Title
Unit 56 - Demographics and Network Applications

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Compiled with assistance from David Cowen, University of South Carolina

UNIT 56 - COMMERCIAL APPLICATIONS

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A. INTRODUCTION

- this unit looks at some of the more specialized applications of GIS
- demographic analysis
  - spatial information plays a major role in many marketing and retailing decisions which involve decisions about the location of new stores, shopping centers, etc., and for evaluating the demographic characteristics of present and future trade areas
  - similar applications in the government sector include redistricting - changing electoral boundaries in response to changing distributions of population
- network analysis
  - delivery and emergency vehicles benefit from up-to- date information on the condition of the transportation network as well as real-time route planning

B. MARKETING, RETAILING AND ELECTORAL REDISTRICTING

- location factors are critical to success of retailing
- accurate knowledge of spatial distributions is essential for advertising, direct mail campaigns
- GIS technology useful in designing sales areas, analyzing trade areas of stores
- similar applications occur in politics
  - design of voting districts (apportionment, gerrymandering) has enormous impact on outcome of elections
  - major interest in reapportionment after 1990 census
- GIS applications in these areas are still at early stage

Characteristics of application area

- scale:
  - street centerline, census reporting zones - i.e. 1:24,000 and smaller
  - data at block group/enumeration district scale (250 households) is needed for locating smaller

    commercial operations like gas stations and convenience stores
  - data at census tract scale (2,000 households) is good for the location of larger facilities like supermarkets and fast food outlets
- data sources:
  - much reliance on existing sources of digital data
    - especially TIGER and DIME
    - similar data available in other countries
  - additional data added to standard datasets by vendors
    - e.g. updating TIGER files by digitizing new roads, correcting errors
    - e.g. adding ZIP code boundaries, locations of existing retailers

- functionality:
  - dissolve and merge operations, e.g. to build voting districts out of small building blocks
  - modeling, e.g. to predict consumer choices, future population growth
  - overlay operations, e.g. to estimate populations of user- defined districts, correlate ZIP codes with census zones
  - point in polygon operations, e.g. to identify census zone containing customer's residence
  - mapping, particularly choropleth and point maps of consumers
  - geocoding, address matching

- data quality:
  - more concern with accuracy of statistics, e.g. population counts, than accuracy of locations

Types of applications

- districting
  - designing districts for sales territories, voting
  - objective is to group areas so that they have a given set of characteristics
  - "geographical spreadsheets" allow interactive grouping and analysis of characteristics
    - e.g. Geospreadsheet program from GDT

- site selection
  - evaluating potential locations summarizing demographic characteristics in the vicinity
    - e.g. tabulating populations within 1 km rings
  - searching for locations that meet a threshold set of criteria
    - e.g. a minimum number of people in the appropriate age group are within trading distance

- market penetration analysis
  - analyzing customer profiles by identifying characteristics of neighborhoods within which customers live

- targeting
  - identifying areas with appropriate demographic characteristics for marketing, political campaigns

Organizations

- many data vendors and consulting companies active in the field, many large retailers

- no organization unique to the field

- American Demographics is influential magazine

C. EXAMPLE - REDISTRICTING

- GIS has applications in design of electoral districts, sales territories, school districts
- each area of application has its own objectives, goals
- this example looks at designing school districts

Background

- the Catholic school system of London, Ontario, Canada provides elementary schools for Kindergarten through Grade 8 to a city of approx. 250,000
  - about 25% of school children attend the Catholic system
  - 27 elementary schools were open prior to the study
- population data is available for polling subdivisions from taxation records
  - approx. 700 polling subdivisions have average population of 350 each
- forecasts of school age populations are available for 5, 10, 15 years from the base year (see Taylor et al., 1986) at the polling subdivision level
- children are bussed to school if their home location is more than 2 miles away, or if the walking route to school involves significant traffic hazard

Objectives

- minimal changes to the existing system of school districts
- minimal distances between home and school, and minimal need for bussing
- long-term stability in school district boundaries
- preservation of the concepts of community and parish - if possible a school should serve an identifiable community, or be associated with a parish church
- maintenance of a viable minimal enrollment level in each school, defined as 75% of school capacity and > 200 enrollment

Technical requirements

- digitized boundaries of the polling subdivision "building blocks"
- an attribute file of building blocks giving current and forecast enrollment data
  - for forecasting, we must include developable tracts of land outside the current city limits, plus potential "infill" sites within the limits

overhead - London polling subdivisions, development tracts and infill sites
  - 748 polygons
  - development tracts are the isolated areas outside the contiguous polling subdivisions

  - infill sites are shown as points

- the ability to merge building blocks and dissolve boundaries to create school districts
  - school districts are not required to be coterminous - if necessary a school can serve several unconnected subdistricts

- a table indicating whether walking or bussing is required for each building-block/school combination

Current districts

overhead - Current allocation of students

- "starbursts" show allocations of building blocks to 29 current schools (includes two special education centers)
  - note bussed areas in NW and SW - separate enclaves of recent high-density housing allocated to distant schools
  - this strategy allows an expanding city to deal with
    - dropping school populations in the core leading to an excess of capacity
    - rising school populations in the periphery but lack of funds for new school construction

    - without constantly adjusting boundaries

overhead - Enrollment projections

- overhead shows projections of enrollment based on current school districts
  - note rapid increase in developing areas e.g. St Joseph's (#3), St Thomas More (#4) NW
  - note decrease in maturing areas of periphery e.g. St Jude's (#8) - SW area
  - note rejuvenation in some inner-city schools due to infilling e.g. St Martin's (#15) - lower center
  - note stagnation in other inner-city schools e.g. St Mary's (#17), decline e.g. St John's (#14) - center

Redistricting

- general strategy - begin with current allocations, shift building blocks between districts in order to satisfy objectives

- requires interaction between graphic display and tabular output
  - quick response to "what if this block is reassigned to the school over here?"

- implementation allowed School Board members to make changes during meetings, observe results immediately
  - using map on digitizer tablet, tables on adjacent screen

Proposals

overhead - Summary statistics for closure plan

- shows one alternative plan developed

- note:
    - assumes closure of 6 schools
    - rise in enrollment as percent of capacity
    - stability of projections through time
    - reduction in number of "non-viable" schools (&LT200 enrollment)
    - increase in percent not assigned to nearest school
    - increase in average distance traveled

D. VEHICLE ROUTING AND SCHEDULING

- includes systems to aid in vehicle navigation, systems for routing emergency vehicles, scheduling delivery vehicles

- important actors include:
    - automobile industry - vehicle navigation aids
    - parcel services - express, courier
    - emergency services - ambulance, fire

- rapid development of technology, databases

Technology

- systems in vehicles
    - e.g. ETAK navigator
        - small processor, database on cassette tape or optical disk (CD ROM), display showing location of vehicle and surrounding streets, also best route to destination
        - similar systems under development in Japan, Europe
    - e.g. Macintosh Hypercard systems installed in fire trucks - Cameo developed by NOAA
        - information on route to fire, layout of buildings, nearby hazardous materials

- car rental agencies
    - systems at airport checkin counters offering driving instructions to user-defined places

- vehicle scheduling
    - systems which automate vehicle routing given locations which have to be visited on call, e.g. parcel delivery
    - systems to assign optimum routes to e.g. school buses

Databases

- heavy reliance on TIGER and DIME
    - problems with update

        - these products are geared to the 10-year census cycle
    - problems with completeness
        - DIME for urban areas only, lack of addresses in rural TIGER
    - problems with attributes
        - simple street layout is not sufficient for detailed vehicle routing
        - e.g. TIGER lacks data on one-way streets, no left turns, temporary road construction problems
    - problems with topology
        - e.g. roads which cross but do not intersect

- growing interest among vendors in adding value to TIGER by dealing with some of these problems

- lack of standards
    - no organization responsible for developing standards

    - no responsibilities of Bureau of the Census beyond census itself

Functionality

- simple retrieval and display for vehicle navigation systems

- finding optimum route requires fast, intelligent algorithm

- address matching essential to identify location from street address

Data quality

- street centerline, i.e. 10-20 m accuracy is adequate

- attribute accuracy may be important because of risk of lawsuits in cases of accidents

E. EXAMPLE - VEHICLE NAVIGATION SYSTEMS

- considerable research is currently being conducted to develop vehicle navigation systems

  overhead - Automatic vehicle location systems

- these systems require databases that have:
    - topological information
    - methods for determining position in the network
    - street attributes such as width, number of lanes, direction, surface condition, perhaps even usage information keyed to time of day
    - identification information like street names and other local names for special grades, bridges, landmarks

- these systems need:
    - technology for determining current location, may be:

automatic determination from use of GPS and similar technology
        - dead reckoning based on distance travelled in the network and map-matching (snapping location to coordinates of links and intersections)
    - computer hardware and databases, may be:
        - internal to vehicle or at a central location with transmission of data to the vehicle
    - input for identifying starting location and destination
    - output to provide route instructions
        - must be able to generate maps for any location in the network at a speed that is compatible with the rate of movement of the vehicle
        - may be visual or verbal driving instructions

F. HIGHWAYS PLANNING AND MANAGEMENT

- other transportation applications involve the use of network GIS for the planning and management of highways and roads

- Nyerges and Dueker (1988) outline three levels at which GIS can play a role in State Transportation functions

  handout - GIS and State Departments of Transport

- Level I are planning applications that generally relate to the state as a whole
    - the data needed at this level is coarse and spatial accuracy is not important
    - aggregated data are preferred to illustrate major trends

- Level II are management applications focusing on smaller areas such as a county
    - this is the level at which traffic safety and pavement management activities are conducted
    - e.g. pavement data is often collected by taking vertical photographs of the road surface from a moving vehicle every few meters
        - locations can now be determined using GPS
        - photos can be accessed by tying them to a GIS of the road network

- Level III are engineering applications requiring very large scale data and high accuracy
    - projects at this level would cover small project or corridor areas
    - at this level the GIS would provide input to the preliminary engineering design
    - as-built plans from completed projects could be added to the state highway database at this scale

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EXAM AND DISCUSSION QUESTIONS

1. Examine recent copies of American Demographics and discuss what they reveal about the significance of GIS and GPS in this application area

2. Discuss the importance of geographic scale in retailing and marketing studies. Make a list of various types of retailing and discuss the appropriate geographic scales in each case

3. At this date (1990) there is no current national street database of the US, although TIGER is a substantial approximation. Discuss the advantages of such a database, possible reasons why it has not been developed, and alternative methods for obtaining street data for retail analysis.

4. Review the Golden and Bodin article in the references. How would you structure a GIS to interface with the software reviewed there? What data models are appropriate for these applications?

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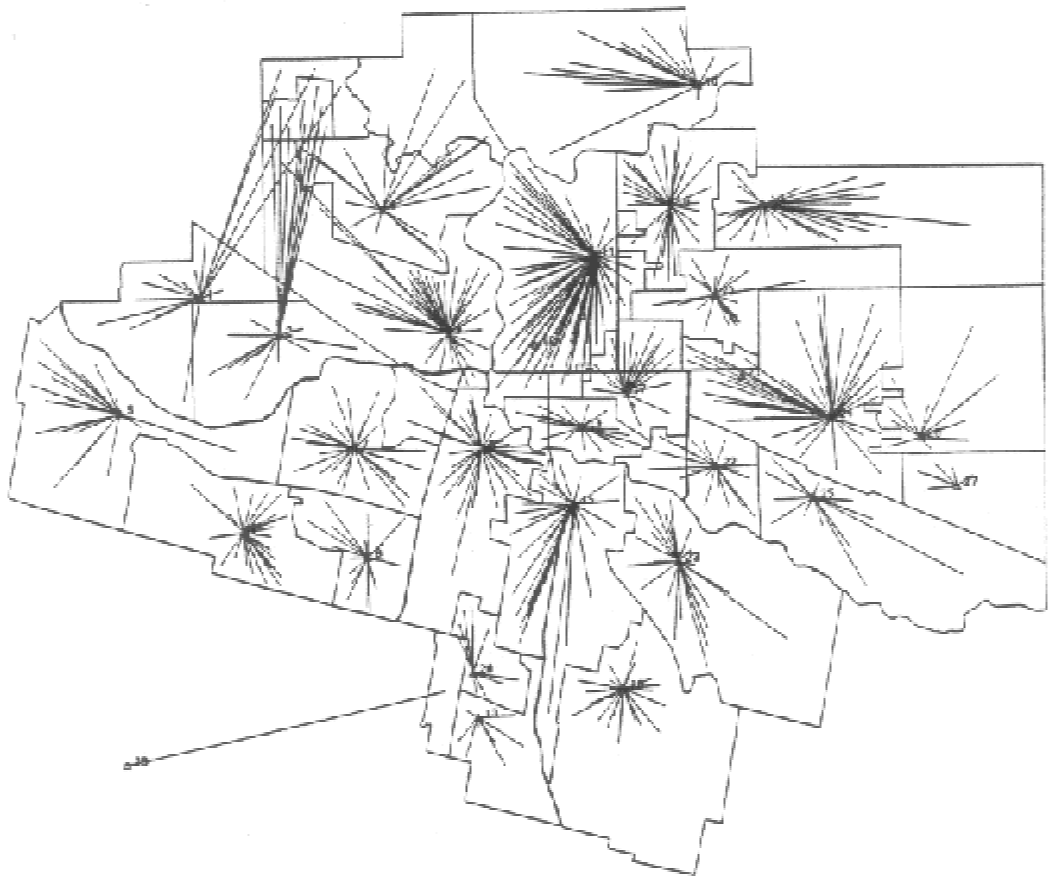
UNIT 56 IMAGES



#	School	Enrollments			
		Actual	Projections		
		1981	1986	1991	1996
3	St. Joseph's	186	341	423	496
4	St. Thomas More	229	340	479	496
8	St. Jude's	433	292	218	204
14	St. John's	223	149	139	108
15	St. Martin's	244	345	383	385
17	St. Mary's	169	116	106	114

	Current situation				Closure plan			
Number of schools	27				21			
Total capacity	11,488				9,446			
	1981	1986	1991	1996	1981	1986	1991	1996
Percent capacity	67	62	63	63	82	76	77	77
Number of schools	14	17	16	17	5	5	7	6
Number of schools	5	7	8	7	2	0	0	0
Percent not assigned	13	19	20	21	18	23	25	27
Mean distance travelled	0.59	0.72	0.79	0.83	0.67	0.79	0.87	0.93