Using GIS to Identify Potential Locations for Bike Rentals in Houston Area

A Project Report submitted for partial fulfillment of course requirements for

CVEN 658

Civil Engineering Applications of GIS

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December 6th, 2010

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Abstract

Bike sharing/rental systems have become increasingly popular in Europe and Asia. Bikes are better than other modes of public transportation for shorter trips because they reach unmerited destinations, require fewer infrastructures, reduce congestion, etc. This paper aims at using ArcGIS for identifying the potential locations where bike rental stations can be setup in the Houston area. The ArcGIS software was used to overlay various layers for the analysis, calculate geometries and other attributes, create buffers, edit and add points on the map network and finally display the results. Data was obtained from US Census Bureau, City of Houston Geometric Information Systems and the Houston-Galveston area council websites. Locations where bike rental systems should be set up were identified after analyzing the city bus and bikeway network with respect to population density and places of interest/utility.
Introduction and Literature Review

Bikes have both advantages and disadvantages when compared to other means of public transport like bus, etc. The benefits include congestion mitigation, lesser and cheaper infrastructure and maintenance, reduction in pollution, accessibility improvement as well as exercise. However, it is not so safe, applicable for only very short trips, disadvantageous for people with disabilities, cannot be used in certain weather conditions and topography. In general, two types of bike sharing exist; one is for the community use and one is for residential use as observed by Matsuura (2003). Bike sharing program first evolved in 1968 in the Netherlands but was a failure because of theft issues. After improvements like pickup and drop-off at specific locations, it again came into existence in 1995 in Denmark but theft was again a factor in the failure. The advent of electronic security system for the program was sought for and helped in further improvements and fighting off theft. The bike fleets can be small or large depending on the demand. A bike sharing system in Norway consists of 50 bikes only whereas another in Berlin, Germany constitutes of as many as 1700 bikes. The longest surviving bike rental system is in Rennes, France and it has been operating for 12 years now. Figure 1 shows a bike rack in Barcelona, Spain. Table 1 gives a summary of bike sharing in various parts of the world.

Figure 1: Bicing in Barcelona, Spain.
Table 1: Summary of smart bike programs

<table>
<thead>
<tr>
<th>Country</th>
<th>City</th>
<th>Name of Program</th>
<th>Operator</th>
<th>Year Started</th>
<th>No. of Bikes</th>
<th>No. of Stations</th>
<th>Status</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Vienna</td>
<td>Citybike¹</td>
<td>Gewista</td>
<td>2003</td>
<td>120</td>
<td>13</td>
<td>functional</td>
<td>49 more stations and 880 more bikes planned for '04.</td>
</tr>
<tr>
<td>France</td>
<td>Rennes</td>
<td>Vélo à la Carte²</td>
<td>Clear Channel Adshel</td>
<td>1998</td>
<td>200</td>
<td>25</td>
<td>functional</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>Berlin</td>
<td>Call a Bike³</td>
<td>Deutsche Bahn</td>
<td>2002</td>
<td>1,700</td>
<td>43</td>
<td>functional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frankfurt</td>
<td>Call a Bike²</td>
<td>Deutsche Bahn</td>
<td>2003</td>
<td>720</td>
<td>66</td>
<td>functional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Munich</td>
<td>Call a Bike²</td>
<td>Deutsche Bahn</td>
<td>2001</td>
<td>1,350</td>
<td>55</td>
<td>functional</td>
<td></td>
</tr>
<tr>
<td>Netherland</td>
<td>Amsterdam</td>
<td>Depo²</td>
<td>Depo BV</td>
<td>1999</td>
<td></td>
<td></td>
<td>folded</td>
<td>Program ended due to theft and lack of funding.</td>
</tr>
<tr>
<td></td>
<td>Countrywide</td>
<td>OV-Fiets²</td>
<td>ProRail</td>
<td>2001</td>
<td>650</td>
<td>52</td>
<td>functional</td>
<td>500 more bikes planned for '04.</td>
</tr>
<tr>
<td></td>
<td>Rotterdam</td>
<td>City Bike Rotterdam⁶</td>
<td></td>
<td>1997</td>
<td>25</td>
<td></td>
<td>folded</td>
<td>Program folded in '98 due to poorly functioning racks.</td>
</tr>
<tr>
<td>Norway</td>
<td>Bergen</td>
<td>Bergen Bysykkelen²</td>
<td>Clear Channel Adshel</td>
<td>2002</td>
<td>100</td>
<td>10</td>
<td>functional</td>
<td>Evaluating program for possible continuation.</td>
</tr>
<tr>
<td></td>
<td>Drammen</td>
<td>Drammen Bysykkelen²</td>
<td>Clear Channel Adshel</td>
<td>2001</td>
<td>250</td>
<td>28</td>
<td>functional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oslo</td>
<td>Oslo Bysykkelen²</td>
<td>Clear Channel Adshel</td>
<td>2002</td>
<td>300</td>
<td>30</td>
<td>functional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Porsgrunn</td>
<td>Porsgrunn Bysykkelen²</td>
<td>JCDecaux</td>
<td>2003</td>
<td>50</td>
<td>8</td>
<td>functional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sandnes</td>
<td>Sandnes Bysykkelen¹¹</td>
<td>The Sandnes City Bike Foundation</td>
<td>2000</td>
<td>75</td>
<td>16</td>
<td>functional</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>Bukit Batok</td>
<td>SmartBike²</td>
<td>Clear Channel Adshel</td>
<td>2000</td>
<td>100</td>
<td>10</td>
<td>folded</td>
<td>Program ended due to lack of funding.</td>
</tr>
<tr>
<td></td>
<td>Bukit Gombak</td>
<td>SmartBike²</td>
<td>Clear Channel Adshel</td>
<td>2000</td>
<td></td>
<td></td>
<td>folded</td>
<td>Program ended due to lack of funding.</td>
</tr>
<tr>
<td></td>
<td>Tanjong Pagar</td>
<td>SmartBike²</td>
<td>Clear Channel Adshel</td>
<td>2001</td>
<td></td>
<td></td>
<td>folded</td>
<td>Program ended due to lack of funding.</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Portsmouth</td>
<td>Bikeabout²</td>
<td>Portsmouth University</td>
<td>1996</td>
<td></td>
<td></td>
<td>folded</td>
<td>Program ended due to lack of funding.</td>
</tr>
</tbody>
</table>

Source: DeMaio and Gifford (2004)
There are certain factors which are critical for the success of bike rental systems which include demand for the service, safety, profitability, theft issues and connection to other transit services. The use of bikes is high in European countries like Germany and Netherlands, with London being the latest to launch the service in 2010 and it has increased from 0.6% to 0.9% in the USA from 1977 to 1995 according to Putcher et.al (1999). According to USDOT (2002), which gained information from the bureau of transportation statistics, 80 million people use bikes in the USA. Pucher and Dijkstra (2000) observed that only 9% of the people use bikes for commuting to workplace and hence, bike rentals will not be effective in reducing congestion. DiDonato (2002) also observed a similar point. Hence, the main aim should be to feed the commuters to bus stops using bike sharing policy and in turn, the bus transit so that more people use the public transportation. A survey conducted by OV-fiets revealed that approximately 50% of bike users use it for social or personal business purposes and 40% use it for recreational purposes.

Pucher and Lefevre (1996) observed that USA has only 1% model split for bikers. Komanoff (1997) studied about the safety issues with biking in the USA. DeMaio and Griffard (2004) highlighted a major issue with the bike rental system which is that no bike system has ever made profit to date. Theft was one of the major issues earlier but now it has been minimized because of the advent of electronic security. Bike rentals are usually located in the downtown areas. USDOT observed that short trips in urban settings are ideal for smart bikes as the average bike trip length is about 2 miles and 24 minutes long.

This paper aims at identifying potential locations of bike rentals racks in and around Houston area so that commuters can be fed to the Houston Metro service and encouraged to use the transit service more.

**Methodology**

In order to establish the bike rental locations, we need to know where the population density is high. After calculating the high population density areas, we get hold of the bus routes in the city, the locations of the bus stops and create a buffer around the bus stops so that we can find out the extent to which there bus stops serve the city. The locations where the population density is high, where the bike routes/lanes are present and till where the bus stop buffers extend help us determining the initial locations of the setup. Later, we find out where the major
universities/colleges, libraries, parks are present in the city and depending on the bus stops buffer and presence of bike lanes, the bike rental locations are located. The bike locations are obtained by careful survey of the map.

**Application, Results and Discussion**

The Houston Census data of the year 2000 was obtained from City of Houston Geometric Information Systems website (http://cohgis.houstontx.gov/cohgis2009/index.htm) and the files consisted of the areas of all the blocks and other information of the city of Houston. Houston is spread over 3 counties, namely, Harris County, Montgomery County and Fort bend County. The population of these counties, by blocks, were obtained from the U.S Census Bureau website (http://factfinder.census.gov/home/saff/main.html?_lang=en). With the help of these 2 data files, whose attributes were joined using tabular join, the population density of the various blocks were obtained. The population density was divided into 3 categories, high, medium and low. Figure 2 gives a snapshot of a part of the city (zoomed for clarity) and its distribution by population density. The bus stops of Houston Metro, bus routes, bikeways in the city of Houston were obtained from the website of the Houston-Galveston area council (http://www.h-gac.com/rds/gis/clearinghouse/default.aspx). They were overlaid on to the map network. A buffer zone was created around the bus stops’ locations for a spread of 1 mile. The maps with bus stop locations, bikeways and the buffer zone are shown in figures 2 and 3 respectively.
Figure 2: Population density in Houston
Figure 3: Metro Bus stops and bikeways.
Figure 4: Buffer area of bus stops
After creating the buffer zone, the bikeway network was overlaid on the map. The places with medium and high population densities which were lying next to the buffer zone and which had bikeways in the vicinity were chosen. After carefully examining these areas, probable bike rental locations were determined. This is shown in figure 4.

Next, the shapefiles of the locations of universities/colleges, parks and libraries were overlaid on to the map network. The bikeways and buffer area were also present. The places where bikeways exist as well as where the universities/colleges, parks and libraries locations were lying adjacent to the buffer area were chosen as the potential bike rental locations. Figure 5 shows the bike rental locations based on places of interest/utility.

Figure 6 shows a map in which the population density, buffer zone, bikeways, parks, university/college, libraries, potential bike rental locations because of population density and places of interest/utility are present.

In all, 30 potential bike rental stations were located in the Houston area, 18 of which were based on population density and 12 of which were based on places of interest or utility.

Figure 7 shows the potential bike rental locations on a Houston block area map.
Figure 5: Bike Share locations based on Population density.
Figure 6: Bike Share locations based on utility and purpose.
Figure 7: Locations of the bike rentals along with all the attributes in the map.
Figure 8: Bike Rental locations – Final.
Conclusions and Recommendations

A map showing the potential locations of the bike rental stations in Houston area based on population density and places of interest and utility is obtained. The bus stop area buffer acts as the base on which the bike rental system has been installed. Together with the help of population density and places of interest/utility, the bike share system can be used to help people reach bus stations with more ease than earlier. In all, 30 potential bike rental stations were located in the Houston area, 18 of which were based on population density and 12 of which were based on places of interest or utility. The analysis shows that with the existing bus network and the presence of bikeways throughout the city, bike rental system can be encouraged in the city of Houston.

Future work can be done by building on the present analysis. The employment density can be calculated and based on that some rental stations can be setup. Trip distribution data could be used to check for ideal bike share stations. The presence of universities/colleges in and around Houston can also be used for analysis. Bike rental system can be brought about in the campuses of these universities so that more people get into using the bikes which will add to profit making of this setup. This paper mainly focuses on the area outside the buffer area of the bus stops. Analysis can be done in the downtown area to determine the possible locations of bike rentals as this area is more crowded with people and traffic during weekdays. Bike rental is a cheap and effective way of commute for short trips in these circumstances.
References