and EMME/2 simultaneously. But currently, the two software must be used separately and an interface between them is cortically needed to share the data between the two systems.

3. Current effort in sharing data between the two software’s.

Sharing spatial information between a transportation planning software (EMME/2) and a GIS software (Arc/Info) is a complicated task because of their inconsistencies in data structures. But the work is of great interest to traffic engineers because of the great benefit it can achieve. So much effort has been put forth in this area.

3.1 TOOLS AVAILABLE FROM INRO CONSULTANTS
INRO staff has developed a prototype program called EMARC to convert data between ARC INFO and EMME/2 and vice-versa. EMARC is a set of procedures consisting of ARC INFO Macro Language macros, EMME/2 macros and AWK scripts. However, the implementation of this protocol requires that there is a one-to-one correspondence between an EMME/2 network and ARC INFO coverage. The utility program itself is not capable of creating this one-to-one correspondence. The user would have to pre-arrange for existence of such databases. Additionally the user would have to spend some time learning the use and application of the scripts.

3.2 TOOLS DEVELOPED BY PUGET SOUND REGIONAL COUNCIL

The Puget Sound Regional Council (PSRC) has a well-established travel demand model based on EMME/2 and a GIS database on ARC INFO. The PSRC staff has developed node-to-intersection and link-to-street correspondence that interfaces between their EMME/2 model and Arc View coverages. The advantage of the procedures developed by PSRC is that it has already done a considerable amount of work to build a platform to transfer data between the two databases. PSRC staff has developed the required tools and programs to take any EMME/2 model street network and develop an Arc View street coverage with every arc (street) uniquely related to a corresponding EMME/2 link.

Unfortunately, this tool is not commercial software and it is unavailable to us.

3.3 TOOLS DEVELOPED BY TRAVEL MODEL SYSTEMS GROUP

Travel Model Systems Group developed M2View to promote the use of the EMME/2 Macro Functions and ArcView extension products. M2VIEW is likely to be the most useful tool to the data exchange. It provides an easy, user friendly integration between EMME/2 and ArcView. An easy to use interface is integrated into ArcView's GUI. M2View imports and exports EMME/2 networks using the standard EMME/2 "batchout" files. M2View currently contains modules for reading and writing the following EMME/2 data: network link and/or nodes; transit lines; turn penalties (as points and/or lines; matrices; zone groups.
Of all the tools that convert data from EMME/2 into ARC VIEW coverage, M2view offers almost all the functions, and a high degree of automation. But every good thing has its cost. This software sells at $1800, which is far beyond our expectation. We cannot afford this price just for building the network.

3.4 Conclusion

From the above literature review, we cannot find any appropriate and affordable existing software for us. After exploring the data structure of the two systems, we decide to transform the data using Matlab programming by ourselves. And we can use the free Enif software to demonstrate and analyze the results, which serves a similar function of GIS software.

4. Data structures of Arc/Info and EMME/2

4.1 Data structure of EMME/2

The network of EMME/2 describes the transportation infrastructure, and is mainly defined by the following elements:

a) Base network: base network of EMME/2 is made of nodes and links to represent road and transit. They are defined as follows: [5]
   - A regular node may correspond to an intersection, a transit stop, etc.
   - A centroid is a node associated with a zone: all trips from and to the zone originate and end at that node
   - A link is a directional connection between two nodes, using one or more modes
A connector link is a link which connects a centroid to a regular node.
b) modes: modes in EMME/2 are grouped in four types:
- Auto mode
- Transit modes (ex.: bus, train, tramway)
- Auxiliary transit modes (ex.: pedestrian)
- Auxiliary auto modes (ex.: trucks, high occupancy vehicles)

The file 2.11.in in EMME/2 contains all the network information of an EMME/2 databank. It stores the network information in the following format:

<table>
<thead>
<tr>
<th>Operation index</th>
<th>Node number</th>
<th>X coordinate</th>
<th>Y coordinate</th>
<th>User data 1</th>
<th>User data 2</th>
<th>User data 3</th>
<th>Node label</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>1</td>
<td>443309</td>
<td>258575</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operation Index</th>
<th>From node</th>
<th>To node</th>
<th>Length</th>
<th>Mode</th>
<th>Link type</th>
<th>Number of lanes</th>
<th>Volume delay function</th>
<th>Three user data items</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>1</td>
<td>2</td>
<td>0.728</td>
<td>c</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>0 0 0</td>
</tr>
</tbody>
</table>

The file 2.11 in the EMME/2 data bank is in the following format:

t nodes init
a 1 443309 258575 0 0 0 1
a 2 447154 258546 0 0 0 2
a 3 452444 258519 0 0 0 3

.........
t links init
a 1 2 0.728 c 1 1 5 0 0 0 0
a 2 3 1.002 c 1 1 5 0 0 0
a 4 3 1.002 c 1 1 5 0 0 0

.........

4.2 Data structure of Arc/Info[1]

Arc/Info stores coordinates only for points, arcs, and nodes, and uses topological relationships for defining networks and polygons. Here are the three topological concepts used to define features:
• The arc-node topology defines the connectivity of arcs; arcs are composed of two nodes and up to 500 vertices, and are connected at nodes; a set of connected arcs can define a network (streets and intersections);
• A polygon is defined as an ordered series of connected arcs, but the first and the last arcs must connect (area definition topology); for each arc, the left and right polygons are identified (left-right topology).
• Regions are defined as a set of polygons

To represent transportation networks, Arc/Info uses the following classes as the basis of the network data model. The model consists of:
• Network links are modeled as Arc/Info arcs; links are bidirectional; the network link attributes are stored in the arc attribute table (AAT);
• Network nodes are modeled as Arc/Info nodes; the node attributes are stored in the node attribute table (NAT);

4.3 Relationship of the two systems:

The following table contains general object descriptions found in a transportation planning infrastructure, and the corresponding elements in both software packages:

<table>
<thead>
<tr>
<th>Objects</th>
<th>Arc/Info items</th>
<th>EMME/2 items</th>
</tr>
</thead>
<tbody>
<tr>
<td>directed street section</td>
<td>arc</td>
<td>link</td>
</tr>
<tr>
<td>intersection</td>
<td>node</td>
<td>node</td>
</tr>
<tr>
<td>region</td>
<td>region</td>
<td>zone, group, ensemble</td>
</tr>
<tr>
<td>TAZ (traffic analysis zone)</td>
<td>polygon</td>
<td>zone</td>
</tr>
<tr>
<td>Origin and Destination</td>
<td>node, center</td>
<td>centroid</td>
</tr>
<tr>
<td>O-D matrix</td>
<td>-</td>
<td>matrix</td>
</tr>
</tbody>
</table>

Source: Revised from Reference [5]

4.4 Difference between the two systems

<table>
<thead>
<tr>
<th>Arc/Info</th>
<th>EMME/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>arcs can be bidirectional (with directional attributes)</td>
<td>links are unidirectional (represent flow of traffic)</td>
</tr>
<tr>
<td>each arc can be composed of up to 500 vertices, including from-node and to-node</td>
<td>each link is composed of an i-node (from-node) and a j-node (to-node)</td>
</tr>
<tr>
<td>a node is created by the CLEAN command when two arcs crossover (polygon topology)</td>
<td>links can pass one over another</td>
</tr>
<tr>
<td>all feature attributes are stored in a relational-like data base (&quot;horizontal&quot; structure) that is managed by the INFO information manager (or other external relational data base)</td>
<td>-</td>
</tr>
</tbody>
</table>
5. Integrated use of GIS and traffic demand modeling software.

To realize the data transform process, the first step is preparation work. The available map data for us is the base map of Lyon County generated by Arc/Info in lyon.e00 format along with traffic count on each link.

The software we will use includes the following:
1. Arc/Info version 8.0
2. EMME/2 version 9.0 (limited to 5000 links and 250 centroids)
3. Matlab 6.0
4. Enif used to display and edit EMME/2 data bank.
5. Microsoft Excel.

The main procedures of our works are as the follows:
First we change the lyon.e00 file to a Arc/Info Coverage by using arctools, and then we transform this file to a Arc/View layer shape file. So we can view the file in the arcview/arcmap.
To build the network of EMME/2 format, we have to transform this shape file of Arc/Info format to data file to export the coordinates of nodes and length of the arcs and attributes on each arc. We get two data files. One is smp4lyon.m, which records the coordinates of the arc. Another is lengthvol.m, which records attributes (length and volume) for each link.

Data stored in the smp4lyon.file is like the following:

```
END
```

```
1  0.4433093E+06  0.2585753E+06
   0.4439278E+06  0.2585707E+06
   0.4447198E+06  0.2585640E+06
   0.4455118E+06  0.2585588E+06
   0.4463399E+06  0.2585517E+06
   0.4470440E+06  0.2585468E+06
   0.4471540E+06  0.2585457E+06
END
```

```
2  0.4471540E+06  0.2585457E+06
   0.4472641E+06  0.2585447E+06
```
We wrote a program in Matlab named lyonnetwork.m (Appendix 1) to realize the transformation. The basic idea of the program is as the following:

Load the “smp4lyon” data file and read each line at a time. If there is only one number in this line, it means it is the beginning of a new link. If the line consists of “end”, it means this is the end of the arc. At this time, we record the first point and last point as the from node and end node of a link. This process iterates until it reach the end of the file.

After this process, we got a network map consisting of the all roads in Arc/Info. The number and length of links in EMME/2 and the number and length of arcs in Arc/Info should be the same.

To do the traffic assignment in EMME/2, we need to define zones to locate the origin and destination of traffic demand, that is adding some centroids in the network. Since our license of EMME/2 limit the number of centroids to 250, we uniformly located 15*15=225 centroids in the network. We also added some external centroids to model external to internal and external to external traffic. After completion, we got a network consisting of 248 centroids and 4413 links. (See addcentroid.m in Appendix 2)
The following figure is the final map of our network in EMME/2. We can use the software Enif to see the detailed part of network, which serves the similar function of Arc/Info.

Figure 5  Final network in EMME/2(derived from Arc/Info)
Figure 6  Detailed part of the network showed in Enif.

Figure 7  Detailed part of network in Arc/Info.

Comparing the detailed EMME/2 map to the detailed part of the map in Arc/Info, we can see the two maps are basically the same. But all the links in EMME/2 are all lines rather than Arcs. There are two lines between two nodes in EMME/2 map while there is only one bi-directional arc in Arc/Info map. But the roads in the two systems have the
same length. We can say that the map in EMME/2 is an approximation to the real road, but for traffic demand modeling, this approximation is good enough.

6. Conclusions.

The problem of build a network map in EMME/2 format is often encountered by many EMME/2 users. Through the above practice, we can successfully transform data from Arc/Info to build a network map in EMME/2 using Matlab Programming. Although we cannot build a unified platform serving the functions of both EMME/2, and Arc/Info, we achieved our goal in a practical and economical way by the combined use of Arc/Info, EMME/2, and Enif. From this process, we clearly realized the different structure of the Arc/Info and EMME/2 and have a deep understanding of various efforts that contributed to the process.

Integrating Arc/Info and EMME/2 in a uniform platform is a complicated but beneficial work. Unfortunately, we are still far from this ideal condition. We can only use GIS and Traffic Demand Modeling software separately and try to share data between the two systems. Currently, the work is done by various means mentioned above. It is either costly or labor intensive. Hopefully, new and sophisticated software will come out soon, thus reducing the labor work of individual EMME/2 users.

REFERENCE:
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