The Google GIS Suite

How Modern Software Changed Maps

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1. Introduction

Humans are innately attracted to the concept of maps. Since the beginning of recorded history cartographers have worked meticulously to chart, plot, and illustrate every corner of the globe. People yearn for demystification of the land around them. Having more geospatial knowledge helps to orient oneself in a space. Maps help expand perception of the world beyond the immediate line of sight. They are an invaluable and versatile tool that is integral to navigation.

The advent of computers, the internet, and smartphones has drastically changed how a user interacts with a map. However, the motives are still relatively the same. Interactive digital maps are also used to reveal our surroundings and assist in navigation. The expanded functionality is where we begin to see the monumental difference between physical maps and digital geographic information systems (GIS). Computers and the networks that connect them are immensely powerful. In a way, vastly more so than the human mind. There are innumerable tools and features included in modern GIS that are opening new possibilities.

The most popular and accessible GIS today was created and is supported by the technology giant Google. The company has a massive collection of data and statistics comprising a back-end database that powers various user interfaces. Google Maps, Google Earth, and Waze are the primary applications available to the public. Able to be used on either desktop or mobile devices, this free software is an exponential improvement on historical analog maps. This paper will investigate these three applications and how society is coping with access to so much information. With an enormous amount of data, it is critical to have efficient interactive design so users can ultimately benefit. The following studies have drastic differences, but all examine whether humans are using this new technology to its fullest advantageous potential.

2. Review of Papers

‘Outsmarting Traffic, Together’: Driving as Social Navigation

Waze is the most social of all the navigation applications that Google offers. The company began as a small startup out of Israel before it was purchased by Google for $1.1 Billion. It stands out from its competitors with an array of community-driven functionality. It allows users to report road hazards, accidents, speed limits, gas prices, map issues, closures, police traps, and most importantly, traffic jams. Drivers also have an individual account to personalize the experience. Default “Home” and “Work” locations can be set. An organized list of recent destinations and favorites allow for efficient destination selection. There are dozens of cartoon avatars called “Moods” to choose from, and these are how Wazers see each other on the live map. Drivers can compare themselves to the leaderboard to see how they stack up against the most active users. Teams can also be set up so groups of Wazers are designated with a special icon at specific events. Additionally, the friends list is the most social aspect of the app. Waze lets travelers share their estimated time of arrival (ETA) with a friend so they both can track progress to the destination. On a more whimsical note, the “Beep Beep” button is the equivalent of a Facebook “Poke”. It simply alerts a friend they are both driving and online with a jovial sound effect.

All these unique features make Waze the go-to navigation app for a lot of drivers. This new technology has also redefined modern automotive travel. Waze’s tagline is “Outsmarting Traffic, Together”, which inspires a sense of togetherness. Could an app really transform commutes into an intelligent, social endeavor? In 2014, a study published in the *Warwick Research Journal* explored the rise of what has been called ‘social navigation’. It asserts that “Satellite navigation devices – perhaps the ultimate driving aids – are adept at capturing, storing, tracking, anticipating and visualizing the vast array of possible driving interactions much more so than the traditional A-to-Z road atlas” (Hind & Gecker, 2014, 165). Google uses all of this information collected from the community to create a smarter GPS. If there is an accident on the main road causing standstill traffic, Waze will suggest an alternative route that bypasses the congestion with minimal delay. Construction is constantly shifting and road closures are sporadic and unpredictable. Waze reporting offers real-time confirmation of closures and allows drivers to plan a detour. By working together, the public can empower navigators in their commute.

In their publication, Alex Gekker & Sam Hind also discuss an interesting phenomenon in the way humans interact with technology. The ‘ludic turn’ is a common theme in recent media studies that emphasizes play as a fundamental component of all human culture. This theory conjectures that human playfulness has integrated itself into interactive system design. Touch screens are a new type of interfacing with a computer that exemplifies this theory. The user plays with an invisible membrane to use the operating system. The study introduced a “plethora of new tactile strokes, sweeps and taps are steadily and qualitatively replacing the metronymic and calculative clicks of computer mice, keys and other vehicular dashboard controls” (Hind & Gekker, 2014, 169). The way smartphones are used is a game of sorts. Players swipe and drag their way through menus to achieve goals or accomplish a task. This design is intentional and meant to entertain. ‘Gamification’ is “the adoption of game-like mechanics, rules, modes, and structures for everyday tasks…only recently taken up in the field of digital mapping” (Hind & Gekker, 2014, 168). Humans are predisposed to enjoy a sense of play and gamesmanship. Waze capitalizes on this by turning an often-boring task into game. It is a new hybrid form of casual gaming that takes place passively as a driver navigates. Play conventions are acquired as a user continues to use the app. Users soon realize they can share a trip with a friend, compare scores on the leaderboards, or choose how their vehicle looks on the map. Occasionally there are even limited items located on the map that are obtained if driven over. All this functionality adds a bit of fun to an otherwise tedious activity. Waze employs a lot of the fundamental building blocks of casual gaming such as “low barriers to entry (easy to pick-up), incremental progress (lots of short levels), forgiveness towards player mistakes and the use of ‘social mechanics’, such as the option to invite or compare results with friends on social networking sites” (Hind & Gekker, 2014, 168). Turning travel into a game, and evoking human propensity for playfulness, have helped Waze etch out a substantial market share in the GIS market.

Traffic Condition Is More Than Colored Lines on a Map: Characterization of Waze Alerts

A paper published in the journal *Social Informatics* dives further into the concept of community-driven navigation. A participatory sensing system (PSS) is a “mobile interface that allows people carrying smartphones to share data about the environment (or context) they are inserted in at any time and place” (Almeida, 2013, 309). This system is built upon the GIS concept of volunteered geographic information. Citizen sensors serve as information gathering nodes. A PSS aims to make ubiquitous computing a reality. Location-based Social Networks (LBSNs) utilize this innovation to alter the user experience based on where they are. Having a large LBSN can help provide valuable information in powering an application such as Waze. A study was conducted to examine the participatory sensor network derived from Waze. Since the traffic information was not publicly accessible by an API, these researchers used an intriguing workaround. Since the Twitter API is public, they gathered 212,814 tweets containing alerts about traffic shared by Waze users. Their research revealed some interesting conclusions.

First, they found that compared to other photo and location sharing services such as Instagram or Foursquare, Waze users actively participated less. It would seem people are more likely to want to share a photo of lunch than report a traffic jam, which is understandable to a certain extent. Only 16% of Wazers contributed more than 10 alerts a month (Almeida, 2013, 315). Though this does not mean people are not using the app for its basic navigational purposes. It merely collects less user information than other LBSNs. Second, they found that Waze adjusts where an item of interest is located on the map based on multiple user reports. If 50 drivers report the same accident, it uses an algorithm to discern precisely where the alert should appear on the road. Third, there is a predictable diurnal pattern with app activity. As expected, rush hour is when most traffic is flowing through both the physical roads and the digital app. This allows for a certain predictability when approaching how to improve traffic. The vast collection of user-contributed data could assist in alleviating jams. The study suggested "that this information could be used to assure the quality and improve traffic condition information services, such as those offered by Google Maps" (Almeida, 2013, 317). The information age got its name for a reason. Many recent technological advancements were made possible by the careful analysis and application of unfathomable amounts of data. The data collected by Waze could change the way we use digital maps.

The study also contemplated future advancements in the industry. How can humans make the technology work for them? One application is real-time identification of locations with potholes or animals in the road. It is usually hard to detect roadkill or hazards, but Waze makes it feasible when citizen sensors are used. Problematic roads can be identified and located by Wazers. If a landslide makes a coastal highway impassable, a simple alert can inform nearby users of the blockage. Behind the scenes, all this information can be used in the constant tweaking of algorithms that control navigation. Waze is perpetually building upon itself to assure the quality of the suggested route. An urban planner could use the data to assess the effectiveness of previous roadwork or construction. The possibilities are endless when there are millions of nodes volunteering precious geospatial information.

Implementing the Wisdom of Waze

Cartographers of ancient history would need to walk a road themselves and sketch the path as they went. Today, billions of drivers traverse streets everyday using smartphone navigation apps that gather data of their precise route. Warehouses full of servers store incredible amounts of data about the way traffic flows through a complex concrete infrastructure. What is the most effective way to analyze this feedback and solve real-world problems? At the 2015 International Joint Conference on Artificial Intelligence, three university scholars presented how they applied Bayesian principles to optimize alternate route selection. For example, numerous Wazers could be sitting in a traffic jam with a possible detour approaching. Using a cost function, these researchers found the optimal number of users to divert to the alternate route. In their experiment, a mediator is responsible for knowing the behind the scenes cost function. The mediator in this case is Waze. The app offers an incentive compatible recommendation. The incentive being less traffic and similar estimated time of arrival at the destination. This research also examined when a user rejects some recommendation and proceeds with the current course. This is a peculiar instance where the operator has confidence that their knowledge trumps the calculated suggestion. There exists a “*mediated equilibrium* obtained from an incentive compatible mediation protocol and the social optimum” (Feldman, 2015, 660). This equilibrium is the sweet spot between the computer-generated route and the driver’s street smarts. Michael Feldman from Tel Aviv University believes his algorithms can reduce efficiency loss when considering multiple paths. The key performance indicator is the total travel time of the system.

Most people want to personally make it to work on time, but this effort looks at the big picture. Travel would be much easier if the activity spikes around 9am and 5pm could be facilitated more intuitively. The research concluded that humans should adopt a smart approach to traffic to spend less time traveling and more time living. This study was a relevant example of how new information can unlock opportunities for advancement. A phone now has the power to influence a pilot. GPS is trusted just as traditional road signs are. This is due to signage being an essential factor in navigation and reading directions. Software like Waze now gives each driver a dynamic signage medium right on their dashboard. It is an asynchronous channel with the ability to inform of traffic, police, or road hazards in an instant. It is important to optimize this signage by learning from data it provides. Travel time could be much improved because "Waze knows exactly which road has an accident, and can route each driver to his individually optimal road" (Feldman, 2015, 660). In a perfect world, rush hour flows like water and automotive travel is engineered to be easy. Until then, data must be processed and put to good use towards that goal.

Academic Uses of Google Earth and Google Maps in a Library Setting

Traditional classrooms before the digital age would have the cliché rollup world map right above the chalkboard. Maps have always been an integral component in education and academia. Google Maps and Google Earth revolutionized the study of geography. It put the entire globe at the fingertips of public. Scholars also were able to transpose historical map collections onto 3D models and view them within the software. Universities worldwide applauded the "powerful ability to share and host projects, create customized KML (Keyhole Markup Language) files, and to easily communicate their own research findings in a geographic context" (Dodsworth & Nicholson, 2012, 102). In the *Information Technology and Libraries* journal, results were published from a survey that aimed to find out what libraries were doing with these applications. 83 respondents, mostly librarians, described their experience with Google GIS products. 85%

reported having worked with Google Maps, and 83% reported having worked with Google Earth. This is an astounding proportion and means that this software is thoroughly engrained in modern libraries. Another interesting figure were the 36% of respondents that claimed to have worked with the Google Maps API. This means that the public API is being significantly utilized for the creation of original content. The statistics on frequency of use were scattered, but revealed power-users. More than 25% use Google Mapping products for work-related activity more than

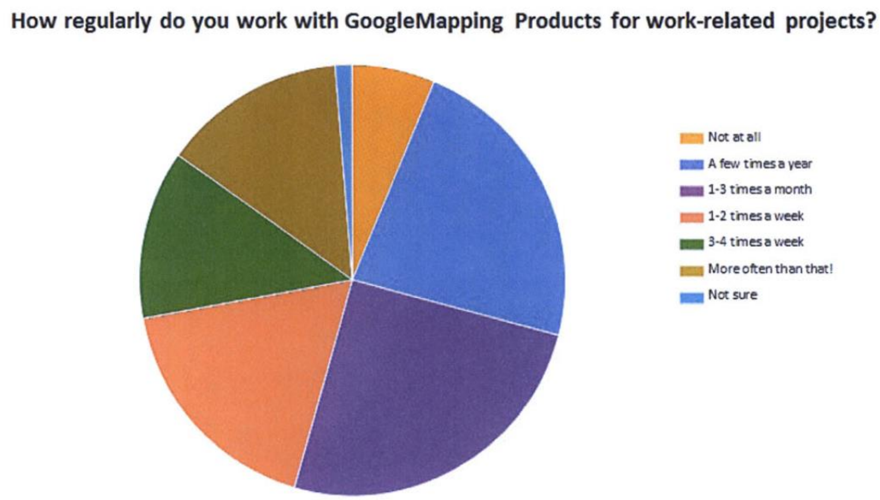

Figure 1

3-4 times a week, or more (Figure 1). Since it is a versatile tool, the public has found a multitude of uses. Students and teachers use Google Earth and Google Maps for answering research questions, creating or accessing a finding aid tool, instructional purposes, promotion/marketing, georeferencing imagery, building webpages, or creating learning objects. The results also indicated that the applications were being used most in graduate level courses. It would seem that secondary education embraces modeling technologies more than undergraduate degrees. This research exposed an extensive relationship between academia and the Google GIS suite. Librarians, teachers, and student all trust and use this software in a constructive way. Having the GIS tools be free to download has allowed them to become ubiquitous in classrooms around the world, as opposed to bookshelves full of atlases. Google has assumed an awesome responsibility by providing such an invaluable resource. Keeping it free of cost, easy to use, and flexible is critical to its success in schools around the world.

Three Applications of V.3 Google Maps: Just for Display of Data, or Analysis as Well?

The previous research study discovered that users are manipulating the public Google Maps API to model their own maps. The application has a wide array of development tools that allow for alternative uses. Alan Philips published a paper in the *Journal of Geographic Information System* that questioned if Google's GIS software could be used for heavy analysis in addition to simple presentation. An important functionality is asynchronous loading between the display and the selected data. In the GIS community, there is robust analytical software used for mapping. Some question the capability of Google's freeware to process large data sets efficiently. Philips argues "geobrowsers [such as Google Earth]… are very different from typical GIS applications. They have none of the analytic, modelling, and inferential power of GIS, and while oriented to visualization are nevertheless very limited in what can be visualized" (Philips, 2014, 549). Philips is skeptical of the newer, simpler geobrowers and defends complex GIS software. Research found that asynchronous callback through Google Earth will produce lags in program execution. These delays could cause the viewer to make a conclusion based upon an incomplete display of data. This inaccessibility to raw data is a detrimental setback toward legitimizing the Google GIS suite. However, this study concedes that the recent V.3 of the public Google Maps applications is a large improvement from V.1 and V.2. This edition is written in Javascript and doesn't require a personal key. It also includes potential for "finding and sharing information about locations, recording environmental conditions, and displaying land parcels for mortgage loans" (Philips, 2014, 549). As more features are added, Google Earth will catch up to its more adaptable competitors. Being free to download also puts it in the hands of exponentially more users. All of these users could contribute information to a communal digital map. Alan Philips dreams that Google Maps could "put into public practice the notion that an accessible, agile, adaptable GIS can be built that accepts direct, local, even vernacular public input and, in turn, puts out a usable, unique, localized and important results" (Philips, 2014, 549). If engineered correctly, Google Maps could become an open-sourced, digital representation of the physical world. All of it would be powered by the public who contribute geospatial information through our modern technologies. What if a user could search through millions of custom maps like searching YouTube for a specific video? The possibilities are endless with open source GIS applications, even if they are simple and accessible.

3. Conclusion

Google Maps, Google Earth, and Waze have completely changed the GIS landscape. For the first time in history, humans have digital, interactive, smart maps. To power these applications, there is community-collected data that allows for intelligent navigation. Additionally, smartphones have made all these new technologies mobile. Navigational aids for the iPhone, Android, and other mobile devices have revolutionized the way people drive.

Waze is a startup that has grown to redefine automotive travel. The commute is now a social experience with all drivers working to minimize net travel time for the entire system. Wazers act as citizen sensors that provide information that can help improve transportation. This volunteered geographic information will be used to drive future innovation in infrastructure. The app also embraces the sense of playfulness in users and turns driving into a game. Connecting with friends, changing the avatar, and checking the leaderboards, all add an entertaining aspect to a traditionally tedious activity.

Google Earth and Google Maps are extremely useful tools in modern geography. They are being used in libraries and classrooms all through academia. Teachers and students alike use the software to better understand our planet. The applications are also being constantly updated to allow for expanded functionality and increased versatility.

There are many opportunities to expand on research already conducted. With this much data, there will always be new analysis that could reveal previously unknown findings. If Waze's API was public, there would be even more information at the disposal of researchers. If Google Maps and Waze worked together, they could improve the travel time for users of both apps. Algorithms will continue to be tweaked in an effort to reduce inefficiency. In addition, technology will only continue to transform. Soon there will be new functionality that will further expand the way we can interact with GISs. With more powerful processors and cheaper storage space, software will improve beyond our current capabilities.

Google's GIS suite is demystifying geography and navigation, and doing it for free. An immense amount of knowledge and information is available to anyone with a computer and internet connection. Christopher Columbus certainly could have used an iPad Pro, cellular enabled, with Google Maps and Waze downloaded. Humans have a lot of power at their fingertips with computers and smartphones. Although, with great power comes great responsibility. Society needs to embrace the digital age and put data analytics to work towards starting beneficial change and achieving constructive goals. Google's GIS suite and accompanying dataset could solve traffic jams, map historical battlefields, or give an elementary school class an interactive quiz of the 50 states. The days of the atlas are over, and the information age has abandoned analog. The transformation has brought a streamlined approach to geographic navigation and cartography. Today, much more information is processed in a much shorter time. People can learn so much more about their surroundings with an intuitive interactive design. Many things will change in the future, but the close relationship between humans and maps is here to stay.

4. References

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