Go Bike Boulder:
ArcIMS Interactive Bicycle Routing Website

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Abstract

This paper will outline the planning process, work tasks and results obtained in creating *Go Bike Boulder*, an ESRI based solution, interactive bike routing website, developed for the City of Boulder, Colorado. The goal of this project is to create an easy-to-use, bike routing website that promotes bicycling as a non-polluting, healthful, and economical means of travel for Boulder citizens. The principal development components of this project include: ArcIMS, VB.NET, Network Analyst, ArcGIS Topology, and SDE.
The bike routing mapping website will include: the ability to map bike route information by an address, map location or landmark and the ability to modify that route search by specifying on-street or off-street bike routes.
A Hill Elevation Graph, Directions, Calorie Counter, Fuel Saving Calculator and Survey input form will also be displayed.

I. Project Overview

City of Boulder Transportation and GIS staff partnered with an ESRI business partner (Kuhns' and Associates), and Traffic Engineering consultant (Fox-Higgins) to develop a customized, interactive web application (GO Bike Boulder) that allows citizens to query and access City of Boulder bike routing information in a convenient and useful manner. The application utilizes an interactive Geographic Information System ArcIMS interface with dynamic links to other bike information web pages and web-based resources. The application was launched in June, 2007, and was funded by a federal grant administered by the Colorado Department of Transportation and endorsed by the Denver Regional Council of Governments (DRCOG). A principal goal of this project is to reduce vehicle miles traveled by single occupant vehicles in the city of Boulder.

A primary strategy to achieve the goals of the city's Transportation Master Plan is to provide transportation options for bicycling that support an active community. The city of Boulder has constructed a majority of its master planned bicycle network and its current bicycle mode share of all trips completed by Boulder Valley residents is 14%. The city offers over 350 miles of dedicated bicycle facilities, including on-street bike lanes, designated bike routes, paved shoulders, and paths. With an extensive bicycle network already in place, the city's focus is shifting more toward encouraging residents to increase use of their transportation options. Increasing the number of daily bicycle trips will require that the city provide health-conscious messages and programs that encourage its population to utilize bicycling as a viable transportation option for active living.

It is believed that valuable byproducts of developing this bike routing website would be the scripting of a “how to” GIS technology procedure, as well as the documentation of a data model schema and hardware/software system architecture. This information could then be made available to other front-range municipalities that might be interested in developing a similar application. Since Denver Regional Council of Governments (DRCOG) staff and numerous communities in the Denver Metro area are already using ESRI GIS software products, it is felt that there is great potential to develop over time, a “unified” bike routing website that would be of benefit for citizens throughout the DRCOG regional planning area.

II. Principal Components of the GO Bike Boulder Web Application

Main components of the GO Bike Boulder interactive web bike routing site include:

1. The ability to search for bike best routing origin and destination information by:

- Address
- Map Location
- Point of Interest

2. The ability to modify the route search query by specifying an on-street or off-street route preference. Those preferences are described as follows:

On-street bike network - for cyclists that are comfortable traveling on the roadway either in a dedicated on-street bicycle lane, side by side with motorists or in on a dedicated bike route, where cyclists and motorist share the travel lane. This route choice will generally offer the most direct route and most appropriate for regular bicycle commuters or avid cyclists. Cyclists traveling on-street have the same rights and responsibilities governing Boulder’s rules of the road as motorists.

Off-street bike network - for cyclists that favor traveling on a dedicated multi-use path, physically separated from vehicular traffic. This route choice may be less direct than one that makes the best use of Boulder’s on-street bike network and is appropriate for occasional bicycle commuters or cyclists with modest urban riding experience. Please note that multi-use paths are shared by other non-motorized users including walkers, runners, in-line skaters and skateboarders.

3. When a queried route is displayed in the map interface, the following information can also be accessed:

- Route Summary Information
- Elevation Graph
- Turn by Turn Directions
- Calorie Counter
- Environmental Calculator
- Cost Calculator

4. The application also includes a print map functionality that includes turn by turn directions.
5. A Rider Survey input form page located on the website that feeds to a SQL express database.

III. Application GIS Data

The City had an existing SDE transportation street and bike data set that provided the back bone for developing the final network routing data that was used in the web routing application. The creation for the routing network data set was accomplished in house by city GIS staff. Additional GIS datasets used in the application include:
1. Point of interest dataset that mapped various community features (Schools, Parks, Trail Heads, Shopping Centers)
2. A city wide elevation point grid was created at 20'intervals. This dataset was created as a means to display route elevation graph information.
3. High resolution 6" color orthographic aerial imagery.

IV. Building the network routing dataset

Network Data preparation involved the following steps

1. ESRI Network Analyst was utilized on sample city street and bike datasets in order to develop a routing schema and classification strategy for developing a city routing dataset.

2. In order to assess the level of connectivity that existed in the current street and bike GIS dataset an SDE Topology process was run on that dataset. The 2 ArcGIS topology rules employed for that process were:

Must Not Have Dangles - *Requires that a line feature must touch lines from the same feature class at both endpoints. An endpoint that is not connected to another line is called a dangle. This rule is used when line features must form closed loops, such as when they are defining the boundaries of polygon features. It may also be used in cases where lines* *typically connect to other lines, as with streets. In this case, exceptions can be used where the rule is occasionally violated, as with cul-de-sac or dead end street segments. (1)*

Must Not Overlap *- Requires that lines not overlap with lines in the same feature class. This rule is used where line segments should not be duplicated; for example, in a stream feature class. Lines can cross or intersect but cannot share segments. (2)*

This process was most helpful in identifying areas in the network dataset where connectivity was lacking or redundant.

3. Based on those topology indicators, city GIS staff in a series of SDE geodatabase edit sessions corrected city wide those areas of the network dataset that warranted connectivity edits. This connectivity assessment also included the city wide creation of numerous intersection connector line features in the network dataset.

4. Overpass - underpass modeling was accomplished by the use of inserting a vertex on a line feature where connectivity was desired and removing the vertex at the intersection of two line features where connectivity was not warranted (i.e. the intersection of an overpass street with an underpass trail). City GIS staff felt this was an effective methodology to use in order to model overpass and underpass routing characteristics.

5. In order to model and plot elevation data on a the system wide network dataset the following steps were employed:

System wide an ArcGIS split line at vertices geo-processing operation was run on the entire network dataset. This created a series of line segments that were planarized at vertex locations, but where a vertex did not exist the line segment was not split. This is important, because it did not compromise the route modeling characteristics of overpass underpass locations.

The next operation was a spatial join procedure that was run using an ArcGIS geo-processing tool. This was accomplished by “spatially joining” the segmented network dataset to an existing city elevation grid point data set, which effectively joined an elevation attribute value to each line segment in the network data set. This process enabled elevation graph data to be calculated and displayed for any selected route in the web mapping interface.

V. Rating the network routing dataset

1. The network routing algorithm operates on the principal seeking that shortest distance from the point of origin to the point of destination. Route preference is modeled by assigning a rating value of line segments generally between the range of 0 and 100. The higher the rating value the more preferred the route. One way to think of it is as a comparative logic selection. For example, let's say 2 routes of equal distance exist from a selected origin and destination. If one route is rated at 70 and the other route is rated at 30, the algorithm will select the higher rated route (70).

2. As part of this project a traffic consultant engineer rated the entire city street and bike system based on the following criteria:

Bike Lane or Shoulder Width
Steep Grade
Driveway Frequency
Intersection Frequency
Speed
Volume of Street Traffic
Outside Lane Width
Directness
Volume of Path Users
On-Street Parking
Pavement Type
Pavement Condition
Path Width
Grade Separated
Adjacent To Roadway

3. Based on that analysis, rating values were derived by the traffic engineer for every segment of the network routing dataset. Those ratings were calculated into the network routing dataset by city GIS staff and they provide the primary basis for determining what routes will be selected in an origin and destination route search in the web mapping interface.

VI. Programming Language, Software and Hardware Components of the GO Bike Boulder Application

The GO Bike Boulder routing algorithms and mapping interface were scripted in VB.NET, Java Script and dynamic HTML code. Microsoft Visual Studio 2005 was the programming compiler software utilized for this project. The application runs on an ArcIMS platform and is deployed through a a dedicated Dell PowerEdge 2850 server that has a dual processor, 4 gig of RAM and RAID 5 with 3 - 73gig 15 K HDD. Application software installed on the dedicated application server includes:

1. ArcIMS 9.2.
   - -ArcMAP Server
   - -Active X Connector
2. SQL Server Express w/ Free Manager and Service Pack 1 Upgrade
3. ASP.net

VII. Preparing the data the ArcIMS Web Application

1. On a separate street dataset that is part of the routing application, a geo-coding service was built that enables the web site to search and find city wide address locations.

2. By using a tool provided by the GIS consultant, an indexing operation is performed on rating fields in the network dataset which facilitates faster search selections of route queries.

3. When switching new network datasets in the web routing application the following code updates need to occur in the web config file.The shapefile and route index file used for routing are referenced by the web.config file. The Web.config is located at c:\inetpub\wwwroot\bikeroute\web.config. on the application server. It can be opened and edited by wordpad. These are the paths to these files in web.config:
<add key="shapePath"
value="c:\inetpub\wwwroot\bikeroute\routedata\NW_Elev_012307.shp" />
<add key="routePath"
value="c:\inetpub\wwwroot\bikeroute\routedata\NW_Elev_012307.rdx" />

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