11-19-2015

Utilizing Web-Based GIS Applications for Spatial Analysis of Real Estate Appraisal Data

Esther Bowlin

Utilizing Web-based GIS Applications for Spatial Analysis of Real Estate Appraisal Data

Esther Bowlin

University of Denver Department of Geography

Capstone Project

for

Master of Science in Geographic Information Science

November 19th, 2015

Table of Contents

Abstract

Internet-based map applications have become a widely implemented GIS tool, and by most estimations, will experience continued growth over the coming years. The real estate industry is particularly well positioned to capitalize on the boom of web mapping technologies as real estate is a largely spatial discipline. To fulfill the marketing objectives of a real estate appraisal firm, a web-based mapping application was developed to execute simple spatial analysis tasks. The application is capable of analysis tasks such as heat mapping and includes geolocation services as well as coordinate conversion. All processes are executed within the Google Map API and are presented on the client's web page. The application utilizes open source technologies that are not constrained by the what-you-see-is-what-you-get model common with large GIS vendors.

Introduction

Traditionally, a GIS is composed of complex proprietary software that is designed for networked use by GIS professionals on desktop computers. The Environmental Systems Research Institute (ESRI) defines a GIS as an information system that allows the user to "visualize, question, analyze, and interpret data to understand relationships, patterns, and trends" (ESRI 2015). Traditional systems are capable of sophisticated cartographic and spatial analysis processes, but require a significant financial investment in personnel training and software/hardware acquisition. A networked enterprise system requires extensive hardware and software implementation, an established secure network, and a robust content management system. Experienced IT and GIS personnel are also required to implement and manage the system. A well-established company-wide GIS may also require management staff be assigned to supervise the operation of the GIS and GIS staff. Changes to the workflow within an established GIS often requires careful implementation planning and execution. In an effort to control quality and continuity, some businesses delay in integration of new technologies into an established GIS. This makes upgrading technologies or adopting more sophisticated techniques a time consuming process.

Although a business may benefit from the implementation of a GIS, these requirements create a financial obligation leading some small companies to forego a GIS due to budgetary constraints. Furthermore, businesses not

familiar with GIS technology are often unaware of the advantages associated with the incorporation of spatial analysis techniques. The unwillingness to explore new methodologies in established workflows may further slow the progression of GIS into non-traditional industries.

In response to the traditional investment-heavy GIS model, open sourced web GIS has emerged in both the public and private sector allowing users access to spatial data manipulation tools through web applications. An internet-based system circumvents proprietary software, grants universal access to cartographic processes and escapes the financial investment of a traditional GIS. Many internet-based systems utilize a wizard to guide users through complex spatial analysis tasks thus further reducing the need for specialized training. A wizard is an automated process that provides the user step-by-step instructions to execute a task. Although the use of a wizard creates a what-you-see-is-what-you-get (WYSIWYG) development environment, the process requires no background in GIS or computer programming. The WYSIWYG model results in a limited development environment in which the user may select from pre-developed tools and map components. The selected components are then integrated into the application through automated processes in the Application Program Interface (API)s source code. Eliminating the need for code manipulation is a significant advantage of a WYSIWYG. These pre-built application development environments are often supplemented with support

documentation and user guides to further assist the developer and moderate the technical complexity of the build process. Additionally, developer networks and forums such as StackExchange and even YouTube channels offer question and answer pages and instructional videos respectively. Due to the intuitive design and extensive support environment, training costs for staff are reduced and easily managed. This is a significant advantage to small businesses or individuals unable to hire or consult GIS professionals during development.

To capitalize on the trend of web GIS ESRI, an industry leader in desktop GIS software, has developed a WYSIWYG environment for subscribers to create web maps in a pre-developed interface (figure 1). ArcGIS for Developers is a specialized service created by ESRI in which users may gain access to limited ArcGIS functionality in a web GIS environment. A subscription program allows user access to additional ArcGIS processes resulting in an effective GIS development environment. Other large vendors such as Google have adopted a similar approach to the distribution of GIS technologies and have created user friendly wizard environments for novice developers. The functionality of the Google environment is somewhat more limited than that offered by ESRI and requires a basic level programming skill to implement effectively.

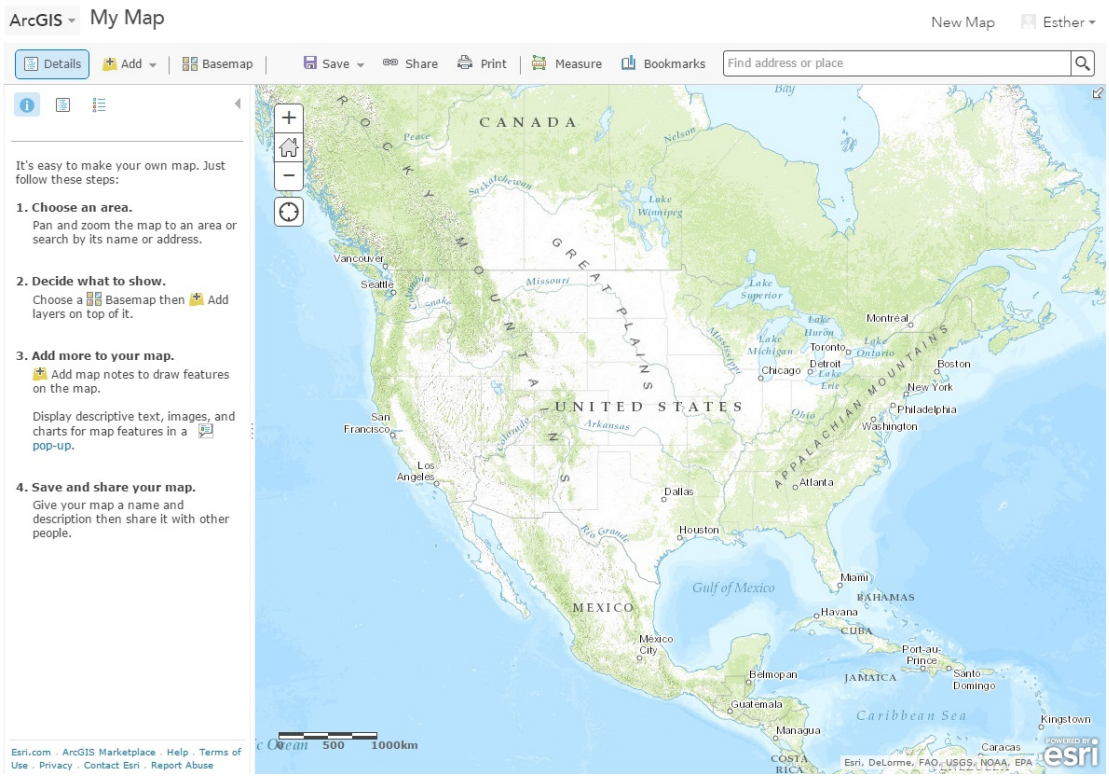

Figure 1. WYSIWYG mapping application developed by ESRI. Source: ESRI.

Unfortunately, a considerable disadvantage exists within the WYSIWYG model. In pursuit of an intuitive, novice-friendly development environment, many internet-based GIS applications are severely limited in functionality. A typical web GIS will allow the user to select from pre-built basemap templates and incorporate limited datasets. Little to no spatial analysis functionality is offered for the datasets making visualization the only useful aspect of the system. Applications that allow for analysis functions often require the user to incorporate code snippets which the user may not be familiar with. The analysis tools are often pre-developed by the application provider and made available to users within developer networks. This creates a difficult development environment for users not experienced in

programming techniques. The incorporation of a new open sourced technology, even an intuitive WYSIWYG, across a large user group also creates a considerable challenge. If a GIS workflow is already established within a workgroup, adopting an open source technology will require the development of standard operating procedures, quality control measures, and training efforts. Furthermore, ensuring the new technology is utilized in a uniform fashion requires an investment by managing and supervisory staff, thus offsetting the benefit of the simplified user environment.

The limitations of the WYSIWYG model, however, create a niche for GIS and web developers who are capable of creating custom web applications that feature GIS functionality. Custom functionality is a substantial benefit for small businesses who may be willing to hire a short term developer to create an application and prevent the need for full time GIS staff.

Since their inception in the early 2000's, internet mapping and web GIS systems have become sophisticated and have begun augmenting the traditional desktop model (Thrall 1998). Most systems include core functionality including data visualization, data layer manipulation, map templates and basic filtering. These simple analysis tools allow the user to manipulate data and create professional grade applications with little to no prior experience. Eliminating the need for software expertise has also allowed non-traditional GIS users to incorporate GIS tasks into their research, workflows, and public web interfaces. Widening the audience from

traditional desktop users to non-traditional internet users has led some industries to integrate GIS into their business and marketing strategies.

The real estate industry, traditionally not engaged in GIS processing, has begun incorporating the technology and by many estimations has benefited from its application. The process of property valuation is particularly well suited to the implementation of GIS as value is largely dependent on geographic location and proximity to services. "The geographic location of a house determines access to employment, shopping and recreation; neighbors and neighborhood characteristics; proximity to environmental amenities; and the level and quality of public services" (Can 1998). A GIS may be utilized to create property maps, asses risk, determine property value, identify trends in valuation, and provide a structured database or content management systems to organize existing property attributes. The spatial and statistical analysis capabilities of a GIS are also useful to real estate appraisers as value estimates may be generated through modeling rather than on-site visits. Valuation models can be developed within a web-GIS that identify regions with the highest number of desirable attributes. The proximity of a property to these desirable areas assists in the valuation process and may be easily managed within a GIS.

In real estate applications, the usefulness of a GIS may be further increased by creating a web based GIS application that is capable of receiving imported property data and applies analysis functionality to that data. Due

to the restricted functional capabilities of a web-based application, only limited training and external software are necessary for operation. Most training can be conducted "in-house" with resources made available by the application's vendor. This serves as a cost cutting measure for real estate firms that are unwilling to invest in infrastructure or training.

One real estate appraisal firm that has opted to integrate a custom GIS application into their business model is Appraiser Matters, LLC. The company, referred to hereafter as the client, has invested in the development of a web based GIS application in the interest of advertising appraised properties and executing basic spatial analysis functions. The client's business is headquartered in Richardson, Texas and conducts property valuation primarily in Dallas. The company focuses on commercial real estate appraisal but seeks to represent appraisal firms in the industrial and residential sectors. The business also facilitates the hiring of appraisal firms by customers in the residential sector. By offering a web mapping feature within their website, the client intends to make the application's functionality available to other appraisal groups.

The application specifications outlined by the client include a user form for data submission, a map for display of appraised properties, geocoding, and a method for displaying the value of properties as it varies based on spatial location. The client intends to make the application available to its customers as part of a membership plan. Customers will access the application via the

client's website which will be password protected and require user credentials. Customers may then carry out all spatial and data entry functions made available by the application. The membership plan will serve as a revenue generator and advertisement service for the client.

The application was designed to execute the following workflow. The client or the client's customers access the application from the client's website. The website's functionality is minimal and features only a basemap and user form. Appraised property attributes are entered manually by the user in the user form. Form fields are controlled for the correct input to prevent the user from entering incorrect data types. The form allows for the mapping of multiple properties on a single basemap. Relevant property attributes include appraisal date, location, appraised value, appraised condition, and property type. The user data are submitted through the user form to the database and retained on a secure server.

Geocoding is used to convert property addresses to coordinate points on the map display. Heat mapping is incorporated to evaluate regions with high property value by mapping each appraised property based on its proximity to desirable services. Currently, the coordinates of services and properties are hard coded into the application's source code. Future development will allow for user input to be displayed in the heat map. Services of interest include shopping centers, recreation opportunities, and major employers. This workflow allows the client and customers to interactively view and

display property data as well as make that data available internally and to external interests.

Although the success of websites such as Trulia and Zillow have brought a boom of internet mapping utilities to the real estate market, few real estate appraisal firms have made mapping capabilities available to their customers. By developing a custom, interactive application hosted on the client's website, the client will grant customers greater control over their spatial data. The customers may then pass that knowledge onto their respective customers. The mapping application seeks to bridge the gap between GIS and real estate professionals by bringing quality spatial analysis and analytical capabilities to a web application which may be easily deployed on a commercial website.

Literature Review

GIS and Internet Mapping

The integration of new technologies into established workflows is a deliberate and extensive process. The application development industry has been slow to integrate web mapping technologies into publically accessible APIs due to the proprietary nature of most GIS systems. Although the enormous potential for web mapping services was recognized in the early 2000's, only major companies such as Google and Yahoo were willing to investigate the utility of web mapping as a component of their browser services (Boulos, 2005).

One of the first exploratory studies to determine the feasibility of web mapping systems was conducted in 2002 by Alesheikh et al. The authors cite the high cost of a traditional GIS, system-specific databases and software development costs as significant disadvantages to the desktop GIS (Alesheikh et al. 2002). The study analyzed the GIS capabilities of eight major web mapping companies and compared their products to those rendered by traditional GIS software. The authors also created a project implementation plan for the dissemination of road networks in Iran using only web mapping technologies. The study used similar implementation planning strategies to those required in the development of a traditional GIS. Implementation steps included hardware/software evaluation, system integration planning, conceptual design and database design. Utilizing this planning method, the authors developed a successful web mapping application with suitable analysis and data display functionality. Although application development was considered successful, several disadvantages were cited such as unreliable internet connectivity in the study's host country, and excessive data processing times.

In 2005, a seminal article published in the United Kingdom by Maged N Kamel Boulos demonstrated the potential for web mapping applications in the healthcare industry. The author utilized and compared three

web mapping applications, Google Maps API, Google Earth, and MSN Virtual Earth, to develop maps of healthcare services throughout the country. Each application interactively displayed the location of healthcare providers and the services offered by each provider. The success of the project led the author to speculate as to the relevance of proprietary software such as ESRI's ArcGIS. The author also cited ESRIs incorporation of satellite imagery and street-view mapping to their MapMachine services as a direct response to Google Earth and MSN Virtual Earth. Although the president of ESRI identified web based applications as the "future" of GIS, the company was slow to join the open source movement (Boulos 2005).

Contrary to the results of similar studies, the author identified the complexity of the APIs as a disadvantage. The study was conducted in 2005 after the initial launch of Google Maps and this early time frame may explain the discrepancy in opinions regarding usability. Later studies found the APIs to be user-friendly and not requiring a knowledge of programming or GIS techniques. Improvements on the user interface and changes to the services provided by the APIs likely accounts for the differences in usability.

In addition to the concerns above, the author also explored issues relating to data privacy and security. "As geospatial technology progresses and becomes more readily available to the wide masses

around the world who are connected to the Internet, the interrelated issues of GIS and map data confidentiality/individual privacy, and even national security start to surface, calling for further examination of, and research into these delicate aspects of Internet GIS and Web maps" (Boulos 2005). Issues relating to privacy are important in the implementation of a GIS and should be carefully mitigated through secure servers and privacy measures.

A later study in 2008 by Edwin Chow at the University of Michigan sought to explore the potential and limitations of mapping APIs by evaluating raster and vector data through the Google Maps API platform. The term, maps API, was coined to describe all internet-based web mapping applications that brought basic GIS functionality to the user through a graphical user interface (GUI). A maps API is defined as the source code necessary to access program libraries developed without service requests (Chow 2008). Although these applications were developed, tested, and launched concurrently, the first major application to be introduced to the public was Google Maps. Since its inception, Google Maps has become the standard-bearer in the web mapping industry against which many other maps APIs are measured. The study aimed to establish whether or not the Google Maps API would provide the necessary tools to evaluate traditional cartographic data outside of proprietary GIS software. Urban sprawl in

Michigan was utilized as a case study and basic spatial analysis techniques were applied within the application.

The authors found the web mapping API to be a suitable solution for restricted data exploration. Major benefits included the free and open sourced formatting, code-driven and wizard-driven programming options, and the ability to explore data with no formal training in GIS principals. Disadvantages included lengthy data processing time and limits on data analysis functions and manipulation. Extensive data processing time was required for the large geographic markup language (GML) text files that were integrated into the application. The limited analysis functionality was also discussed as a major disadvantage as much of the application's services were focused on data display. "The built-in classes of existing Maps APIs lack much spatial and analytical functionality essential in the "traditional" Internet Mapping Services (e.g. ESRI's ArcIMS). Currently, the built-in classes offer limited spatial operations such as distance calculations between two points and routing" (Chow 1998). At the time of the study, extensive coding on the part of individual developers would have been required to augment the analysis functions within the application.

These studies illustrate the common and persistent challenges associated with internet mapping. Although global accessibility is a significant advantage of the web mapping methodology, the nature of

data transfer protocols produces challenges in processing time. Internet connections capable of high speed data transfer are necessary to perform analysis tasks within web applications thus limiting the availability of the applications to remote or poorly connected communities. Additionally, the limited capacity for internet-based maps to include complex spatial analysis tasks ensures a market for proprietary desktop GIS vendors such as ESRI, Trimble, and Hexagon Geospatial. Advanced analysis tools must be developed outside the maps API and incorporated into the source code separately. This type of code integration requires the expertise of a software developers and is often cost prohibitive for the average user. However, studies indicate that investment by major companies such as Google in the development of internet mapping products has spurred rapid innovation. Lastly, privacy concerns should be carefully weighed and mitigated in the development of GIS applications. The publication of private data is a sensitive issue and is strictly prohibited by a number of laws. Copyright issues may also arise in the creation of a web GIS and must be considered during the development process.

GIS and real estate

Real estate is a spatially driven and spatially dependent industry exemplified by the idiom "location, location, location." The value of a property is determined by its spatial relationship to amenities and

services such as employment opportunities, shopping, and emergency and public services. "The current state of the art allows for the application of sophisticated spatial statistical techniques in conjunction with an operational GIS environment that is geared to support policy analysis as well as business decision making" (Anselin 1998). Spatial and statistical analysis techniques have long been used to quantify the value of property as it relates to geographic location, although the use of GIS to quantify these relationships is still in its infancy.

The influence of spatial location on the marketing, value, and financing of real estate was investigated by Ayse Can in 1998 and was found to be largely dependent on "neighborhood effects". These effects were defined as the geographic proximity to desirable services. "Geographic location is a major determinant of household residential satisfaction and the resulting patterns of household mobility and neighborhood change" (Can 1998). The study sought to evaluate the relationship between spatial dependence and neighborhood effects and suggested an "explicit spatial treatment" of the market. At the time of the study, Can cited the lack of comprehensive analytical tools made available by off-the-shelf GIS vendors as an impediment to the spatial treatment of neighborhood effects.

With the best available technologies, Can evaluated the spatial influence of the following four neighborhood effects: accessibility,

physical environment, and public-service provisions. The spatial investigation was split into a two-tier approach. The first stage, exploratory spatial data analysis, involved an analysis of the spatial structures within the geographic dataset. During this phase patterns such as clustering and random distribution were identified. Statistical analysis of the resulting structures was used to quantify the effect of independent variables. This was largely a descriptive exercise that did not seek to explain the relationships observed.

The second stage, confirmatory data analysis, used modeling techniques to evaluate the impact of spatial structures on the outcomes of valuation. This phase tested for spatial autocorrelation in regression residuals and was used to confirm the systematic occurrence of patterns within the geographic data and create models based on the observed patterns. The resulting models were used to determine the impact of neighborhood effects on valuation and lending rates. The resulting models identified spatially dependent patterns within geographic data that appeared to vary depending on geographic location and neighborhood effects. The application of statistical analysis techniques confirmed the presence of the patterns and their variation according to independent variables.

The author discussed the role of GIS in the study as being integral to the evaluation of neighborhood effects and valuation. GIS was praised

as "offering an optimal research environment for exploiting the information content inherent in geographic data sets" (Can 1998). GIS most benefited the study during the processes of visualization, organization, and management of geographic data.

Statistical methods to evaluate the spatial-temporal correlation between property value and location were also investigated by Gilley et al. The study utilized regression analysis to identify the correlating variables and quantify the degree of their association with the value of appraised properties. Several applications of housing data are cited as benefiting from the use of statistical analysis and the incorporation of GIS into statistical models. These applications include property tax assessment, lending as determined by appraised value, price comparison between properties, hedonic modeling and price forecasting (Gilley et al. 2000). The authors recognized that spatial data are often aggregates of more precise points and cited GIS as a solution to the "disaggregate data having precise spatial and temporal references" (Gilley et al. 2000). The study found a strong correlation between spatial and temporal indicators and the value of properties. The authors concluded that relatively simple computation methods may be incorporated into a GIS to achieve high level statistical analysis and aid in the prediction of value in accordance to spatial and temporal variables.

Research by Kim Peterson explored the implementation of GIS as a spatial decision support system (SDSS) in the management of real estate. Peterson cites a GIS's ability to "organize, manage, and analyze information in ways that were not possible with traditional information management systems" as a significant advantage (Peterson 1998). The author defines a SDSS as a system that integrates spatial and non-spatial data, uses analytical and statistical modeling, and uses a graphical interface to convey data to the user. This definition of a decision system is well supported by the inherit functionality of a GIS. A GIS-based system was recommended by the Peterson research as a method to display the results of regression analysis and encourage informed decision making on the part of appraisers and other real estate industry professionals. The author also identified risk assessment as an aspect of real estate appraisal benefited by GIS. "In the area of risk management, GIS and SDSS have been developed to help mortgage lenders and insurers improve their underwriting procedures and price their policies. These applications help to determine whether a property is located in an area prone to natural disaster (e.g., floods or earthquakes) and to calculate rates based on automated assessment of neighborhood crime rates and distances to fire hydrants, fire stations, and police stations" (Peterson 1998).

The use of GIS to evaluate spatial dependency of property value was investigated in two research papers published in 1998 by Luc Anselin and Grant Ian Thrall. The papers sought to identify the role of GIS in delivering spatial analysis capabilities to appraisers that, until then, had relied on the hedonic model to interpret the influence of spatial elements on property value. The Anselin study focused on the research infrastructure needed to augment the traditional GIS in the analysis of real estate markets. The author found two primary fields of research that required further investigation. The first was the "scope and relevance of spatial econometrics and spatial statistical methods for real estate analysis" (Anselin 1998). The second was the setting in which technical aspects of the analysis could be developed. This includes the user experience of the software development environment. The author concludes that although there are many traditional GIS software solutions to challenges in real estate analysis, a continued need exists for customized GIS tools.

The research by Grant Ian Thrall sought to explore the feasibility of systemic implementation of GIS into the real estate market. Thrall acknowledges the real estate industry as being spatially driven and spatially dependent. The inherent spatial nature of real estate makes GIS an excellent tool for analysis and market valuation. Traditionally, the real estate brokerage market made use of the Multiple Listing

Service (MLS) to facilitate transactions between buyers and sellers. The MLS database was largely flawed as it held limited information about the market, did not incorporate information on newly built properties, and only held information submitted by active MLS members.

Thrall proposed that these issues, among others, could be solved by the implementation of a GIS system. A GIS system would allow for more efficient database management, is capable of spatial analysis functions that evaluate market value, and can be easily updated to reflect newly build properties.

In addition to the overall benefits of a GIS, the article also explores the software currently available to meet the needs of valuation professionals. Appraisal is also addressed in the article and GIS is proposed as a tool to determine the value of a property based on its spatial attributes. The GIS is proposed as a solution to comparative valuation. These solutions led Thrall to conclude that GIS is especially well equipped to meet the challenges of the real estate industry. These studies highlight the benefits of GIS integration as it applies to processing of large databases, increased opportunity for complex spatial analysis, and supporting evidence for the results of statistical analysis.

The findings of the Anselin and Thrall studies are further supported by studies in 2001 by Thomas Zeng and Qiming Zhou in which a real estate GIS prototype was developed to evaluate property value in Australia. The study utilized a GIS to complete analysis tasks in the optimal spatial decision making methodology. This methodology is defined as "a branch of decision-making science. In general optimal spatial decision- making involved analysis of factors and constraints that effects the decision-making" (Zeng et al. 2001). The GIS prototype incorporated statistical analysis techniques such as rule-based systems and fuzzy set theory. These techniques are common in the analysis of real estate value and prediction of property value. The utility of the GIS was further enhanced by the integration of advanced spatial statistics tools that provided a means for regression analysis inside the GIS. The application developed during the course of the case study proved sufficient to predict property value as it corresponded to a multitude of independent variables. Independent variables included distance to metropolitan zones, air pollution, noise pollution, physical environment and amenities. The GIS component of the application displayed the results of the regression analysis. The study concluded that the real estate GIS could help both buyers and sellers assess value, assist property managers, and provide prediction metrics for property valuation. Incorporating expert knowledge into

public decision making systems is citied as a significant advantage of the real estate GIS. The application closely resembles the model currently in use by real estate websites such as Zillow and Trulia.

These studies establish that GIS is a versatile and functional utility when investigating the value of real estate as it pertains to geographic location. Useful applications of GIS to the real estate market include property valuation, market forecasting, modeling, and mapping of existing properties. Although limitations exist in the application of GIS to real estate, the potential for growth in the field is recognized by a multitude of researchers.

Design and Implementation

The client's primary objective was to graphically display appraised properties to potential customers as a means of advertisement and revenue generation. Additionally, the client had no method of analyzing where high property values existed in relation to lower values. Appraisal data accumulated by the client had been stored by the client in Microsoft Excel spreadsheets which were static and not displayed in any media outside of Excel. Accessing these records required a significant time investment as they were ordered only by date and property address. This organizational system made managing or displaying property value cumbersome and ineffective.

A solution to the static system involved creating an interactive environment in which static records may be queried and displayed. This strategy sought

to migrate property information away from static tables and into a GUI. By creating an interactive environment for the data, the client may analyze and display the data with methods unavailable in static worksheets. An application proved to be an excellent solution for the data transfer from worksheets to a GUI. To bring the client's experience to a wider audience, properties of interest are entered into the user form in the application and displayed on the base map. Spatial analysis techniques are applied to the properties to highlight regions of high property value.

In the future, the application will be made available to customers of the client to analyze and advertise their own appraisal data. Customers will use a similar data migration approach to export property information out of static spreadsheets.

The client's application was built with a piecemeal approach. This approach included building each component of the application separately then integrating each component once it was successfully tested and found to be fully functional. First, a simple website was developed in CSS and HTML 5 to provide an operational platform for the GIS application (figure 2). The website consists of a landing page, application interface, and a user log in feature. The user log in feature is available on the web page but is currently not functional. The display and operation of the website is controlled by AngularJS. AngularJS is a JavaScript framework that extends HTML's restricted functionality making it suitable for dynamic views (AngularJS

2015). Ideal for the development of single page applications, AngularJS was preferred over JavaScript due it its advanced functionality. However, the language is highly technical which led to the need for consultants on the project. By design, the functionality of the website is limited. Due to time constraints the client requested that all development efforts be focused on the web application and not the delivery platform.

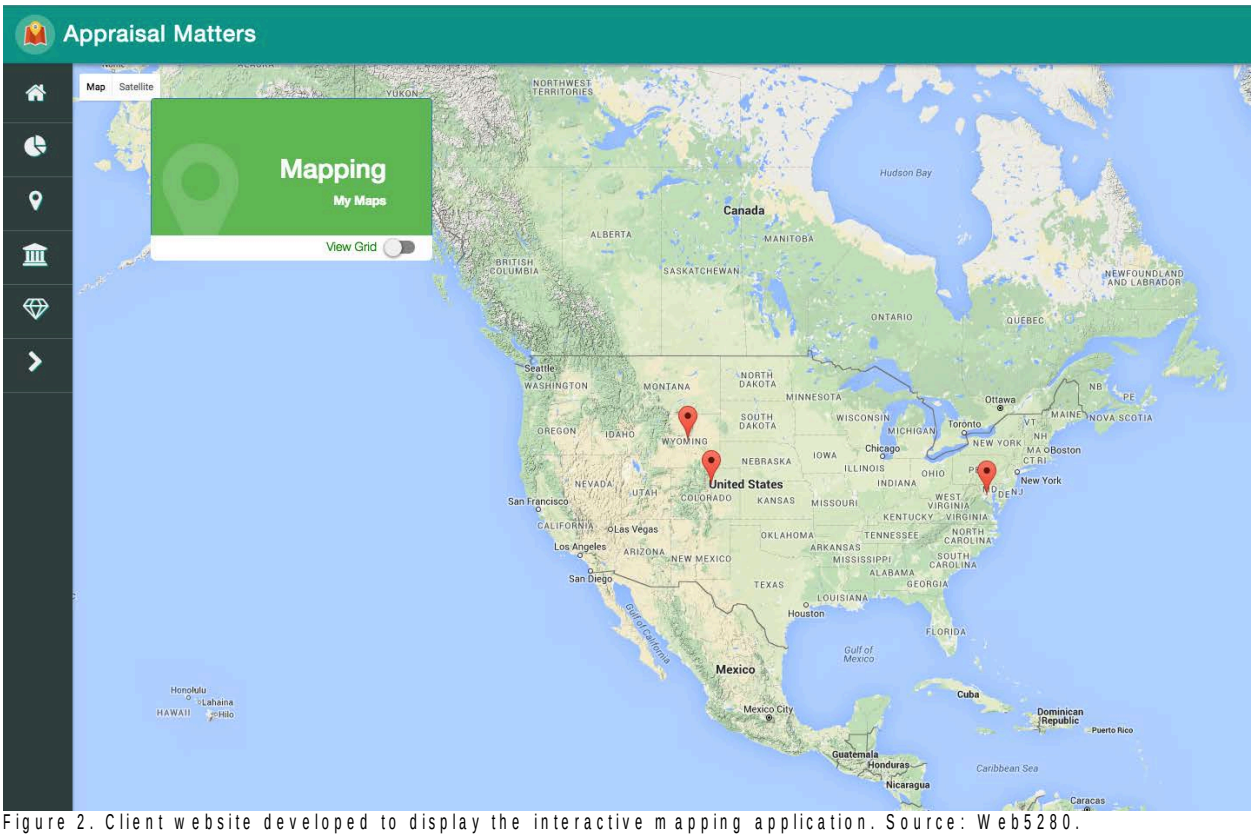

Figure 2. Client website developed to display the interactive mapping application. Source: Web5280.

Second, the visual map display of the application was developed. The embedded application had two functional requirements: spatial analysis and a means of data visualization. Considering the spatial analysis and accessibility requirements established by the client, the Google Maps API was selected for development of the application. The API offers several

development methods, including the WYSIWYG model. A technical approach was taken for development that allowed custom components, such as the user form, to be integrated into the application. Avoiding the WYSIWYG model increased the development time but created greater flexibility in client deliverables and customization.

The spatial analysis tools, in this case heat mapping, were added to the web application with a specialized plug-in designed by Google. The heat mapping plug-in code was manually added to the Google Maps API source code in order to be utilized by the client's web application (figure 3). The plug-in is available in JavaScript format. The heat mapping plug-in allows the client and its customers to evaluate the average value of properties. Property coordinates were hard coded into the application, and cannot be mapped from addresses input by the user.

JAVASCRIPT JAVASCRIPT + HTML

```
var map, heatmap;

function initMap() {
  map = new google.maps.Map(document.getElementById('map'), {
    zoom: 13,
    center: {lat: 37.775, lng: -122.434},
    mapTypeId: google.maps.MapTypeId.SATELLITE
  });

  heatmap = new google.maps.visualization.HeatmapLayer({
    data: getPoints(),
    map: map
  });
}

function toggleHeatmap() {
  heatmap.setMap(heatmap.getMap() ? null : map);
}

function changeGradient() {
  var gradient = [
    'rgba(0, 255, 255, 0)',
    'rgba(0, 255, 255, 1)',
    'rgba(0, 191, 255, 1)',
    'rgba(0, 127, 255, 1)',
    'rgba(0, 63, 255, 1)',
    'rgba(0, 0, 255, 1)',
    'rgba(0, 0, 223, 1)',
    'rgba(0, 0, 191, 1)',
    'rgba(0, 0, 159, 1)',
    'rgba(0, 0, 127, 1)',
    'rgba(63, 0, 91, 1)',
    'rgba(127, 0, 63, 1)',
```

Figure 3. Example of heat map source code provided by the Google Developer network for the Google Maps API. Source: Google.

The data visualization component of the GIS was also manually added to the Google Maps API. The visualization capabilities of a GIS allow the user to not only display information, but also query data within geographical databases (Can 1998). Data visualization was achieved by entering the property address into the website's user form. The address was then geocoded and displayed on the Google basemap.

Third, the user form was developed separately as a simple table and incorporated into the application source code (figure 4).

Figure 4. Interactive user form developed for the entry of property attribute data. Source: Web 5280.

The table is responsive, checks fields for correct data type, supports drop-down functionality, and allows the user to submit data to the database for display on the basemap. The "relevant condition" field is repeated four times to allow for multiple drop-down selection. This functionality was requested by the client. Geocoding is used to enhance visualization and convert addresses into latitude/longitude coordinates compatible with the visual map display. This unit conversion was added to the web application manually and was also built upon a Google service. These functions allows the client and customers to generate maps of their appraised properties.

Lastly, the database was developed in MongoDB and integrated into the application source code. The database is a critical component of the web mapping application as data are entered into the application manually and

must be carefully stored before attempting to retrieve them for display on the map. The database consists of the following attributes:

- Property address
- Property type
- Date appraised
- Condition
- Appraised value

All database components are sourced internally from the client. No external resources are required to populate the application's database. Because the application's core functionality depends on data transfer between the user form, located on the client's website, and the server/database. This transfer of data is facilitated by the JavaScript-based object oriented service, JSON. JSON is a data transfer service that is designed to be "human readable" and is widely used by internet applications and websites.

Due to the data transfer requirements between the website and the server, a non-relational database is used. "Object oriented methodologies have been viewed as especially useful for spatial analysis because of their ability to accommodate the complexity of spatial objects and the relationships among them" (Peterson 1998). The website, coded with AngularJS, uses the JSON service to communicate with the server and requires a non-relational database to store data from the website in the web server. A MongoDB

database is used to store and organize data entered in the user form. The database uses a flexible framework to communicate with the Google Maps API and is not constrained by the tabular format of a relational database. This database format supports the object oriented programming structure of the Google Maps API and of the AngularJS source code making it the most sensible database solution.

In many cases the need to develop proprietary software creates a bottle neck in the GIS and real estate industries. Software developers often lack the expertise for data maintenance and data vendors do not possess software development skills (Thrall 1998). This project circumvents the bottle neck by relying only on open sourced software. The only GIS software required for the web application is the Google Maps API which is made available to the public, at no cost, by Google. The software is available for download through the Google Developer network and is fully operational at the time of download. The API utilizes a wizard service and support documentation to guide users through project initiation and includes functionality such as data visualization, layering, and KML file upload. Useful plug-ins, such as those used by the client's application, are also available from the Google Developer network but must be downloaded and integrated into the application separately. The plug-ins are also open sourced.

Hardware requirements for the web application are simple. A desktop personal computer is required to develop and launch the application. There

is no preference between Microsoft, Apple or LINUX systems in the operation of the application. An internet connection is required during development and use of the application as the application is not accessible without an internet connection. An external server is required to store the database and facilitate communication between the website and the application (figure 5). There are many options for acquiring server space that are relatively low in cost. For the development process, a server hosted by Rackspace was utilized. Responsibility for maintaining the server or switching to an alternative server will be appointed to the client when the web application becomes live. The use of an external server ensures that all uploaded data are stored safely off-site in the event of a loss of power or damage to the personal computer's hard drive. Calls to the server require at 32-bit central processing unit (CPU) and minimal random access memory (RAM).

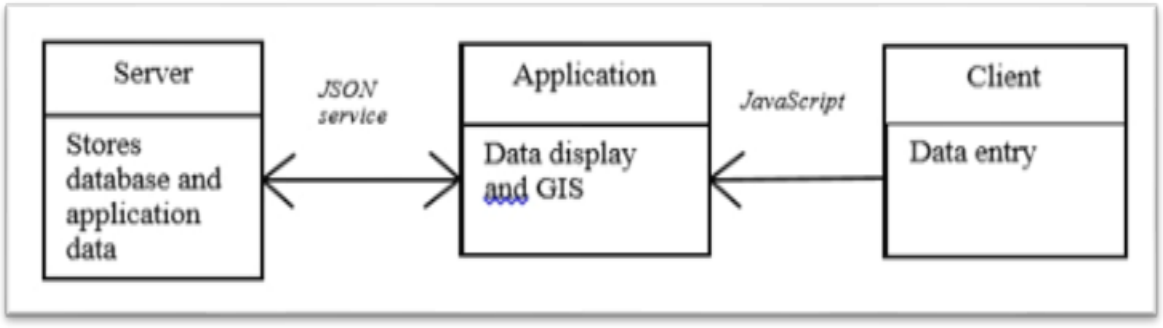

Figure 5. System configuration diagram. Displays basic configuration of GIS system and transfer of data. Source: Esther Bowlin.

Results and Discussion

The application's functionality was successfully implemented through the Google Maps API. The AngularJS programming language, although highly

technical, was an excellent methodology for developing the application. The most significant challenges involved the sophisticated user functions included in the website. These include the interactive user form with field validation and the transfer of data between the application and the database.

The incorporation of the user form and advanced user interface functionality required a piecemeal approach to code development. Plug-ins for data visualization, geocoding, and heat mapping were added and tested for functionality before the website's user interface was created. The heat mapping function was successfully integrated, but was not an interactive feature. Data points were hard-coded into the application source code for display. A future iteration of the application will include interactive heat mapping that will be generated from user input as opposed to hard-coded. The latitude/longitude coordinates generated by the coordinate conversion service will auto-populate the "getPoints" function and allow the user to view the heat gradient on-the-fly. This function will be written into an AngularJS service to allow the application to reference the service when the submit button is selected by the user. Generating on-the-fly heat maps is an advanced function that fell outside the scope of this project due to time constraints.

The heat map gradient was based on the proximity of a property to a desirable service or geographic feature. Properties located at a close distance to the service were valued higher than those at larger distances.

Each property was individually mapped according to its latitude/longitude coordinates. For the purpose of this application only a limited number of fictional properties were mapped. A greater number of properties will produce a more comprehensive picture of property value within the area of interest. The author used shopping centers as the desired service, and mapped the value of the surrounding properties based on its distance from that service. Alternative services may be selected, but the valuation methodology remains consistent regardless of the selected service. An improvement on this valuation model would be the incorporation of multiple desired services to better determine the value of a property. Each service should be weighted to reflect its influence on pricing. Multiple desirable services should be added to the heat map to render an accurate portrayal of value. Additional services will better reflect the conditions of the real-world market.

The user form and services were developed independently of the Google Maps API and added to the source code individually. The user form was developed entirely in AngularJS and tested in a third party environment, JS Fiddle, before its addition to the application source code. The form was constructed of a simple table with columns for each attribute. Upon user submission, the table is updated and the user input is refreshed in the table. The landing page was also developed in AngularJS and provides the platform for the application. Only simple navigation elements were added to the

landing page. The integration of the application into the landing page added a significant degree of complexity to the source code and required frequent testing to identify and resolve issues. A full refactoring of the code is recommended in the future to eliminate redundant and relic code from the source code. The refactoring is not necessary for the functionality of the application but is recommended as a best practice.

The geocoding service was fully functional and was easily incorporated into the application via Google Maps API plug-in. A specialized geocoding service was chosen that allows for user input into embedded forms. Traditional geocoding services are not interactive and can only be accessed with hard coded addresses. Geocoding operates in the application by entering a property address into the user form. When the user submits the data, a JSON call was made to the server and returns a latitude/longitude coordinate pair. This pair was then automatically added to the map display in the form of a Google Maps marker. This geocoding service was particularly important as the client identifies a property by its street address, not its geographic coordinates. The automated conversion of address to coordinate pair was an essential service. Although additional spatial analysis functions are native to the API, the client chose to forgo the services in the interest of development time.

The decision to build the application in the AngularJS framework as opposed to JavaScript was based on the need for advanced service integration.

AngularJS is a single-page-application engine based in JavaScript. As defined by the AngularJS language, a service is a snipped of code that can be referenced and used across the application, but is only instantiated if needed to execute a process or function (figure 6). This service functionality was utilized in the referencing of addresses in the geocoding and the data display functions. Making the converted address available to each component of the application was a key operation that needed to execute on-the-fly when the user submitted the data. This service will later be used in the interactive heat mapping function. Additionally, the user log in function was developed entirely in an AngularJS service and integrated into the application's source code. The log in function was added to the application in the interest of client and customer confidentiality. A password protection option was added to the log in creating a safe environment for customers to enter their property data. The log in feature, complete with password protection was a considerable challenge that required input from experienced AngularJS developers to create.

```
}

_getMapData($scope) {
  MAPPINGSERVICE.get(this).getMapPoints().then(function (data) {
    if (data && data.length) {

      //console.log(data);

      //_createMap(data);
      var mapOptions = {
        zoom: 4,
        center: new google.maps.LatLng(40.0000, -98.0000),
        mapTypeId: google.maps.MapTypeId.TERRAIN
      }

      $scope.map = new google.maps.Map(document.getElementById('map'), mapOptions);

      var infoWindow = new google.maps.InfoWindow();

      var cities = data;


      for (var i = 0; i < cities.length; i++) {
        //_createMarker(cities[i]);
        createMarker(cities[i]);
      }

      function createMarker(info) {

        var marker = new google.maps.Marker({
          map: $scope.map,
          position: new google.maps.LatLng(info.latCoord, info.longCoord),
          title: info.city
        });

        marker.content = '<div class="infoWindowContent">' + info.description + '</div>';
        var infoWindow = new google.maps.InfoWindow();

        google.maps.event.addListener(marker, 'click', function () {
          infoWindow.setContent('<h2>' + marker.title + '</h2>' + marker.content);
          infoWindow.open($scope.map, marker);
        });

        var markers = [];

        markers.push(marker);
      }


    }
  });
```

Figure 6. Example of mapping service code developed in AngularJS. Source: Web5280.

A second significant benefit of the AngularJS framework is its handling of HTML code. HTML is the corner stone of the web development process and gives a webpage its design, layout, and color scheme. AngularJS provides a "shorthand" notation for HTML and CSS styling creating cleaner source code and less opportunity for error. AngularJS also allows for dynamic display of HTML and CSS code, despite both languages being developed for static environments (AngularJS 2015). A dynamic environment means the page can be displayed on a variety of user devices, and will automatically resize

when the user changes the size of the viewing window. This was a substantial benefit as the application needed to be accessible from a dynamic commercial website.

The website was developed first in the HTML 5 markup language before the application was added. A simple design was chosen for the application platform to avoid confusion for the user. Only necessary functions such as user log in and the application window are available from the website in its current form. Design and layout of the public-facing website were approved with the client prior to application development.

Recommendations

The application in its current form would benefit from the integration of additional spatial functions and user services. The technical capabilities of the application could be improved by both Google Maps API plug-ins and custom services developed specifically for the application. The most significant improvement would be the ability to add data to the application via Excel spreadsheet upload. Uploading populated spreadsheets would allow for the visualization and analysis of large datasets and create a time saving measure for the user. In many cases, real estate valuation data are stored in static spreadsheets making the records unavailable for analysis by other programs. A service could be created that reads the contents of the spreadsheet, identifies the relevant fields, and imports that data into the web application. An external programming language, such as Python, would

be an excellent choice for this task. Python's ability to read opened files and extract data based on attributes makes the language the most convenient solution. The data could then be stored in the client's database for future retrieval. This service could be useful to customers who wish to visualize large volumes of data.

The Excel records could also be made available to a graphing function which performs basic statistical analysis on the records and generates tabular or graphical results. Unfortunately, code for the spreadsheet upload would need to be developed from scratch so adequate time and funding would be required to implement the feature. This feature, however, would provide a significant time saving benefit to the client and should be implemented at the client's earliest convenience.

Additionally, a more robust GIS could be created by implementing supplemental spatial features into the application. Many of these features are available in the form of services pre-developed by Google. Useful services include KML file upload, street view of properties, statistical analysis, and graphing. KML file upload and street view would allow a more detailed view of properties and would benefit the client as an advertising tool. The KML file upload could be implemented to incorporate custom line or polygon files into the map display giving the user the ability to delineate areas of interest or identify important map features. The statistical analysis and graphing functions would create an analytical environment in which the

client could determine average property values, visualize underperforming regions, and create reports for potential customers (figure 7). These functions are available within the Google Maps API, but would require several additional hours of development time to incorporate into the existing application.

Additional features native to the Google Maps API are layering, polygon creation and manipulation, and the geometry library. With the integration of these plug-ins, a robust web-based GIS could be developed. Although these features will benefit both the client and its customers, they are not imperative to the application's success.

Lastly, the public-facing website design should be revisited to allow for maximum functionality for the client's customers. Currently the page serves only as the application's platform and offers little functionality. If charting and Excel upload functions are added to the application, these features should be integrated into the website separately in an additional page. The page should be linked to the application platform page and operate independently.

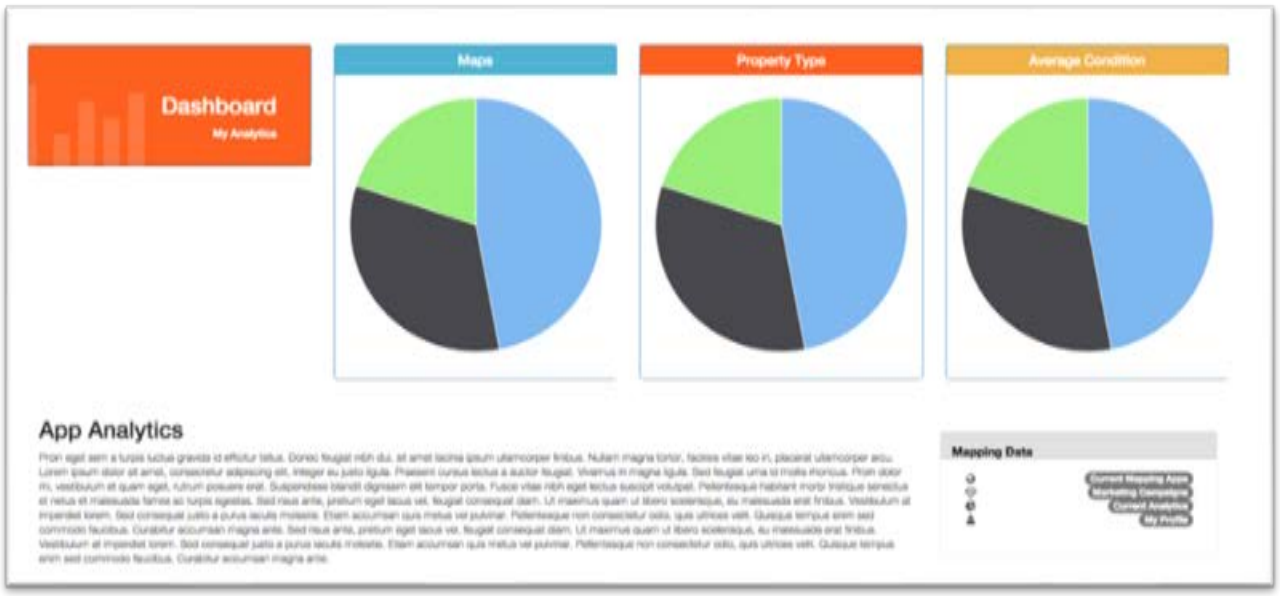

Figure 7. Proposed graphing function to be added to client website. Source: Web5280.

Areas for Future Research

There are many opportunities for future research into the application of web GIS in the real estate industry. As the prevalence of mobile and internet-based applications grows, GIS products could be evaluated for their effectiveness in real estate applications. For example, ESRI's Developer Network offers a multitude of internet mapping and GIS products for developers. An application could be developed using ESRI's application software and applied to an area of interest in the real estate industry such as property value prediction. Service location could also be utilized by the GIS to identify regions of high value based on their proximity to desirable services. This process could then be replicated in other web-based GIS software such as Google Maps API or MSN's Visual Earth. By exploring the capabilities of all web GIS products, the most efficient application development system could be identified. Limitations to each web GIS could

also be identified giving developers a better focus on services that are not well covered by major GIS and mapping vendors.

The amalgamation of useful features from a variety of application vendors in to a single application is also a pertinent research topic. Each internet-based mapping vendor features a set of useful analysis and visualization functions. However, no vendor offers every available function within their development environment. A method of integrating the most valuable functions from independent application platforms would create a sophisticated and versatile web GIS application. This cherry-picking method could identify and utilize the useful functions such as KML file upload from platforms like Google and integrate them with the advanced mapping templates made available by ESRI. The most significant challenge associated with this research would involve identifying a suitable programming language to communicate with each platform's source code. A combination of JavaScript source code and a Python service layer would likely be the most sensible and tidy approach to integration. The ability to combine the on-the-fly display capabilities of the Google Maps API with the robust ESRI analysis environment would make this research valuable to many industries.

Another valuable area of research is the integration of statistical analysis techniques into real estate applications. Statistical analysis has been used to determine value, predict development trends and quantify the spatial dependence of property value (Anselin 1998). A method of integrating the

results of these analyses may improve the functionality of a web GIS and give users greater insight into the market of interest. In order to bring statistical analysis to a mapping environment, code would need to be developed that executed basic analysis tasks such as auto regression. The analysis code would then require access to the data entered by the user. This passing of data to the server and across the application creates complications that are well handled by AngularJS. The integration of a statistical analysis service, although complex, would be highly valuable to the application's user.

Lastly, the incorporation of GPS capabilities into real estate applications could yield a more robust web GIS for potential clients. GPS services may be integrated by operating a web application on a GPS enabled device such as a smartphone or tablet. The application could utilize the device's native GPS to gather data points which may be stored by the application. Many devices are equipped with native GPS which is easily accesses by internet-based applications. Although the accuracy of a native GPS tends to be low, it would likely be sufficient for the purposes of appraising and mapping properties. The location of services, appraised properties, or points of interest could be logged during appraiser site visits and used to create a map. Gathering geographic data in the field may increase the accuracy of the final map visualization and could reduce the time needed to enter addresses into the application manually.

Conclusion

The web application developed for the client allows for the visualization and analysis of real estate appraisal data. The use of GIS as a content management system and analysis tool is well supported by multiple studies. Researchers have found that multiple real estate business applications benefit from the implementation of a GIS and can bring sophisticated spatial analysis techniques to an inexperienced user. The internet-based real estate application was developed on open source GIS software and does not require specialized hardware to operate. All data were acquired from the client and are stored on a secure remote server. Once uploaded, data are displayed on the map and can be manipulated within the application. Spatial analysis techniques such as heat mapping demonstrate where highest property values exist and assists in valuing neighboring properties. Geocoding and coordinate conversion allow the client to enter addresses which are then converted within the application and displayed on the map.

The application uses open source technologies to bring rudimentary geospatial analysis techniques to a non-technical client at little to no cost. The geospatial capabilities of the application make identifying areas of high property value possible for the client and embedding the application in the client's website makes sharing the technology with the client's customers a feasible growth strategy.

Internet mapping is an excellent GIS solution for small to mid-sized businesses looking to incorporate spatial analysis techniques into their established workflow. Advances in mapping applications have brought increasingly sophisticated analysis techniques that, in many cases, are accessible through a wizard. By bringing advanced functionality to non-traditional users with an operation wizard, companies may reduce their staff training costs. Advanced functions include layer editing, polygon and line manipulation, and basic filtering. Prior to the advent of internet mapping, these spatial functions were accessible only through traditional GIS software.

Non-traditional GIS industries, such as real estate, stand to benefit from the incorporation of GIS. Real estate is identified as an industry highly dependent on spatial relationships making GIS an excellent solution to valuation and development workflows. Simple internet-based mapping applications may be incorporated to determine areas of high or low property value, map existing properties, and develop predictive value models. As internet mapping grows, the real estate industry will likely continue to develop innovative ways to incorporate GIS technology.

References

Alesheikh, Ali Asghar, and H. Helali. "Web GIS: Technologies and its Applications". Symposium on Geospatial Theory, Processing and Applications. 2002, Ottawa, Canada. 2002. Print.

AngularJS. "Why AngularJS?" Web. 2015. https://AngularJS.org/.

Anselin, Luc. "GIS Research Infrastructure for Spatial Analysis of Real Estate Markets." Journal of Housing Research 9.1 (1998). Print.

Boulos, Maged N. Kamel. "Web GIS in Practice III: Creating a Simple Interactive Map of England's Strategic Health Authorities using Google Maps API, Google Earth KML, and MSN VirtualEarth Map Control." International Journal of Health Geographics 4 (2005). Print.

Can, Ayse. "GIS and Spatial Analysis of Housing and Mortgage Markets." Journal of Housing Research 9.1 (1998). Print.

Chow, Edwin. "The Potential of Maps APIs for Internet GIS Applications." Transactions in GIS 12.2 (2008). Print.

ESRI. "What is GIS?" 2015. Web. http://www.esri.com/what-is-gis.

Gilley, Otis, and C. F. Sirmans. "A Method for Spatial-Temporal Forecasting with an Application to Real Estate Prices." International Journal of Forecasting (2000). Print.

Peterson, Kim. "Development of Spatial Decision Support Systems for Residential Real Estate." Journal of Housing Research (1998). Print.

Thrall, Grant Ian. "GIS Applications in Real Estate and Related Industries." Journal of Housing Research 9.1 (1998). Print.

Zeng, Thomas, and Qiming Zhou. "Optimal Spatial Decision Making using Gis: A Prototype of a Real Estate Geographical Information System." International Journal of Geographic Information Science (2001). Print.

Zhang, Ran. "An Improved Spatial Error Model for the Mass Appraisal of Commercial Real Estate Based on Spatial Analysis: Shenzhen as a Case Study." Habitat International 46 (2015): 196. Print.