A Web Application Approach to Street Sign Inventory Development

Georgia Institute of Technology
School of City and Regional Planning

Spring 2011

CityPOINTS

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Spring 2011

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Summary

Maintaining accurate and comprehensive spatial data on infrastructure at the municipal scale is a challenge that comes with serious challenges. Obtaining such data often requires such extensive resources and time that many municipalities may completely abstain from even considering this seemingly insurmountable task. Regardless of these substantial hurdles and the additional budgetary constraints imposed by difficult economic times, municipal infrastructure maintenance and repair is a necessary function of a municipal government. In the case of street signage, formally part of the umbrella known as traffic control devices (TCD), this municipal role has come to be required under federal regulations.

To aid local governments with this critical function in a cost-effective manner, Georgia Tech researchers developed a web-based application in the fall of 2010 that utilizes Google Street View to remotely locate and catalogue street signs in an urban environment. This inventory tool, dubbed CityPoints, proves superior to field identification using a GPS unit because of an increased positional accuracy and decreased cost of both time and labor. The density of urban space requires a finer resolution than most GPS units can provide. On top of this inherent flaw, there is an increased risk of positional inaccuracy due to interference caused by the reflection of satellite signals against medium- and high-rise buildings, making an approach based on in-field GPS data collection wholly insufficient. CityPoints' time and labor savings result from the convenience and accessibility of the Street View technology. Accessed through any Internet-connected consumer workstation, the web-based application eliminates the travel component associated with field work and enables data collectors to work independently in an office or

other indoor environment. Users input data directly into a backend database associated with the web application, which again reduces labor over the conversion of handwritten data to a digital spreadsheet format that may be involved with field data collection.

In spring 2011, a studio of Georgia Tech graduate city planning students assessed the real world applicability of CityPoints. Their assessment included the development of use instructions for municipal employees (Appendix 3), a comparison of both the rate of data production and the accuracy of data produced using a GPS unit versus CityPoints, statistical analysis of data collected with CityPoints to estimate the number of street signs in the City of Atlanta, and a couple of corollary reports on the use of CityPoints for other applications (Appendix 1). Conclusions of their work confirmed the efficiency of the web application method over GPS field data collection. Though field work maintains some advantages over remote data collection, such as the visibility of more recently added features and signage, CityPoints allows for drastically reduced time and labor costs, while still maintaining its edge on positional accuracy and precision. Having collected data with CityPoints, researchers refined and enhanced the information with GIS and developed models with which they came to statistically sound estimates of the number of street signs.

1 Studio Introduction

The Atlanta City Government, as with many other local jurisdictions around the nation, is subject to the compliance requirements created by the Department of Transportation regarding the standards, guidance, options and supporting information related to traffic control devices. All relevant agencies must implement a traffic sign management method by a given timeline in order to comply with the new standard. One fundamental element of the new management method has been to develop a traffic & street sign inventory, which is needed for the following two reasons, as stated on http://streetsigninventory.com/.

> **Worn street signs create a safety hazard for drivers**
>
> •Street signs are constructed with special film "sheeting" which has a reflective material to create retroreflectivity. **Over time the reflection degrades, making the sign much harder to see at night, which creates a safety hazard for drivers.**
>
> **Inventories allow for a Proactive Traffic Sign Replacement and Maintenance Schedule**
>
> •The ability to **collect and manage critical data associated with each asset** allows for effective planning and budgeting for street sign replacement and maintenance.

Street signs in Atlanta city boundaries have been gradually added over decades. While scattered paper records exist to document a small subset of maintenance activities, there is no systematic database to enable effective sign management.

In summer 2010, the Atlanta City Government contracted Georgia Tech to work on a cost-effective approach to sign inventory development. The city government has been severely constrained by budget and was unable to contract any consulting firm to develop the database. Instead, a new approach has been jointly developed by Jiawen Yang, assistant professor in the School of City and Regional Planning at the Georgia Institute of Technology, Ramon Creese, information technology manager in Atlanta City government, and Xuan Shi, research scientist in the Center for Geographic Information Systems at the Georgia Institute of Technology.

This new approach includes a web application based on the Google Maps API. A newly designed algorithm can calculate the longitude and latitude of any street sign that is identified by human eyes in Google Street View. This work was completed in the fall semester of 2010. With this web application, data collection through field trips can be possibly replaced by virtual trips on the Internet with Google's Street View.

In order to test the applicability of this approach, a studio was organized in spring 2011 at Georgia Tech, in which eight graduate students of city planning participated in a semester long-project and worked on the following tasks.

a. Learn to use the web application and write an easy-to-follow instruction manual
b. Collect a sample of the street sign data
c. Assess the effectiveness of the web application based approach
d. Estimate the number of signs for the city government

By the end of the semester, the group stated the following benefits and features of the web application, which is titled CityPoints.

BENEFITS: CityPoints minimizes the need for field-based data collection efforts, saving time, effort, and money. There is no need for transportation to sites or expensive GPS units. Data collectors can work indoors from any location at any time regardless of weather conditions. All you need is an Internet connection!

FEATURES: The main interface of the program is used for locating and cataloguing data points. It features Google street and satellite views from which the data collector may accurately locate infrastructure or any other item of interest. Additionally, this interface includes an address locator, geographical coordinates, and various infrastructure categorization menus, with features that allow data entry, updating, and deletion of data points. CityPoints also has the ability to identify the current location of users for use on mobile devices in the field.

This report documents all activities and results produced by the student group. The manual for the CityPoints program was completed during the first month of the semester. After manual writing and collection of the pilot dataset, teams split into four groups of two to focus on a specific utilization or test of the tool or data collected with the tool. The first group worked on developing an estimation of the number of signs for the City of Atlanta using the pilot dataset. The second team focused on testing the accuracy and currency of data collected using CityPoints compared to other data collection methods. A third group worked on studying the feasibility of applying the CityPoints tool to Complete Streets analysis. The final group worked to develop a design for the CityPoints homepage that would integrate the different projects and create a helpful and welcoming environment for those utilizing the tool.

This studio culminated in a presentation to the Atlanta Public Works Department at City Hall, where the team presented their findings and discussed the potential use of CityPoints and its possible benefits for the City of Atlanta.

2 Web Application Description

According to Wikipedia (http://en.wikipedia.org/wiki/Google_Street_View), "Google Street View is a technology featured in Google Maps and Google Earth that provides panoramic views from various positions along many streets in the world. It was launched on May 25, 2007, originally only in several cities in the United States, and has since gradually expanded to include more cities and rural areas worldwide. This technology displays images taken from a fleet of specially adapted cars. Areas not accessible by car, like pedestrian areas, narrow streets, alleys and ski resorts, are sometimes covered by Google Trikes (tricycles) or a snowmobile. On each of these vehicles there are nine directional cameras for 360° views at a height of about 8.2 feet, or 2.5 meters, **GPS** units for positioning and three laser range scanners for the measuring of up to 50 meters 180° in the front of the vehicle. The following picture shows a Google camera car on street."

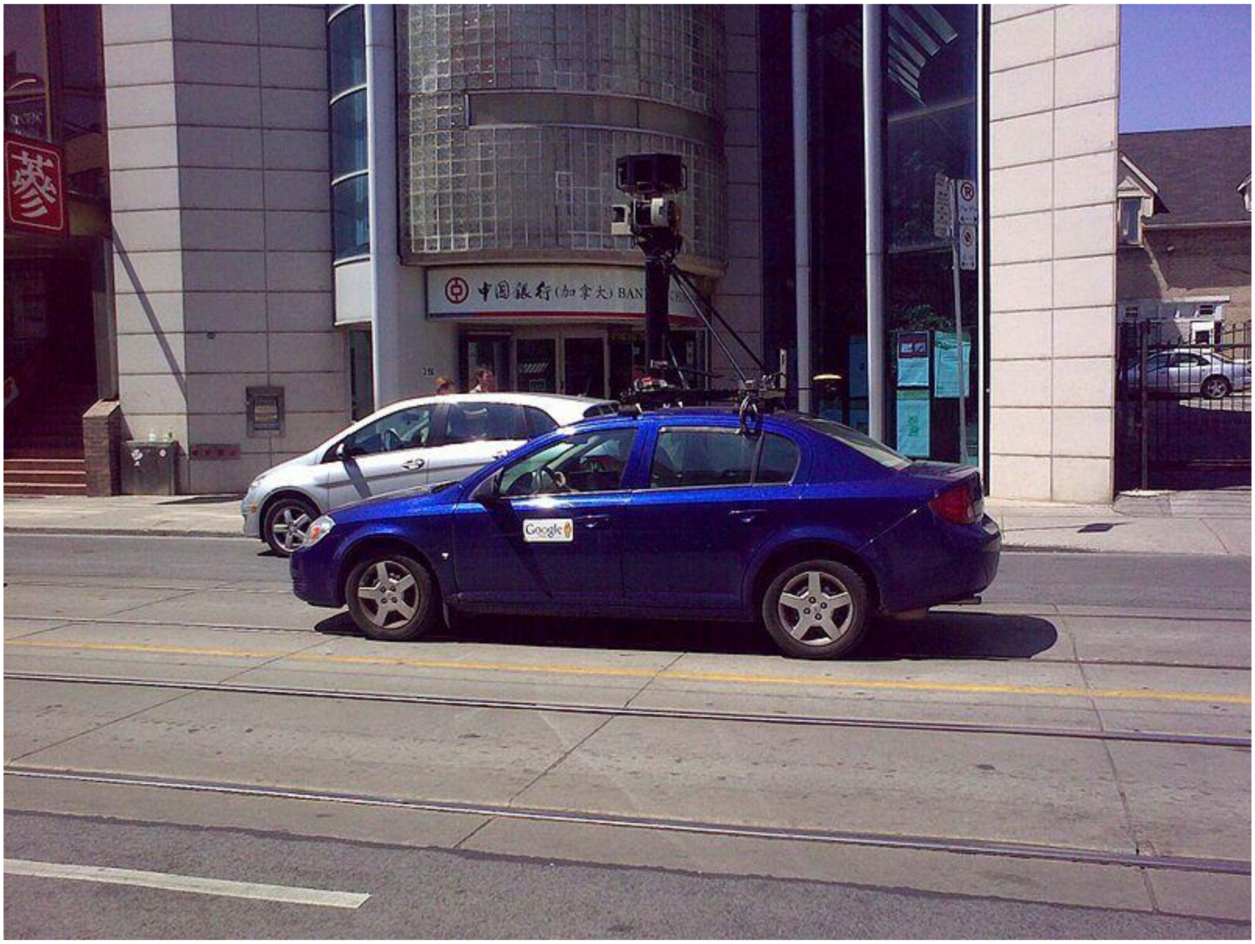
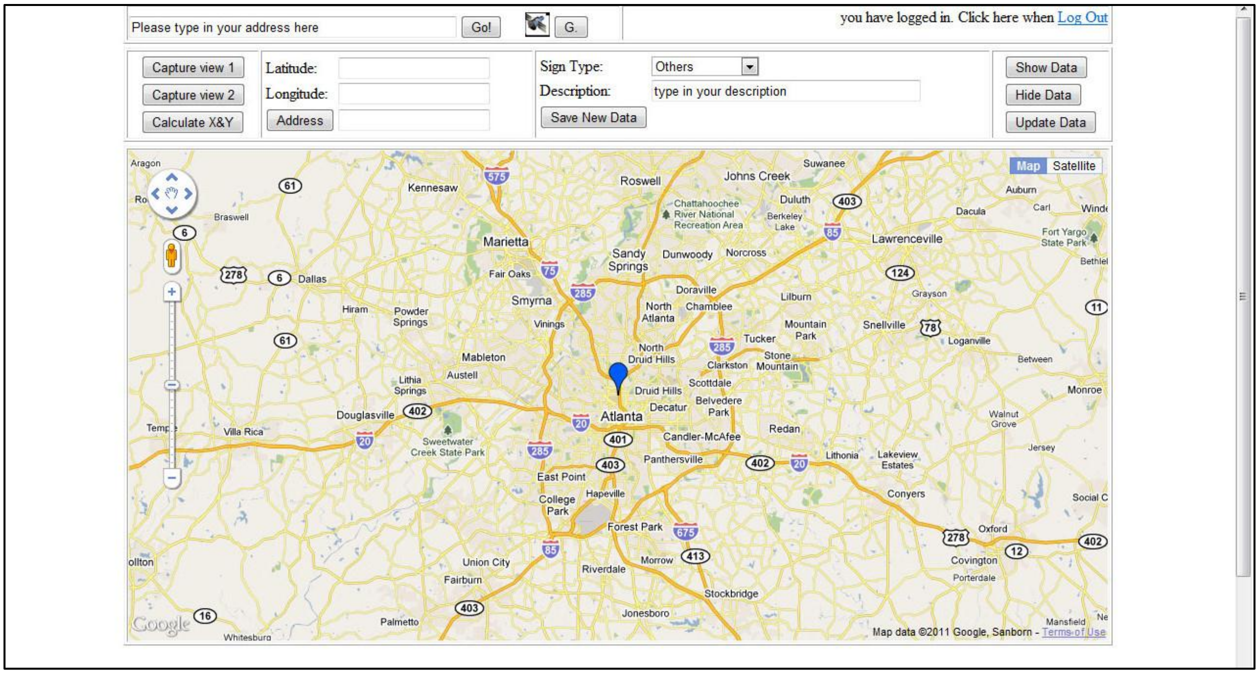
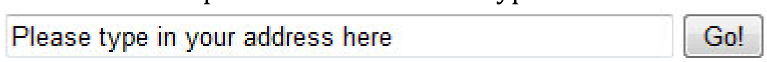


Image 2.1: A Google Maps Camera Car in Chinatown, Toronto, Ontario

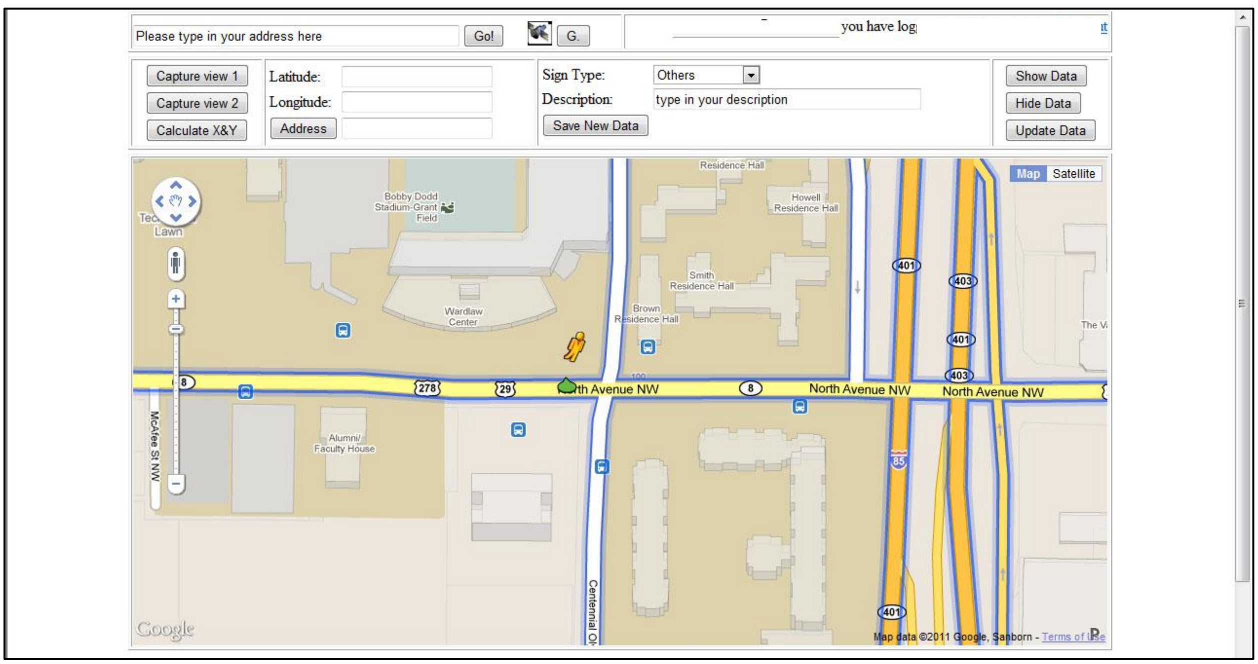
Source: http://en.wikipedia.org/wiki/File:Google_Street_View_Car_in_Chinatown,_Toronto.jpg, taken on June 5, 2009.

Since street signs are designed to be visible for an on-street observer while s/he moves along the street, those signs are also visible in the images of Google Street View. As the camera takes multiple shots in all directions when the vehicle moves forward, a single sign can show up in multiple images taken by the same camera, but at slightly different locations and different directions. Two Georgia Tech researchers, Jiawen Yang and Xuan Shi, designed an algorithm and a web application to estimate the x and y coordinates for any visible sign by using the multiple images that contain the same sign. The following set of instructions illustrates the process of extracting and identifying coordinates with the web application.

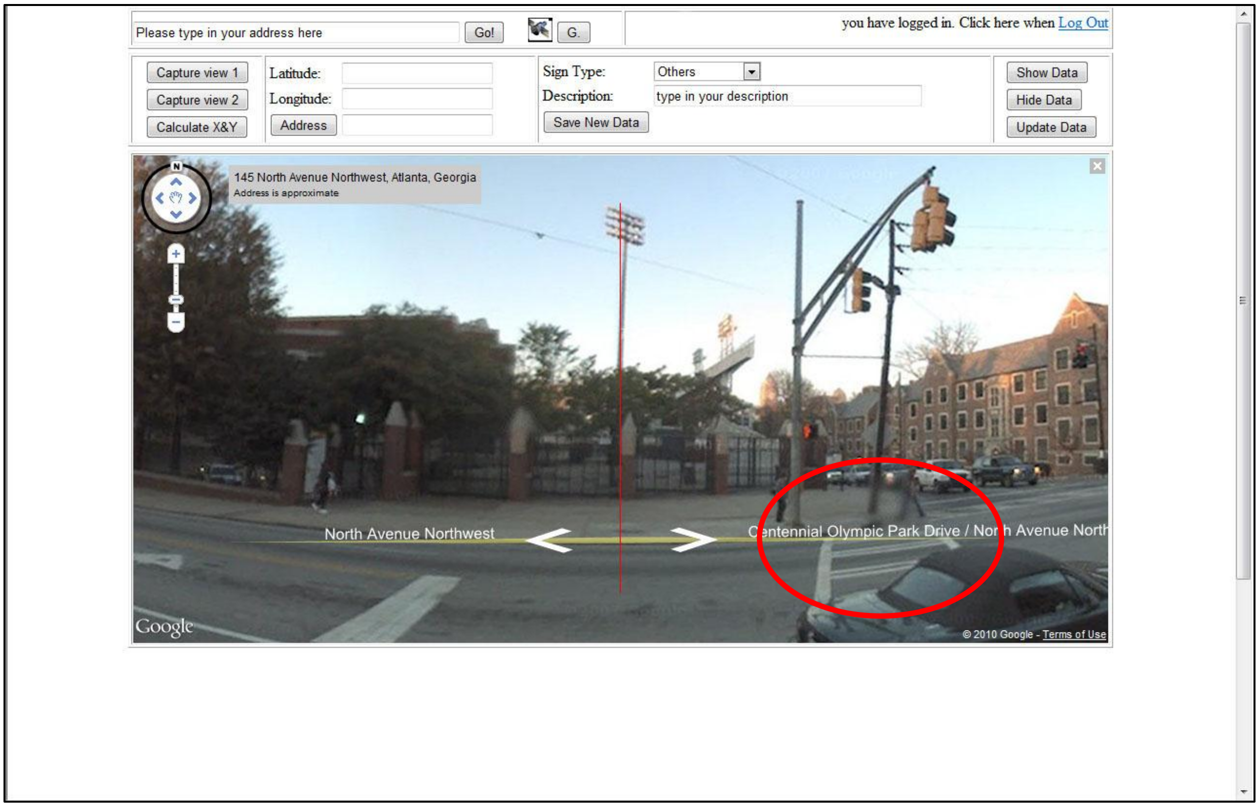


1. Open the CityPoints website at http://city facility.gatech.edu/sign/main.php
2. Log in with username and password supplied by a system administrator.
3. Determine a location of interest and either pan to that location or type in the address in the dialog box shown at right. 

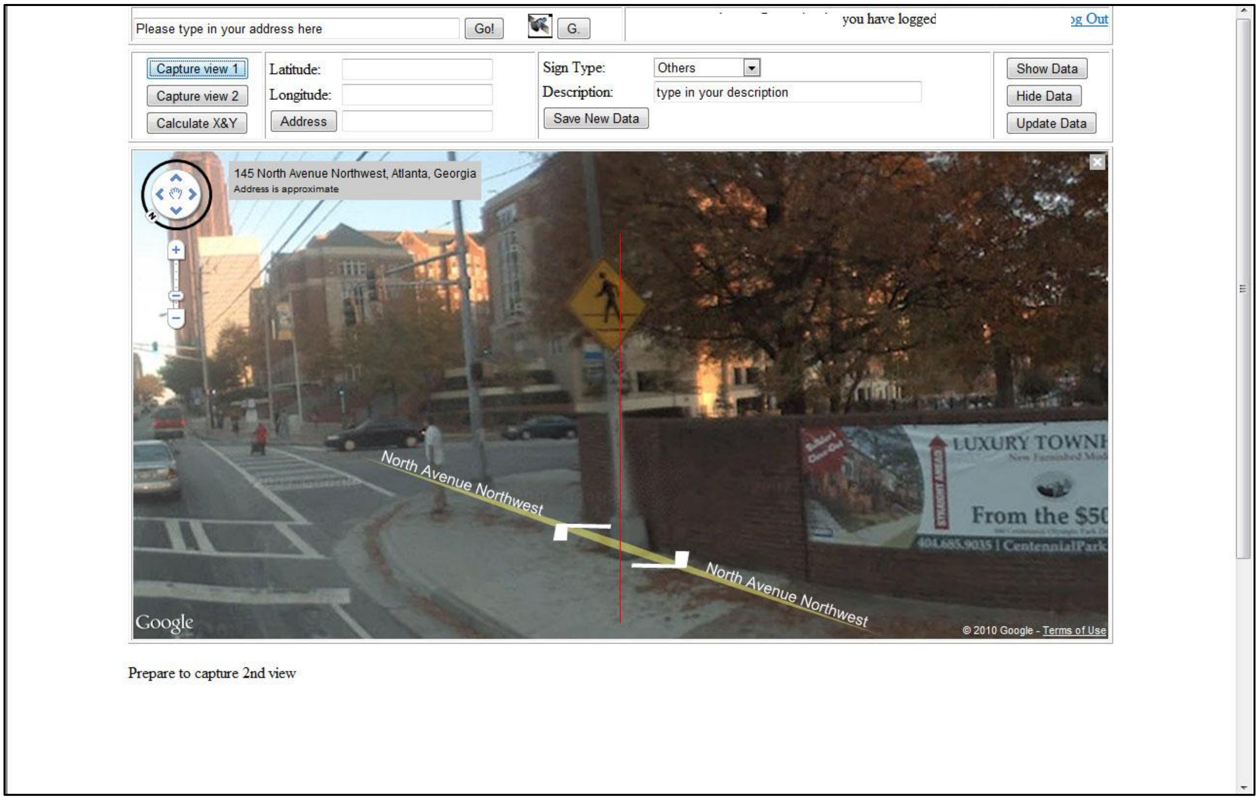
4. Click and hold the street view "gold man" symbol and drag it to the desired location. Wait until a green pin appears under the "gold man" symbol and release it.



5. Once in Street View you will see a vertical red line in the middle of the screen accompanied by two white arrows with the name of the street.
6. To locate sign or item of interest, use white arrows along the street to move forward or backward and click and hold the screen to rotate your view.

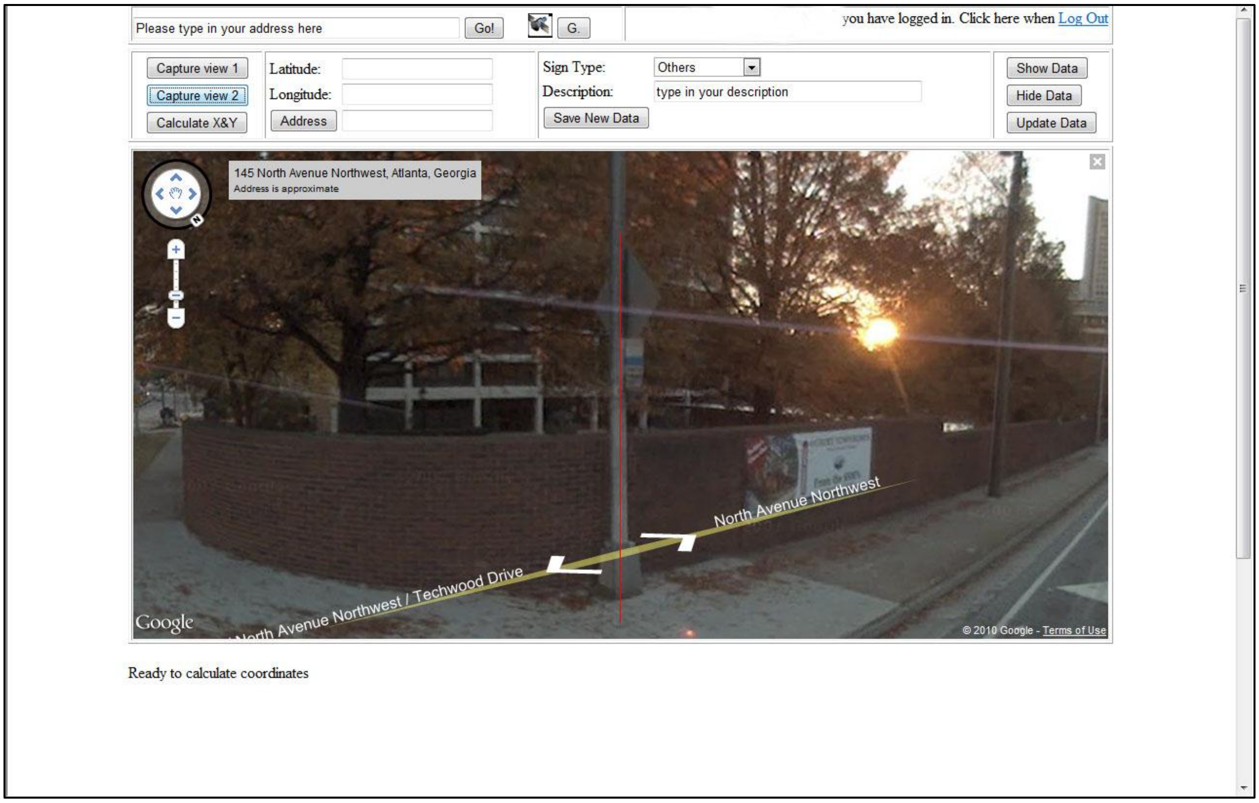


7. Once you have located the sign or item of interest you would like to catalog, find the view closest to that item and place the vertical red line over the sign.

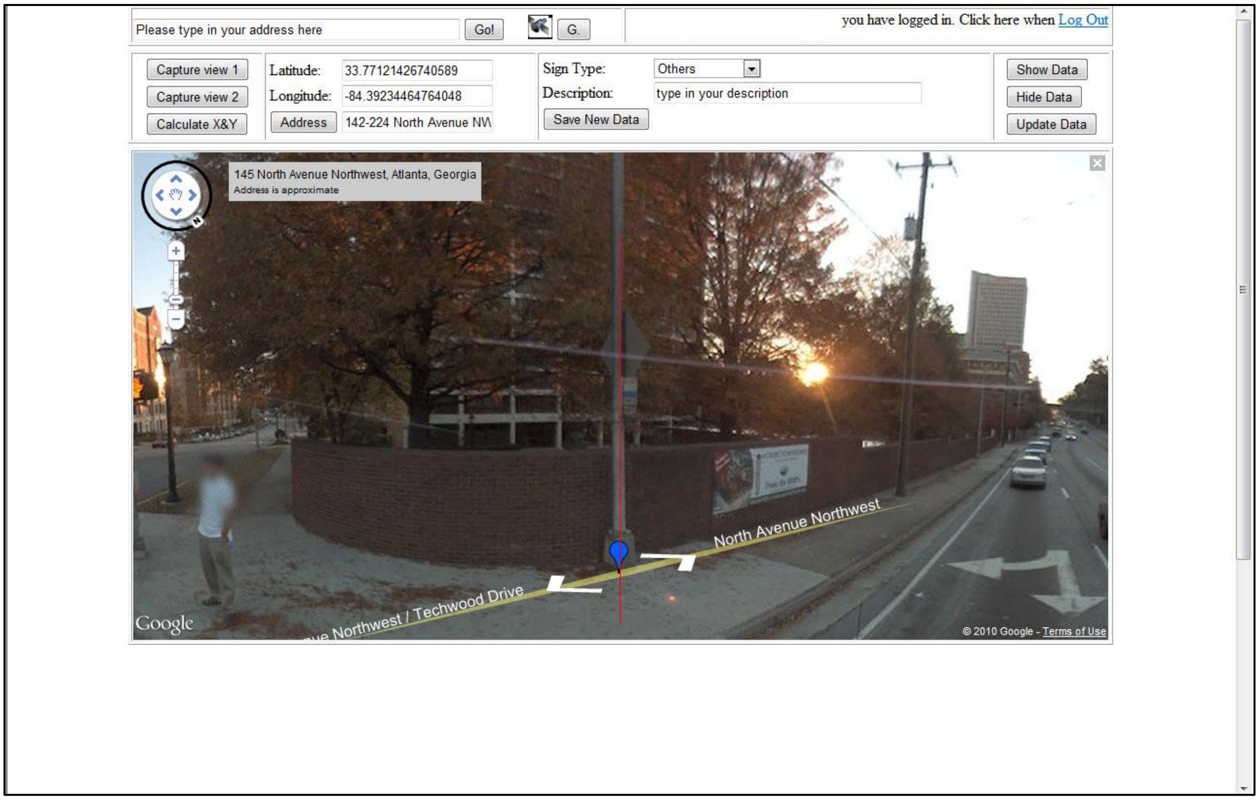


8. Now click "Capture view 1".

9. After capturing the first view, click the white arrow again to move past the sign and move the camera view to realign the vertical red line with the sign from a different angle. If possible, use closest camera option to the item of interest.

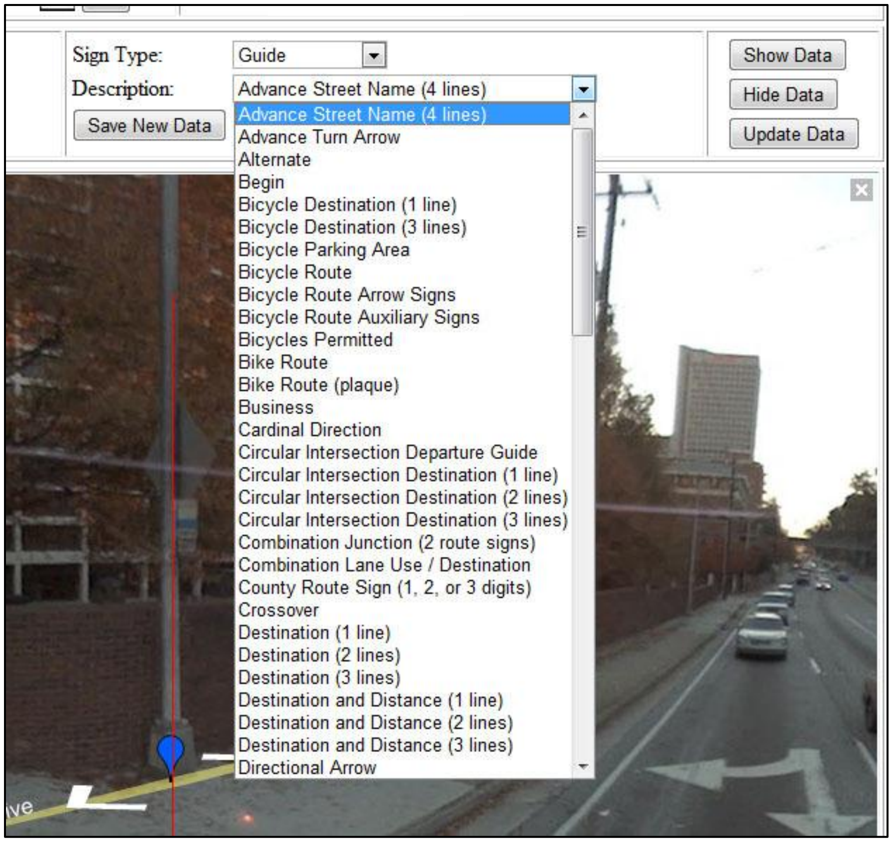


10. Now click "Capture view 2". The application triangulates the coordinates of the sign.
11. Now click "Calculate X&Y" to calculate the latitude and longitude on the item of interest.
12. A Blue pin should appear. DO NOT MOVE IT MANUALLY, even if the Blue pin does not exactly lie on the sign, as this will reduce the accuracy of the coordinates.



13. Select the sign type from the drop-down menu listed as "Sign Type."

14. Click the drop-down menu for "Description" and select the exact sign being catalogued.
    Note: if "Other" is chosen for the Sign Type, you must enter the description manually.



15. Click the "Save New Data" button to enter the sign into the database.
16. Clicking the "Show Data" button will ensure that the data has been catalogued. A window will appear saying "Data Inserted" and a white pin should show up at the base of the sign or item of interest.

The web application also has the capability to view, update, and delete the data. One can take a look at the complete menu to know more functionalities of this web application.

3 Sample Data Collection

A sample of street sign data is collected for two purposes: 1) to assess the effectiveness of this web application based approach; 2) to estimate the number of street signs for the city government. A significant portion of the sample data was collected while the team spent time learning to use the web application, with the Midtown area as the testing bed. After that, an attempt was made to collect at least 4 blocks of data from each of the 12 City Council Districts of Atlanta. This adds up to over 1000 signs for over 60 blocks all over the city, but the majority of the signs are in the Midtown area. This was done as a collaborative effort and shows that multiple users can focus on collecting data in the same area or at various areas throughout the city. Since the CityPoints tool is web based, it also allowed for users to collect data at times that best suited their schedule so that work could be done independently. A screenshot of collected data is below

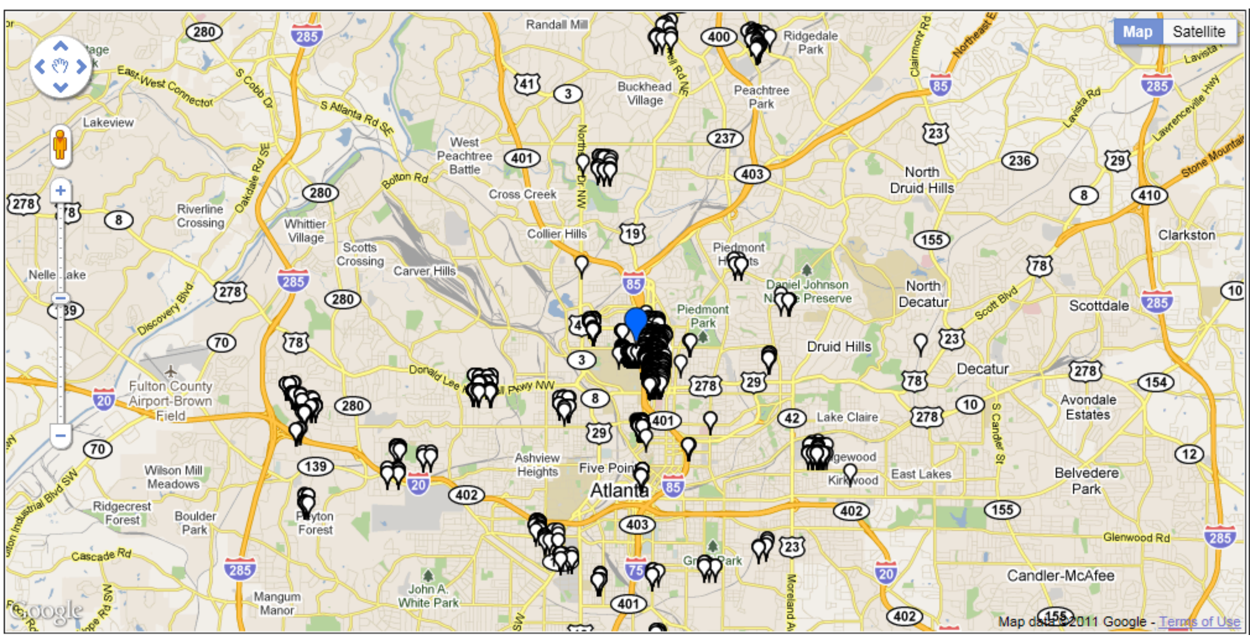


Figure 3.1 Screenshot of sample data

4 Assessment through Field Work

We conducted field analysis to test the validity and effectiveness of this web based approach. This work has three purposes: 1) to understand the time savings associated with the remote data collection via the CityPoints web application, 2) to understand the positional accuracy of field work with GPS unit and the Street View algorithm-based calculation, and 3) to understand typical human errors in data collection.

We selected two sites and collected street sign data with three different approaches: 1) manual coordinate collection using a GPS locator in the field, 2) data logging in the field using the CityPoints program on an iPad with a 3G connection, and 3) data logging from a remote location using the CityPoints program. The two selected sites include a downtown block to the east side of CNN headquarters and a neighborhood of single family housing to the north side of Georgia Tech's campus. Two students repeat the data collection for the same two sites with the three approaches, so that human errors in data collection can be relatively easily detected.

The students collected the data for the downtown site first and, later in the semester, the single family neighborhood. A comparison between the data points collected by the two students show good consistency for the downtown block, but drastic differences for the second site, which indicates significant human error in the field work, which may be attributed to the field work's proximity to the semester end. Data collected for the second site was thus excluded for further analysis. We used the data for downtown block for this assessment. The picture below is a satellite image for the downtown block. It has on-ground parking and two buildings. Signs are present on both sides of the surrounding streets. The students collected data only for signs on the inner side of the selected block.

Image 4.1: Site of field work (to the east side of CNN)

4.1 Assessing Rate of Data Production

The tables below show the time cost of data collection with three different approaches. For the first approach, students held one GPS unit and recorded the GPS coordinates for each street sign manually on paper. They then returned to Georgia Tech's campus and input the data into an excel sheet. The transportation time, data collection time and the time used to enter the data into computers are all recorded. For the second approach, the student used an iPad with a 3G connection and a GPS locator. The iPad loaded the web application and determined the x & y coordinates of the student with the GPS locator. The student then chose the signage description from a dropdown list and submitted it online. The third approach, remote data collection, is similar to the second and is fully described in section 2. The student used an Internet-connected office computer to open the web application, located street signs with Google Street View imagery, and calculated the x & y coordinates using the previously outlined process of selecting Street View imagery to identify signs. For the sake of clarity, the students who performed these assessments will henceforth be referred to as Student A and Student B. Student A attempted sign location and identification with the first approach, Student B with the second. Both students attempted the third approach in an effort to further understand the accuracy of the CityPoints application.

Approach No. 1: Field work (by hand)

When: Wednesday, March 16
Where: Harris, Centennial Olympic Park, Williams, Andrew Young block
Who: Student A

Departed Georgia Tech:		2:37pm
Arrived On-site:		2:57pm
	Total	**20 Min**
Begin Analysis:		3:10pm
End Analysis:		3:32pm
	Total	**22 Min**
Depart Site:		3:54pm
Return Georgia Tech:		4:04pm
	Total	**10 Min**

Begin Excel data entry:		2:28pm		
End Excel data entry:		2:43pm		
w/ partner reading coordinates			Total Time (by Hand)	**37 Min**
	Total	**15 Min**	w/ transport time	**67 Min**

Number	**Sign**	**Latitude**	**Longitude**
1	One Way	33.7610746621972	-84.3919219301993
2	Street - Harris St. NW	33.7610746621972	-84.3919219301993
3	Street - Centennial Olympic Park Dr. NW	33.7610746621972	-84.3919219301993
4	No Parking	33.7611832328321	-84.3915901931791
5	One Way	33.7610946069702	-84.3911812996857
6	No Parking	33.7610946069702	-84.3911812996857
7	Interstate 75 w/ "TO" and (arrow)	33.7610692457857	-84.3907508338426
8	Interstate 85 w/ "TO" and (arrow)	33.7610692457857	-84.3907508338426
9	One Way	33.7608455891597	-84.3905450454676
10	Street - Harris St. NW	33.7608455891597	-84.3905450454676
11	No Left Turn (symbol)	33.7606927911559	-84.3901970816739
12	Street - Williams St. NW	33.7599065321738	-84.3905886418534
13	No Left Turn (symbol)	33.7599065321738	-84.3905886418534
14	Do Not Block Intersections	33.7599065321738	-84.3905886418534
15	No Parking	33.7597247759221	-84.3914902708283
16	No Parking w/ small red Left arrow below	33.7597621592229	-84.3918263439892
17	No Parking	33.7597527730101	-84.3919704788332
18	No Parking	33.7600670839816	-84.3921219439971
19	No Parking	33.7602857338169	-84.3919971715446
20	No Parking	33.7612195986036	-84.3918486308169

Approach No.2: Field Data Collection (with Tool)

When: Wednesday, March 16
Where: Harris, Centennial Olympic Park, Williams, Andrew Young block
Who: Student B

Began Analysis		3:35pm
Completed Analysis		3:52pm
	Total	**17 Min**

Approach No.3: Remote Data Collection

When: Wednesday, March 30
Where: Georgia Tech
Who: Student A

Opened Program		3:15pm
Navigated to Analysis Site		3:17pm
Completed Analysis		3:34pm
	Total	**19 Min**

When: Monday, March 28
Where: Georgia Tech
Who: Student B

Opened Program		2:48pm
Navigated to Analysis Site		2:48pm
Completed Analysis		3:03pm
	Total	**15 Min**

The time cost information shows that logging data by hand in the field is the least time- and cost-effective method due mainly to the effort required to write down coordinates and later log this information into an Excel format. Using the hybrid approach of the web application in the field allows users to bypass the handwritten logging of coordinates and later entering data into Excel. This method also may help collect data of newly added signs as data collectors are able to see what signs are actually physically onsite. However, travel time must be factored into this analysis, which increases costs.

Remotely logging signage data using the web application may not document 100% of the signs, as the Street View images are typically several years old and recent changes in street signs may not be observed. The primary cost advantage of CityPoint is that it allows users to catalogue data from any location that has an Internet connection, thereby eliminating any travel time required by the other methods. In this sense, the remote use of the application is the most time- and cost-effective method, although the collected data is not as complete as physically visiting the site.

4.2 Assessing Positional Accuracy

Given the density of street signs in urban areas, positional accuracy is a very important issue. GPS reading usually can only guarantee a maximum of 5 meters accuracy, which means there exists a 95% chance that the sign is within 5 meters of the GPS reading. This maximum positional accuracy cannot always be achieved in urban areas because high-rise buildings can reflect satellite signals and reduce positional accuracy. Given the width of streets in urban areas, a street sign could be mis-located to the other side of the street, an inaccuracy which would cause confusion in sign maintenance.

In this field work, the coordinates of every sign is obtained by two methods: readings from the GPS unit and calculation based on Google Street View. This enables a comparison between the positional accuracy of these two different approaches. Since the Street View approach requires human interaction with the web application, as illustrated in section 2, we compare the coordinates collected by two students with the remote approach against readings from a GPS unit in order to assess if the Street View approach is sensitive to human factors. Appendix 3 contains the three sets of coordinates for each sign around the selected urban block.

We convert the three sets of coordinates into three shape files and then three KML files. These files are then loaded into Google Earth and put on top of the satellite images. GPS readings are marked by triangles. The circles and pentagons show the positions calculated by each student with the Street View approach.

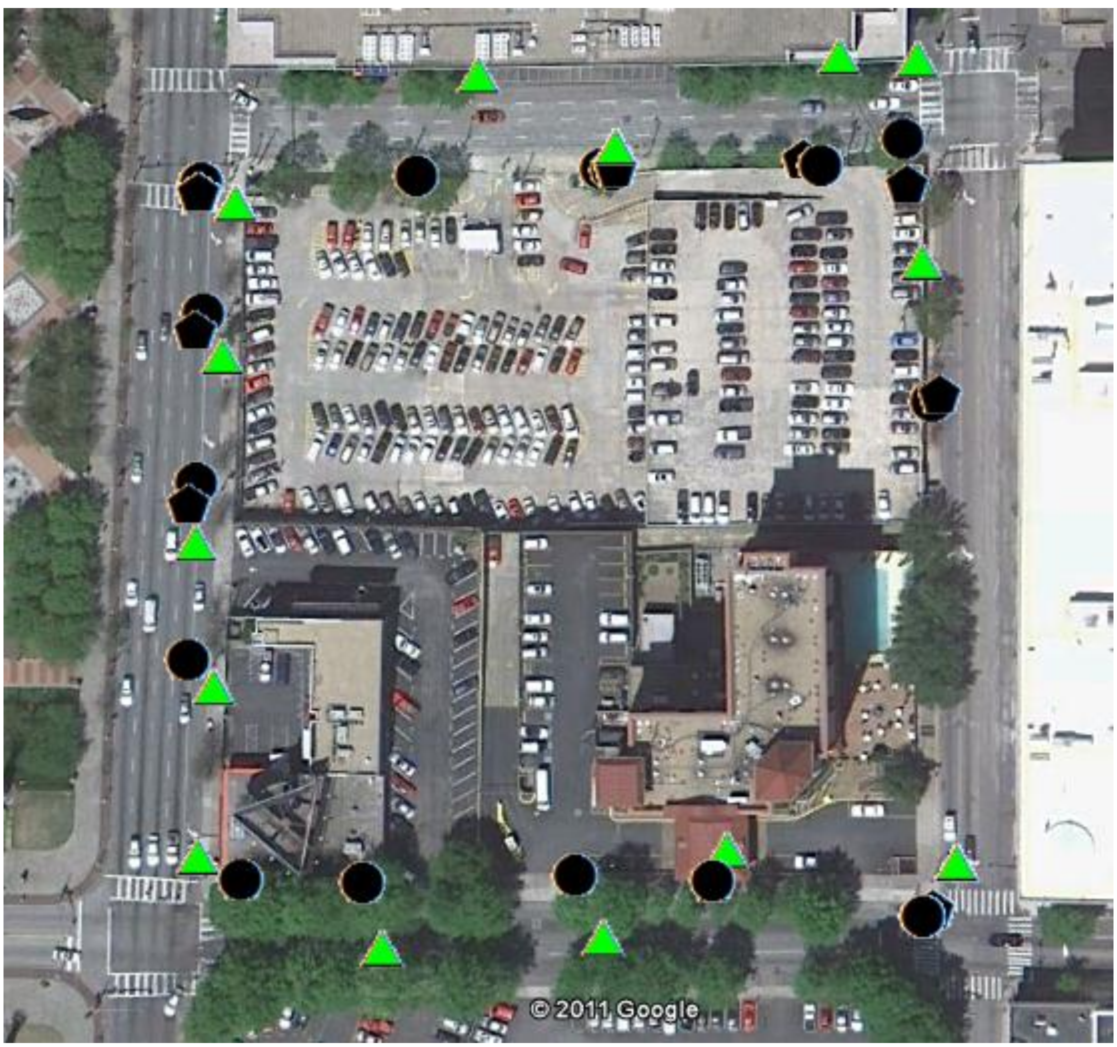


Image 4.2: The triangles show the position of the signs by field work, based on GPS reading; The pentagons show the position of the signs collected remotely by student A; The circles show the position of the signs collected remotely by student B.

The picture shows obvious differences in positional accuracy between these two approaches. The Street View approach does not mislocate any sign to the other side of the streets, while the GPS reading mislocates three of them to the other side of the street (on the north side of the block) and positions two of them in the middle of the street (on the south side). The Street View approach demonstrates excellent consistency. Positions collected by the two students may not line up perfectly, but overall, they are close to each other. While one may argue that the satellite image, which is used as the background image here, may not be positioned accurately itself, we can at least assert here that Street View approach offers much better consistency. The spatial relationship between different signs is well preserved with the Street View approach. Signs on a straight line will be positioned in a straight line.

A detailed examination of the street sign to the east side of the block can tell a similar story. That block has only one traffic sign, as illustrated in the Street View image below. The triangle and the circle are distanced from each other by 7 or 8 meters. Opening Google Street View within Google Earth, we find the circle and pentagon close to the sign, but not the triangle, which again demonstrates the lack of positional accuracy from GPS reading.

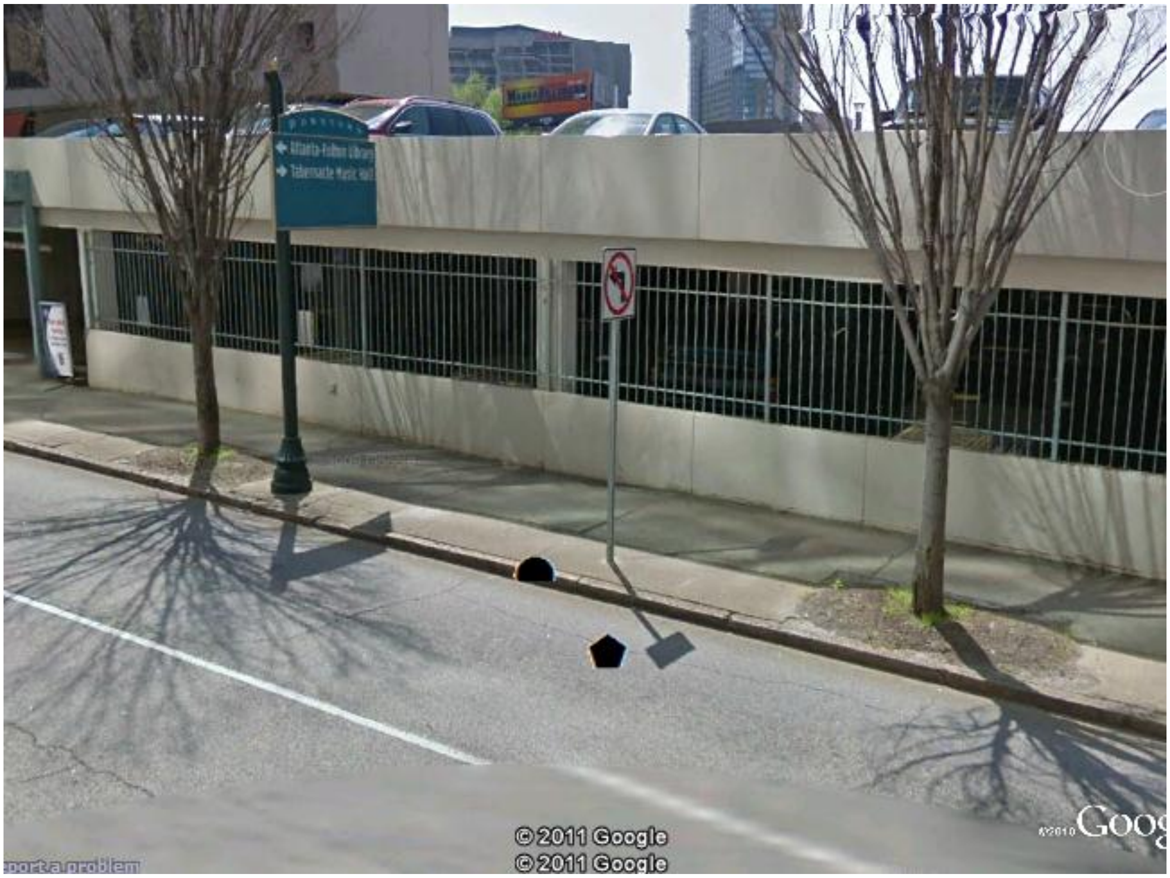


Image 4.3: Street sign on the right side of the block

5 Sign Number Estimation

The Atlanta City Government has lost track of sign installation and replacement. No one knows how many signs exist on the streets. With a sample of the geographically distributed signs, we can now estimate the total number of signs. The data points we collected in section 3 were exported from the online CityPoints database as an Excel file. That file was then loaded into ArcGIS where the signs were plotted using their X and Y coordinates. This enables us to begin the work of sign estimation.

5.1 Methodology

A grid layer was used to divide the city into 500 by 500 square foot blocks (Figure 5.1). These grids will be used as the units of analysis for regression and estimation. Our regression will use the number of different types of intersections and the length of road as the independent variables.

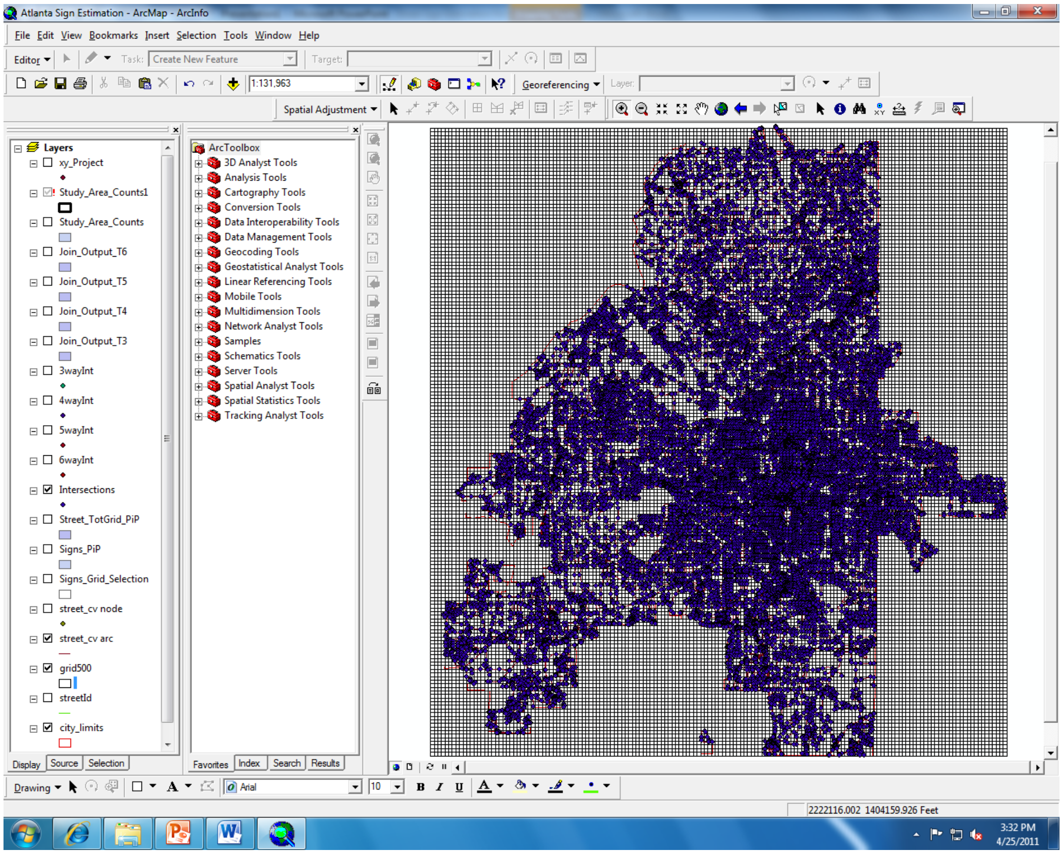


Figure 5.1 500 foot grids used in sign estimation analysis

Intersection data was derived from the nodes of the road network shapefile. A node is the intersection of two or more road segments. Each node has a "to node" and a "from node." Summarizing the count of "to nodes" and "from nodes" for road segments and summing the total for each individual node provides the number of road segments that meet at each node. Nodes that have a count 3 or more road segments meeting are considered an intersection. Shapefiles were created for 3 way, 4 way, 5 way, and 6 way intersections. These will serve as independent variables for the regression analysis. Figure 5.2 shows a screenshot of the road and node network in ArcMap used to create intersections.

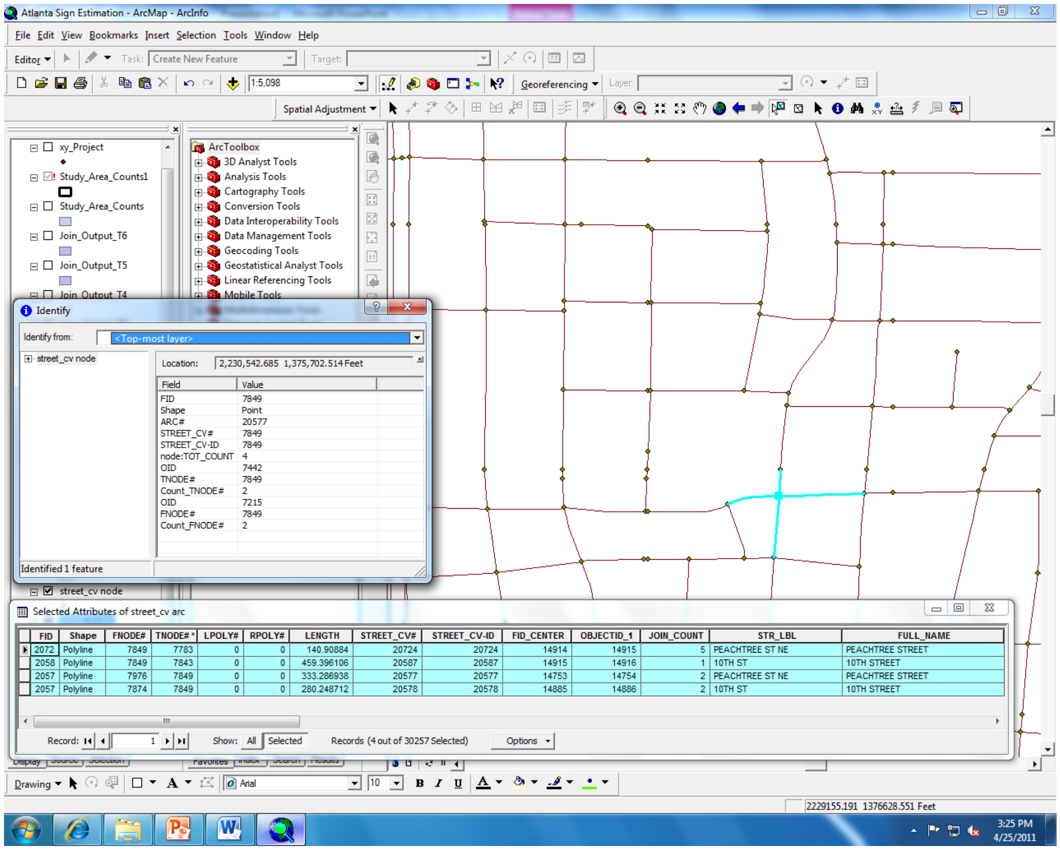


Figure 5.2 Road segments and nodes forming intersections.

Using the spatial join tool, the sample sign data and the intersection data was joined to the grid layer. This gave a sum of the total number of signs in each grid and the sum of the different types of intersections in each grid. The next step was to calculate the road length located in each grid area. The road network was first clipped to our grid area using the intersect tool and then exported as a personal geodatabase feature class. This automatically updated the sum of the length of road in each grid. The clipped road network was then spatially joined to the grids. Once this step was complete, all the necessary data was compiled in one shapefile that could be used in regression. Grids with signs were selected out of the layer and exported as a separate "study area" shapefile. These grids are shown in Figure 5.3.

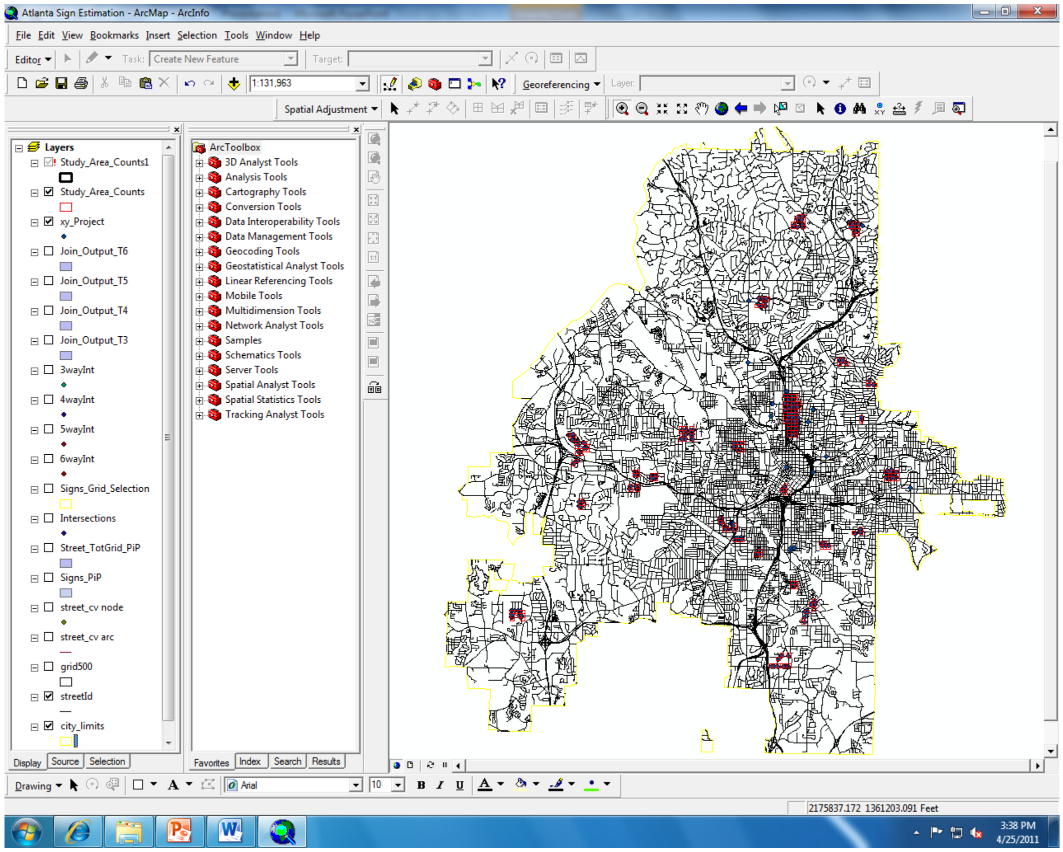


Figure 5.3 Grids containing pilot sign data.

It was then necessary to clean our dataset of extraneous and incomplete data collection. In order to be included in any estimation analysis, grids needed to have complete sign collection data. Some grids caught data that was on the edge of study or sign collection areas. In order to get the best results from our regression analysis, we had to parse through the data to find and delete these signs. This process involved visually inspecting grid areas. It also involved calculating ratios between total signs and total intersections. Ratios lower than the number of intersections were inspected and deleted if necessary. Cleaning the data in this manner allowed for a more accurate regression analysis. This pared our study area dataset to 115 grids out of an original 191. The resulting study area grids can be seen in Figure 5.4.

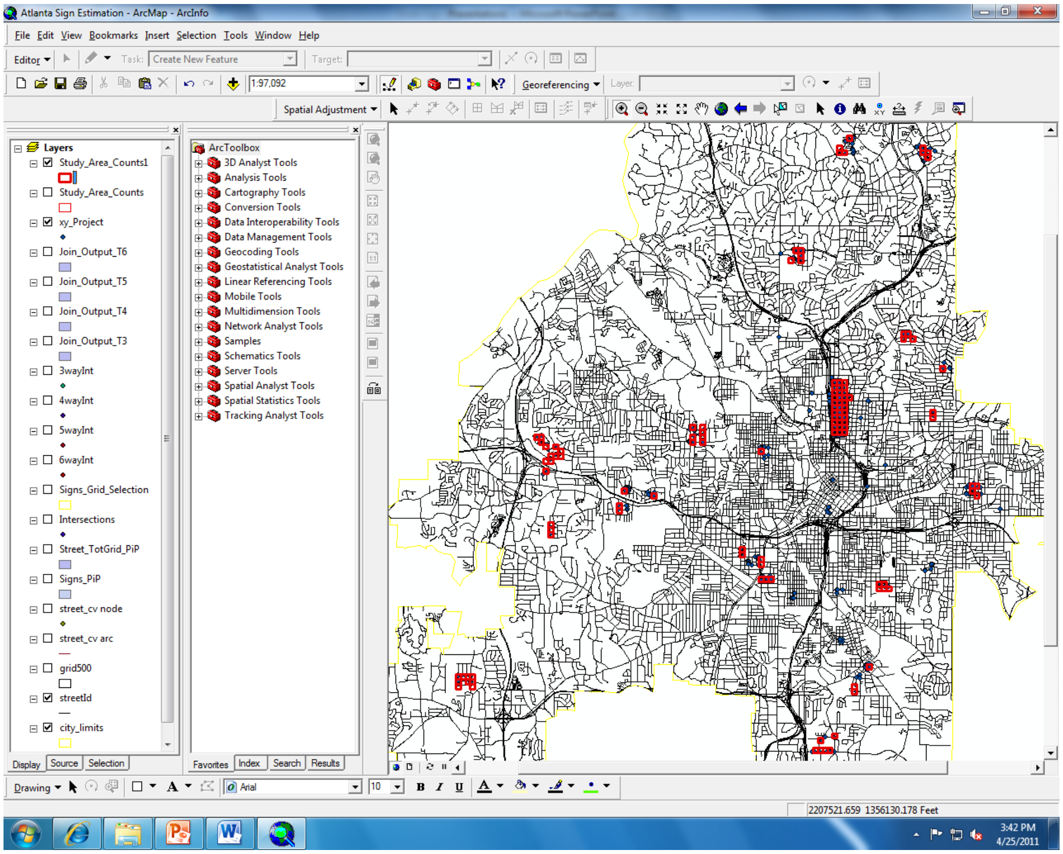


Figure 5.4 Complete study area grids after being cleaned of incomplete data.

After the study area data was cleaned this provided us with a study area data sample to run regression with and a complete Atlanta grid file to apply our regression results for sign estimation. Now that our study area had all of the data necessary attached to it, the data table for the layer was exported into an Excel spreadsheet for analysis. Using the Analysis Toolpak, regression analysis was run to determine the equation to apply to the total area to arrive at our sign estimate. Results of the regression and sign estimation will be covered next.

5.2 Regression Results

For the purpose of our regression, the total number of signs was used as the dependent, or Y, variable. The independent, or X variables, were the number of 3 way intersections, the number of 4 way intersections, and road length. The intercept for all models was set at 0.

We ran two different regression models. The first regression model looked at all the grids combined. The second regression model divided the study area data into two groups based on the sum of road length in each grid. The first model looked at the entire group combined. The results are in Table 1.

Table 1

Regression Statistics	
Multiple R	0.835379653
R Square	0.697859164
Adjusted R Square	0.669211277
Standard Error	3.074523032
Observations	59

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	1222.649255	407.5498	43.11468	1.81723E-14
Residual	56	529.3507449	9.452692		
Total	59	1752			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
3W_Int	0.561476934	0.846232461	0.663502	0.509731	-1.133730391	2.256684258	-1.13373039	2.256684258
4W_Int	3.936095715	1.299119552	3.029818	0.003699	1.33364653	6.538544899	1.33364653	6.538544899
Sum_Shape_	0.003271893	0.000776982	4.211026	9.31E-05	0.00171541	0.004828376	0.00171541	0.004828376

Results from the first regression show a strong Adjusted R Squared value of .65 meaning that 65% of the number of signs is explained by these variables. Coefficient values are all positive indicating that each variable contributes to the total number of signs. All the variables are significant to the 95% level based on the P-value. This means that there is only a 5% chance that we would get these results in a random sample. Based on these results we came up with the equation $Y = 2.247X^1 + 7.871X^2 + .002X^3$, with X^1 equal to the number of 3 way intersections,

X^2 equal to the number of 4 way intersections, and X^3 equal to the length of road. This will be applied to the total Atlanta grid data for an initial estimate.

For the second approach, the data was sorted in ascending order by road length. The first 60 records were selected and represented "low density" Atlanta. The road length divide was reached at 1,379 feet. Regression results can be seen in Table 2.

Table 2

Regression Statistics	
Multiple R	0.824900465
R Square	0.680460778
Adjusted R Square	0.649534769
Standard Error	8.134046113
Observations	56

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	7467.376573	2489.126	37.62128	4.55332E-13
Residual	53	3506.623427	66.16271		
Total	56	10974			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
X Variable 1	4.323532641	2.175661063	1.987227	0.052076	-0.040290823	8.68735611	-0.0402908	8.687356106
X Variable 2	11.20404658	3.239821935	3.458229	0.00108	4.705786712	17.7023065	4.70578671	17.70230646
X Variable 3	0.000160966	0.001980213	0.081287	0.93552	-0.003810837	0.00413277	-0.0038108	0.00413277

The second regression was run on only half the data grids and is considered "low density". The results of this regression show a strong Adjusted R Squared value of .669 meaning that 67% of the number of signs in lower density areas is explained by these variables. Coefficient values again are all positive indicating that each variable contributes to the total number of signs. All the variables are significant to the 95% level based on the P-value. This means that there is only a 5% chance that we would get these results in a random sample. Adjusted R squared and P values are all stronger for this group than when done in the overall regression model. Based on these results we came up with the equation $Y = .561X^1 + 3.936 + .0033X^3$, with X^1 equal to the number of 3 way intersections, X^2 equal to the number of 4 way intersections, and X^3 equal to the length of road. This will be applied to Atlanta grids with a sum of road length less than 1,379 feet and combined with the equation derived for the second half of the data for another estimate.

For the second group, the final 54 records were run through regression and represented “higher density” Atlanta. Results are in Table 3. The road length divide was reached at 1,379 feet.

Table 3

Regression Statistics	
Multiple R	0.81744619
R Square	0.66821828
Adjusted R Square	0.65336503
Standard Error	6.13992659
Observations	115

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	8503.745771	2834.582	75.19045	1.27393E-26
Residual	112	4222.254229	37.6987		
Total	115	12726			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
3W_Int	2.24724538	1.166412373	1.92663	0.05656	-0.063851219	4.55834198	-0.063851219	4.55834198
4W_Int	7.87084677	1.73819967	4.52816	1.49E-05	4.426826939	11.31486661	4.426826939	11.3148666
Sum_Shape_	0.00201779	0.001054703	1.913138	0.058284	-7.19659E-05	0.004107552	-7.19659E-05	0.00410755

The results of this second group regression show a strong Adjusted R Squared value of .649 meaning that 65% of the number of signs in lower density areas is explained by these variables. Coefficient values again are all positive indicating that each variable contributes to the total number of signs. The two sign variables, X1 and X2, are significant to the 95% level based on the P-value. This means that there is only a 5% chance that we would get these results in a random sample. The variable road length, X3, was not significant based on its high P-value. Adjusted R squared and P values are strong for this group with the exception of the road variable. Based on these results we came up with the equation $Y = .4.323X^1 + 11.204 + .00016X^3$, with X^1 equal to the number of 3 way intersections, X^2 equal to the number of 4 way intersections, and X^3 equal to the length of road. This will be applied to Atlanta grids with a sum of road length and combined with the "low density" equation for a total sign estimate.

5.3 Calculating Sign Number

The equations derived from the regression results were then applied to each grid in the total Atlanta area. The Atlanta area grid layer's data table was opened in an Excel spreadsheet. The first estimate was done by applying the equation derived from the regression model for the entire study area. The results for each grid were then summed to reach our first estimate. Based on this equation, the estimated amount of signs in Atlanta was 88,055 signs.

The second estimate applied the two equations derived from the "low" and "high" density regression models to the Atlanta grid. The Atlanta grid was sorted in ascending order based on the sum of road length in each grid. Grids under the dividing distance of 1,379 feet had the "low density" equation applied. Grids over 1,379 feet of road length had the "higher density" regression equation applied. The results of each grid cell were then summed to reach an estimate. This method produced an estimate of 109,481 signs. Much higher than the initial estimate.

Team members conducted a study that compared different methods of collecting sign data. They compared using CityPoints with field collection methods to determine the differences the number of signs collected. Based on their results, 20% fewer signs were collected using CityPoints than in the field. To account for this difference in our estimation we multiplied our final estimate by 1.2. This increased our final estimate to 131,377 signs.

These results can be compared to basic initial calculations we performed on the data using regression and averages for the grids. Initial regression run without properly cleaning the data and without using the road length variable yielded an estimate of just over 65,000. It also had a very low adjusted R squared value. This obvious underestimation of the initial regression showed that the data needed to be cleaned properly and that the road length variable would need to be integrated to capture signs in grids that may not have intersections. This initial attempt served to guide the development of our regression model and strengthen or estimate.

We also did a very basic estimate using the average number of signs for each grid. First we found the average number of signs in each study grid and applied that to every Atlanta grid with roads. With an average of 7.374 signs, this resulted in an estimate of 90,001 signs. Much less than our regression estimates. Breaking our study area into “low” and “high” density areas and calculating averages to be applied yields an estimate of 101,372 signs, still several thousand less than our regression estimates. While this effort was much closer than our initial regression attempt, it still seems to underestimate the number of signs. Another problem with estimates using only an average is that they do not establish any connection or explanation as to why there are that many signs. The regression results provide a better estimate that explains the results and the effects variables have on the estimate. It also allows you to continue to refine the model and search for ways to improve the estimate.

Appendix 1: Complete Street Analysis

CityPoints was initially designed as a fast, efficient way to catalogue street signs using a remote, web-based application. Individuals can use this data to create databases for specific streets or for the purposes of estimating the number of street signs in a larger area. The software's application, however, is not limited to collecting data about signs. Any object visible on Google Streetview or satellite image maps can be spatially located and recorded into a database, allowing this application to be adapted to a variety of other potential uses.

One such use of particular interest to the planning and public works communities is the concept of Complete Streets. Many jurisdictions have enacted Complete Streets ordinances requiring that new or redesigned streets include infrastructure supporting a variety of uses, including walking, cycling, transit, and driving. This requires such components as wide sidewalks with street trees, adequate lighting and other street furniture, safe and well-marked pedestrian crossings, and bicycle and transit infrastructure. Because all of these are visible on Google Streetview and satellite image maps, they be located and catalogued using CityPoints.

In order to explore this potential use, we analyzed existing Complete Streets conditions in portions of the Midtown neighborhood and the Georgia Tech campus. We began by analyzing the conditions on an approximately one-mile stretch of Spring Street between 12th Street and Linden Avenue. This area is known to be largely devoid of Complete Streets infrastructure. It features narrow, broken sidewalks with little furniture, long stretches with limited shade, and nearly nothing in terms of transit or bicycle infrastructure. We then examined Ferst Drive/Fifth

Street from West Peachtree Street west into the Georgia Tech campus, features infrastructure typical of a complete streets setting. It has wide side sidewalks, tree cover, bicycle lanes, street furniture, and trolley stops. Through cataloging the Complete Streets infrastructure in these two areas, we have developed the following list of potential uses and recommendations.

The following images are examples of visualizations of CityPoints data from Midtown Atlanta, including Fifth Street and Spring Street.

Image A1.1: Fifth Street looking east toward Spring Street. This recently developed block includes bicycle lanes, transit stops, street tress, curb extensions, and street furniture.

Image A1.2: Spring Street looking south from 8th Street. This block has minimal Complete Streets infrastructure, with free-flowing automobile traffic being the top design priority.

Image A1.3: Fifth Street at Spring Street. CityPoints provides a quick visualization of Complete Streets infrastructure location and density.

Image A1.4: Spring Street between Ponce de Leon and North Avenue. Gaps in CityPoints data points draw attention to areas without significant Complete Streets infrastructure.

Image A1.5: Spring Street between 8th Street and Peachtree Place. The west side of the street lacks Complete Streets infrastructure and includes potential hazards to pedestrians. All trees on this side of the street are on private property, and are not guaranteed to stay in place in perpetuity. The east side of the street was redeveloped with a new mixed-use development, and includes wide sidewalks, street trees, curb extensions, and bicycle parking

CityPoints can be an effective tool to quickly and efficiently catalog the Complete Streets infrastructure that presently exists in a given area. We were able to catalog more than 250individual items over a stretch of nearly two linear miles of road in less than two work-hours. This provided us with a "big-picture" overview of the existing conditions in the area. This is the principal application of CityPoints to Complete Streets. If a jurisdiction wishes to implement a Complete Streets ordinance or plan and wishes to gain an understanding of present resources, CityPoints provides a way to gather this information in a short amount of time without conducting field work.

For example, we were able to quickly determine the average density of types of Complete Streets infrastructure on both Fifth Street/Ferst Drive and Spring Street. Using the database feature allowed us to sort our points to infrastructure types and create the following table, which shows the higher densities of infrastructure along Fifth/Ferst:

	total	per linear mile
SPRING		
bike parking	3	2.9
blocks with bike lanes	1	1.0
bus stops	1	1.0
signed crossings	28	26.7
unsigned crossings	9	8.6
trees	70	66.7
FIFTH/FERST		
bus stops	4	6.7
blocks with bike lanes	7	11.7
signed crosswalks	14	23.3
bike parking	8	13.3
unsigned crossings	3	5.0
trees	78	130.0

Table A1.1: Average densities per mile of Complete Streets infrastructure

Obviously, implementing any sort of street modifications would involve detailed on-site survey work. CityPoints, however, is a tool to with a different resolution that is most useful at a different point in the planning process. It provides an up-front way to broadly visualize which areas are strong and weak when it comes to Complete Streets infrastructure. This information has the potential to inform estimates of additional infrastructure requirements.

We also note that while it is possible to estimate the number of street signs in a large area by collecting a small sample and extrapolating data through statistical analysis, Complete Streets data does not transfer well from one area to another. Street signs have been implemented based on a uniform regulatory framework, while Complete Streets infrastructure has been created in many cases through *ad hoc* or piecemeal efforts, meaning that there is no guarantee of consistency from block to block. As an example, stretches of Spring Street with almost no Complete Streets infrastructure are located less than a quarter-mile from the relatively infrastructure-rich sections of Fifth Street.

Appendix 2: Data Collected for Urban Block

Sign Num	Signage description	GPS reading		Google Streetview: student A		Google Streetview: student B	
		Longitude	Latitude	Longitude	Latitude	Longitude	Latitude
1	NO PARKING	-84.3919900150609	33.7598583368609	-84.391910234449	33.759825491577	-84.391045704265	33.759822141301
2	NO PARKING	-84.3919670917569	33.7601138351225	-84.392018124803	33.760157120506	-84.391297844204	33.759830929581
3	NO PARKING	-84.3920102404522	33.7603351870682	-84.392025769317	33.760398912649	-84.391686657642	33.759820475574
4	NO PARKING	-84.3919676539943	33.7606281792787	-84.392019720778	33.760672208655	-84.391910929429	33.759823812739
5	ONE WAY	-84.3919479903064	33.7608722114701	-84.392018053635	33.760892393213	-84.392013238385	33.760904078891
6	Centennial Olympic Park dr	-84.3919479903064	33.7608722114701	-84.392018053635	33.760892393213	-84.392013238385	33.760904078891
7	Harris st	-84.3919479903064	33.7608722114701	-84.392018053635	33.760892393213	-84.392013238385	33.760904078891
8	NO PARKING	-84.3914847233135	33.7610726851331	-84.392508240971	33.761137521176	-84.391602729127	33.760915371528
9	NO PARKING	-84.3912236769259	33.7609558587025	-84.391224296352	33.760927269131	-84.39122965785	33.76092006491
10	ONE WAY	-84.3912236769259	33.7609558587025	-84.391224296352	33.760927269131	-84.39125135129	33.760921584267
11	Interstate Route Sign	-84.3912236769259	33.7609558587025	-84.390872731232	33.760934168004	-84.390840967697	33.760920906607
12	Interstate Route Sign	-84.3908070164027	33.7610889430971	-84.390872731232	33.760934168004	-84.390840967697	33.760920906607
13	Harris st	-84.3906651922208	33.7610801757244	-84.390683597424	33.760890605724	-84.390691107512	33.760957907078
14	Do not block intersections	-84.3905986450125	33.7598492168504	-84.390642976979	33.759780877621	-84.390661058852	33.7597679821
15	No left turn	-84.3906568405391	33.7607665056273	-84.390626169136	33.760566565743	-84.390639636688	33.760552806809
16	No left turn	-84.3905986450125	33.7598492168504	-84.390642976979	33.759780877621	-84.390661058852	33.7597679821
17	NO PARKING	-84.3910198908587	33.7598677273272	-84.391045083439	33.759821736208	-84.39201740935	33.760155702381
18	NO PARKING	-84.39124663455	33.7597363390134	-84.391298399695	33.759832636999	-84.392013325096	33.760428509658
19	NO PARKING	-84.3916514859293	33.7597212723317	-84.391686173256	33.759822627732	-84.392005046932	33.76069597674
20	Williams st	-84.3905986450125	33.7598492168504	-84.390642976979	33.759780877621	-84.390661058852	33.7597679821

Section 1: Introduction

What you will learn in this section:

- ✓ Introduction
- ✓ Applications for this program
- ✓ Description of program features

Introduction

Congratulations on your purchase of CityPoints, advanced infrastructure mapping database tool! The following sections will provide you with all of the necessary information to get started using this tool right away. This manual will provide step-by-step instructions to optimize your data collection experience. We will conclude with a tutorial that allows users to identify and catalogue actual infrastructure!

Applications

PURPOSE: This program is designed to streamline on-the-ground data collection efforts from any remote location identifiable by Google's Street View application.

BENEFITS: CityPoints minimizes the need for field-based data collection efforts, saving time, effort, and money. There is no need for transportation to sites or expensive GPS units. Data collectors can work indoors from any location at any time regardless of weather conditions. All you need is an internet connection!

FEATURES: The main interface of the program is used for locating and cataloguing data points. It features Google street and satellite views from which the data collector may accurately locate infrastructure or any other item of interest. Additionally, this interface includes an address locator, geographical coordinates, and various infrastructure categorization menus, with features that allow data entry, updating, and deletion of data points. CityPoints also has the ability to identify the current location of users for use on mobile devices in the field.

Description of Features

CityPoints is highly accurate given the advanced latitude and longitudinal system used by Google. It also allows users to defer the purchase of GPS units. Google provides a highly accurate standardized coordinate system which may not be achieved using some commercial GPS units. Once infrastructural items are identified, they may be "Submitted" and stored cleanly in the database. The database may then be exported for use in programs such as Microsoft Excel, Microsoft Access, and various Geographical Information Systems (GIS) software programs.

Section 2:
Getting Started

What you will learn in this section:

- ✓ Components of the Tool
- ✓ How to Use this Program
- ✓ Troubleshooting

Components of the Tool

In order to maximize the efficient use of the program, a brief introduction of the components and their utility is provided to help you get started.

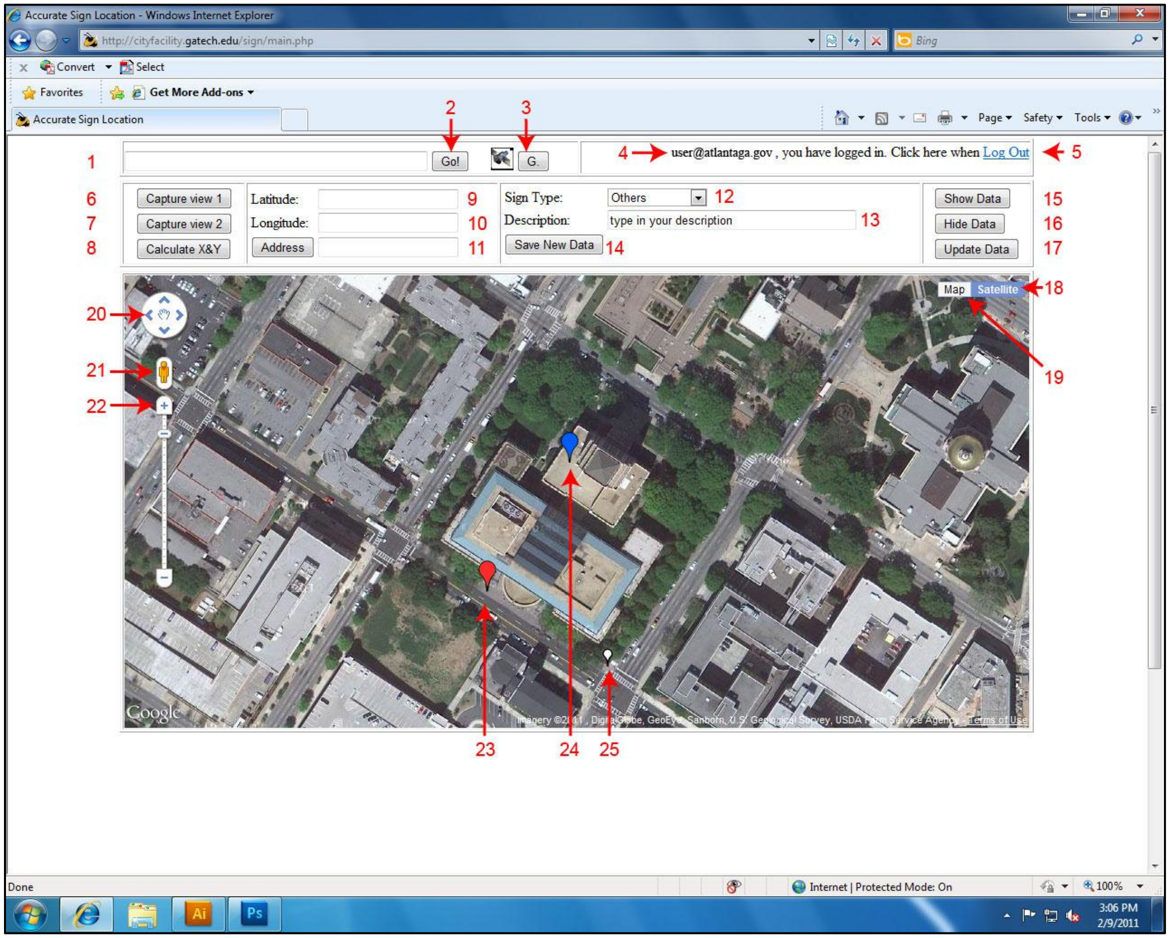
1. **Active Address Search Bar** - When beginning your search, this is where you can enter your location address, street name, or street intersection.
2. **Go!** - Click this button after inputting address into the Active Address Search Bar
3. **G.** - Located next to the satellite image, this button marks your current location on the map. This button is for portable GPS devices.
4. **Username** - This shows which user is logged into the program.
5. **Log Out** - Click here when you are finished with you session and would like to close the program.
6. **Capture View 1** - Takes a picture of the item of interest (must be done in Street View).
7. **Capture View 2** - Take a second picture of the item of interest (must be done in Street View). In order to maximize the effectiveness of the "Capture View" buttons, make sure "View 1" and "View 2" are captured from two different angles.

8. **Calculate X & Y -** Calculates the X and Y coordinates of the item of interest only after "Capture View 1" and "Capture View 2" have been logged using the Street View perspective.
9. **Latitude** - Displays the latitude of the current pin location.
10. **Longitude** - Displays the longitude of the current pin location.
11. **Passive Address Bar**- Displays the address of the current pin location.
12. **Sign Type** - Drop-Down field housing the different categories of street signs from which you can choose.
13. **Description Field** - Drop-down field housing each specific sign within the sign type category.
14. **Submit Data** - Click this button when you have entered both street view (Capture view 1 & 2) and click "Calculate X & Y", and the information will be saved in the program's database.
15. **Show Data** - Click this button to show the data points already loaded into the system.
16. **Hide Data** - Click this button to hide the data points previously entered into the system.
17. **Update Data** - When updating the latitude and longitude coordinates, or when updating the sign description, click this button after you complete your edits in order for the system to store your changes.
18. **Blue Pin** - Current data point with which you are working.
19. **Red Pin** - Previously entered data point with the full description being shown in fields (include field letters).
20. **White Pin** - Previously entered data point. Click the pin to make it red and display information about the data point.

Google Maps Functionality Buttons

21. **Map** - The map display shows the streets and buildings, like you could find on a map.
22. **Satellite** - The map display shows a satellite image of the area you are currently viewing.
23. **Labels** - This button appears when the satellite view of the map is selected. Check the box next to "Labels" in order to view streets and their names in the satellite view.
24. **Terrain** - This button appears when the "Map" view of the map is selected. Check the box next to "Terrain" to display topographic features of the area you are currently viewing, with street names superimposed over the topographic image.
25. **Pan Arrows** - Click these arrows to move the map up, down, left or right.
26. **Zoom Bar** - The zoom bar can be adjusted to zoom in or out in satellite view.

27. **Street View (Golden Man)** - Drag the Golden Man to the area of interest to see the street view. Click the white arrows to switch to different camera angles. Drag the “N” button on the top left corner to change orientation. Click the cross on the top right corner to exit Street View.



How to Use the Program

Using Satellite Image

- Click “Satellite” button on Google Map
- Use “Zoom Bar” to enlarge the satellite map
- Drag “Blue Pin” to interested area (ex. a traffic sign)
- Latitude and longitude data will update automatically
- Click “Passive Address Button” to display the address of current pin location
- Select “Sign Type” and “Description” from the drop-down menu
- If “Others” is chosen for “Sign Type”, enter your description in the blank field
- Click “Save New Data” button to submit the data
- A window will appear saying “Data inserted”
- Click “Show Data”
- A white pin will appear and indicate the location of this traffic sign

Using Street View

- Click and hold the Golden Man on the zoom line and drag him to the view you want on the map
- Use street arrows to move down the street and locate a sign
- When you find a sign you would like to input, move the red line in the middle of the image so that it aligns with the sign
- **Note:** Always use the closest camera locations to the object you are capturing when entering data using street view
- Click “Capture view 1”
- Click the appropriate arrow on the street to go to the opposite side of the sign

- Rotate until you see the back side of the sign and align the red line in the screen so it aligns with the sign
- Click “Capture view 2”
- Click “Capture X&Y”
  - Latitude, Longitude, and Address automatically populate
- Select sign type from the drop-down menu
- Select description from the drop-down menu
  - **Note:** If “Other” is chosen for the sign type, you must enter a description into the field manually
- Click “Save New Data” button to submit the data
  - A window will appear saying “Data inserted”
- Click “Show Data”
  - A white pin will appear and indicate the location of this sign

Using Satellite Image

- At the center of the intersection there will be multiple arrows
- Each arrow will include the name of the road it corresponds with
- When you are entering a sign, use camera locations from the same side of the intersection on the same street
- **Note:** To ensure the greatest possible accuracy, do not use the camera position in the center of an intersection when entering data points

Updating Data: Changing the Attribute

- Click “Show Data”
- Select a data point by clicking one of the white pins

- The selected pin turns red
- Information will automatically populate
- You can change the sign type and description if necessary
- Click “Update Data”
- A window will appear saying “Data updated”

Position Adjustment

- **Note:** Do not use street view for position adjustment, use the satellite image
- Click on the White Pin you would like to adjust
- The pin will turn red
- Click and hold the Red Pin and a Blue Pin will appear
- Drag the Blue Pin to the appropriate location
- Click “Update Data”
- A window will appear saying “Data updated”
- Click “Hide Data”
- Click “Show Data”
- The Red Pin of the data point that was entered incorrectly will disappear and the White Pin will show at the new location

Deleting Data

- Click on a White Pin
- Change the numbers in the Latitude and Longitude fields so that they read as "0"
- Click “Update Data”

- A window will appear saying “Data updated”
- The database administrator will delete the entry on the back-end

Troubleshooting

What do I do if the street sign is hanging above the intersection?
Put the data point at the base of the pole as shown in picture.

What if there are multiple signs on one pole or in the same location?
Keep the data point in the same location but just change the Sign Type and Description before clicking the Save New Data button that creates a new entry in the database.

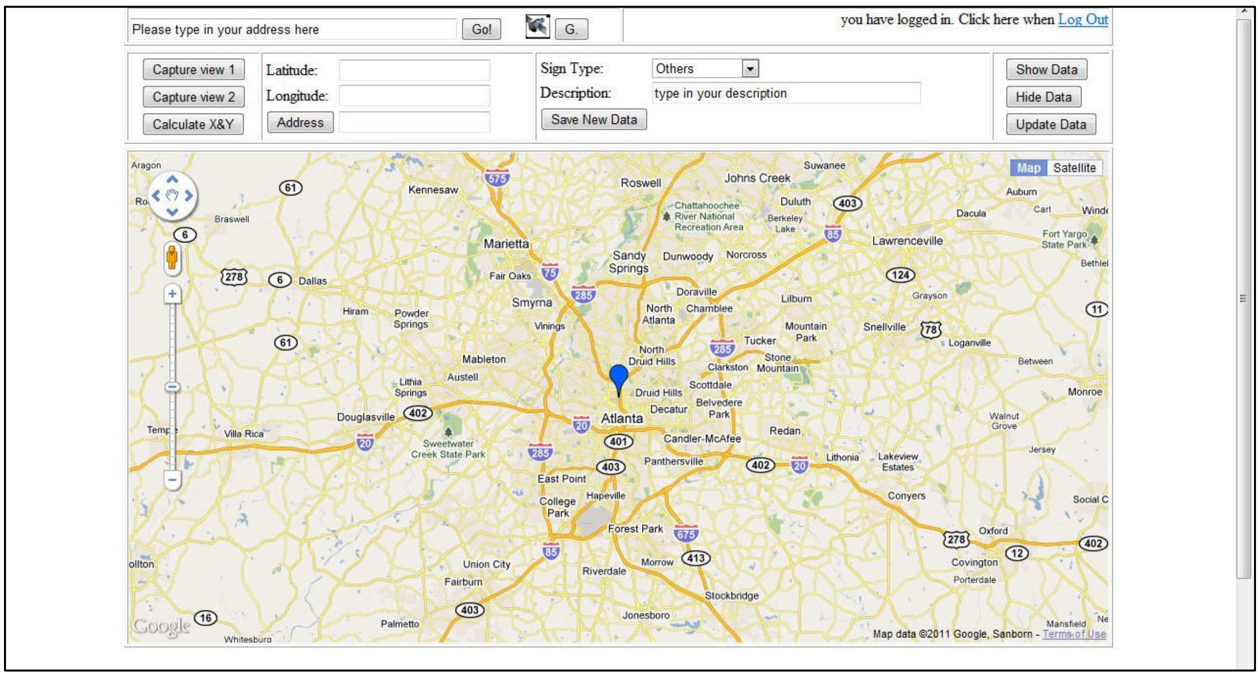
Why can I not click the “Terrain” button under the “Map” view of the map?
Simply move the Blue pin to a different location to enable the “Terrain” function.

Section 3: Tutorial

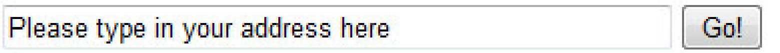
What you will learn in this section:

✓ Walk-Through

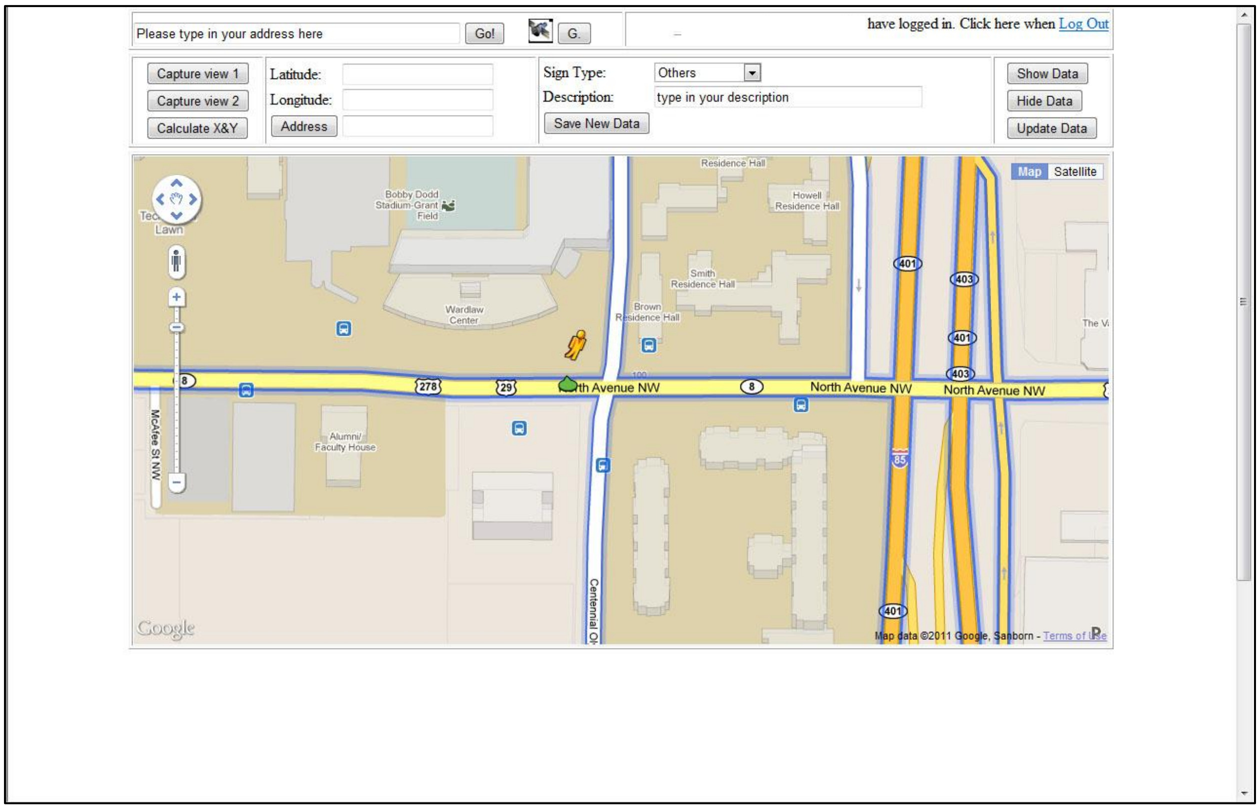
Walk-Through



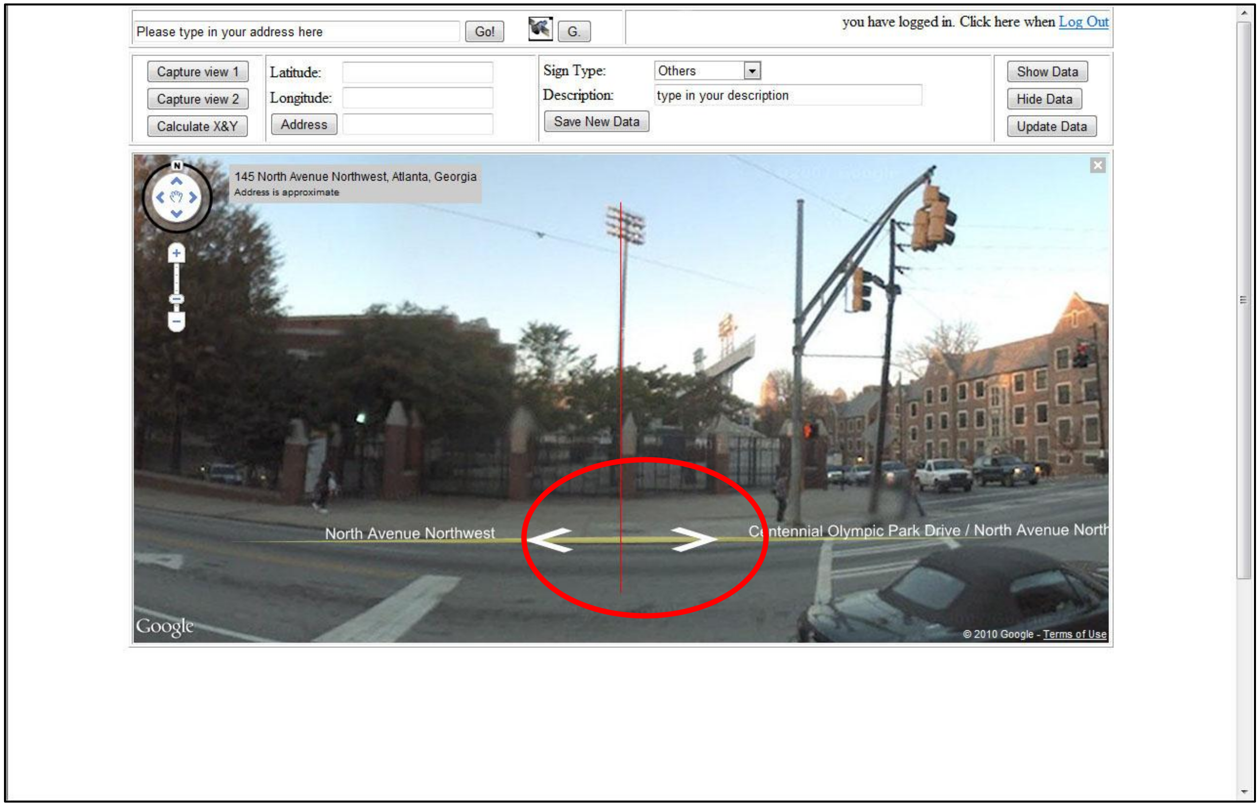
1. Open CityPoints database at http://city facility.gatech.edu/sign/main.php
2. Log-in with username and password supplied by a system adminstrator.
3. Determine a location of interest and either pan to that location or type in the address in the dialog box shown below.



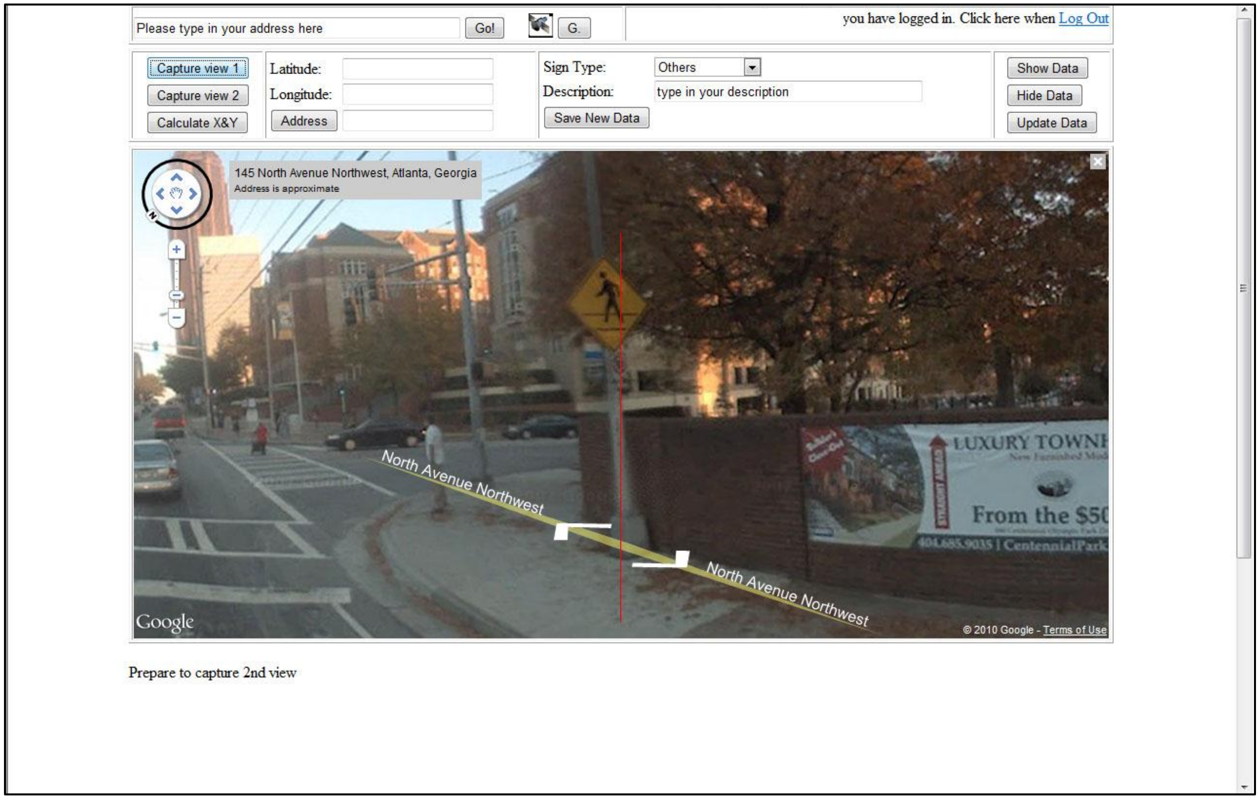
4. Click and hold the street view "gold man" symbol and drag it to the desired location. Wait until a green pin appears under the "gold man" symbol and release it.



5. Once in the Street View you will see a vertical red line in the middle of the screen accompanied by two white arrows with the name of the street.
6. To locate sign or item of interest, use white arrows along the street to move forward or backward and click and hold the screen to rotate your view.

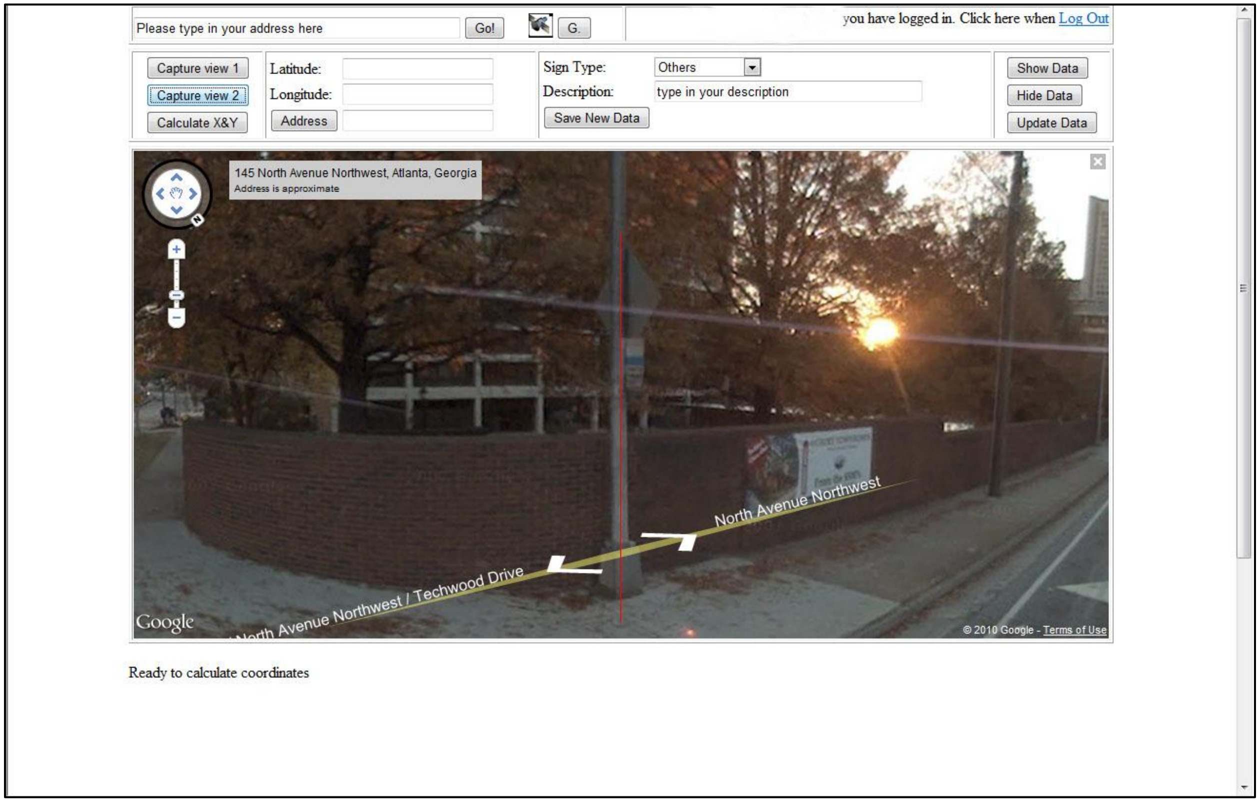


7. Once you have located the sign or item of interest you would like to catalog, find the view closest to that item and place the vertical red line over the sign.



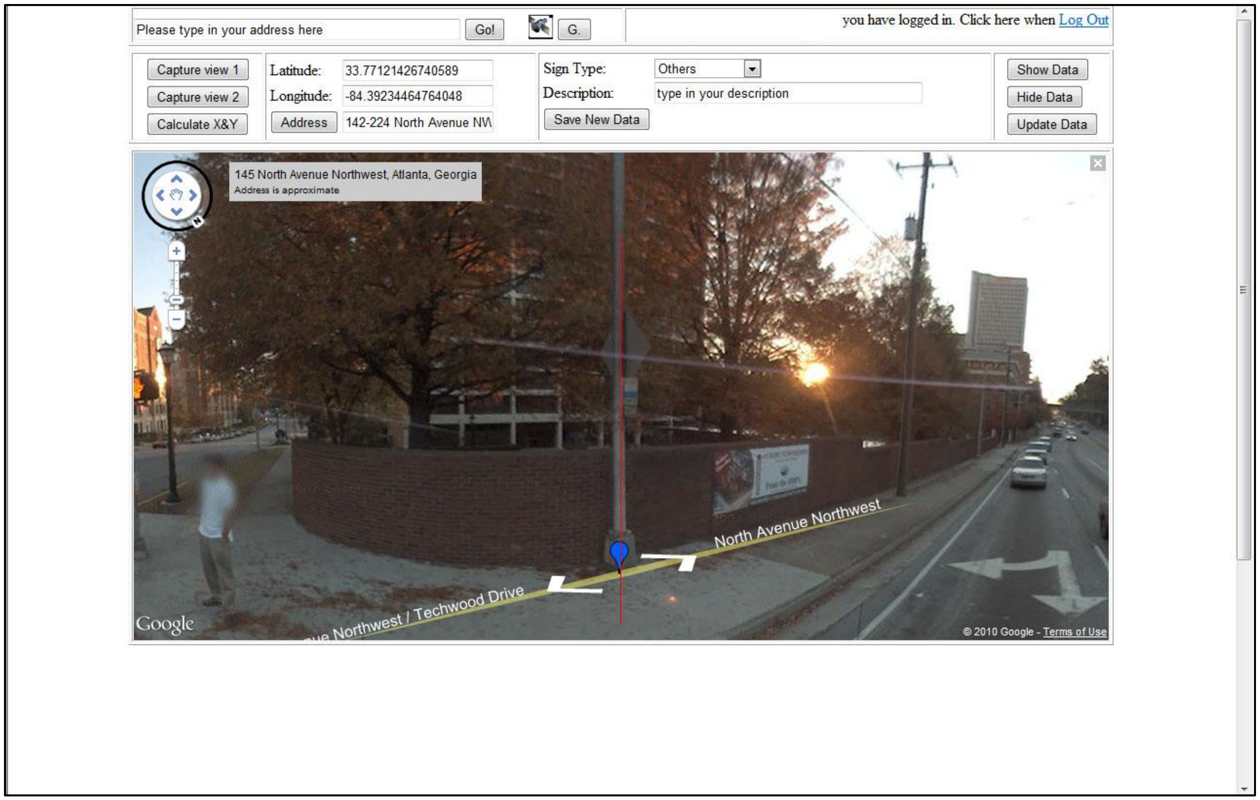
8. Now click "Capture View 1".

9. After capturing the first view, click the white arrow again to move past the sign and move the camera view to realign the vertical red line with the sign from a different angle. If possible, use closest camera option to the item of interest.



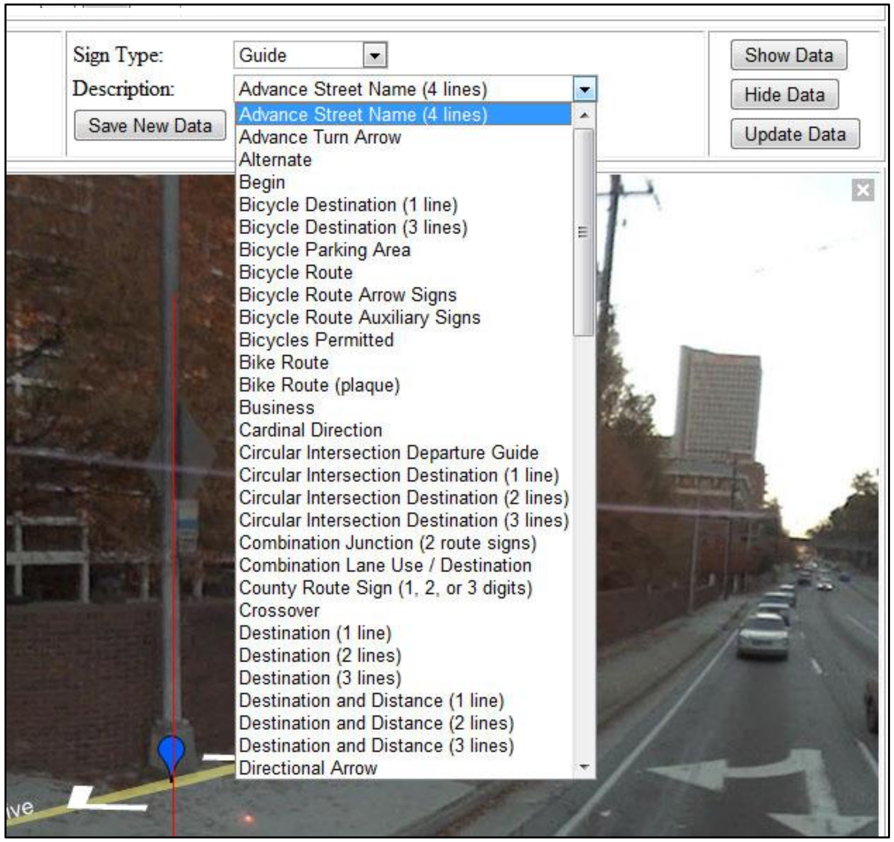
10. Now click “Capture View 2”. The application triangulates the coordinates of the sign.
11. Now click “Calculate X&Y” to calculate the latitude and longitude of the item on interest.

12. A Blue pin should appear. DO NOT MOVE IT MANUALLY, even if the Blue pin does not exactly lie on the sign, as this will reduce the accuracy of the coordinates.



13. Select the sign type from the drop-down menu listed as "Sign Type."

14. Click the drop-down menu for "Description" and select the exact sign being catalogued. **Note:** if "Other" is chosen for the Sign Type, you must enter the description manually.



15. Click the "Save New Data" button to enter the sign into the database.

16. Clicking the "Show Data" button will ensure that the data has been catalogued. A window will appear saying "Data Inserted" and a white pin should show up at the base of the sign or item of interest.

To Update an Item of Interest

1. Click “Show Data”
2. Select a data point by clicking one of the white pins
3. The selected pin turns red
4. Information will automatically populate
5. You can change the sign type and description if necessary
6. Click “Update Data”
7. A window will appear saying “Data updated”