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Research-in-Progress

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Abstract

This study develops a visualization Proof of Concept that is aimed at improving the quality of life for the city in the South-Eastern part of US as a case study. Using design science research method, we create interactive visual maps called the quality of life explorer (QoLE) for improving the livelihood of residents of the city under study. We then used analytics techniques to customize the map and enhance its visualization and interactivity capabilities in a way that is simple to understand and use. Furthermore, the QoLE website has built-in capability that allows report generation as well as increase interactivity of Map and data distribution tables. The outcome from this study will help the city authorities and residents to better visualize the data in a smarter and realistic way so that they can make informed decisions in redeveloping their city. More specifically, the study outcomes will help the City authorities and stakeholders integrate the disparate data into a centralized location for easy accessibility and use for decision making.

Keywords: Quality of life, business analytics, design artifact, capabilities, visualization, location analytics.

Introduction

The Center for Housing and Community Studies (CHCS) – a university-based research, evaluation and technical assistance center – provides technical assistance to governmental and nonprofit agencies. Some projects undertaken by the CHCS addresses areas of housing, continuum of care for the homeless, housing market trends and market segmentation studies, community indicators projects, asset mapping, county and regional community planning, impact of housing on health, etc. One such prominent project undertaken by the center is based on a request from the local city on "housing market segmentation". This study provides data for the revitalization and redevelopment of a city based on three key areas: physical state of housing, socio-economic demographic conditions and overall opportunity. Although the city has very rich large data to tap into to achieve the aforementioned housing and socio-economic objectives, it currently faces challenges in terms of how to use the dataset as well as which technique or processes to use in achieving its overarching objective. A major challenge is that the data is currently in diverse sources (in siloed repositories) and not available at a single place for analysis and visualization (Bacic & Fadlala, 2016)

To address this challenge, we use design science approach (Hevner, March, Park, & Ram, 2004) to develop a decision support artifact, *Quality of Life Explorer* (QoLE) prototype, which uses geo-spatial visualizations and descriptive analysis reporting techniques. QoLE is an interactive online tool designed to help neighborhoods, government leaders and staff, businesses, community organizations, new residents and others learn more about their communities. The tool maps the city data through interactive maps, making

it easier for the stakeholders to use and understand its outputs. It has potential to project trends over the years and showcase distribution over areas (Making Data Actionable, 2014) to help stakeholders better understand their community (Quality of Life Dashboard 2014). QoLE addresses a dire need from cities and community improvement standpoint (Trieu, 2017) in how analytics techniques and process can help improve understanding and interpretation of neighborhood data.

According to studies by Gartner (2012, 2014), analytics and business intelligence (A&BI) is the top priority of chief information officers and primary area of technology investment in most businesses including government and non-profit organizations. Owing in large part to such attention, A&BI has now become an important inclusion for performance improvement in many business organizations. Most prior literature has focused on the contribution of A&BI technologies within the context of their functional areas of application. However, it is our contention that the true value of such technology is not evident unless viewed through the lens of how they contribute to the overall quality of life within a given society. It is our premise that understanding the same is important for both academics and practice. From an academic standpoint, outcomes from this study will provide novel contribution to the existing literature on A&BI to study and evaluate A&BI systems not only from traditional standpoints (e.g., their contribution to inter and intra-organizational integration, user-friendliness or effectiveness) but from a viewpoint of where and how a A&BI system fits within the larger context of societal needs. This potentially will allow city managers and residents to understand and evaluate QoLE-based A&BI systems by going beyond the usual cost-benefit analysis and asking the higher-level question such as, *relative to other systems, how well does A&BI-driven QoLE system contribute to overall socio-economic improvement?*"

Several current studies in the literature have proposed models, typologies and domains of A&BI adoption in organizations (Chen, Chiang, & Storey 2012; Holsapple et al. 2014; Wixom, Yen, & Relich, 2013). Other studies focus on the supply chain analytics capabilities (Chae, Olson, & Sheu, 2014) of organization from a resource-based view (Barney 1991) and dynamic capabilities (Eisenhardt and Martin 2000) perspectives (Chae and Olson 2013). However, based on extensive review of the current literature and to the extent of our knowledge, there is significant lack of research that explores and/or demonstrates how A&BI capabilities are being explored with the aim of improving quality of life (Bacic & Fadlala, 2016).

When viewed from the standpoint of applications, analytics can be classified into three major categories (Davenport 2013): descriptive analytics, predictive analytics and prescriptive analytics. Descriptive analytics is used to answer '*what has happened*?', predictive analytics to answer '*what could happen*?', and prescriptive analytics to answer '*what should happen*?' (IBM 2013). City management authorities may use different combinations of the three types of analytics for deployment to help identify deplorable locations within the communities and instantly respond to the needs of those communities by providing intervention mechanisms. Hence, this study's main research question is: "*how can A&BI help in identifying locations within a given community where resources are needed to help improve the livelihood of citizens within such communities*?"

Thus, the main objective of this study is to develop an A&BI-driven working proof of concept website for QoLE using the city in the southeast region of USA as a case study. In addition, the prototype created is customized for better user interface to enhance user interaction. Furthermore, QoLE website will allow report generation as well as increase interactivity of map and data distribution tables.

To accomplish these objectives, we use design science research approach (Hevner et al. 2004) to build an artifact that incorporates: interactive maps for quality of life improvement; use A&BI techniques to customize the map; and enhance its visualization and interactivity capabilities in a way that is simple to understand and use. The outcome from this study will help the city authorities and residents to better visualize the data in a more smart and realistic way so that they can make informed decisions in redeveloping their city.

Background

The National Neighborhood Indicators Partnership (NNIP) (www.neighborhoodindicators.org/) is a collaboration between the Urban Institute and local organizations connecting people with neighborhood data. They deal with data in education, health, housing, economic opportunity, and public safety. The NNIP started in 1996 as a network of local data intermediaries that saw a need for neighborhood-level data to inform local decision-making. They believed in the principle of democratizing information by empowering

local governments and non-profit organizations to better model their programs to target the distressed neighborhoods and improve them.

NNIP is made possible due to the advances in GIS technology in recent times that allow for location based information to be made available to the general public. NNIP is mainly supported and coordinated by the Urban Institute's evidence-based research and expertise. Urban Institute is similarly committed to making information available to the public and drive databased decision-making. The job of building the field of local information infrastructure is not one that only NNIP can accomplish on its own. NNIP works by partnering with other national and local organizations to build a field of local information that can be readily accessible by the public. They also partner with Community Indicators Consortium (www.communityindicators.net), which has an inventory of indicator projects and information on integrating community indicators with performance management.

The Need for Neighborhood Indicators

Local government and non-profit organizations need recurring data and technology to regularly monitor local neighborhood conditions. This helps them design their outreach programs in a better way (Making Data Actionable, 2014). Also, having data available from many sources enables these organizations to identify relationships among the variables, and judge their progress in the neighborhood. In an instance where there is a lack of such progress, certain measures can be taken to improve them. For this, they need properly projected data represented as an information system based on which they can make smart decisions. Having access to such data can foster public-private partnership to build better communities.

Quality of Life Utility

Though the Neighborhood Indicators Project is a great step towards democratizing data and facilitating data-driven decision-making, most of the information systems that are part of the NNIP are inadequately represented (Trieu, 2017). Most of these sites show static maps and trends, and are not interactive. Some of them are even formatted as reports. This can drive away users from utilizing the information available to them. Also, the data sources that provide the neighborhood indicators are very fragmented. Most websites have limited data variables and don't encompass a wide range of data that the public is looking for. Some sites may have health data, some sites have crime, housing etc. Even though the sites project the information in the most progressive way, there is still a lot left to be desired in the way public information system is to be designed and created. Quality of life Explorer bridges the gap between these fragmented data sources and inadequate representation. It integrates all the data at one place in an interactive map that permits the user to view how the areas they live in are progressing. This creative way of showcasing the data, enables the viewer to understand the community and neighborhoods better. The website is easy to access. Though the website represents data in a static form currently, there is huge scope to make the website dynamic by using API's to project the data. This helps in projecting real-time information to users, based on which community outreach and neighborhood improvement projects can be designed and targeted.

The Quality of Life Explorer, helps in developing blighted Neighborhoods into vibrant economic and diverse communities. Even though similar data is available across many websites and platforms, all the data is not available in one place in an easy to use format. ESRI is a great platform to represent data in an interactive way, but it is an application that needs to be learned for a while in order to be used properly. This may cause a hindrance to the general users and many may not take the pain to learn the tool even though it contains useful data.

Quality of life explorer fills this gap between the user and data availability. It aggregates all the data required and presents it in a very interactive format. This helps users understand their neighborhoods better and help improve their communities. The capabilities of this website include Interactive Maps, Reports, Distribution Tables, Trend Lines, etc.

Methodology

This study uses design science research approach (Hevner et al. 2004) to create an IT artifact intended to address socio-economic problems. Design science research paradigm seeks to extend the boundaries of human, socio-economic and organizational capabilities by creating new and innovative artifacts (Gregor & Hevner 2013; Hevner et al. 2004; Sein, Henfridsson, Purao, Rossi, & Lindgren). Given that our research's aim is to develop QoLE artifact to help improve the socio-economic condition in the case city, we deem it appropriate to follow the design science research principles to achieve this objective.

To achieve this objective, a true understanding of and appreciation for design science must be followed. Design science research approach is both a process (set of activities) and a product (artifact) according to Walls, Widmeyer, and El Sawy (1992). It describes the world as acted upon (processes) and the world as sensed (artifacts). The design processes followed in this study is a sequence of activities leading to the creation of an innovation product (i.e. the design artifact called QoLE). The evolution of the artifact provides feedback information and a better understanding of the problem in order to improve both the quality of the product and the design process. This build-and-evaluate loop is typically iterated a number of times before the design artifact (i.e. QoLE) is finally created (Markus, Majchrzak, and Gasser 2002). During the artifact creation process, researchers were deeply involved with the evolving design process leading to the actual design of the artifact.

Specifically, researchers followed the two popular design processes (build and evaluate) to develop the QoLE artifact. During the "build" stage, the QoLE artifact was designed and built to address an unsolved problem. A detailed evaluation will be conducted at a later stage when more features are added to the artifact. This artifact is classified as an instantiation as the proposed solution is being presented for a specific problem. The solution is in the form if IT application which is expected to help users understand their neighborhoods better. The technical specifications are described in detail in subsequent sections.

The idea for the QoLE artifact came into being in 2015 supported by the Community Development & Housing Director of case city in the study. The request was for a Market Segmentation Analysis to be conducted based on models developed to study housing market by Youngstown, Ohio and Newark, New Jersey. This prior study contained a maximum of 7-9 variables, all related to housing conditions. They did not include Social, Ethnic and Cultural demographics. Our study had a broader scope, including social and cultural demographics data.

Data Analysis & Preliminary Results

This study's segmentation analysis was conducted using seventeen variables. These variables encompassed a wide variety of categories from housing conditions, market value, tax rates, crime data, socio-economic demographic data etc. The data was collected from various sources such as the police department, Fire department, Water, Electrical, City planning for code Enforcement, Housing and Remodeling permits, etc. The housing conditions data was collected by the CHCS team using Loveland Technologies, Site control software. The site control software offers a block level data for the houses. However, it was customized for CHCS research purposes to contain Google Street View so housing condition can be ascertained by the researchers from their desktop instead of site visit. This saved considerable time and money in research.

The data from these sources came in various formats including csv, paper, reports (pdf files) and xls sheets. Also, some of the data were parcel level data, some census tract data, some block group level and some point data. The data from all these various sources and formats had to be cleansed and formatted to be represented at the block level. Pearson's Correlation Matrix was used to find relationship between various variables and home market value. Table 1 below is a summary variables used in this study.

Table 1: Variables utilized/implemented in the preliminary analysis stage.

Variable	**Definition & Sources**
Vacant_Lot	Vacant lots percent with no structure on parcel CHCS Remote Assessment 2014 images
PCT_SUBSTANDARD	Substandard CHCS Remote Assessment 2014 images

PCT_OWNER_ OCCUPIED2013	Percent owner occupied CHCS computed - U.S. Census Bureau, 2009-2013 5-Year American Community Survey
PCT_Moved_Last_ Year_2013	Mobility CCHS computed from geographical mobility in the past year for current residence--Metropolitan Statistical Area Level in The United States 2009-2013 5-Year American Community Survey
PCT_MORTGAGES_ OwnerOCC2013	CHCS computed - percent with mortgages U.S. Census Bureau, 2009-2013 5-Year American Community Survey Owner-occupied housing units
Loans_Originated_2014	Loan originations CHCS computed at tract level divided by number of block groups HMDA 2014
ESRIMedian_Value2012	Median value (Dollars) ESRI projection based on 2010 Census
PCT_DELINQUENT	Percent Tax Delinquent Properties CHCS computed - Guilford County Tax Assesor 2015
calls_for_service_1000	Police calls for violent crimes per 1000 residents (HPPD data 2014 and Census 2010 population)
PCT_NON_WHITE	Non-White percent CHCS U.S. Census Bureau, 2009-2013 5-Year American Community Survey
PCT_FOREIGN_BORN_ TRACT_2013	Foreign born percent CHCS U.S. census bureau, 2009-2013 5-Year American Community Survey
PCT_FOUR_ YEAR_2013	CHCS computed Four Year Degree Educational Attainment for the population 25 years and over U.S. Census Bureau, 2009-2013 5-Year American Community Survey
POP_PCT_ 18under_2013	18 and under CHCS computed from U.S. Census Bureau, 2009-2013 5-Year American Community Survey
POP_PCT_ 65ove_2013	65 and over CHCS computed from U.S. Census Bureau, 2009-2013 5-Year American Community Survey
MEDIAN_HH_ INCOME_2013	Median Household Income U.S. Census Bureau, 2009-2013 5-Year American Community Survey
PCT_POVERTY_2013	Percent income below poverty rate last 12 months computed from U.S. Census Bureau, 2009-2013 5-Year American Community Survey
PCT_FOOD_ STAMPS_2013	Public support CHCS computed Food Stamps/Snap in The Past 12 Months from U.S. Census Bureau, 2009-2013 5-Year American Community Survey

Technical Specification

The website was adapted from version 3 of the original Quality of Life Explorer website which is not available to the public yet. However, developers can access it through Github site. This code has been adapted by many organizations to varying extents.

The version 3 code utilizes the following software:

Node.js - Node.js is an open-source, cross-platform JavaScript run-time environment for executing JavaScript code server-side
Vue.js - Open-source progressive JavaScript framework for building user interfaces
Mapbox GL JS - Mapbox GL JS is a JavaScript library that uses WebGL to render interactive maps from vector tiles and Mapbox styles
QGIS - QGIS is a user friendly Open Source Geographic Information System (GIS)
NPM – Package manager for JavaScript. Default manager for Node.js
FileZilla – A free, open-sourced FTP client
Material Design Lite – Provides stylesheets and templates to improve look and feel of websites
ATOM Editor- For creating and editing files
The next process after installation and setup of the above software is to create data files for the case under study in a format that would allow the code to read and project it to the maps.

The data format is as follows:

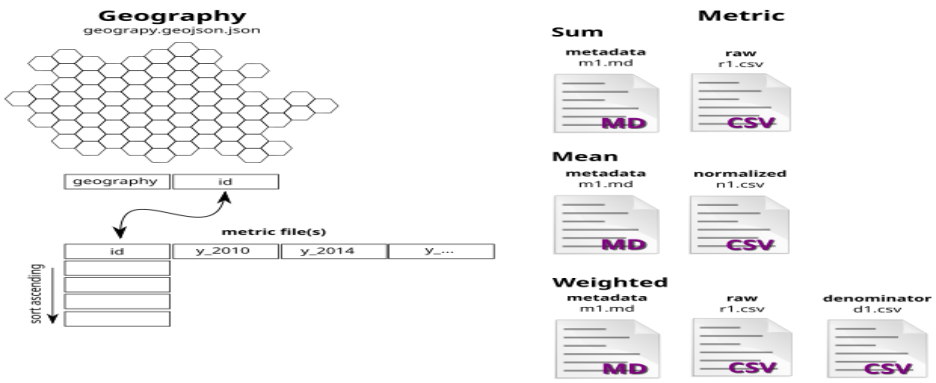

Figure 1: Schematic Diagram to Illustrate the Input Data Format.

The metric files contain the raw data which is to be projected. The metadata files are the descriptions of the metrics. They define and describe the metric variables along with mentioning the sources of data. The metric data is represented in three types- sum, weighted, mean. Based on the type of data needed, the metric data will be either summed, averaged or weighted at the county level. If a sum is selected, only the r{metric number}.csv files will be selected. If weighted is selected, r{metric number}.csv and d{metric number}.csv are selected. The r{metric number}.csv provide the numerator and the d{metric number}.csv provide the denominator. For mean, the n{metric number}.csv files are selected. Currently, the site hosts, seventeen variables from categories ranging from housing, education, age, ethnicity etc.

Even though the variables were added and the website was rendering, there were minor functionalities that were not working properly and needed to be changed. One of the main functionalities of the map was the OSM-Liberty base-tiles which contain street level view of the maps, did not render properly. This was due to the website being hosted over HTTPS protocol which was a secured protocol and the base-tiles link was hosted over a HTTP protocol. This led the HTTPS protocol to block the content. The older link was replaced with a new link containing similar style base-tiles. After this, the base-tiles rendered perfectly and the streets of the city could be viewed.

This was followed by changing the logos to the city in the case study. The next biggest functionality that had to be enabled were the Report and Print map functionality which generated reports and Print page for the maps respectively. For these functionality to be enabled, a separate code for reports and embed maps had to be adapted for the city data. Once adapted successfully, this was then uploaded to the server. The embed maps code served the functionality of both printing the map and embedding the maps in the report. The Embed maps button took a while to be functional as the map was not being projected onto the Reports or print page. This was due to the maximum bounds for the map. The bounds needed to be expanded to give space for the map to be projected onto the desired space. Otherwise it was projecting to the right direction.

The basic functionalities of the website's Proof of Concept are currently functional and the url is not included to maintain anonymity for review. Screen shorts are provided below. Figure 2 below is a pictorial view of the website's homepage that displays

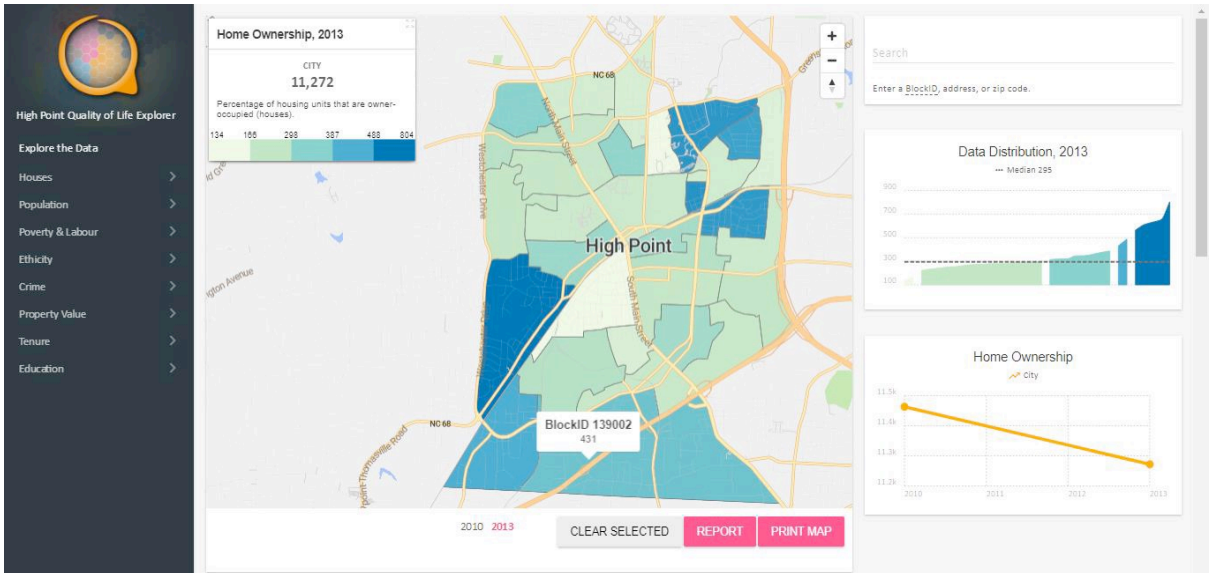

Figure 2: Homepage of the Interactive Quality of Life Explorer Map.

Home Page also displays description of each variable along with the data sources from which data was obtained for that particular variable. It also contains links to various websites for further information. It also displays links to related variables, usually variables from the same category. By clicking on these links, that particular variable selected will be displayed.

In addition, the QoLE tool also enables users to search information on the population of residents in city case study area. Poverty and economic information, ethnicity, crime rate, etc. are also other interesting socio-economic information that can be obtained by a user from the Map. Due to space constraints, we are unable to show pictorial examples of these examples at this time.

Discussion

The website currently maps only static data in csv files. As we move forward with the website, the plan is to introduce both live and historic data through the years e.g. 2010-2017 etc. Live data can be queried by making API. Certain organizations like American Community Survey have their own API's that can be used to extract data directly from them. The county also has their own API's which they use to post live data on their website. This will make the website more dynamic and project data in real-time. Presenting data through the years also enables observing trends over the years and making predictions regarding future patterns.

Currently the website represents only one variable at a time. In the future, more layers will be added to the map to represent multiple variables for e.g. Ethnicity and home ownership. This kind of overlapping variables, help the user understand trends in homeownership based on ethnicity. This may also help develop a causal relationship between variables which can help improve neighborhoods better. This data can also be represented as point data and heat maps. Heat maps, show concentrations on a map. Point data pertains to a specific location on a map for e.g. hospitals in an area etc., this helps users locate the services they need around their neighborhoods.

Currently the site hosts seventeen indicators. The plan is to include all 86 variables in the future for case study on the website. Key things accomplished thus far include: (i) creation of a static website that only features one variable at a time and showcase a single year information at a time; (ii) a data distribution table for each year and a Trend line that shows how data is distributed for each year; (iii) a search bar for searching areas based on Block ID's; (iv) a static report generating function; and (v) a printable map. In the near future, we plan to implement additional features that will have the capability to: (1) showcase multiple variables at a time (e.g. population, ethnicity and homeownership); (2) include data of more cities with each city having its own address; (3) use API's to update the data to enable real-time access; (4) embedded heat map generation functionality; (5) provide description and sources of each variable; (6) have a dynamic

report generation functionality; (7) showcase data in multiple levels (e.g. parcel, block group, and block ID level); (8) include data across multiple years; (9) have automation functionality that allows data to be directly projected from a database as opposed to Excel sheet; (10) show causal relationship (e.g. bad housing conditions and asthma), etc.

When completed and successfully implemented, the key utility of the QoLE artifact will be the ability to have multiple variables and seasonal data displayed concurrently at a single time. This will enable government and non-profit organizations improve the community with specifics to housing conditions improvement. The overarching objective is to implement a fully integrated and data-driven decision support system with its own database architecture that will feed data to the system according to pre-specified rules. The system will then, in real-time, analyze the data and project the results onto a map in a way that is easy to understand and help make informed decisions. This way, users can understand how well their community is developing with respect to rest of the nation.

Due to space constraints, we could not include the remaining variables to be implement in this paper. We intend to rather present the remaining variables at the conference for further discussion.

Conclusion

Using design science research method, we create an interactive artifact for quality of life improvement. The artifact uses A&BI techniques to customize the map and enhance its visualization and interactivity capabilities in a way that is simple to understand and use. The QoLE artifact created from this research is an A&BI-driven working Proof of Concept website for the case city under consideration. Furthermore, QoLE website has built-in capability that allows report generation as well as increase interactivity of map and data distribution tables.

The outcome from this study will help the case study city authorities and residents to better visualize the data in a more smart and realistic way so that they can make informed decisions in redeveloping their city. More specifically, the study outcomes will help the city authorities and stakeholders overcome their current constraints of having this rich and valuable huge data in a centralized location for easy accessibility and analysis.

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