Cartography M.Sc.

Master thesis

Integrating Visual Analytics Tools into Geomarketing

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Integrating Visual Analytics Tools into Geomarketing

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Statement of Authorship

Herewith I declare that I am the sole author of the submitted Master's thesis entitled: "Integrating Visual Analytics Tools into Geomarketing".

I have fully referenced the ideas and work of others, whether published or unpublished. Literal or analogous citations are clearly marked as such.

Munich, September 10, 2019 Iñigo Etxeandia Rodríguez

Abstract

In business, proper assessment of spatial information is widely known to have critical importance in determining the competitiveness and future prosperity of an enterprise. From the analysis of geo-coded data for marketing purposes, the field of geomarketing (or spatial marketing) was born. For a long time, researchers tended to tie geomarketing to the use of Geographic Information Systems and the use of automatic digital analysis to solve its tasks (Schüssler 2000; Tappert 2007). With recent developments in graphical user interfaces (GUIs) and interaction devices, the interest in visual data exploration has notably increased in the scientific community (Thomas and Cook 2006). Many researchers claim that, for complex tasks like geomarketing problems, including human interaction and visual feedback could facilitate the analysis process and presentation of results (Keim 2010). However, the limited amount of scientific literature suggests that the introduction of these analysis methods into geomarketing processes is still at an early stage.

The goal of this thesis is to determine whether the introduction of Visual Analytics techniques would provide significant improvements to the geomarketing reasoning process and presentation of results. To this end, this study has made a thorough research on the current trends in VA and Geomarketing fields and how these domains could connect with each other. After that, with help of a domain expert, comprehensive guidelines for the integration of interactivity into geomarketing applications were defined.

In order to test those guidelines, an interactive web tool was designed, implemented and evaluated. The testing showed very promising results in terms of the benefits that could be brought by incorporating VA methods into the spatial marketing field. Applying Visual Analytics principles, the difficulty in geomarketing analysis was reduced, without limiting exploration, meaning users with modest geostatistical expertise can reach valuable insights through visual exploration.

Keywords: Geomarketing, Spatial Marketing, Visual Analytics, Interaction, Interactive Cartography

Acknowledgements

When I was about 4 years old, my mom told me that to leave a mark in this world I needed to do at least three things: plant a tree, write a book and have a child. However, that day, she only taught me how to plant a tree. Apparently, I was too young to learn how to write and way too young to learn how babies are made.

A few years later I learned how to write and today I am finishing what might be the closest that I will ever be from writing a book. Therefore, I do not want to miss this opportunity to thank everyone who has helped me get this far:

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A Cinthya, mención especial para tu corazón risueño y atento al que nunca le importó hacer un esfuerzo adicional por ayudarme en aquello que necesitara.

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List of Abbreviations

GIS	Geographic Information System
GUI	Graphical User Interface
NA	Not Available
OSM	OpenStreetMap
PDF	Portable Document Format
QGIS	Formerly “Quantum GIS”
SMEs	Small and Medium-sized Enterprises
UCD	User-Centered Design
UI	User Interface
UX	User Experience
VA	Visual Analytics

1 Introduction

1.1 Background and Context

In the past, most of the research around the spatial aspects of the economy had a tendency to limit itself to the coding and geographical division of space, with limited importance being given to the statistical analysis of spatial components (Cliquet 2013). The growth of the geostatistics field made it possible to push the limits of geographic data treatment and provide valuable elements for the definition of business strategies (Cliquet 2013). This particular marketing use of spatial analysis lead to the appearance and current blooming of the geomarketing or spatial marketing field (Kaar and Stary 2019).

For many years, the ever-increasing computational power available for statistical analysis put the spotlight on automatic data processing until researchers like Thomas and Cook (2006) realized that human interaction through visual interfaces could facilitate the extraction of valuable insights from data. From this combination of automated and visual analysis based on interaction, the research field of Visual Analytics was born (Keim 2010).

Due to the relative recency of the study branches of Geomarketing and Visual Analytics, there seems to be very little research work discussing the integration of the two. The analytical needs of geomarketing processes are currently being solved in generic geographic software and the presence of interaction is very limited (Later discussed in "2.2.2 Advantages Over Traditional Geomarketing Workflow"). Successful introduction of interactive cartography and VA into the Geomarketing field would certainly create plenty of opportunities for further research.

1.2 Research Identification

1.2.1 Objectives

The main goal of this thesis is to determine whether geomarketing professionals would benefit from the introduction of Visual Analytics techniques into their reasoning process and presentation of results. If so, this study also aims at indicating what are those specific benefits and provide a working example for a selected geomarketing method.

Subordinate to these main objectives, there are 4 underlying objectives that need to be tackled throughout this study:

- **Objective 1:**
  Determine what are the iterative processes present in common geomarketing solutions. In other words, what are the stages of the data exploration/analysis conducted in geomarketing that may need to interactively try out parameters.
- **Objective 2:**
  Design a Visual Analytics implementation that enables geomarketing professionals to interactively examine data, mapping variations in real time.
- **Objective 3:**
  Ascertain whether the designed implementation is beneficial for solving the tasks and identify possible improvements.
- **Objective 4:**
  Propose design guidelines for the analyzed geomarketing solution, based on the Visual Analytics framework and taking into account possible improvements on the initially designed implementation.

1.2.2 Research Questions

To meet the objectives stated above, several corresponding research questions will require an answer from this study.

The core question is: "Can the introduction of Visual Analytics techniques provide significant improvements in the field of Geomarketing? What are those improvements?".

Along with that core question, these 4 questions will also require an answer to reach the underlying partial objectives:

- **Research Question 1:**
  What are the iterative stages of geomarketing processes that could benefit from the visual feedback of interactive cartography?
- **Research Question 2:**
  How can Visual Analytics and interactive cartography be integrated into a tool for solving a selected geomarketing problem?

- **Research Question 3:**
  Is the designed implementation helpful throughout the analysis task? Is it helpful for presenting the results?
- **Research Question 4:**
  How can the initial implementation be improved?

1.3 Thesis Outline

This thesis is divided into 6 chapters as follows:

1 Introduction:
The purpose of this initial section is to introduce the context of this study, and present its objectives, research questions and general structure.

2 Conceptual Framework:
The second chapter, Conceptual Framework, will describe the research fields of Geomarketing and Visual Analytics in detail, highlighting the potential for successfully combining the two.

3 Methodology and Practical Application:
This section details and validates the followed research method, describing the development of the practical case study from its initial design to its functional implementation.

4 Empirical Study:
After the development of the pilot visual analytics tool, an empirical study will be executed to assess its performance. This section will describe the specifics of the planning, procedure and outcomes of that study.

5 Results:
The results will report and discuss the most important outcomes of the conducted research, tightly linking them with the objectives and research questions that were considered in chapter 1.

6 Conclusions:
Finally, the conclusions will try to summarize the main takeaway points of this thesis as well as suggesting some possible improvements and future implications of those findings.

2 Conceptual Framework

The following section will present the current conceptual understanding of the research fields of Geomarketing and Visual Analytics, with specific focus on how these domains connect with each other to lay the foundations of this research. Some of the most common geomarketing tasks will be described and we will discuss what are the advantages that Visual Analytics could provide to solve them.

2.1 Geomarketing

2.1.1 Definition

It is already a well-known fact, that location plays a key role in competitive business management and particularly at the time of reaching customers and satisfying their needs. This long-known fact has led to the appearance of Geomarketing, a sub-branch of Marketing focusing on the use of geographically referenced data to generate actionable business insights (Noorian 2015).

German research literature has mostly relates geomarketing exclusively with Geographic Information Systems, for example for Schüssler (2000) geomarketing involves "planning, coordination, and control of companies' customer-oriented marketing activities through a GIS" and Tappert (2007) defines geomarketing as the "optimization of marketing and sales through the application of a GIS". However, the term "business GIS" coined by Longley and Clarke (1995) might be more accurate name for this limited view on geomarketing.

In a broader sense, geomarketing it is a whole system powered by cartography, informatics and statistics that enables the analysis of the socioeconomic reality (Yrigoyen 2003). As a whole, this system allows enterprises to better understand spatial marketing elements for the definition of future business strategies (Cliquet 2013)

2.1.2 Common Tasks

Some of the most common geomarketing solutions that market research companies include among their offered services are:

- **Site Planning:**
  In business, and particularly in sectors like retail, selecting the right place to open a new branch could mean all the difference. "Site planning", sometimes also called "Location Analysis", focuses on finding the best possible location to set up a new branch based on present and predicted future parameters. Some of the factors that influence this decision the most are: area demographics, desired location type, foot traffic, competition positioning etcetera. (WIGeoGIS 2019c; Merz 2017)

- **Target Group Analysis:**
  Also known as "Target Audience Analysis", this geomarketing solution examines purchase trends within the local market. Different kinds of georeferenced data, such as socio-demographic information, help identify areas with high concentration of potential new customers. In certain cases, this method can also detect opportunities to persuade existing customers to buy a different product or service (cross-selling) or something additional or more expensive (upselling). (Vojtech 2019b; WIGeoGIS 2019e)

- **Market Penetration Analysis:**
  Tightly linked with the aforementioned "Target Group Analysis", this geomarketing study evaluates the degree of correlation between the business potential of the different distribution areas and the location of former sales of the company. Once the potential-measures of the local market have been estimated, decision makers can detect weak and strong selling points, identifying branches performing bellow the expected results and offices where reasonable targets were successfully met or even overachieved. (WIGeoGIS 2019d; Vojtech 2019a)

- **Sales Territory Planning:**
  Possibly the most extensive market study, "Sales Territory Planning" involves, in one way or the other, all the above-mentioned core methods. This geomarketing solution is most beneficial for medium-sized and large enterprises with a sales network (a set of connected sales establishments) already in place. Companies of this magnitude, often see their sales territory grow or change over time and therefore it requires periodic restructuring to make sure customers are being reached and their demands properly covered. In order to

successfully perform this rearranging of sales representatives, “Sales Territory Planning” takes into account the business potential of all covered markets, current performance in them and minimization of travel times. (WIGeoGIS 2019b; GfK Global 2019)

2.2 Visual Analytics

2.2.1 Definition

In recent years, technological advances seem to have changed the focus from data acquisition to data treatment. As the volume of so called “Big Data” continues to grow, so does the potential knowledge waiting to be discovered within it. As a result, the transformation of data into information has become the primary problem nowadays (Kerren and Schreiber 2012). The need to handle these large amounts of data was one of the fundamental motives for the emergence and adoption of visual analytics (Kielman, Thomas, and May 2009).

Thomas and Cook (2006) defined visual analytics as “the science of analytical reasoning facilitated by interactive visual interfaces” and highlighted its fitness for deriving insight from large, dynamic and heterogeneous amounts of data. A few years later, Keim (2010) went further describing visual analytics as the “tight coupling of automated and visual analysis through interaction”, emphasizing the complementary and alternating role played by modelling and visualization. To illustrate this, Keim (2010) also created a flow diagram of the proposed visual analytics process (Figure 1).

This schema synthesizes the key steps of the visual analytics workflow. The initial need of selection, integration and overall preprocessing of the heterogeneous source data is followed by both visual and automatic analysis methods in parallel. Visual representations of the data enable human interaction, whose findings on that data assist the model building process for computerized processing. At the same time, the automated analysis produces model visualizations that can be explored by the user, closing the iterative analysis loop that eventually leads to valuable insights.

However, the process does not finish on that uncovered knowledge, since interactive visuals serve as a great tool to communicate the study’s assessments (Thomas and Cook 2006) with the end results therefore becoming great input data for further research.

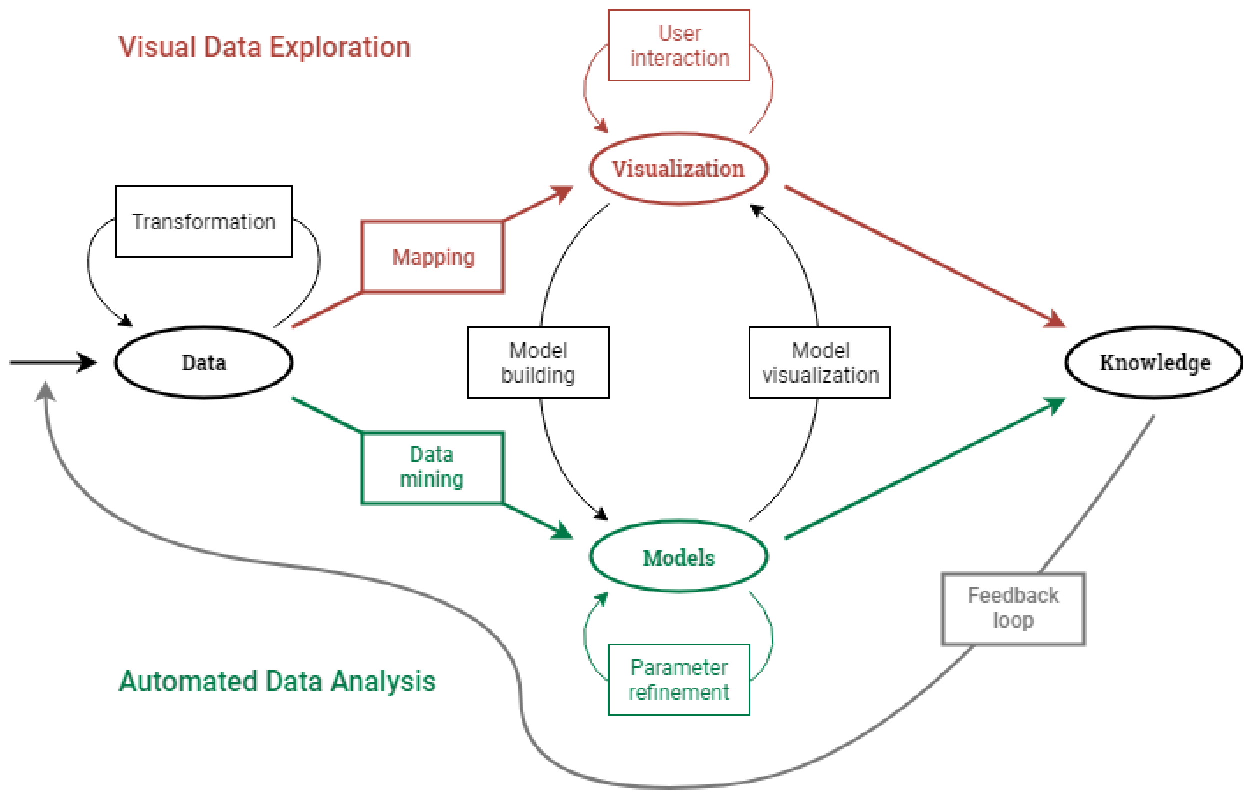

Figure 1: *The visual analytics process*. Figure redrawn from Keim (2010)

A good practical example of the successful use of visual analytics is the analysis of climate networks. Geophysical networks are extremely time- and location-dependent and their study involves the interpretation of data coming from large number of sampling nodes. For the understanding of this vast amount of information, the capabilities of computer-based automatic processing are combined with the strengths of the human visual system. First, digital-processing using conventional statistical methods produce different kinds of plots and diagrams of climate simulations. Then, the visual interpretation of those graphics by climate experts is what leads to the identification and modelling of trends that would otherwise go unnoticed. (Nocke et al. 2015).

2.2.2 Advantages Over Traditional Geomarketing Workflow

Analytical problems such as common geomarketing tasks, have commonly been solved through automatized statistical methods and data mining, independent from visualization and interaction techniques. Traditional market research companies currently use GIS software to conduct their geomarketing studies and visualize their results (WIGeoGIS 2019a). GIS software offers very powerful analytic processing power but provides very limited visual feedback throughout the reasoning stage and until the final outcome is ready (Cliquet 2013).

Geomarketing results are customarily presented to the client as a report, containing one or several thematic maps (Merz 2017), thus, the client has no control over the analysis result. Considering the target audience of geomarketing reports are marketing domain experts, thematic maps and their high level of abstraction (conceived to present information to a broad audience) might not be the best channel for the cartographic communication of these results.

In recent years, following the developments in interaction devices and graphical user interfaces (GUIs), the interest in visual data exploration has significantly grown. However, the limited amount of scientific literature suggests that the introduction of these analysis methods into geomarketing processes is still at an early stage. As we have seen in the previous section (See "2.2.1 Definition"), many authors claim that incorporating user interaction and continuous visual feedback contribute to better decisions and presentation of results in complex tasks like geomarketing solutions. Therefore, the introduction of interactive cartography into the field, as a replacement for GIS and thematic mapping, could lead to more efficient analyses and better conveyance of their results.

3 Methodology and Practical Application

The following chapter thoroughly reports the followed research method, describing the development of the practical case study. From the initial considerations, through the design choices and until the final implementation of the application, this section will focus on substantiating the validity of the considerations made throughout the study.

3.1 Research Procedure

In 1952, Arthur Robinson's book "The Look of Maps" broke with the preconceived idea of treating cartography as a craft and advocated for the use of empirical studies as the primary tool for understanding maps and refining their construction. This project has followed this empirical-study structure, first gathering background information and requirements, then designing a pilot project and finally examining the feasibility and performance of the design concept through testing (See "4 Empirical Study").

3.2 Requirements Interview

Since the main objective of this thesis is to evaluate the benefits of the introduction of Visual Analytics into current geomarketing methods, the first step was to get in contact with a geomarketing professional of the private sector. This would help identify the requirements for the subsequent design of the prototype tool.

In order to complete this first step, an interview was arranged with an expert in the geomarketing field. The following subsections explain in further detail the characteristics, questions and findings of that interview.

3.2.1 Interview Characteristics

The user who would benefit from the results of this study is expected to be a skilled professional. Therefore, this initial requirements-search has been framed within the qualitative research methods' characteristics.

The interview participant is a purposefully chosen field expert and no material is required other than the questions. These questions will be broad and allow for discussion, following a semi-structured interview style. There is no need to derivate any representative codes or metrics from the responses since the results will be analyzed from a descriptive synopsis report of the provided information. The interview is planned to find out about three core aspects of the geomarketing workflow: common tasks, working procedure and software.

3.2.2 Interview Questions

As is customary in semi-structured interviews, in order to allow new ideas to be brought up by the interviewee, the questions were meant to only establish a framework of topics to be examined. Throughout the interview, the following purposefully-broad questions were brought up:

1. What are the most frequent geomarketing tasks/analyses you solve in your professional role?
2. How do you usually solve those geomarketing tasks/analyses? (Software?)
3. When (on what stages) do you use map visualizations? (Data exploration? Analysis? Presentation of results?)
4. What problems do you usually have throughout your workflow?
5. What other geomarketing solutions does your employer offer?
6. What results do you give back to the client? How do you present them?
7. From all tasks, which ones you think would benefit from interactive cartographic tools or the implementation of VA methods?
8. (Open-ended question) Is there anything worth mentioning about your geomarketing work I have not asked you about?

3.2.3 Interview Findings

The most important outcome of the interview is how it further confirmed the information gathered during the preceding research on traditional geomarketing methods (See "2.2.2 Advantages Over Traditional Geomarketing Workflow"). The answers provided by the interviewed professional seemed to perfectly align with the hypotheses that VA could help alleviate some of the shortcomings of current methods.

It is also important to note that the interviewee is working on geomarketing software-development and therefore the obstacles faced during his work are not connected to analytical matters. Likewise, due to the size of the company, the interviewee was not aware of the duties and methods of other departments within it. Therefore, questions number 4 and 5 did not lead to any significant information.

The results of the discussion can be summarized as:

1. The most common geomarketing tasks the company is usually inquired about are Site Planning and, to a lesser extent, Target Group and Market Penetration Analyses (See "2.1.2 Common Tasks" for details).
2. In order to solve those problems, the company provides a simple web-based visualization tool for data exploration, which also includes some basic tools for Site Planning operations. Any analysis requiring deeper examination is carried out in GIS software.
3. Map visualizations are present on every stage and product the company uses or provides to the client with. A map is the main interface component of their self-developed web application, as it naturally is of the GIS programs they use.
6. The results the client is usually provided with, are either the simplified web-based Site Planning tool itself or, for other geomarketing tasks, a PDF format static report.
7. As for what aspects of geomarketing could benefit from interaction, the geomarketing expert mentioned they are in the process of incorporating interaction to their web-based application. Input data exploration and Site Planning seem to be tasks that to their understanding would profit from the possibility of human interaction. However, so far, the only interaction included among the tool's functions is the activation/deactivation of layers and some filtering and sorting on the menus.
8. Finally, the interviewee wanted to emphasize how customers demand simplicity in the tools and the "recommendations" (consulting results). Moreover, he also highlighted how interaction may be particularly helpful for simplifying data exploration when the input is "Big Data".

3.3 Interactive Geomarketing Application Development

3.3.1 Design

Taking into account the information gathered in the requirements interview and the theoretical background research on geomarketing and visual analytics, this design step consists in the design of an interactive cartographic tool enabling visual data exploration and location planning.

- **Target:**
  In recent years, the software design sector has swiftly adopted the "User-Centered Design" development method. When used, this production framework is considered to lead to elevated usefulness and usability (Vredenburg et al. 2002). On this basis, the first step in the design of the interactive cartographic application will be the consideration of the target use (tasks focus) and target user (user focus), core concepts of the first UCD principle mentioned in the "Handbook of Usability Testing" (Rubin and Chisnell 2008).
  The target use case of this tool will be Site Planning, this is, finding the best possible location to set up a new business branch (See "2.1.2 Common Tasks" for details). Due to the crucial importance of location in retail, it is the sector that most often requires the location-analysis geomarketing solution and despite the recent pronounced growth of e-commerce, 90% of retail transactions are still made offline (CARTO 2019). Therefore, this application is designed to be used in finding an ideal location for a new "brick and mortar retail store" (traditional street-side businesses).
  As for the target user, the application is meant to be used by small and medium-sized enterprise (SMEs) entrepreneurs. This means that the target user will be expected to be versed in the particularities of business plans and commercial practice but not necessarily know of the geographic implications of them. The early-stage flexibility of SMEs and the geomarketing-inexperience of its executives adequately match the profile that would most benefit from an interactive and simplified geomarketing tool.

- **Features and Architecture:**
  The web-tool's features will concentrate on human-interaction facilitating elements, enabling the user to carry out geomarketing tasks through visual data exploration. The interactive application will enable a city-level location analysis which, for this particular example will be the applied for the city of Munich, Germany. However, the chosen city is not significant in terms of the reproducibility of this study.

The functionality needs of the cartographic tool are very tightly linked with the requirements for solving the Site Planning geomarketing problem (See "2.1.2 Common Tasks"). At the time of choosing the placement of a business site, one of the first narrow-down decisions managers have to make is selecting the location type. Store locations are available in many different forms, such as free-standing buildings, downtown commercial districts or shopping malls (Entrepreneur Media Inc 2019). Each business plan has different target specifications, which require a certain type of location. Therefore, this choice will be the first one to be included in the designed geomarketing software, as an option that will dynamically switch the focus depending on the selected location type.

The analysis in each of the aforementioned categories should be different depending on their characteristics, hence, the remaining interaction-enabling options should conditionally appear depending on the type of location.

In the case of free-standing locations, rent costs per square meter are usually reasonable and the store mostly attracts nearby customers (Waters 2019). This makes local demographic information and its trends crucial for the success of the new branch.

Downtown areas are a common premium choice for specialty stores, rent prices are considerably higher and shops tend to be clustered around shops of similar pricing brands and retail sectors (Waters 2019). Because of this, among its tweakable parameters, the functionality of the app should include the rent price and the brand category and sector for downtown locations.

Finally, shopping malls tend to be scattered around the city so they serve customers in a similar way to the free-standing location shops, the only main difference being that, due to city development directives, only a few shopping malls are built and therefore those are the only options available.

- User Interface:

  Taking the previous "Features and Architecture:" aspects into consideration and focusing on simplicity, a minimalist UI was designed. The projected interface would feature a map, prominently taking the center of the screen, and two side elements: On the left, the legend, providing contextual information to interpret the map and on the right, the interaction menu, offering the different variable options to the user (Figure 2).

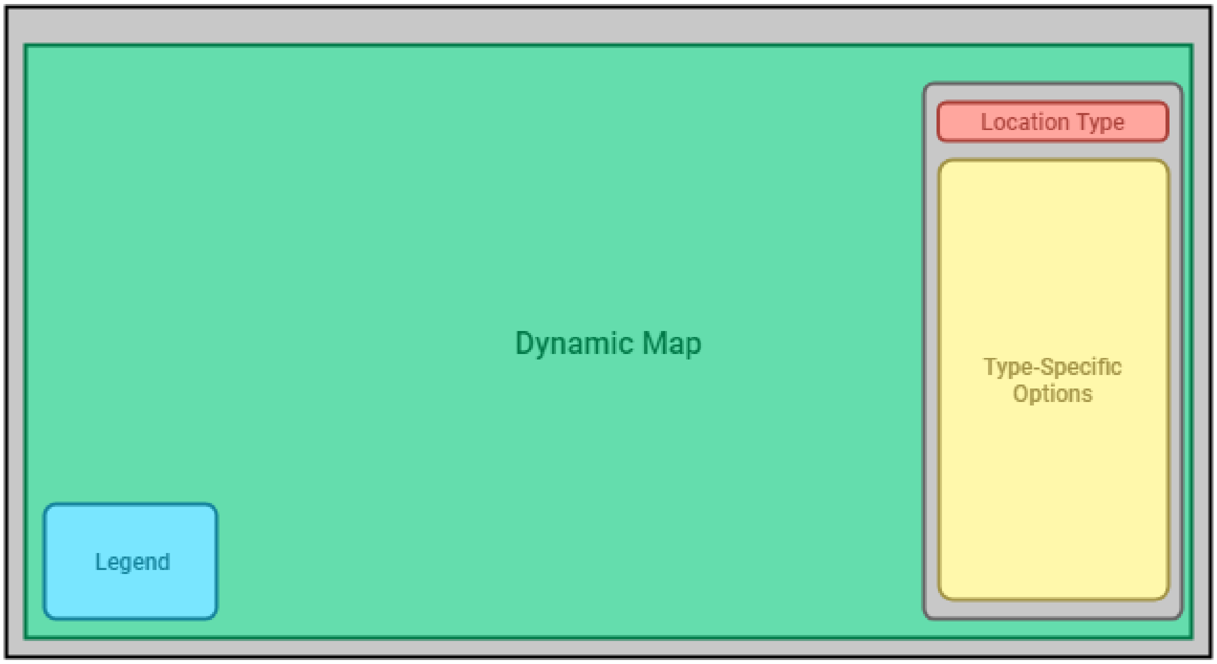

Figure 2: *Designed User Interface*

The two components on the sides, are designed to float on top of the map. Different updates of the map will regenerate a suiting legend and each Location Type choice will also have a corresponding Type-Specific Options menu, both of which may be of a different size. Making these containers float, ensures that when elements retract to a smaller size they reveal more map space (Figure 3), instead of blank background of a reserved space (Figure 4).

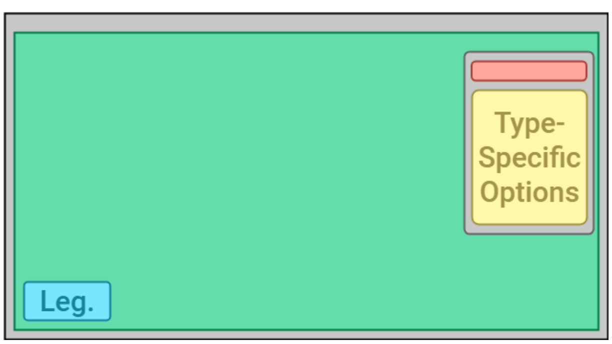

Figure 3: *Expected UI Adaptability*

Figure 4: *Undesirable UI Performance*

For choosing the location type, the user will be presented with a dropdown menu (Figures 5 and 6). The available options will be only three and they will not vary since they do not depend on any other previous selection. Typing the desired option would be slower and the user is not expected to need to move back and forth between options. All those conditions fit in the design guidelines for the use of dropdown menus.

The rest of the menus will vary depending on the selected location type. As analyzed in the "Features and Architecture: section, for free-standing locations, the most relevant information in location planning are demographic data and its trends.
To allow the interactive analysis of population records, the main menu for this window will be a list of checkboxes. These checkboxes will correspond to the different age brackets that the retail business is trying to sell their products to. Checkboxes have been chosen over radio buttons, because they offer the user the option to select more than one age bracket, allowing for individual on-off toggle. Radio buttons would unsuitably provide mutually exclusive selection values, since the same retail branch could be targeting multiple age groups (e.g. a supermarket sells a variety of products with different articles satisfying the needs of customers of different age groups).
On top of the age-brackets menu, a time slider will also be included so that the user can dynamically move back and forth through the demographic data of different years and spot trends that could help forecast future performance.

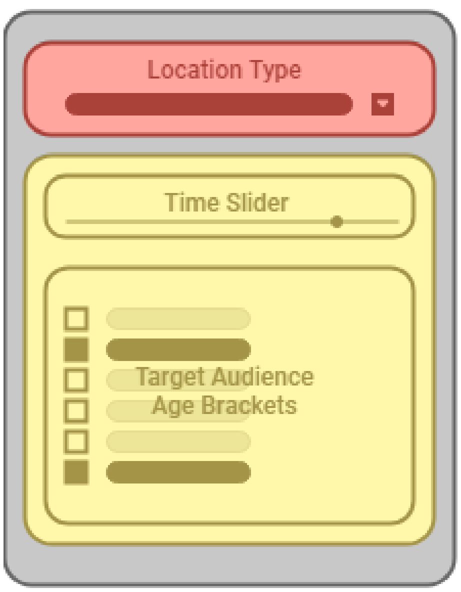

Figure 5: *Menu for Free-Standing Location*

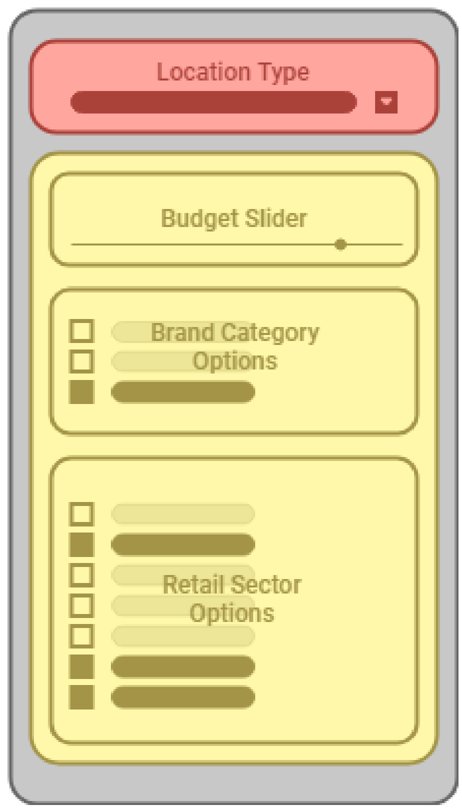

Figure 6: *Menu for Downtown Location*

This time slider will complete the interactive options menu for the screen corresponding to the free-standing location type (Figure 5). The shopping mall location type will also share this same UI, since the priorities for choosing the best possible placement are the same, with the only difference being that in this case, only shopping malls are considered.
Regarding the downtown location type, in this case the rent prices and the brand and product characteristics play a more significant role (See "Features and Architecture" for details). For this reason, the UI corresponding to this type will be headed by a slider that allows the user to establish an upper limit for the property rent budget.
Following that, the projected design includes two menus giving the user the options to select from different brand categories (luxury, mass market…) and from different retail sectors (automotive, clothing…). Both menus will be checkbox based to allow once again multiple simultaneous choices, since the same retail branch can be selling multiple brands of different identities, or products of different retail sectors (e.g. clothes and shoes).

3.3.2 Materialization

This is the coding stage, when the designed tool will be implemented into a proper functional program to be tested later on.

- **Software:**
  As we saw in the "
  2.2 Visual Analytics" part of the "2 Conceptual Framework" chapter, the VA process is characterized by the combination of visual analysis through human interaction and computer-assisted automatic analysis. Due to the simple nature of the program developed in this study, a powerful environment for computational processing is not imperative. However, to enable future expandability and to make the final product as true as possible to an industry level software, the implementation has been made in R programming language. Specifically built for statistical treatment and graphics (Ihaka and Gentleman 1996), R is according to some surveys the most popular programming language for Data Analysis (KDnuggets 2012) and its popularity is only growing (Tippmann 2015). The limited scope of the demo app built for this research does not take advantage of all the capabilities of R, but aims at providing a peek into the possibilities it would offer in the "automated analysis" path of the Visual Analytics framework.

Along with its computing power, one other great advantage of choosing R as the language for the materialization of the designed software, is the Shiny package. Shiny provides a web framework for building interactive web applications straight from R, without requiring HTML, CSS, or JavaScript programming skills. In words of their own creators, "Shiny combines the computational power of R with the interactivity of the modern web" (RStudio Inc 2017) and it is this fitness for enabling interaction that makes it ideal for the implementation of the VA cartographic tool.

Lastly, the final piece that confirmed the suitability of R for the development of this project, was the convenience of Leaflet for R. Leaflet is one of the most popular open-source libraries for creating interactive maps (Agafonkin 2019) and it is now available as an R package. This was the mapping engine used for the dynamically-changing maps in the application.

- **Data Sources:**

  Although not usable for every city this case study could be applied on, here are the data sources used for this particular implementation (See "Appendix A" for web-links and download information):

  1. Munich demographic data:
     Indikatorenatlas München - Landeshauptstadt München
  2. Munich downtown street retail indicators:
     Retail Market Germany Property Report 2019 - BNP Paribas Real Estate
  3. Munich shopping malls data:
     Retail in Munich, Sector Information - City of Munich Department of Labor and Economic Development
  4. Munich district subdivision borders:
     OpenStreetMap - OpenStreetMap Foundation
  5. Munich downtown street polylines:
     OpenStreetMap - OpenStreetMap Foundation

- **Product Implementation:**

  With the design aspects of the tool determined and the data ready to use, we proceeded with the coding of the demo software in R. Shiny provides a solid framework for the development of interactive applications with the UI and Server building blocks clearly differentiated.

  This architecture powers a 4-step responsiveness process (Figure 7) that begins with the UI selection element. When the selection value is changed in that interface component, it becomes an input value that the server can use to recalculate new output values. In this case, this new output values are the parameters that define the characteristics of the updated map. The UI component then takes those parameters and replots the map for the user.

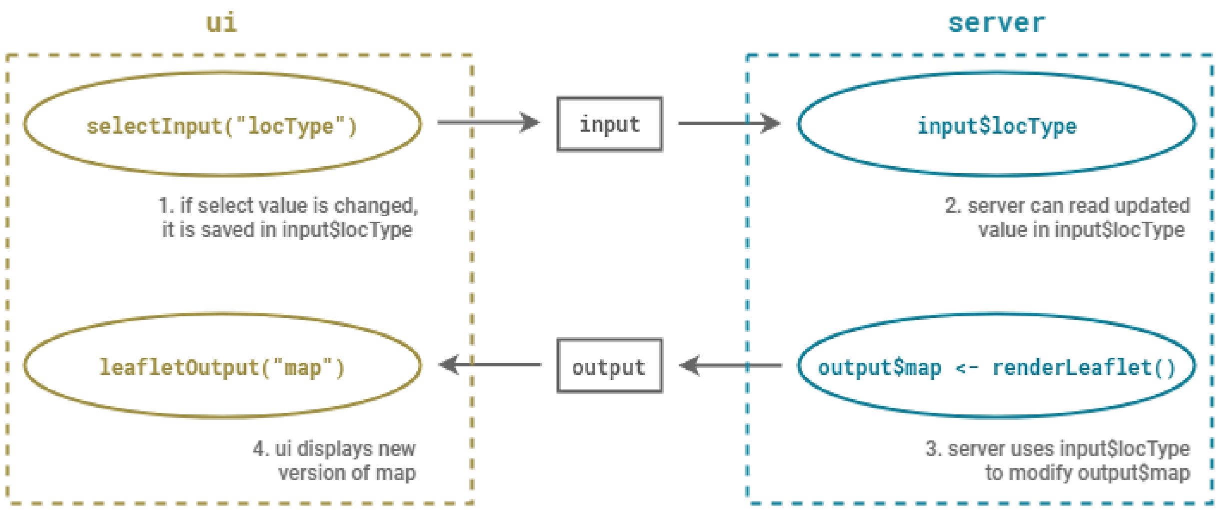

Figure 7: *Basic shiny architecture*. Figure adapted from Attali and Cheng (2019)

Proper understanding of Shiny's architectural functioning made it much easier to convert the design of the application into operational R code.
The UI elements described in the User Interface: section (See "3.3.1 Design") become `selectInput` (for drowpdown menus), `sliderInput` (for sliders) or `checkboxGroupInput` (for checkbox menus) elements. Every options menu that depends on the location type was included in `conditionalPanel` functions so that they only appear if a particular selection is made in the Location Type dropdown menu.
Once the interaction-enabling menus are coded, the web-tool's functionality has to be programmed on the server-component of the code.
In case of the free-standing location, the input data employed have been the Munich district subdivision borders, with the corresponding demographic data of different years and for different age brackets. This data is processed in three very simple steps to obtain a representative potential-customers figure: First, the year number selected by the user in the slider menu is applied to filter the matching-year population numbers from the attribute table. Then, the age-bracket checkboxes' state is used as input to only sum as potential customers the inhabitants of the selected age groups. Finally, since the previous steps return absolute numbers, using these totals to color the unevenly-sized districts would be highly misleading. Therefore, the polygon's area size is used to relativize the total numbers into "potential customers per square kilometer" figures. Figures that can now be used to color the central choropleth map for the user's inspection. The interface is lastly completed with the

corresponding updated legend and on-hover contextual information for the polygons (Figure 8).

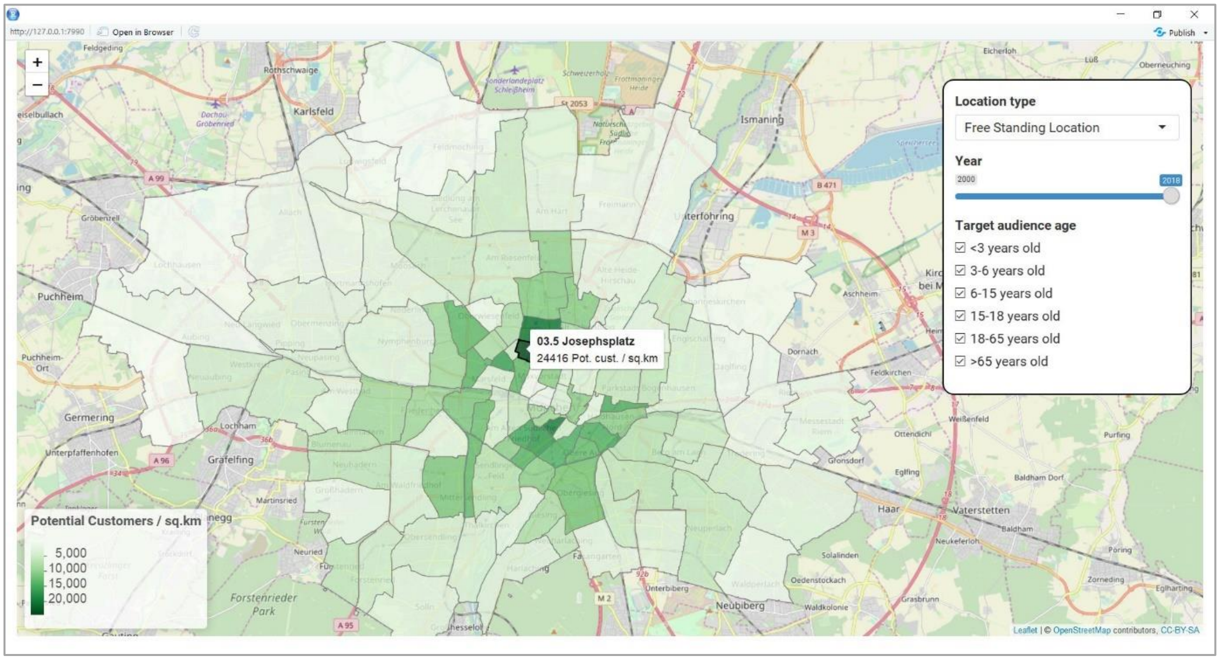

Figure 8: *Free-Standing Location screen of the application*

In case the location type is changed to Downtown, the first noticeable variation is the initial-zoom state of the map. In this case, the map is meant to focus only on the downtown area of Munich (Figure 9), which becomes the new area of study.

Apart from the altered zoom level, this second screen will also alter the focus to concentrate only on the most significant commercial streets of downtown Munich (Figure 10). These streets, are loaded as polylines onto the map with the relevant attributes, which include: average venue-rent cost, footfall per hour (the number of people entering the street in one hour), dominant brand category (the brand-type that is currently most established on a given street) and dominant retail sector.

In the Downtown location-type screen, a different method will be tested to indicate the most appropriate location to open a new branch. This will be shown by a "suitability index", a percentage figure that will introduce a higher level of abstraction than the previous "potential customers" number. The suitability index will be calculated as follows:

First, the footfall values of every street are scaled to percentage values, where 0 footfall corresponds to 0% and 12,870 footfall value (the maximum) corresponds to 100%.

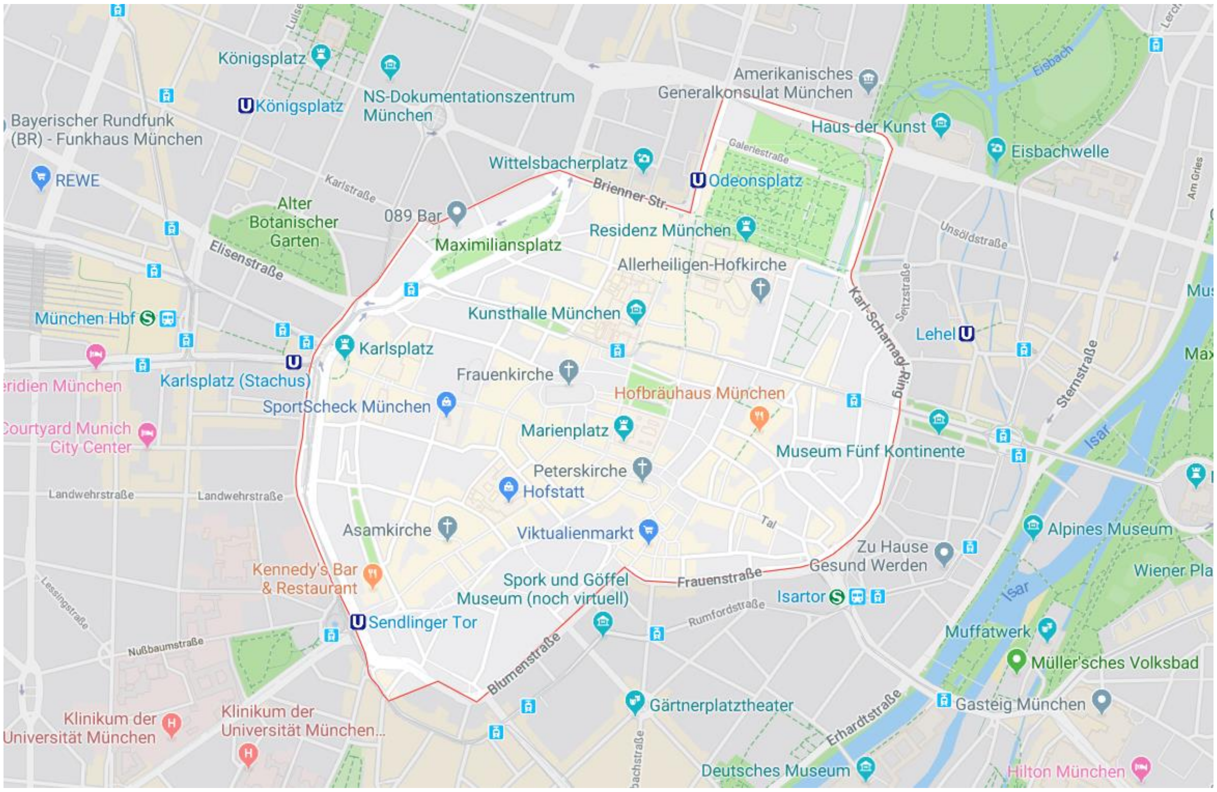

Figure 9: *Munich Downtown Area.* ©2019 GeoBasis-DE/BKG (©2009), Google

Figure 10: *A-locations with key indicators* (BNP Paribas Real Estate 2019)

Then, depending on the user's selections in the Brand Category and Retail Sector checkbox lists, the initial percentage varies to reflect the suitability of the street. If a checked category or sector matches an attribute of a street, that street's suitability is kept untouched (multiplied by 1). However, if a checked category is not present among one street's attributes, that street's suitability is reduced (multiplied by 0.1, or by 0.5 in case of partial match, that is, in case a similar attribute is present).

Once the suitability percentage of every street is calculated, streets with a rent cost superior to the rent budget selected on the slider by the user, are given a NA (Not Available) value. Street polylines are then colored to represent the suitability of the streets, graying out the out-of-budget streets (Figure 11).

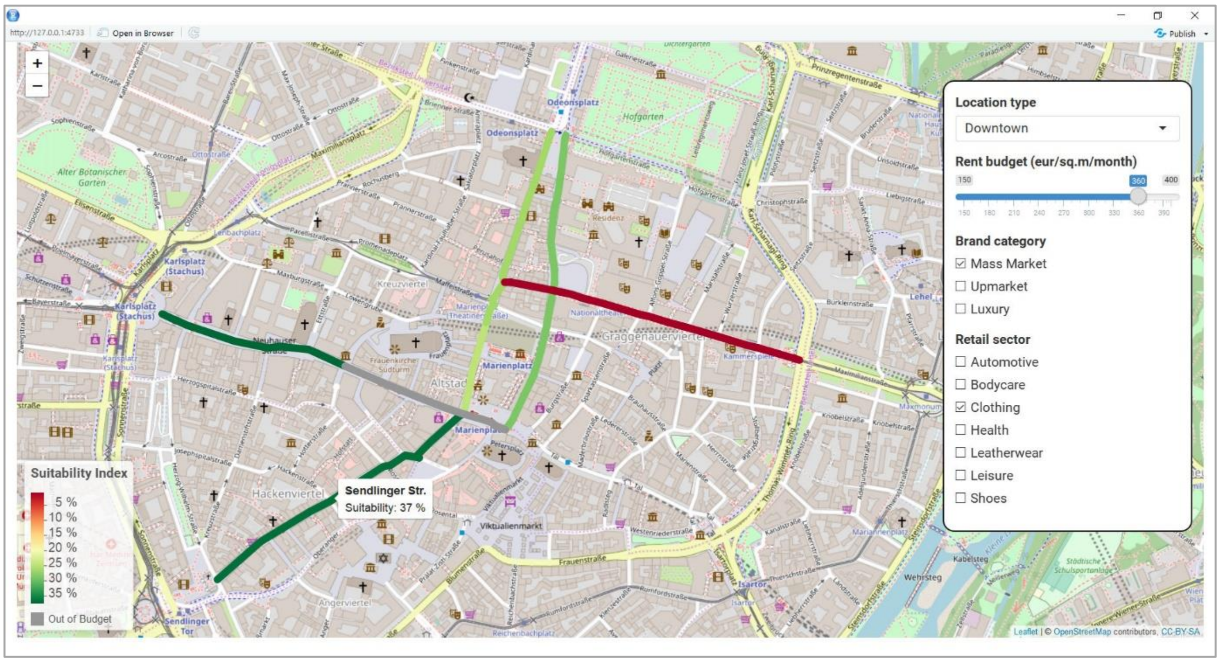

Figure 11: *Downtown Location screen of the application*

The last screen, the one corresponding to the shopping malls location type, mostly resembles the free-standing location screen. In this case, however, the formerly area-relative potential customer values are considered as absolute values. This is done under the assumption that each shopping mall will be serving customers coming from a determined area around them. This potential customers figure is used to color the points that represent each of the existing shopping malls, which will also present a label with the exact number when the user hovers over them (Figure 12).

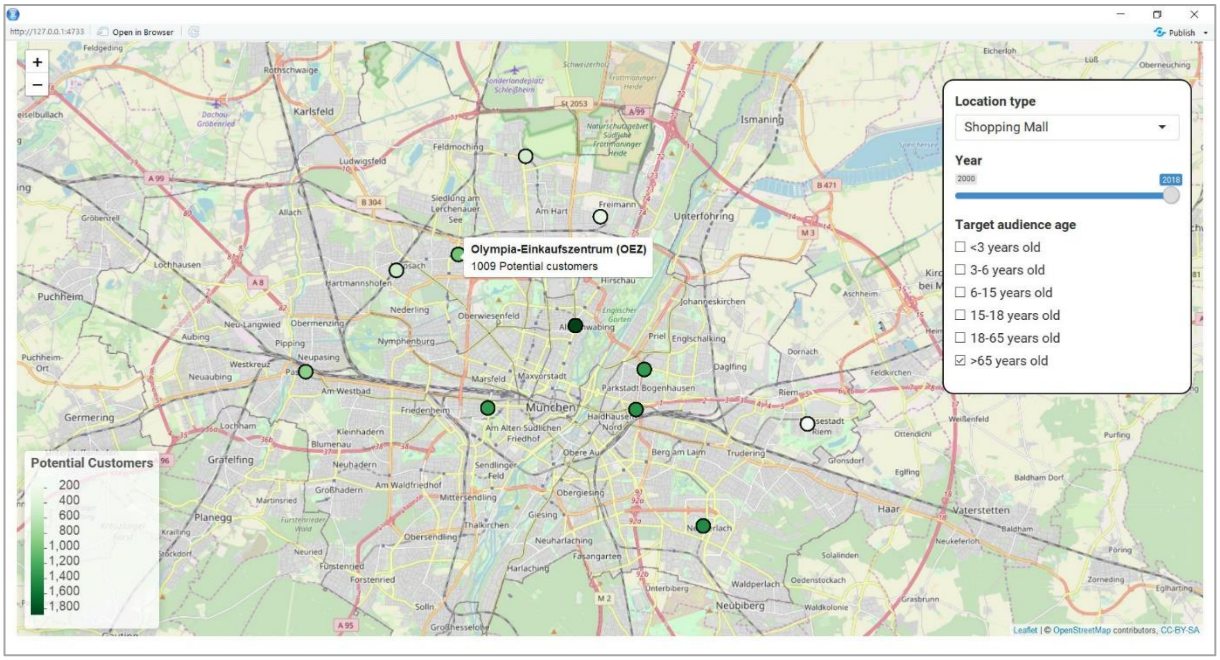

Figure 12: *Shopping Mall Location screen of the application*

4 Empirical Study

As suggested by the paper "User studies in cartography: opportunities for empirical research on interactive maps and visualizations" (Roth et al. 2017), after the development of the pilot cartographic tool, an empirical study of it will be carried out to assess its performance. This section will describe the specifics of the planning, procedure and outcomes of the performed study.

4.1 Study Characteristics

Since the application is meant to be used by a selected group of experts, this empirical evaluation will be mainly focusing on testing it from a qualitative point of view. Therefore, most of the study procedure will be based on participant observation and semi-structured interviewing of a geomarketing professional currently working in the private sector.

However, to simultaneously tackle the evaluation of multiple aspects of the tool (Roth et al. 2017), quantitative methods will also be mixed in the experiment, asking the interviewee to talk and think aloud while performing the tasks and tracking his mouse usage. The qualitative methods will focus on evaluating the utility (feature inspection, "usefulness") of the interactive elements of the tool, while the quantitative methods will be centered on testing the usability (use effectiveness and satisfaction).

4.2 Study Procedure

The study began by providing the user with information about the intended use case of the tool, the available menus, the meanings of the labels and the underlaying functions that made it work. Meanwhile, the participant was asked to familiarize himself with the tool by browsing through the screens and trying out different options at his own will.

After the user had become accustomed to the application, the test proceeded with the participant observation phase. The geomarketing expert was asked to solve the Site Planning task in three different scenarios, deliberately chosen to evaluate three hypothetic benefits that VA could provide to geomarketing:

- Scenario 1:
  An enterprise selling skateboarding-related products is planning to open a new free-standing branch. According to the business plan, the company is targeting high-schoolers (Ages 15 to 18).
  Where should the new store be located for optimal customer reach?
  Where should the new store be located for optimal customer reach in 3 years' time?
  This scenario is meant to evaluate whether the application facilitates the discovery of trends (in this case, over time).

- Scenario 2:
  A big fast-fashion chain selling clothes and shoes wants to enter the Munich market with strength. For this, it is planning to open three new stores in downtown Munich by the end of the year. One of the stores will be selling a mass-market brand, a second store will be selling luxury products and the last one will again be selling mass-market brands, but this time with a limited budget for the venue of 320€ per square meter per month.
  What downtown Munich street should each of the three stores be located at?
  Task number 2 is designed to assess the benefits of interactivity at the time of operating with multiple variable parameters that affect the solution.

- Scenario 3:
  A supermarket chain selling a wide variety of products targeting all age brackets has been given the opportunity to open a new venue in the south east of Munich. The company has the option of opening the supermarket in one of these two shopping malls: "Das Einstein" or "Munich-Neuperlach (PEP)".
  Which one should they choose?
  This scenario tries to test if the tool's interactive options allow the user to efficiently compare between elements.

While solving these three tasks, the user is asked to talk and think aloud, narrating the steps he is taking and the reasons behind them. Mouse movements and clicks are also recorded using dedicated software. These will allow to recognize frustrated attempts throughout the application's usage and identify possible User Experience (UX) improvements.

After the user provided an answer for the three suggested scenarios, a semi-structured interview (See "3.2.2 Interview Questions" for details) concluded the evaluation, framed around three very open questions:

1. What are your impressions after having used the tool?
2. Do you find it useful? For what users? For what use cases?
3. What improvements do you think could be made?

4.3 Study Findings

The most encouraging result in terms of the utility of the app is that the participant successfully provided an answer for every scenario, with a high degree of self-declared confidence while doing so.

In Scenario 1, when asked the follow-up question demanding a future forecast ("in 3 years' time"), the user seamlessly shifted attention to the time slider and began to dynamically inspect possible positive or negative tendencies.

Similarly to the previous, Scenario 2 was solved very quickly and intuitively by the user, altering the menus to fit the needs of each of the variants of the task and dynamically examining the reactive map for results.

Scenario 3, which was meant to evaluate whether the application facilitates the comparison of multiple elements, took longest to solve. However, this was not caused by shortcomings regarding the interactivity features of the app, but rather, by a usability issue. The Shopping Malls screen of the software displays the shopping mall locations as prominent dots, colored to represent the potential customers value. The small area of these dots, makes it difficult to compare malls using exclusively the color reference. The participant of the experiment, worked around it by using the potential customer values labeled when hovering over a dot, to compare between elements. Possible solutions for this challenge could be: increasing the dot's area to better appreciate color-value variations, changing the representation of the potential customers to a different visual variable like size, or keeping the now on-hover labels permanently next to the shopping malls.

When asked for impressions, the geomarketing expert provided positive feedback on the application's interactive offering. He highlighted the potential of the software as a cheap "one size fits all" solution for simple site planning problems not requiring too much personalization. According to the interviewee, proper customer training is key and once provided, any user with a marketing background would be able to reach the desired answers without any prior cartographic knowledge. In such a use case, instead of providing a high level of abstraction that would restrict the exploration, enabling visual interpretation adds the right amount of simplicity to the analysis.

As for the features that the geomarketing professional missed, there were two that he considered could improve the app significantly:

1. Including competitor's locations.
   While performing the tasks, the participant felt the need of including some hypothetical competitor's data into the analysis. He considered it essential to even the most simplified version of Site Planning solutions.
2. Filtering or Selection options.
   The user indicated how in his professional geomarketing work, different clients demand analyses on geographical regions of a variety of scales or focusing on a few specific areas. He suggested that the app could be further expanded with the addition of a filtering or selection option that would allow exclusive analysis of an isolated group of elements.

Regarding usability, sliders were the most intuitive interactive menu for the user, who fruitfully used them every time the scenario task demanded it.

On the other hand, the most frustrating usability aspect for the participant, was the dropdown menu for selecting the location type. Even within the same task, the user would try back-and-forth different location types, to corroborate the selection was the most suitable for the provided scenario-brief. This operation, unforeseen in the design phase, produced an unnecessary number of clicks, as it was later evidenced by a large top hotspot on the mouse-usage heatmap (Figure 13). To solve this issue, one possible solution discussed with the participant was replacing the current three-screen system with a layer-based one. Instead of the dropdown menu, a permanent layers-menu would precede the type-specific interactive options. The activation or deactivation of layers, via checkboxes, would make those type-conditional menus appear or disappear, as well as the corresponding map elements. This would provide a higher level of interactivity and a steadier connection between the different location types.

Finally, the last user experience shortcoming is related to software, to the way the Leaflet library is implemented in R. When using Leaflet for a reactive Shiny web-application, the map is updated by a combination of the function `clearShapes` followed by an addition function (e.g. `addCircles`). The first function removes the symbols from the map and the later places them again, in their updated version. The lack of a progressive transition between the former symbology state and the new one, provokes a “flickering” effect when the symbols disappear and reappear. This effect complicates the appreciation of differences and worsens the overall interactive experience. A possible solution for this issue would be using a JavaScript data visualization library tailored for dynamic graphics (e.g. D3.js or P5.js) for the symbols that lay on top of the Leaflet basemap.

Figure 13: *Mouse-Usage Heatmap*

5 Results and Discussion

This chapter will report the most significant results of the conducted research, tightly linking them with the objectives and research questions that motivated this thesis. The relevance of these outcomes will also be discussed, connecting the results with existing literature and the current theoretical understanding of geomarketing and visual analytics.

5.1 Results Structure

As it is the goal of this thesis, the results chapter will focus on answering the research questions that were formulated in chapter 1.

There are 4 constituent research questions which, when provided with an answer, would then resolve the core question "Can the introduction of Visual Analytics techniques provide significant improvements in the field of Geomarketing? What are those improvements?". This results section will be structured the same way, first summarizing the findings of the study corresponding to each of those 4 underlying questions and then interpreting their aggregate result.

5.2 Thesis Results

5.2.1 Constituent Research Questions

- **Research Question 1:**
  What are the iterative stages of geomarketing processes that could benefit from the visual feedback of interactive cartography?

  One of the first steps on the development of this study was the requirements interview that helped identify the geomarketing needs for the later design of the interactive prototype tool. In that interview, the participant highlighted the potential for interactivity integration in the input data exploration phase and the Site Planning geomarketing solution. These two tasks had already been regarded as processes where the introduction of interaction could facilitate the analysis.

- Research Question 2:
  How can Visual Analytics and interactive cartography be integrated into a tool for solving a selected geomarketing problem?

  The "3.3.1 Design" section of this dissertation includes a detailed explanation of all the steps and considerations taken for deciding on how to integrate interactive cartography into a geomarketing application. In short, the outline of that design process of a visual analysis tool for spatial marketing can be summarized in three steps:
  - Target definition:
    Decide on a target use (a geomarketing problem that the tool will attempt to solve) and user (the client that the application should be tailored for).
  - Feature definition:
    Identify what are the variable parameters that influence the solution of the selected geomarketing problem.
  - UI design:
    Plan and arrange an interface for the application that will allow the target user for seamless interactive operation of those parameters.

- Research Question 3:
  Is the designed implementation helpful throughout the analysis task? Is it helpful for presenting the results?

  The evaluation of the application returned encouraging feedback regarding the Site Planning analysis and also as a presentation tool for multiple results of such an analysis. In particular, the interviewed geomarketing expert considered the software an improvement over existing static cartographic products in situations where simplicity is required but a high level of abstraction would limit the exploratory findings. These use-cases include:
  - Cheap, low-individualization geomarketing solutions.
  - Users coming from a marketing background (no cartographic expertise).

- Research Question 4:
  How can the initial implementation be improved?

  There are three possible improvements pointed out throughout the study that are directly connected with the interactive usefulness of the designed application.

Those potential improvements are:

- Adding filtering or selection options:
  Geomarketing clients sometimes have particular demands in terms of what specific geographical regions the desired analyses should focus on, sometimes even asking for multiple combinations or comparisons. To satisfy the needs of those clients, the designed geomarketing tool could be further expanded with the addition of filtering or selection options that would allow exclusive analysis of an isolated group of elements.
- Replacing the multi-screen system with a multi-layer one:
  Contrary to what was predicted during the design stage of the application, the location-type menu was also a menu where the user often tried different options back-and-forth. Hence, the dropdown menu selection leading to three independent analysis screens hindered the interactive experience rather than facilitating it. Instead of this system, a layer-based implementation would provide a higher level of interactivity and a steadier connection between the different location types.
- Using an implementation technology that allows progressive transitions:
  When updating the geomarketing application's map, the lack of a progressive transition between the previous state and the new one, provokes a "flickering" effect which complicates the appreciation of differences. A possible solution for this issue would be using a JavaScript data visualization library tailored for dynamic graphics (e.g. D3.js or P5.js) for the map symbology.

A better implementation of those three aspects of the designed visual analytics tool, would provide better feedback and overall responsive experience. This would further facilitate the interactive visual analysis aimed at.

5.2.2 Aggregate Outcome

The main research question tackled by this study was "Can the introduction of Visual Analytics techniques provide significant improvements in the field of Geomarketing? What are those improvements?"

The interactive pilot application developed throughout this study has shown very positive results in terms of the advantages that could be brought by incorporating VA methods into the geomarketing field. The testing of the tool, within its limitations (See "6.2 Outlook"), proved that using the interaction enabling menus and inspecting the live-feedback of the reactive map, allowed the participant to find quick and accurate answers for the suggested tasks. Applying Visual Analytics principles, the difficulty in geomarketing analysis was reduced without limiting exploration, meaning users with modest geostatistical expertise will be able to reach valuable insights through visual exploration. This unrestrictive simplification is the main benefit of the introduction of VA into Geomarketing.

5.3 Discussion

The geomarketing software designed and developed throughout this study has shown the feasibility of applying a visual analytics approach for solving the Site Planning task. As it has been stated in chapter 2 (Conceptual Framework), many authors in VA research have long claimed that continuous visual feedback contribute to better decisions and presentation of results in complex analytic tasks. In line with the results of other existing literature dealing with other geomarketing methods and use cases (Ernst, Voss, and Berghoff 2007), interactivity appears to add substantial benefits to the complex processes of spatial marketing. Therefore, the introduction of interactive cartography into the field, as a replacement for GIS and thematic mapping, should definitely be considered as a thread worth pursuing in future years.

6 Conclusions

The following section will summarize the main takeaway points of this study. Additionally, some potential improvements will be suggested, as well as future implications of the thesis' findings.

6.1 Thesis Conclusions

This thesis aimed to ascertain whether geomarketing professionals would benefit from the introduction of Visual Analytics techniques into their workflow. To do so, taking the Site Planning geomarketing problem as an example, an interactive pilot application was developed and tested.

The testing returned very positive results in terms of the benefits that could be brought by incorporating VA methods into spatial marketing. The introduction of interactivity and live-mapped feedback, simplified the geomarketing analysis without limiting exploration, unlike previously used highly-abstract cartographic products. This way, the demo tool showed great potential as a versatile solution that could allow users with no cartographic expertise to visually explore the multiple geographic implications of marketing factors.

6.2 Outlook

The research described in this dissertation has been performed particularly around the design and implementation of a single Site Planning application, one of the various existing geomarketing methods. After that, the developed tool has been evaluated based on participant observation and interviewing of a geomarketing expert, whose personal observations cannot be taken as consolidated absolute facts. Nevertheless, taking those limitations into consideration, we recommend further research expands on the findings of this thesis with more examples and extensive testing. The encouraging results of this study suggest a fruitful future in the integration of visual analytics and geomarketing methods.

Bibliography

Agafonkin, Vladimir. 2019. "Leaflet - a JavaScript Library for Interactive Maps." 2019. https://leafletjs.com/.

Attali, Dean, and Joe Cheng. 2019. "A GRadual IntRoduction to Shiny." 2019. https://laderast.github.io/gradual_shiny/app-1-connecting-ui-and-server.html.

BNP Paribas Real Estate. 2019. "Retail Market Germany Property Report 2019."

CARTO. 2019. "Data Analytics for Retail." 2019. https://carto.com/industries/retail/.

Cliquet, Gérard. 2013. *Geomarketing: Methods and Strategies in Spatial Marketing*. John Wiley & Sons.

Entrepreneur Media Inc. 2019. "Retail Location Definition - Entrepreneur Small Business Encyclopedia." Entrepreneur Small Business Encyclopedia. 2019. https://www.entrepreneur.com/encyclopedia/retail-location.

Ernst, Vera Hernández, Angi Voss, and Felix Berghoff. 2007. "Visual Analytic Services for Geomarketing in Spatial Data Infrastructures." In *Proceedings of the 15th Annual ACM International Symposium on Advances in Geographic Information Systems*, 42. ACM.

GfK Global. 2019. "Geo+SalesTerritories." GfK Global. 2019. https://www.gfk.com/products-a-z/geo-salesterritories/.

Ihaka, Ross, and Robert Gentleman. 1996. "R: A Language for Data Analysis and Graphics." *Journal of Computational and Graphical Statistics* 5 (3): 299–314.

Kaar, Claudia, and Christian Stary. 2019. "Intelligent Business Transformation through Market-specific Value Network Analysis: Structured Interventions and Process Bootstrapping in Geomarketing." *Knowledge and Process Management* 26 (2): 163–81.

KDnuggets. 2012. "Poll Results: Top Analytics, Data Mining, Big Data Software Used." 2012. https://www.kdnuggets.com/2012/05/top-analytics-data-mining-big-data-software.html.

Keim, Daniel. 2010. "Mastering the Information Age: Solving Problems with Visual Analytics."

Kerren, Andreas, and Falk Schreiber. 2012. "Toward the Role of Interaction in Visual Analytics." In *Proceedings of the Winter Simulation Conference*, 420. Winter Simulation Conference.

Kielman, Joe, Jim Thomas, and Richard May. 2009. "Foundations and Frontiers in Visual Analytics." *Information Visualization* 8 (4): 239–46.

Longley, P, and G Clarke. 1995. "Applied Geographical Information Systems: Developments and Prospects." *GIS for Business and Service Planning*, 3–9.

Merz, Stefan. 2017. "Geomarketing Location Analyses for Filling Stations."

Nocke, Thomas, Stefan Buschmann, Jonathan F Donges, Norbert Marwan, Hans-Jörg Schulz, and Christian Tominski. 2015. "Review: Visual Analytics of Climate Networks." *Nonlinear Processes in Geophysics* 22 (5): 545.

Noorian, Shahin Sharifi. 2015. "A Decision Support System for Sales Territory Planning Using the Genetic Algorithm." Technische Universität München. http://cartographymaster.eu/wp-content/theses/2015_Shahin_Thesis.pdf.

Robinson, A. 1952. "The Look of Maps." Madison, Wisconsin: University of Wisconsin Press.

Roth, Robert E, Arzu Çöltekin, Luciene Delazari, Homero Fonseca Filho, Amy Griffin, Andreas Hall, Jari Korpi, Ismini Lokka, André Mendonça, and Kristien Ooms. 2017. "User Studies in Cartography: Opportunities for Empirical Research on Interactive Maps and Visualizations." *International Journal of Cartography* 3 (sup1): 61–89.

RStudio Inc. 2017. "Shiny." 2017. https://shiny.rstudio.com/.

Rubin, Jeff, and Dana Chisnell. 2008. "How to Plan, Design, and Conduct Effective Tests." *Handbook of Usability Testing*, 13.

Schüssler, Frank. 2000. *Geomarketing: Anwendungen Geographischer Informationssysteme Im Einzelhandel*. Tectum-Verlag.

Tappert, Werner. 2007. *Geomarketing in Der Praxis:[Grundlagen, Einsatzmöglichkeiten, Nutzen]*. Harzer.

Thomas, James J, and Kristin A Cook. 2006. "A Visual Analytics Agenda." *IEEE Computer Graphics and Applications*, no. 1: 10–13.

Tippmann, Sylvia. 2015. "Programming Tools: Adventures with R." *Nature* 517 (7532):

109–10. https://doi.org/10.1038/517109a.

Vojtech, Filip. 2019a. "Geo+BranchNetworks." GfK Global. 2019. https://www.gfk.com/products-a-z/geo-branchnetworks/.

———. 2019b. "Geo+TargetGroups." GfK Global. 2019. https://www.gfk.com/products-a-z/geo-targetgroups/.

Vredenburg, Karel, Ji-Ye Mao, Paul W Smith, and Tom Carey. 2002. "A Survey of User-Centered Design Practice." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 471–78. ACM.

Waters, Shari. 2019. "The Different Types of Retail Locations." The Balance Small Business. 2019. https://www.thebalancesmb.com/types-of-retail-locations-2890244.

WIGeoGIS. 2019a. "GIS Software for Geomarketing - WIGeoGIS." 2019. https://www.wigeogis.com/en/geomarketing_software.

———. 2019b. "How to Use Geomarketing in Sales Territory Planning." 2019. https://www.wigeogis.com/en/sales_territory_planning.

———. 2019c. "Location Analysis with Geomarketing." 2019. https://www.wigeogis.com/en/location_analysis.

———. 2019d. "Market Penetration Analysis." 2019. https://www.wigeogis.com/en/penetration_analysis.

———. 2019e. "Target Group Analysis." 2019. https://www.wigeogis.com/en/target_group_analysis.

Yrigoyen, Coro Chasco. 2003. "El Geomarketing y La Distribución Comercial." *Madrid: Investigación y Marketing*, no. 79: 6–14.

Appendix A

Pilot project data sources:

1. Munich demographic data:
   Indikatorenatlas München - Landeshauptstadt München
   shorturl.at/kquJP

2. Munich downtown street retail indicators:
   Retail Market Germany Property Report 2019 - BNP Paribas Real Estate
   shorturl.at/fuMR3

3. Munich shopping malls data:
   Retail in Munich, Sector Information - City of Munich Department of Labor and Economic Development
   shorturl.at/bpzI6

4. Munich district subdivision borders:
   OpenStreetMap - OpenStreetMap Foundation
   shorturl.at/stFMZ

5. Munich downtown street polylines:
   OpenStreetMap - OpenStreetMap Foundation
   shorturl.at/stFMZ

OpenStreetMap data has been downloaded using QuickOSM plugin for QGIS.

Appendix B

Code:

```
## ============================================================================
##
## Script name: Interactive Cartographic App for Site Planning
##
## Purpose of script: This script provides a web based (Shiny) interactive
##   cartographic application for Site Planning, one of the most common
##   Geomarketing problems.
##
## Author: Iñigo Etxeandia
##
## Date Created: 2019-08-16
##
## Copyright (c) Iñigo Etxeandia, 2019
##
## ============================================================================
##
## Notes: The purpose of this script is NOT to provide an accurate Geomarketing
##   tool for Site Planning solutions but to serve as a proof of concept for
##   evaluating the possible benefits of the introduction of human interaction
##   into the Geomarketing workflow.
##
## ============================================================================

## Library Inports ============================================================
library(shiny)
library(rgdal)
library(leaflet)

## Hardcoded ==================================================================
MAP_HEIGHT <- "97vh"
STYLE <- "border-radius: 15px; border: 2px solid #000000; background: #FFFFFF;
         font-family: 'Roboto', sans-serif; font-size: 17.5px; padding: 15px;"

## Variables  =================================================================

# shapefile inputs ------------------------------------------------------------
districts       <- readOGR("shp/sbt_w_stats_area.shp",
                           layer = "sbt_w_stats_area")
downtownStreets <- readOGR("shp/downtown_streets_w_stats.shp",
                           layer = "downtown_streets_w_stats")
```

```
outline         <- readOGR("shp/munich_outline.shp",
                           layer = "munich_outline")
malls           <- readOGR("shp/shopping_malls.shp",
                           layer = "shopping_malls")

# color palettes ------------------------------------------------------------
freePal <- colorNumeric("Greens", districts$colorData)
downtownPal <- colorNumeric("RdYlGn", downtownStreets$colorData, na.color = "#969696")
#downtownPal <- colorNumeric("RdYlGn", c(0, 100), na.color = "#969696")
mallPal <- colorNumeric("Greens", districts$colorData)

# lists for ui menus --------------------------------------------------------
locTypes <- c("Free Standing Location" = "free",
              "Downtown" = "downtown",
              "Shopping Mall" = "mall")

ageBrackets <- c("<3 years old" = 1,
                 "3-6 years old" = 2,
                 "6-15 years old" = 3,
                 "15-18 years old" = 4,
                 "18-65 years old" = 5,
                 ">65 years old" = 6)

brandTypes <- c("Mass Market" = 1,
                "Upmarket" = 2,
                "Luxury" = 3)

sectors <- c("Automotive" = 6,
             "Bodycare" = 2,
             "Clothing" = 1,
             "Health" = 3,
             "Leatherwear" = 4,
             "Leisure" = 7,
             "Shoes" = 5)

## User Interface ===========================================================
ui <- fluidPage(leafletOutput("map", height = MAP_HEIGHT),
                absolutePanel(# always shown -----------------------------------
                              style = STYLE,
                              id = "sidebar", class = "sidebar",
                              fixed = TRUE, draggable = FALSE, top = 50,
                              left = "auto", right = 30, bottom = "auto",
                              width = 330, height = "auto",
                              selectInput("locType",
                                          "Location type",
                                          locTypes),
                              # free location ------------------------------
                              conditionalPanel(
                                condition = "input.locType == 'free'",
                                sliderInput("yearFree",
                                            "Year",
                                            min = 2000,
                                            max = 2018,
                                            value = 2018,
```

```
                            step = 3,
                            ticks = FALSE,
                            sep = ""),
                checkboxGroupInput("targetAgeFree",
                                   "Target audience age",
                                   ageBrackets,
                                   selected = ageBrackets)
              ),
              # downtown location ----------------------------
              conditionalPanel(
                condition = "input.locType == 'downtown'",
                sliderInput("rentBudget",
                            "Rent budget (eur/sq.m/month)",
                            min = 150,
                            max = 400,
                            value = 400,
                            step = 10),
                checkboxGroupInput("brandType",
                                   "Brand category",
                                   brandTypes),
                checkboxGroupInput("sector",
                                   "Retail sector",
                                   sectors)
              ),
              # mall location --------------------------------
              conditionalPanel(
                condition = "input.locType == 'mall'",
                sliderInput("yearMalls",
                            "Year",
                            min = 2000,
                            max = 2018,
                            value = 2018,
                            step = 3,
                            ticks = FALSE,
                            sep = ""),
                checkboxGroupInput("targetAgeMalls",
                                   "Target audience age",
                                   ageBrackets,
                                   selected = ageBrackets)
                )
              )
        )

## Server Logic ===================================================
server <- function(input, output) {
  observeEvent(input$locType , {
    # free location -----------------------------------------------
    if(input$locType == "free") {

      # initial map
      output$map <- renderLeaflet({
        leaflet(districts) %>%
          addTiles() %>%
          setView(lng = 11.602331,
```

```
            lat = 48.157831,
            zoom = 12) %>%
    addPolygons(color = "grey",
                weight = 1,
                smoothFactor = 0.5,
                opacity = 1.0,
                fillOpacity = 0.5
                )
})

# update map when options change
observeEvent({c(
  input$yearFree,
  input$targetAgeFree)
} , {

  # input year slider selection
  yearFree <- input$yearFree

  if (yearFree == 2018) {
    startColumn <- 45
  }
  if (yearFree == 2015) {
    startColumn <- 38

  }
  if (yearFree == 2012) {
    startColumn <- 31
  }
  if (yearFree == 2009) {
    startColumn <- 24
  }
  if (yearFree == 2006) {
    startColumn <- 17
  }
  if (yearFree == 2003) {
    startColumn <- 10
  }
  if (yearFree == 2000) {
    startColumn <- 3
  }

  # input target checkboxes selection(s)
  targetAge <- as.list(as.integer(input$targetAgeFree))

  ageU3mult <- 0
  age3to6mult <- 0
  age6to15mult <- 0
  age15to18mult <- 0
  age18to65mult <- 0
  ageO65mult <- 0

  if(1 %in% targetAge) {
    ageU3mult <- 1
```

```
        }
        if(2 %in% targetAge) {
          age3to6mult <- 1
        }
        if(3 %in% targetAge) {
          age6to15mult <- 1
        }
        if(4 %in% targetAge) {
          age15to18mult <- 1
        }
        if(5 %in% targetAge) {
          age18to65mult <- 1
        }
        if(6 %in% targetAge) {
          ageO65mult <- 1
        }

        # calculate potential customers per district
        targetPeople <-
          as.integer(as.character(districts[[startColumn + 1]])) * ageU3mult +
          as.integer(as.character(districts[[startColumn + 2]])) * age3to6mult +
          as.integer(as.character(districts[[startColumn + 3]])) * age6to15mult +
          as.integer(as.character(districts[[startColumn + 4]])) * age15to18mult +
          as.integer(as.character(districts[[startColumn + 5]])) * age18to65mult +
          as.integer(as.character(districts[[startColumn + 6]])) * ageO65mult

        # convert to potential customers per sq.km to color coropleth
        districtsArea <- (districts[[52]]*10)
        colorData <- targetPeople / districtsArea

        # generate titles and labels for updating the map
        legendTitleFree <- "<p style=\"font-family: 'Roboto', sans-serif; font-size:
17.5px;\">Potential Customers / sq.km</p>"
        legendNAvalueFree <- "No Target Selected"
        labelsDistrict <- sprintf("<strong>%s</strong><br/>%g Pot. cust. / sq.km",
districts$name, round(colorData)) %>%
          lapply(htmltools::HTML)

        # update map
        leafletProxy("map", data = districts) %>%
          clearShapes() %>%
          addPolygons(color = "grey",
                      weight = 1,
                      smoothFactor = 0.5,
                      opacity = 1.0,
                      fillOpacity = 0.8,
                      fillColor = ~freePal(as.integer(colorData)),
                      label = labelsDistrict,
                      labelOptions = labelOptions(
                        style = list("font-weight" = "normal",
                                     padding = "3px 8px"),
                        textsize = "15px",
                        direction = "auto"),
                      highlightOptions = highlightOptions(color = "black",
```

```
                                                          weight = 2,
                                                          bringToFront = TRUE)
      ) %>%
      clearControls() %>%
      addLegend(position = "bottomleft",
                pal = freePal,
                values = ~colorData,
                na.label = legendNAvalueFree,
                opacity = 1,
                labFormat = labelFormat(prefix = " ",
                                        suffix = " "),
                title = legendTitleFree)
    })
}

# downtown location ------------------------------------------------------
if(input$locType == "downtown") {

  # initial map
  output$map <- renderLeaflet({
    leaflet(downtownStreets) %>%
      addTiles() %>%
      setView(lng = 11.579105,
              lat = 48.138632,
              zoom = 16) %>%
      addPolylines(color = "red",
                   weight = 10,
                   smoothFactor = 0.5,
                   opacity = 0.5
      )
  })

  # load footfall number to color initial map
  footfall <- as.numeric(as.character(downtownStreets[[5]]))
  footfall <- footfall / 12870 * 100
  colorData <- footfall
  leafletProxy("map", data = downtownStreets) %>%
    clearShapes() %>%
    addPolylines(color = ~downtownPal(colorData),
                 weight = 10,
                 smoothFactor = 0.5,
                 opacity = 1.0
    )

  # update map when options change
  observeEvent({c(
    input$rentBudget,
    input$brandType,
    input$sector)
  } , {

    # input initial footfall value
    footfall <- as.numeric(as.character(downtownStreets[[5]]))
    footfall <- footfall / 12870 * 100
```

```
        # input brand categories checkboxes selection(s)
        brandCat <- as.list(as.integer(input$brandType))

        yesMatchBrand <- 1
        noMatchBrand <- 0.1

        if(1 %in% brandCat) {
          massMultiplier <- c(yesMatchBrand,yesMatchBrand,yesMatchBrand,yesMatch-
Brand,noMatchBrand,yesMatchBrand,yesMatchBrand)
          footfall <- footfall * massMultiplier
        }
        if(2 %in% brandCat) {
          upMultiplier <- c(yesMatchBrand,noMatchBrand,yesMatchBrand,yesMatchBrand,no-
MatchBrand,noMatchBrand,noMatchBrand)
          footfall <- footfall * upMultiplier
        }
        if(3 %in% brandCat) {
          luxMultiplier <- c(noMatchBrand,noMatchBrand,noMatchBrand,noMatch-
Brand,yesMatchBrand,noMatchBrand,noMatchBrand)
          footfall <- footfall * luxMultiplier
        }

        # input sector categories checkboxes selection(s)
        sectorCat <- as.list(as.integer(input$sector))

        yesMatchSector <- 1
        partialMatchSector <- 0.5
        noMatchSector <- 0.1

        if(1 %in% sectorCat) {
          clothingMultiplier <- c(yesMatchSector,yesMatchSector,partialMatchSec-
tor,partialMatchSector,yesMatchSector,partialMatchSector,partialMatchSector)
          footfall <- footfall * clothingMultiplier
        }
        if(2 %in% sectorCat) {
          bodyMultiplier <- c(noMatchSector,noMatchSector,noMatchSector,noMatchSec-
tor,noMatchSector,partialMatchSector,yesMatchSector)
          footfall <- footfall * bodyMultiplier
        }
        if(3 %in% sectorCat) {
          healthMultiplier <- c(noMatchSector,noMatchSector,noMatchSector,noMatchSec-
tor,noMatchSector,partialMatchSector,yesMatchSector)
          footfall <- footfall * healthMultiplier
        }
        if(4 %in% sectorCat) {
          leatherMultiplier <- c(noMatchSector,noMatchSector,noMatchSector,noMatchSec-
tor,noMatchSector,yesMatchSector,noMatchSector)
          footfall <- footfall * leatherMultiplier
        }
        if(5 %in% sectorCat) {
          shoesMultiplier <- c(partialMatchSector,partialMatchSector,noMatchSector,no-
MatchSector,partialMatchSector,yesMatchSector,partialMatchSector)
          footfall <- footfall * shoesMultiplier
```

```
        }
        if(6 %in% sectorCat) {
          autoMultiplier <- c(noMatchSector,noMatchSector,noMatchSector,yesMatchSec-
tor,noMatchSector,noMatchSector,noMatchSector)
          footfall <- footfall * autoMultiplier
        }
        if(7 %in% sectorCat) {
          leisureMultiplier <- c(noMatchSector,noMatchSector,yesMatchSector,noMatch-
Sector,noMatchSector,noMatchSector,noMatchSector)
          footfall <- footfall * leisureMultiplier
        }

        # input budget slider selection
        budgetValue = input$rentBudget

        inBudget <- 1
        outBudget <- NA

        if(budgetValue >= 370) {
          budgetMultiplier <- c(inBudget,inBudget,inBudget,inBudget,inBudget,in-
Budget,inBudget)
        } else if(budgetValue >= 340) {
          budgetMultiplier <- c(inBudget,inBudget,inBudget,inBudget,inBudget,in-
Budget,outBudget)
        } else if(budgetValue >= 310) {
          budgetMultiplier <- c(inBudget,inBudget,inBudget,inBudget,inBudget,out-
Budget,outBudget)
        } else if(budgetValue >= 250) {
          budgetMultiplier <- c(inBudget,inBudget,inBudget,inBudget,outBudget,out-
Budget,outBudget)
        } else if(budgetValue >= 230) {
          budgetMultiplier <- c(inBudget,inBudget,outBudget,inBudget,outBudget,out-
Budget,outBudget)
        } else if(budgetValue >= 210) {
          budgetMultiplier <- c(inBudget,inBudget,outBudget,outBudget,outBudget,out-
Budget,outBudget)
        } else if(budgetValue >= 190) {
          budgetMultiplier <- c(inBudget,outBudget,outBudget,outBudget,outBudget,out-
Budget,outBudget)
        } else {
          budgetMultiplier <- c(outBudget,outBudget,outBudget,outBudget,outBudget,out-
Budget,outBudget)
        }

        # calculate suitability index
        colorData <- footfall * budgetMultiplier

        # generate titles and labels for updating the map
        legendTitleDowntown <- "<p style=\"font-family: 'Roboto', sans-serif; font-
size: 17.5px;\">Suitability Index</p>"
        legendNAvalueDowntown <- "Out of Budget"
        labelsDowntown <- sprintf("<strong>%s</strong><br/> Suitability: %g &#37",
downtownStreets$name, round(colorData)) %>%
          lapply(htmltools::HTML)
```

```
        # update map
        leafletProxy("map", data = downtownStreets) %>%
          clearShapes() %>%
          addPolylines(color = ~downtownPal(colorData),
                       weight = 10,
                       smoothFactor = 0.5,
                       opacity = 1.0,
                       label = labelsDowntown,
                       labelOptions = labelOptions(
                         style = list("font-weight" = "normal",
                                      padding = "3px 8px"),
                         textsize = "15px",
                         direction = "auto")) %>%
          clearControls() %>%
          addLegend(position = "bottomleft",
                    pal = downtownPal,
                    values = ~colorData,
                    na.label = legendNAvalueDowntown,
                    opacity = 1,
                    labFormat = labelFormat(prefix = " ", suffix = " %  \U2004 \U2004
\U2004 \U2004 \U2004 \U2004"),
                    title = legendTitleDowntown)
      })
    }

    # mall location ----------------------------------------------------------
    if(input$locType == "mall") {
      output$map <- renderLeaflet({

        # initial map
        leaflet(outline) %>%
          addTiles() %>%
          setView(lng = 11.602331,
                  lat = 48.157831,
                  zoom = 12) %>%
          addPolygons(color = "grey",
                      weight = 1,
                      smoothFactor = 0.5,
                      opacity = 1.0,
                      fillOpacity = 0.5
          )
      })

      # update map when options change
      observeEvent({c(
        input$yearMalls,
        input$targetAgeMalls)
      } , {

        # input year slider selection
        yearMalls <- input$yearMalls

        if (yearMalls == 2018) {
```

```
  startColumn <- 45
}
if (yearMalls == 2015) {
  startColumn <- 38

}
if (yearMalls == 2012) {
  startColumn <- 31
}
if (yearMalls == 2009) {
  startColumn <- 24
}
if (yearMalls == 2006) {
  startColumn <- 17
}
if (yearMalls == 2003) {
  startColumn <- 10
}
if (yearMalls == 2000) {
  startColumn <- 3
}

# input target checkboxes selection(s)
targetAge <- as.list(as.integer(input$targetAgeMalls))

ageU3mult <- 0
age3to6mult <- 0
age6to15mult <- 0
age15to18mult <- 0
age18to65mult <- 0
ageO65mult <- 0

if(1 %in% targetAge) {
  ageU3mult <- 1
}
if(2 %in% targetAge) {
  age3to6mult <- 1
}
if(3 %in% targetAge) {
  age6to15mult <- 1
}
if(4 %in% targetAge) {
  age15to18mult <- 1
}
if(5 %in% targetAge) {
  age18to65mult <- 1
}
if(6 %in% targetAge) {
  ageO65mult <- 1
}

# calculate potential customers per district
targetPeople <-
  as.integer(as.character(districts[[startColumn + 1]])) * ageU3mult +
```

```
          as.integer(as.character(districts[[startColumn + 2]])) * age3to6mult +
          as.integer(as.character(districts[[startColumn + 3]])) * age6to15mult +
          as.integer(as.character(districts[[startColumn + 4]])) * age15to18mult +
          as.integer(as.character(districts[[startColumn + 5]])) * age18to65mult +
          as.integer(as.character(districts[[startColumn + 6]])) * ageO65mult

        # select the districts of the shopping malls
        selection <- c(94,18,63,26,28,35,41,44,76,100,101)

        # relativize the total potential customers of the district using area
        # ASSUMPTION => each mall serves an area around it of 1 sq.km
        districtsArea <- (districts[[52]]*10)
        colorData <- targetPeople[selection] / districtsArea[selection]

        # generate titles and labels for updating the map
        legendTitleFree <- "<p style=\"font-family: 'Roboto', sans-serif; font-size:
17.5px;\">Potential Customers</p>"
        legendNAvalueFree <- "No Target Selected"
        labelsMall <- sprintf("<strong>%s</strong><br/>%g Potential customers",
malls$name, round(colorData)) %>%
          lapply(htmltools::HTML)

        # update map
        leafletProxy("map", data = outline) %>%
          clearShapes() %>%
          addPolygons(color = "gray",
                      weight = 1,
                      smoothFactor = 0.5,
                      opacity = 1.0,
                      fillOpacity = 0
          ) %>%
          addCircleMarkers(data = malls,
                           radius = 9,
                           stroke = TRUE,
                           color = "black",
                           weight = 2,
                           opacity = 0.8,
                           fill = TRUE,
                           fillColor = ~mallPal(as.integer(colorData)),
                           fillOpacity = 1,
                           label = labelsMall,
                           labelOptions = labelOptions(
                             style = list("font-weight" = "normal",
                                          padding = "3px 8px"),
                             textsize = "15px",
                             direction = "auto")) %>%
          clearControls() %>%
          addLegend(position = "bottomleft",
                    pal = freePal,
                    values = ~colorData,
                    na.label = legendNAvalueFree,
                    opacity = 1,
                    labFormat = labelFormat(prefix = " ",
                                            suffix = " "),
```

```
                    title = legendTitleFree)
      })
    }
  })
  }

## Run ========================================================================
shinyApp(ui = ui, server = server)
```