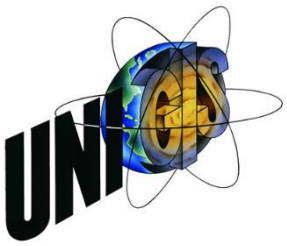

Master Thesis

submitted within the UNIGIS MSc programme at Z_GIS
University of Salzburg

Integrating a chatbot with a GIS-MCDM system

A chatbot provides suitability information on site selection

by
BSc FHNW Andrew J. Frei

A thesis submitted in partial fulfilment of the requirements of the degree of
Master of Science (Geographical Information Science & Systems) MSc (GISc)

Advisor:
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Ehrendingen Switzerland, June 30th 2018

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Acknowledgments and Preface

This is for my lovely wife Janie Amarga Frei and my cute daughter Lia Marie Frei. They have been supporting me constantly and believed in me always.

Thank you also to my colleagues and friends Beda Kuster und Julian Kissling for your support and ideas on requirements engineering, systems architecture review and programming.

Science Pledge

By my signature below, I certify that my thesis is entirely the result of my own work. I have cited all sources I have used in my thesis and I have always indicated their origin.

7/16/2018

X

Andrew J. Frei

Signed by: Andrew Frei

Ehrendingen, July 16th, 2018

Abstract

My Master Thesis' aims to prove that a chatbot can be integrated with a GIS in a meaningful way and that a chatbot can provide multi-criteria analysis information on site selection. The objective is that the chatbot delivers answers to GIS-related questions. The primary motivation is that map-illiterate users also have a desire for spatial information, but are facing barriers such as knowledge or spatial illiteracy.

In the underlying Literature review is comparing different types of chatbots, provides a taxonomy of chatbot models, radiographs this new communication paradigm in context with a GIS-integration and -interaction, and tries to shed light on so called GeoBots.

The Methods section is concerned with the principles and characteristics of a chatbot. Also researched requirements for chatbots are listed. The GIS model and concept are depicted and combined with the chatbot model. Functional & Non-functional Requirements are gathered from existing Real Estate consumer facing platforms, which provide users with site selection information. Processes, sub-processes, detailed data flows, data selection as well as data models are building on those requirements. The Systems Architecture and Components section depicts all chatbot components and all GIS functionalities in one diagram from a user's input view.

The Results very much focus on the aim and the objective. The GeoBot prototype can small talk with the user, perform a Multi Criteria analysis, a user-parameterized Search Nearby and as well as a user-parameterized Walking Time analysis. Eleven GIS-illiterate test users were asked to test the prototype and participate in a survey. The survey results show that a chatbot can be integrated with a GIS in a meaningful way. Almost 64% agree or strongly agree that chatting with a chatbot about Site selection is useful. Eleven people rated the existing spatial analysis possibilities of the GeoBot prototype at 3.8 out of 5 possible stars. Seven out of eleven rated it with 4 or more stars.

Nevertheless, the test users expect more from a productive version. They expect clear advantages over Google / Google Maps, more information, better map visualization, better search results, interactivity and personality of the GeoBot, user guidance and user design.

The GeoBot prototype - as it is today - has its major limitations. The GeoBot's brain, the keyword patterns and the GeoBot's personality. Also, there are GIS related limitations such as the over-simplified Multi Criteria analysis and the spatial reference data which are currently prepared for the City of Baden, Canton of Argovia in Switzerland only.

Nevertheless, combining GIS with a user-centric communication paradigm such as a chatbot is very powerful. Also, understanding that interactivity and personality of a chatbot is key, but very difficult to implement.

I am looking forward to more theses, students' projects, industrial use cases combining GIS and chatbots. It is the right time and place fusing technologies and sciences and testing their impact on spatially less aware users, which have a desire for spatial information.

Table of Contents

Acknowledgments and Preface **1**
Science Pledge **2**
Abstract **3**
List of Figures and Tables **6**
Introduction **8**
Motivation 8
Enabling people 8
Solving problems 9
Problem description 10
Aim & Objectives 10
Literature review **12**
Chatbots - An Overview 12
Turing – The father of chatbots? 13
Elizabeth and ALICE 15
RiveScript chatbot framework 18
A taxonomy of models 19
Retrieval-Based vs. Generative Models 20
Long vs. Short Conversations 20
Open Domain vs. Closed Domain 21
HCI – Interacting with GIS 21
Usability Engineering for GIS 21
Usability evaluation 23
Interacting with geospatial technology 23
GeoBots – Fiction or Reality? 25
Methods **26**
Chatbot Methods and Concepts 26
GIS Model and Concept 28
Integration of Chatbot and GIS concepts 28
Requirements Gathering **31**
Systems requirements 31
Functional & Non-functional Requirements 35
Data & Services **39**

Technical Specification 39
Detailed Data flow 40
Data Selection 45
Data Models 46
Systems Architecture and Components 49
GIS Functionalities of the Chatbot 51
Search Address function 51
Multi Criteria Analysis subroutine 51
Search Nearby Analysis subroutine 52
Walking Time Analysis subroutine 53
Design and User Guidance 55
Results 56
The GeoBot prototype 57
Results of the survey GeoBot prototype 61
Would you recommend this GeoBot for Site Selection? 61
Do you find it useful to chat with a GeoBot on Site Selection? 63
Please rate the overall analysis possibilities of the GeoBot 64
The GeoBot delivers a satisfying answer to Multi criteria analysis. Agree? 65
The GeoBot delivered a satisfying answer to Search Nearby analysis. Agree? 66
The GeoBot delivered a satisfying answer to Walking time analysis. Agree? 67
Further answers to the survey 68
By-products of the GeoBot prototype 79
Discussion 81
Conclusion and Outlook 84
Appendices 86
List of References 94

List of Figures and Tables

Figure 1: TrainDelay Bot 9
Figure 2: Early Days Digital Maps Computing Machines 24
Figure 3: Simplified Chatbot Process 26
Figure 4: Simplified GIS Model 28
Figure 5: Simplified Chatbot-GIS Process 29
Figure 6: Simplified Integrational Structure 29
Figure 7: ZKB's CleverSuchen beta 32
Figure 8: Site Selection Use Case 34
Figure 9: Flow Chart on Technical Processes 39
Figure 10: ‘Small Talk’ Data Flow Diagram 40
Figure 11: 'Search' Data Flow Diagram 41
Figure 12: ‘Multi-criteria’ Data Flow Diagram 42
Figure 13: 'Walking Time' Data Flow Diagram 43
Figure 14: 'Search Nearby' Data Flow Diagram 44
Figure 15: Process Chart Multi Criteria Raster 48
Figure 16: Systems Architecture and Components 49
Figure 17: Small Talk with the GeoBot 57
Figure 18: Asking the GeoBot for Information 57
Figure 19: Searching for 'Martinsbergstrasse 22 in Baden' 58
Figure 20: Multi Criteria Analysis at ‘Martinsbergstrasse 22 in Baden’ 58
Figure 21: Parameterized Call for Nearby Features at Martinsbergstrasse 22 in Baden 59
Figure 22: Results of Search Nearby Analysis at Martinsbergstrasse 22 in Baden 59
Figure 23: Walking Time Analysis of 14 minutes at ‘Martinsbergstrasse 22 in Baden’ 60
Figure 24: Circle Diagram on Recommending the GeoBot 61
Figure 25: Bar Chart on Usefulness of the GeoBot 63
Figure 26: Bar Chart on Analysis Possibilities of the GeoBot 64
Figure 27: Bar Chart on the answer of the Multi Criteria Analysis 65
Figure 28: Bar Chart on the answer of the Search Nearby Analysis 66
Figure 29: Bar Chart on the answer of the Walking Time Analysis 67
Figure 30: Bar Chart on how surveyed Persons gather Information on Site Selection 68
Figure 31: Circle Diagram on Search Function 69
Figure 32: Bar Chart on Realiability of Search Function 70
Figure 33: Circle Diagram on Analysis Functions 71
Figure 34: Bar Chart on Performed Analysis 72
Figure 35: Circle Diagram on Expectations regarding Analysis Possibilities 73
Figure 36: Circle Diagram on Expectations regarding Information on a Site 74
Figure 37: Bar Chart on Quality of conversation 75
Figure 38: Bar Chart on quality of Displayed Results 76
Figure 39: Bar Chart on Quality of the GeoBot's Brain 77
Figure 40: Site Selection Suitability, City of Baden Switzerland 80
Figure 42: Master Thesis Mind Map 86
Figure 43: Master Thesis Project Work Breakdown Structure 86

Figure 44: Master Thesis Project Gantt Chart 87
Figure 45: Extracting Commercial and Industrial Sites out of the OSM dataset 88
Figure 46: Generating Bus Stop Services areas with 300 and 600 Break Values 88
Figure 47: Service Areas with 300 and 600 meters for all the Bus Stops 89
Figure 48: Performing Euclidean Distance Analysis To Kindergarten and Schools 89
Figure 49: Euclidean Distance Analysis Result 90
Figure 50: Services Areas for Bus Stops, Euclidean Distance Analysis for Industrial & Commercial Sites and Kindergarten & Schools 90
Figure 51: Reclassifying Kindergarten & Schools Raster 91
Figure 52: Raster Calculation to generate Multi Criteria Analysis Raster 91
Figure 53: Final Multi Criteria Raster 92
Figure 54: Published Feature Services on ArcGIS Online 92
Figure 55: Survey to gather Feedback from the Test Users 93

Table 1: Comparison Table Alice vs Elizabeth 15
Table 2: User Input and corresponding Respond by Chatbot 17
Table 3: Comparison Overview RiveScript vs AIML 18
Table 4: Overview of GIS related Filters and Functions 32
Table 5: Rating of Requirements 35
Table 6: Functional requirement – describing the behaviour of the system 35
Table 7: Non-functional requirement – elaborating a performance character 37
Table 8: Data Flow and Data Selection 45
Table 9: MCDM Data Modelling 46

Introduction

Motivation

On the 19th of June 2015, I submitted my application for UNIGIS International Professional Diploma. As a Sales person in the field of GIS, I had no clue about what I am selling and what my customers are doing with the software. So, my interest in GIS came from two reasons a) to understand my customers and b) to ultimately increase my sales revenue.

In the meantime, my personal career has developed away from a pure Sales person towards an Industry lead and a point of contact for partners. This is because my curiosity in, my understanding of and passion in GIS have grown. My curiosity has grown because of the endless conversations with clients, colleagues, peers and tutors. My understanding has grown subsequently due to the time I have invested with the different UNIGIS modules. My passion has grown since I am able to apply different methods, tools and execute workflows.

I decided to pursue my master's degree in this mind-opening, fact-based and challenging field. The skillset I acquired is very helpful and gives me amongst others access to geographical, technical and programmatic knowledge. This knowledge is helpful and meaningful to myself and to others.

My research is about the need of consuming spatial information through a chatbot. It goes back to my inner self being of enabling people by solving problems. I am sure that spatial information can be of great help when served at the right time, through the right means and to the right consumers.

Enabling people

My wife and my close friends serve as an ideal user in today's information-based era. This typical user informs herself or himself through different sources of information, amongst others

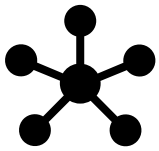
- free of charge newspapers e. g. 20 Minuten at the train stations
- social media platforms such as YouTube, Facebook
- and TV programs and broadcasting services.

Most of these sources are serving global, regional and local content. These users not only have the need to consume information, but they also want to react upon it (thumbs up or down, comment). Sometimes those users have questions related to topics and content, which cannot always be addressed by google maps or by the main stream sources of information. There is where I argue that a chatbot combined with a multi-criteria decision-making GIS system (GIS-MCDM) can be very empowering and meaningful to those decision makers. Of course, some users also have the need to create content on Blogs, Instagram, Twitter, Facebook, YouTube etc., but my focus is on the user's need to address certain questions or simply put to ask for spatial information, which are not easily retrievable, nor accessible, nor understandable.

This work could benefit regular users, but also map-illiterate people and impaired people. This group of interest might be facing barriers in consuming that information and executing analysis today. The barriers to site selection information might be

- knowledge: not aware that information exists, but even if aware; data is not prepared in a way to react upon it -> actionable information.
- map-illiteracy: no training in interpreting spatial information or no interest in acquiring these skills.
- impairment: e.g. poor eye sight and therefore talking to a chatbot is necessary to retrieve geographical information.

Solving problems



My primary focus lies on the integration of an interaction paradigm such as the chatbot and a well-established methodology the MCDM of a GIS system. The chatbot will overcome the knowledge and the map-illiteracy barriers. The impairment barrier is up to further research.

My hypothesis is: When it comes to retrieving suitability information; a chatbot in combination with a GIS-MCDM can provide that actionable information in a meaningful way.

Today there are already functional chatbots serving spatial information. The ones who inspired me and therefore will have an impact on this thesis are the following two chatbots

- Sonar
  - "The Sonar chatbot provides a natural language interface to local government open data and demographic services that helps people ask questions of their community" (Esri 2017). The project and the code can be accessed through: https://github.com/Esri/sonar
  - Esri's GeoEnrichment service, Open data Services and Hosted Services were integrated to perform specific commands such as GetPopulation, GetData, SummarizeData, GetMap.

- TrainDelay bot (EBP 2016)
  - The Train Delay bot checks for delays at any train station in Switzerland. The bot chatbot is accessible through: http://www.traindelaybot.ch/
  - As GIS functionalities Geocoding, Nearby search and Basemaps have been integrated (Heuel 2016).

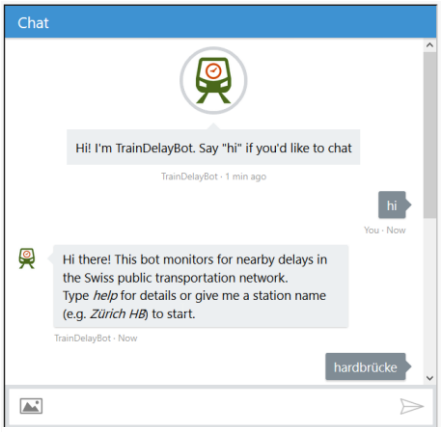


Figure 1: TrainDelay Bot

Problem description

As described earlier the task at hand is to solve the integration of chatbot and a GIS system in a prototype. The prototype chatbot has a chat-window or line and can provide responses to GIS related requests, "how well is it to settle at the address Breitenstrasse 1, 5420 Ehrendingen, Aargau?".

The approach is based on best practices and methods from the literature review. Also, a comparison between the most famous chatbot frameworks Elizabeth and ALICE will be provided, but also modern chatbot frameworks will be discussed. Human Computer Interaction (HCI) plays also an important part when integrating a revived communication paradigm and a well-established system such as GIS.

The expected result is a functional chatbot prototype based on literature review, requirements gathering and existing chatbots including GIS components. This prototype can serve as basis for further studies and further integrations. Further a validation of the prototype including documented interactions and results will be provided in the result section.

Issues that will not be discussed here are an in-depth literature review on GIS-MCDM and a well-defined criteria data preparation on the MCDM. Therefore, the focus lies on the integration rather than the perfect chatbot and MDCM implementation.

There is no specific intended audience. The audience can be broadly defined by users which are using social media and have also the need to address their spatial questions on the same social media platforms or chatrooms.

Aim & Objectives

Aim: My Master Thesis' aim is to prove that

a) A chatbot can be integrated with a GIS-MCDM in a meaningful way and
b) A chatbot can provide multi-criteria analysis information on site selection.

Objectives: A chatbot delivering answers to GIS-related questions.

Behind the answers, is a limited and simplified multi-criteria analysis on suitability based on OpenStreetMap data (OSM) and open data in general.

- Literature review is taking place during the process on
  - Chatbots
  - Communication Science, HCI, Online Media
  - Integration of GIS & chatbots
  - GIR - Geographic Information Retrieval (Semantic, Linguistic, Ambiguity etc.)
- Simple definition of suitability when it comes to locations in the City of Baden (Canton of Argovia, Switzerland)
- Design and build chatbot inspired by www.traindelaybot.ch
  - Chatbot Answering GIS-related questions
  - Design overview of application tier
  - Build Chatbot f. e. using RiveScript in combination with ArcGIS Online

An outline from a technical point of view on how the GIS-MCDA and chatbot are connected:

a) Opening conversation with users.
b) Asking which site, the user is interested in.
c) The Chatbot receives address from user.
d) The Chatbot passes address to GIS.
e) GIS address locator is locating address.
f) GIS-MCDA is carried out for this location.
    a. Identify function is carried out on layers.
g) Values on layers is passed to Chatbot.
h) Chatbot displays values for location.

The thesis structure is as follows:

- Literature review
- Materials & methods
- Results
- Discussion
- Conclusion and Outlook

Literature review

«Hi! I'm a chatbot. Say 'hi' if you'd like to chat» is an introduction only a computer program would make. First no one declares him- or herself as a robot with chatting functions and no one would ask for a formal 'hi' before the interaction begins. The mentioned introduction exposes the computer program as such, and therefore fails the Imitation Game test where a machine could replace and imitate a man (A) or a woman (B) and the interrogator (C) should find out whether the A and / or / nor B is a machine (Turing 1950). Could Alan Turing be the father of the first chatbots?

If you were asked to build a chatbot how would you begin? Probably with a review of the existing chatbots. I will discuss the two chatbots ALICE and ELIZA, their purpose and what good they have done. Also, a taxonomy of models will help to identify the suitable model for the integration of a chatbot with the GIS-MCDM.

If you were asked to make your chatbot-GIS-integration user-friendly, probably you could also consider the study field of Human Computer Interaction (HCI). I will discuss HCI engineering, HCI evaluation and the general interaction related to GIS.

Are Geobots reality or rather fiction? What can we learn from Geobots? These questions will be addressed in the context of integrating a GIS with a chatbot.

The literature on MCDM has been neglected, since it might lead to altered course of research and therefore another master thesis outcome.

Chatbots - An Overview

But again, what is a chatbot? In simple terms, it is a robot which can chat. Shawar and Atwell's definition of a chatbot "is a computer program that interacts with users using natural languages".

The technology goes back to the 1960's, but in recent years chatbots become useful tools. Shawar and Atwell investigated useful chatbot applications in different industries such as:

- a Tool of Entertainment
- a Tool to Learn and Practice a Language
- as Information Retrieval Tool
- Assistants in E-Commerce, Business, and other Domains (Shawar and Atwell 2007).

I can relate to their investigation because from my personal and professional experience I can see the potential of a chatbot in the field of Information Retrieval. There is also a further study field namely the Geographic Information Retrieval, which findings can be combined with the findings on chatbots.

Shawar and Atwell argue that need of chatbots has become important with the widespread use of personal machines. For example, in my country Switzerland, most of the people carry a smart phone and have access to the internet. This availability of computing power and internet access in combination with the widespread usage of social media platforms (such as Facebook) might increase the demand of chatbots on those platforms.

Shawar and Atwell "agreed that the best way to facilitate Human Computer Interaction is by allowing users to express their interest, wishes, or queries directly and naturally, by speaking, typing, and pointing"(Zadrozny, Budzikowska et al. 2000). Again, I understand their argument and see that users express such interests to other users or also to chatbots. In my thesis, I focus on the querying part, whereas users type in directly their questions into the dialog box of a conversation.

The aim of designing a chatbot should be "to build tools that help people, facilitate their work, and their interaction with computers using natural language; but not to replace the human role totally, or imitate human conversation perfectly" (Shawar and Atwell 2007). Shawar an Atwell's argument is broad, but nevertheless define the role of any chatbot regarding why they should be built in the first place. They do not expect a chatbot to pass the Imitation Game put forward by Mr Alan Turing.

So how do chatbots help people facilitating their work and interaction with computers. Here is a shortlist of popular and helpful chatbots (Plummer 2017):

- Transport for London, for live bus arrivals and more available here
- Heston Bot, for culinary recipes with Michelin-starred chef Heston Blumenthal
- DoNotPay, free legal aid to people seeking asylum
- TransferWise, makes remittance easier
- National Health Service

With the advancement of data-mining and machine-learning techniques, better decision-making possibilities and processing tools standards like XML, "chatbots have become more practical, with many commercial applications" (Braun 2013). Better decision-making possibilities can also be driven by a GIS system. In my case this relates to the MCDM process, which will be integrated with the chatbot. The MCDM achievements increase the practicality of chatbots. This shows also the potential of GIS integration in general.

Microsoft's CEO, Satya Nadella stated that "Bots are the new apps" and that Microsoft is going to improve Cortana, an Artificial Intelligence (AI) assistance (Reynolds 2016). Other examples of popular AI assistants are Apple's Siri, Google's Assistant or Amazon's Alexa.

Turing – The father of chatbots?

Computing machinery and intelligence was the title of Alan M. Turing's paper in October 1950. Almost 70 years ago he stated that "We may hope that machines will eventually compete with men in all purely intellectual fields. [...] Many people think that a very abstract activity, like the playing of chess, would be best. It can also be maintained that it is best to provide the machine with the best sense organs that money can buy, and then teach it to understand and speak English."

With his scientific findings and computing machines on his disposal Mr Turing was quite realistic in his hopes. Today not only abstract activities such as chess, but also interactive

augmented reality (AR) and virtual reality (VR) games are common in gaming and entertainment industries. In a shooter game, humans play against or side by side with a machine. In amusement parks a machine can simulate a situation e.g. flight simulator, add real life context to it such as wind, water and movements. In movie theatres, new virtual realities are created with the help of machines. Machines are mowing your lawn, vacuuming your floors, predicting which music or content you would like to play, e.g. Amazon or Spotify, and much more.

Mr. Turing also stated a concept of a child machine, which could be trained by humans. The training would be based on bonus versus malus or punishment and rewards, sort of raising a child. “Some simple child machines can be constructed or programmed on this sort of principle. The machine has to be so constructed that events which shortly preceded the occurrence of a punishment signal are unlikely to be repeated, whereas a reward signal increased the probability of repetition of the events which led up to it” (Turing 1950).

With today’s Deep Learning, Machine Learning techniques and Natural Language Processing (NLP) we are closer than ever before to train children machines f. e. to understand and speak English.

Nevertheless, common challenges exist and will be addressed in the chapter A taxonomy of models, based on Denny Britz’s article on Artificial Intelligence, Deep Learning, and NLP.

Is Alan Turing the father of chatbots? I don’t think so, but more importantly he described fundamental principles to various fields such as NLP, Machine Learning and Computing Intelligence and inspired generations of researchers and scientists which eventually invented chatbots.

Therefore, the Imitation Game is important because it provides context to NLP, Machine Learning and Computational Intelligence. When a machine could imitate a man or a woman and therefore withstand 5 minutes of questioning by the interrogator then the Turing test is passed. There are various objections to this test; here are five, which might also be true for chatbots:

- The theological objection: thinking is a function of man’s immortal soul
- The "Heads in the Sand" Objection: The consequences of machines thinking would be too dreadful. Let us hope and believe that they cannot do so.
- The Mathematical Objection: There are many results of mathematical logic which can be used to show that there are limitations to the powers of discrete-state machines.
- Arguments from Various Disabilities: These arguments take the form, “I grant you that you can make machines do all the things you have mentioned but you will never be able to make one to do XYZ.”
- Lady Lovelace's Objection: “The Analytical Engine has no pretensions to originate anything. It can do whatever we know how to order it to perform” (Turing 1950)

Shawar and Atwell stated that it is not the aim of a chatbot to substitute humans totally, or imitate human behaviour flawlessly. Implicitly this means that a chatbot should imitate a human, but not totally. A chatbot should act as a human, but not perfectly.

Is human like behaviour really what we seek? Microsoft's Tay AI tried to imitate human behaviour, but it was a disastrous launch due to racial and offensive posts on Twitter (Plummer 2017).

Elizabeth and ALICE

Chatbots or so called conversational agents have existed since ELIZA was created back in 1966. The purpose of the ELIZA program was to emulate Rogerian psychotherapist (Shawar and Atwell 2003). Both Elizabeth and ALICE were adopted from the ELIZA program (Weizenbaum 1966). ALICE's development began 1995 by its creator Dr. Richard S. Wallace[1]. He is also the author of Artificial Intelligence Markup Language (AIML). The University of Leeds created Elizabeth in 2002[2].

Up to this day chatbots "are an effective means to counteract the barriers for young adults requiring professional treatment and advice relating to mental health illnesses" (Elmasri and Maeder 2016).

ALICE is a three-time Loebner Prize winner, an annual Turing Test. The Loebner competition is used to judge how much a chatbot convinces a user that it is a real human by chatting for 10 minutes.

These two chatbot systems have their advantages and disadvantages. Below is a comparison table based on the analysis of Shawar and Atwell in 2002 and 2007.

TABLE 1: COMPARISON TABLE ALICE VS ELIZABETH

Advantages	Disadvantages
ALICE • Storage of huge corpus text • Basic Artificial Intelligence, Natural Language understanding and Pattern Matching • Simple patterns and Templates to represent input and output • Splitting of user input into two sentences and combined answer	ALICE • Does not save the history of conversation • Does not truly understand what you say, it simply gives you the response from the knowledge domain
Elizabeth • Provides grammatical analysis for sentences • Basic Artificial Intelligence, Natural Language understanding and Pattern Matching	Elizabeth • More complex rules on Input transformation, Output transformation and keyword patterns (to represent a user input and Elizabeth's answer).

[1] http://www.alicebot.org/bios/richardwallace.html
[2] http://www.philocomp.net/ai/elizabeth.htm

	• Input, Output transformation and keyword patterns need to be written • No templates to represent input and output • Elizabeth structure makes splitting difficult

(Shawar and Atwell 2002), (Shawar and Atwell 2007)

The architecture of the two chatbots are similar since they both are based on ELIZA. The architecture consists of the following parts (Shawar and Atwell 2003):

- A script, which may consist of four parts
    - Script command lines with welcome, void and no keyword messages
    - Input transformation rules, which maps input to another form so that the input is compatible with the defined keywords.
    - Output transformation rules, which changes personal pronouns to be appropriate as a response.
    - Keyword patterns
        - simple patterns: matching only single word
        - composite patterns: matching a sentence of phrase, words, string and letter
- A matching process with 5 steps. The process matches with
    - .. input transformation rules
    - .. keyword patterns
    - .. output transformation rules
    - .. void or no keyword messages
    - and to perform any dynamic process.
- Grammar structure analysis
    - Elizabeth can create an analysis on grammar structure of a sentence. A set of input transformation rules is configured to represent grammar rules.
    - "This provides an introduction to some of the major concepts and techniques of natural language processing".
- Template based sentence building and Short-term memory
    - The short-term memory can keep track of the conversation and makes sure that an answer is not given twice.
    - Because of the memory the chatbot can chat on the current topic and on previously mentioned topics.
    - The chatbot logs users and can draw information from the previous conversation. So, it there is a long-term memory in place.
- Pattern matching and Wild cards
    - For each defined pattern a corresponding template based answer to the user input is given.
    - The pattern matching technique finds those patterns that match the user input.
    - Within the pattern, certain words are replaced by wild cards.

- Example of a wild card, ‘I want *’ where the ‘*’ can be any value.
- The template response says, ‘what would it mean to you if you got *’. ‘*’ is changed to include the word input by the user.

- Automatic indexing
  - The automatic indexing of the data enables the removal of unnecessary suffixes like ‘ing’ and common words like ‘a’, ‘is’ and ‘for’.

TABLE 2: USER INPUT AND CORRESPONDING RESPOND BY CHATBOT

The following trace using the previous script to illustrate different inputs with its responds:

User Input	I nput Transforming	Keyword Patterns	Output Transforming	Respond	Actions
Dad loves Mum	Match: ‘001’ mum => mother ‘002’ dad => father	Match: ‘001’K MOTHER ‘001’ R TELL ME MORE ABOUT YOUR FAMILY.	-	TELL ME MORE ABOUT YOUR FAMILY.	-
My sister is a teacher.	-	Match: ‘006’ K my [phrase] [phrase] => sister is a teacher ‘001’ R YOUR is a teacher?	-	YOUR SISTER IS A TEACHER?	‘fam’ M sister is a teacher
My brother is younger than me.	-	Match: ‘004’ K [phrs1] IS YOUNGER THAN [phrs2] [phrs1] => my brother [phrs2] => me ‘001’ R SO [phrs2] IS OLDER THAN [phrs1].	Match: [phrs1] with ‘003’ my => YOUR [phrs2] with ‘005’ me => YOU	SO YOU IS OLDER THAN YOUR BROTHER.	-
I like reading	-	Match ‘005’ K I LIKE [string]ING [string] => read ‘001’ R HAVE YOU [string]ED AT ALL RECENTLY?	-	HAVE YOU READED AT ALL RECENTLY?	-

(Shawar and Atwell 2003)

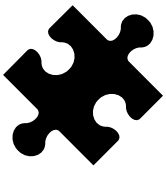
From Shawar and Atwell’s analysis of ALICE and Elizabeth chatbot systems, they concluded that ALICE suits better for their tasks ahead.

For my chatbot and GIS MCDM integration I am going to evaluate another chatbot framework called RiveScript[3]. It “..is a simple scripting language for chatbots with a friendly, easy to learn syntax” (Petherbridge 2018). The main reasons for me to consider RiveScript is because of its huge advantages such as simplicity, flexibility and Open Source.

Further helpful YouTube tutorials provided by ‘The Coding Train!’ are available on YouTube[4]. In this YouTube channel Daniel Shiffman, Assistant Arts Professor at New York University NYU, publishes video tutorials on coding. Amongst other programming languages Daniel Shiffmann tutors RiverScript.

[3] https://www.rivescript.com/
[4] https://www.youtube.com/watch?v=PBsUD40nPkI

RiveScript chatbot framework



RiveScript is a simple scripting language. It adds intelligence to a chatbot. RiveScript is open source and can be accessed on GitHub[5] as well as its community Wiki[6]. It was created by Noah Petherbridge. He began development in 2010[7].

It is a straightforward plain text and line-based language. Without the need to read complex XML code nor remembering random symbols (Petherbridge 2018).

Sample code

+ hello bot

- Hello, human!

+ my name is *

- <set name=<formal>> I will remember to call you <get name> .

Besides the mentioned YouTube channel there are also tutorials provided on RiveScript.com and on metacpan.org/pod/RiveScript.

Based on the comparison on RiveScript.com[8] here is a comparison table of the AIML vs RiveScript. As mentioned in the previous chapter ALICE is based on AIML and was created by Dr. Richard S. Wallace.

TABLE 3: COMPARISON OVERVIEW RIVESCRIPT VS AIML

Functional Comparison RiveScript vs AIML	
RiveScript and AIML are alike • Topic declarations. • Binding of any wildcards in the pattern or trigger. • Insert the bots or users previous reply. • Retrieve a bot or a user variable. • Set a user variable. • Insert the user's ID. • Insert random data. • Redirect one reply to another.	RiveScript easier • Upper- and lowercasing, formalize and sentence-case a string of text. lowercase XXX /lowercase, <lowercase>
RiveScript superior	AIML only features

[5] https://github.com/aichaos/rivescript
[6] https://github.com/aichaos/rivescript/wiki
[7] https://www.rivescript.com/history
[8] https://www.rivescript.com/compare/aiml

• Topics inheriting replies from other topics. < topic A inherits B C • Input pattern. + hello bot • Response to an input pattern. - hello human! • Match the user's input and the bot's last message. • Retrieve a global variable. <env XXX> • Conditionals. ==, eq !=, ne, <> <, > <=, >=	• Wrappers for trigger responses. • Insert the current time. <date /> • Insert of AIML Version and number of loaded AIML categories. • Append to a text file. • Load a new AIML file

(Petherbridge 2018)

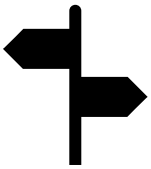
Because of the superiority and the easy approach, I concluded to implement my chatbot and GIS MCDM integration with RiveScript. "..it is designed to be a self-contained software library with a simple API that can be plugged into any existing codebase" (Petherbridge 2018). I will put this reference to the test by integrating it with a GIS system.

Another reason is the availability of tutorials and YouTube channels such as 'The Coding Train!'.

Further the RiveScript reviews are very good and the Gitter community is lively, see below

- Facebook[9]
- CPAN[10]
- Gitter community[11]

A taxonomy of models



"Microsoft is making big bets on chatbots, and so are companies like Facebook (M), Apple (Siri), Google, WeChat, and Slack" (Britz 2016). Certain start-ups build

- consumer apps such as Operator or x.ai
- bot platforms like Chatfuel
- bot libraries such as Howdy's Botkit.

[9] https://www.facebook.com/pg/RiveScript/reviews/?ref=page_internal
[10] https://cpanratings.perl.org/dist/RiveScript
[11] https://gitter.im/aichaos/rivescript?source=orgpage

Microsoft released a bot developer framework. (Britz 2016)

When it comes to chatbots' taxonomy of models Denny Britz has put together an impressive overview.

Britz is defining Retrieval-Based versus Generative Models, long versus short conversations and Open domains versus Closed domains.

Retrieval-Based vs. Generative Models

Britz considers the Retrieval-based models the easier of the two. It uses a "repository of predefined responses and some kind of heuristic to pick an appropriate response based on the input and context" (Britz 2016). A rule-based expression match could serve as a heuristic. This is like the ELIZA derivatives ALICE and Elizabeth. Also, a more complex heuristic such as an ensemble of Machine Learning classifiers could be used. These systems do have a predefined set of responses, and therefore do not generate any new text. In my chatbot GIS-MCDM integration this approach will be investigated.

- ➔ Pros: due to the limitation in predefined responses repository the Retrieval-Based Model does not make any grammatical mistakes. In contrast to Elizabeth it cannot handle grammatical analysis of sentences.
- ➔ Cons: due to this limitation unforeseen conversations cannot be responded properly or at all. It cannot store information f. e. names in earlier conversation. Just like ALICE it cannot save the history of conversations.

Generative models are the harder ones, because they do not work with predefined responses. They are normally "based on Machine Translation techniques, but instead of translating from one language to another, we "translate" from an input to an output (response)" (Britz 2016).

- ➔ Pros: Generative models can "refer back to entities in the input and give the impression that you're talking to a human" (Britz 2016).
- ➔ Cons: This model is difficult to train, since it is prone to grammatical mistakes (particularly longer sentences). It requires a vast amount of training data.

Long vs. Short Conversations

It is logical that if the conversation gets longer, it becomes more difficult to automate it. The goal of single user input is to create short responses. This keeps the conversation on a low level which is easier to handle. The more specific the question is, the shorter the response. This is surely an approach, which I will consider when building the chatbot.

The longer the conversations the harder it gets to handle it. The conversation can get twisted and difficult to follow, while keeping in memory what has been said or written. "Customer support conversations are typically long conversational threads with multiple questions" (Britz 2016).

Open Domain vs. Closed Domain

Where the domain is not clearly defined, the conversation can develop in any direction. So open domains are much harder to model. "Conversations on social media sites like Twitter and Reddit are typically open domain – they can go into all kinds of directions" (Britz 2016). The vast number of subjects and the related knowledge to it, makes it very hard to create reasonable responses.

The easier approach is with closed domains. The system is built only to complete a specific aim. So therefore, the user input is limited and the responses are very specific. This would relate to the GIS MCDM analysis responses, which are very specific responses to user inputs and queries. The system is also not expected to handle any other than GIS analysis.

Common challenges are typically

- Incorporating context into the conversation
- Coherent personality of the chatbot
- Evaluation of models with regards to building a chatbot
- Intention and diversity of the chatbot (Britz 2016)

"… most systems are probably best off using retrieval-based methods that are free of grammatical errors and offensive responses. If companies can somehow get their hands on huge amounts of data then generative models become feasible – but they must be assisted by other techniques to prevent them from going off the rails like Microsoft's Tay did" (Britz 2016).

HCI – Interacting with GIS

HCI is concerned "with how people design, implement and use computer systems (Myers, Hollan et al. 1996), the usability or the effectiveness of the interaction between humans and machines (Butler 1996), and how computers affect individuals, organizations and society, (...)" (Haklay and Tobón 2003). Those issues are also vital to any GIS.

The field covered by HCI is vast and therefore I focus on GIS and chatbot related topics such as

1. Usability Engineering
2. Usability Evaluation
3. Interaction with geospatial technology

The theory regarding the interaction between the user and the chatbot with an underlying GIS MCDM system is discussed below.

Usability Engineering for GIS

The topics covered by "…HCI research in GIScience includes

- perception of spatial cognition (Mark, Freksa et al. 1999)

- development of novel interfaces (Blaser, Sester et al. 2000)
- and ontology in spatial data (Fonseca, Egenhofer et al. 2000) among others" (Haklay and Zafiri 2008)

Haklay and Zafiri argue that there is a lack of research spent on how GIS is used at the workplace, in schools, and at home. This is due to the dramatic change in use of GIS. Today millions of people work with GIS across the globe, and even more users, which use public and freely accessible mapping sites such as Google Maps, Bing Maps, Apple Maps, HERE, OpenStreetMap or providers of GPS based navigation systems in their daily activities (Longley et al., 2001). Haklay and Zafiri continue and argue that "we know very little about these users, and how to design systems for them in a way that ensures that GIS is used effectively, efficiently, and enjoyably" (Haklay and Zafiri 2008).

The focus should be primarily on the advancement of Usability Engineering (UE) for GIS. UE aims to address the system's usability in a reliable and replicable fashion. The 5 E's of Usability "…can be used by system designers and developers to ensure that the system is efficient, effective, engaging, error tolerant, and easy to learn" (Haklay and Zafiri 2008).

The genuine goal is to make an impact with the millions of users today. The shift of focus improves the quality of working life of the millions of users. "The GIScience research community knows very little about the characteristics, needs, skills, and context of these users, be they 'Google Earth browsers' who enjoy using a geobrowser at home or experts who work with GIS on a daily basis" (Haklay 2010).

Usability testing is a very common UE approach. It has been introduced in the 1980s(Schneiderman and Plaisant 1998). In essence the usage of the prototype is being monitored to gather and analyse user and system data and observe the user performance (Lin, Choong et al. 1997) Information can be derived from "…execution time, accuracy, and users' satisfaction as well as video and system logs (Lin, Choong et al. 1997)" (Haklay and Zafiri 2008).

Besides UE also existing user requirements for chatbots should be considered. A prototype chatbot was implemented using AIML. Its purpose was to create a structure human-like conversation (Elmasri and Maeder 2016).

The expert panel decided on the following requirements:

a) "A secure, anonymous and immediate advice and/or information exchange on a users' alcohol related issues which is derived from a trusted and non-biased source;
b) A personality whereby the chatbot is a friendly adviser or mentor to the user rather than a therapist or health care professional;
c) A unique and logical conversation based on individual inputs;
d) A simple means to communicate with an artificially intelligent agent, structuring the conversation to require little input from a user to carry on a conversation.
e) A mechanism that provides feedback and/or advice based on their alcohol assessment and web links to relevant government agencies and private organizations for more information on how to seek help with alcohol misuse " (Elmasri and Maeder 2016).

The following user requirements were generalized from the above list:

a) A secure and immediate information exchange;
b) A personality is neglected in the chatbot;
c) A logical conversation based on the individual's input;
d) A simple means to communicate with a chatbot, and structuring the conversation to require as little as possible user input to carry on the conversation;
e) A logic that provides feedback and or further information.

Usability evaluation

Non-expert users might face difficulties using WebGIS platforms let alone expert tools provided by corporates, government, cantons etc. The obstacles are in terms of "navigating an interface that embeds a language, world view and concepts that support the system's architecture rather than the user's work view" (Traynor and Williams 1995).

HCI and usability evaluation can contribute to the enhancement of the GIS system used (Boott, Haklay et al. 2001) (Haklay and Tobón 2003). There are mainly two reasons for that. First, HCI techniques, including usability evaluation, are trained towards understanding how users interact with applications within an environment. Further usability evaluation is built upon methods researched and validated in a number of scientific fields (Thomas and Macredie 2002). Therefore usability evaluation can aid GIS "in the design of more robust applications that are accessible to a wider range of users, most of them with little or no experience of GIS" (Haklay and Tobón 2003).

Kuligowska has put together an interesting list of chatbot components. The list is called 'Quality components and their evaluation' (Kuligowska 2015). Below is the shortened catalogue:

- Visual look of the chatbot
- Form of implementation on the website
- Knowledge base: basic, specialized knowledge
- Presentation of knowledge and additional functionalities performed by chatbot
- Conversational abilities, language skills and context sensitiveness
- Personality traits
- Personalization options
- Emergency responses in unexpected situations
- Possibility of rating chatbot and the website by the user (Kuligowska 2015)

Interacting with geospatial technology

The ordinary citizen is considered as a regular user and is the main audience of my chatbot. "The spatial citizen, as opposed to spatial analysts and spatial information system managers, is considered to have five competencies within the field of technology/methodology" (Strobl 2008):

- Reading a map, orientation and navigation -> Consumption

- Using GIS functionalities to answer simple questions and go through single-step analytical tasks -> Analysis
- Changing data selection and visualisation and adding labels, marks and comments -> Prosumption
- Use decision-negotiation instruments on the Web -> Social networking (Haklay 2010)

My chatbot GIS MCDM integration focuses on the consumption and analysis competences of a spatial citizen. The regular user can ask (query) simple spatial questions to the chatbot, which in return will perform a multi-criteria analysis and send back the results to the chatbot for the user to read (consume).

Geospatial technologies are lagging behind many applications of computers. "This is due to the complexity of geographic information processing, the need to provide high quality graphic output, as well as the volumes of data that are required in such applications. (…) this has an impact on the attention to, and the development of HCI techniques in GIS" (Haklay 2010).

Figure 1.1 Computers of the type used to produce early digital maps (Courtesy of Carl Steinitz)

FIGURE 2: EARLY DAYS DIGITAL MAPS COMPUTING MACHINES

Interactions with GIS systems are subject to acquiring advanced skills. It involves geography, cartography, statistics, databases and data structures. Further in order to perform analysis functionality GIS users are required to program. "This means that in many cases the user needs to consider what they are trying to achieve in their analysis task, and then string together a series of actions to achieve the needed outcome" (Haklay 2010). So, GIS users are expected to use this programming capabilities within geospatial technology packages.

This is not true for end user GIS applications, but never the less it shows the complexity involved when interacting with geospatial technologies or when building such technologies for end users.

GeoBots – Fiction or Reality?

Whenever GeoBots become reality in our lives geographical information retrieval (GIR) is one of its contributors. "It is this need for public access to geographical information on the Web that has been a major motivation for the growth of the academic field of GIR" (Jones and Purves 2008).

IR has provided the foundation for current Web search engine technologies, by focusing in querying Web documents that are relevant to users. IR methods recognise Web pages that contain query terms. The methods rank documents by applying statistical methods that are geared to emphasise the most relevant. The user queries are phrase- or keyword-based. "This latter type of query is in contrast to the more formal approach common in GIS, where specific geo-referenced data objects are retrieved from a structured database in response to queries that can stipulate precise spatial constraints" (Jones and Purves 2008).

"GIR is therefore concerned with improving the quality of geographically specific information retrieval with a focus on access to unstructured documents such as those found on the Web" (Jones and Purves 2008). Again, there are several research challenges involved with several aspects of GIS. The following aspects require improvement:

- detecting geographical references such as **place names** within documents and in users' queries;
- disambiguating place names which helps to determine the particular intended place;
- geometric interpretation of the meaning of imprecise place names such as the 'Highlands' and contextual spatial adjectives such as 'near';
- indexing documents with regards to geography;
- ranking documents according spatial preferences;
- and developing novel **user interfaces** (Jones and Purves 2008).

The highlighted improvements are relevant to the chatbot GIS MCDM integration or other GeoBots.

Vadym Markov probably invented the term GeoBot in 2017. He built a chatbot which he named GeoBot. Andrew Turner and Dave Bouwman picked up the term GeoBot and presented on them in 2017 at the Esri Developer Summit. Also, EBP's Stephan Heuel mentioned the term in his presentation at the GeoBeer gathering in March 2016. So GeoBots exist. Below are a few examples of such GeoBots. Also, I explain briefly their purpose and how they were built. Nevertheless, they are not a reality, yet.

Vadym Markov's GeoBot https://github.com/vadymmarkov/geobot (Markov 2017)

- Markov's GeoBot can provide the capital, the population, the location and the area of a specific country.

- The chatbot was built using Wit.ai and Vapor Swift web framework.

TrainDelayBot is an R+D project by EBP. http://www.traindelaybot.ch/ (EBP 2016)

- A Chatbot for the Swiss Public Transport
- Stephan Heuel's presentation on the TrainDelayBot held at the GeoBeer in March 2016: https://www.slideshare.net/ping13/forget-apps-bots-will-take-over-gis. The prototype was created with the Telegram chatbot framework and ArcGIS.

Esri's and AJ Turner's sonar https://github.com/Esri/sonar (Esri 2017)

- Sonar bot provides a speech recognition interface to government open data and demographic services.
- The Sonar project[12] is based on the Facebook messenger chatbot framework, Slack and Alexa Echo Skills.

Methods

In this chapter I am going into the following subjects:

- The underlying chatbot method and concept to be applied
- The underlying GIS model and concept
- The integration between the two concepts above

Chatbot Methods and Concepts

The chatbot is implemented according to Shawar and Atwell's User Input and Chatbot Respond overview from 2003, see Table 2. They describe the principles by defining

- User input
- Input transformation
- Keyword patterns
- Output transformation
- Respond

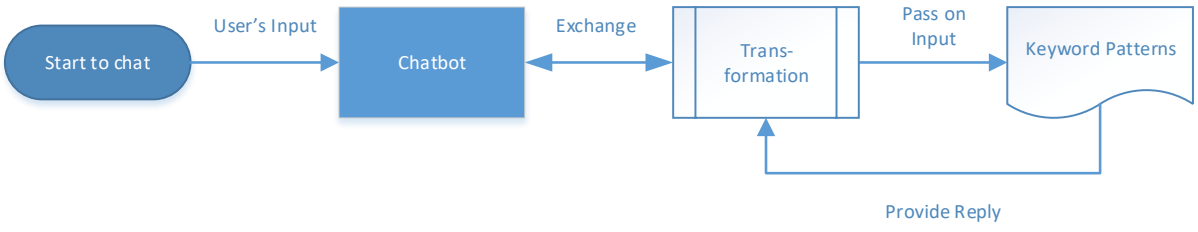


FIGURE 3: SIMPLIFIED CHATBOT PROCESS

[12] Andrew Turner's presentation on "GeoBots: Making the World Accessible Through Ambient Interfaces": https://youtu.be/H_cdn2kVB-E

Therefore, the GIS system should work with those basic components. The GIS system will receive the requests by the chatbot, namely the Input transformation unit. The GIS system will respond to the requests by providing the answers to the Output transformation unit. Thus, the underlying concept of my chatbot is dating back to the architecture of the two original chatbots Elizabeth and ALICE, which are similar since they both are based on ELIZA program.

The technical GIS integration is shown in Figure 16.

The characteristic of my chatbot are

- Storage of text
- Pattern Matching
- Simple patterns and Templates to represent input and output

The chatbot integration is based on the Retrieval-Based Model. As mentioned in section Retrieval-Based vs. Generative Models page 20, the chatbot uses a "repository of predefined responses and some kind of heuristic to pick an appropriate response based on the input and context" (Britz 2016). This repository is called the brain. In Figure 16: Systems Architecture and Components the brain is integrated as a component to the overall systems architecture.

To keep the conversation focused and clear, short answers are required by the user. That is why specific questions are desired over open questions. Specific answers will tend the user to provide short answers. This was discussed briefly in the paragraph Long vs. Short Conversations on page 20.

Since site selection is a closed domain, the chatbot cannot be carried away by long conversations. The chatbot GIS integration is built first and foremost for site selection. The user will expect therefore a conversation on site. This has been also discussed in the paragraph Open Domain vs. Closed Domain on page 21.

Regarding the Usability Engineering the chatbot tries to obey the rations derived from an expert panel while developing a chatbot prototype (Elmasri and Maeder 2016).

The requirements derived from this prototype are:

a) An immediate information exchange;
b) A logical conversation based on the individual's input;
c) A simple means to communicate with a chatbot, and structuring the conversation to require as little as possible user input to carry on the conversation;
d) A logic that provides feedback and or further information.

Further to gather specific requirements on site selections, Swiss platforms on property search are examined. Please see Table 4: Overview of GIS related Filters and Functions, which breaks down the GIS functions of those platforms.

Besides evaluating the components of a chatbot, as listed in paragraph Usability evaluation on page 23, the chatbot will be validated on how random 10 people are handling the chatbot and whether those people are satisfied with the site selection chatbot prototype. The interaction will be documented. The feedback of the people will be linked to to the Table 7: Non-functional requirement – elaborating a performance character.

GIS Model and Concept

The GIS system has the purpose of extending GIS functionalities to the Site Selection Chatbot. Those GIS functionalities are based on requirements, which are discussed in the next chapter Requirements Gathering on page 31.

What is obvious is that the concept requires the GIS to perform spatial analysis on behalf of the Chatbot. Therefore, the GIS system should hold spatial information such as geometries and attributes related to Point of Interest and areas.

The concept is based on the following GIS components:

- Feature Services
- 3rd Party Services

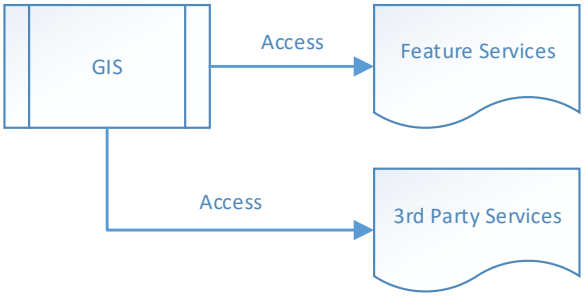


FIGURE 4: SIMPLIFIED GIS MODEL

The Features Services are based on OSM data. The data model and the required detailed datasets are discussed in the chapter Data & Services under Data Models, page 46.

The required 3rd Party Services are discussed in the next chapter called Requirements Gathering under Functional & Non-functional Requirements, page 35.

Integration of Chatbot and GIS concepts

Before getting into the integration it is easiest to illustrate the simplified process with a diagram.

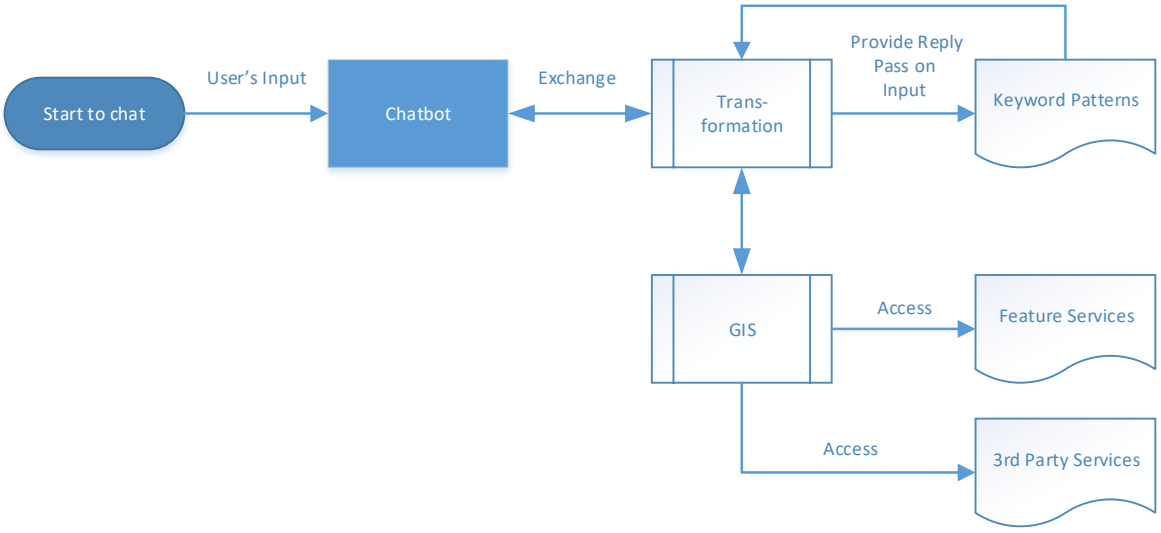


FIGURE 5: SIMPLIFIED CHATBOT-GIS PROCESS

In this diagram it is obvious that the Chatbot and the GIS require an integration. This integration level is best explained when getting into the structure of the Chatbot and its components. Since the Chatbot is based on Rivescript, which I have chosen over AIML as my framework, see Table 3: Comparison Overview RiveScript vs AIML.

The chatbot has the following structure illustrated below:

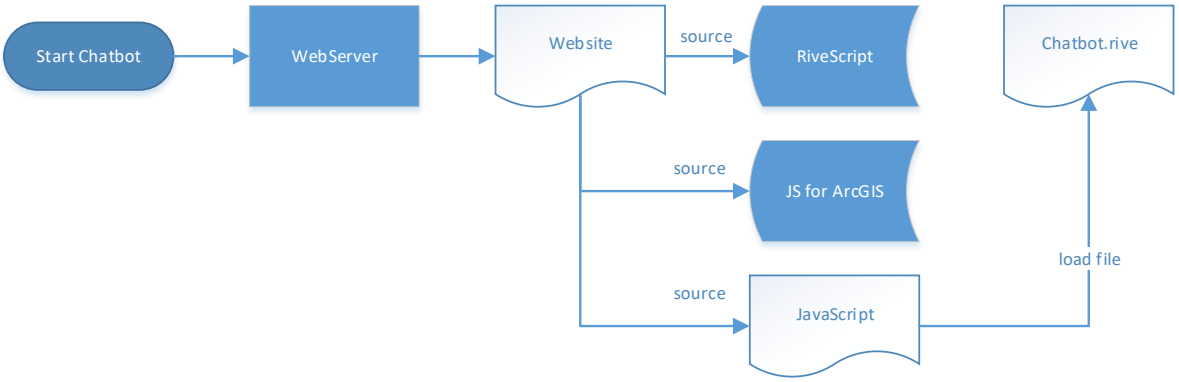


FIGURE 6: SIMPLIFIED INTEGRATIONAL STRUCTURE

The integration is therefore done on JavaScript level, where the script can call different functions of ArcGIS such as Search function, or analysis functions.

Please refer to section 'Systems Architecture and Components' on page 49 for a systems architectural diagram on how the functions and Web Services work together and how the functionalities of the chatbot work out technically.

Project Management Tools

For the master thesis itself, I am applying the next project light excel based program provided generously by Key Consulting (Key_Consulting_Inc. 2017) and a mind map based on the open source software FreeMind. See Appendices

- Figure 42: Master Thesis Mind Map
- Figure 43: Master Thesis Project Work Breakdown Structure
- Figure 44: Master Thesis Project Gantt Chart

Requirements Gathering

In this chapter I am going into the following subjects:

- My approach on how to work on the integration of a chatbot and GIS-MCDM.
    - Including systems requirements gathering on possible functionalities and
    - Functional and non-functional requirements on the chatbot.

The RiveScript package can be enhanced with any JavaScript libraries. Therefore, I am going to write the chatbot in the RiveScript scripting language and integrate the GIS components using ArcGIS API for JavaScript. The latter can be used with a Developer or an Organizational Subscription.

For example, I will integrate a 'Search' component provided in the ArcGIS API for JavaScript or provided by Swisstopo's GeoAdmin API (API REST Services). This will help me to geolocate places.

- ArcGIS API for JavaScript 'Search Widget'[13] and related tutorials[14]
- Swisstopos' GeoAdmin API 'Search Service'[15] and related tutorials[16]

The idea is not to add a search widget to the chatbot, but to pass user inputs to the search functions given in the APIs of Swisstopo or ArcGIS.

In this case the user types in the address in the chat line or window. The address is recognized by the chatbot as an address and passed to one of the 'Search' components above. Especially the integrated search capability is a difficult task. Geo-parsing is a study field itself and highly advanced and complex. I need to make sure it is very clear to the chatbot that the user types in an address in the chat line. This is one systems requirement.

Systems requirements

To find further systems requirements I analyse three common Swiss platforms for property search. These platforms offer hints, ideas and filters on site selection. Those filters and related functions are GIS related or can perhaps be GIS enabled. Some filters might also be missing on those platforms, but could be very useful for site selections. An example would be the proximity to industrial sites, power plants or other factories. The platforms which I analyse to gather more requirements are:

1. www.Comparis.ch
2. www.Homegate.ch
3. www.Immoscout.ch
4. ZKB Clever suchen[Beta]

[13] https://developers.arcgis.com/javascript/3/jsapi/search-amd.html
[14] https://developers.arcgis.com/javascript/3/jshelp/tutorial_search.html
[15] https://api3.geo.admin.ch/services/sdiservices.html#search
[16] https://codepen.io/geoadmin/pen/xZvNEY?editors=0010

TABLE 4: OVERVIEW OF GIS RELATED FILTERS AND FUNCTIONS

Platform	Filters / Functions	GIS relevance
Comparis, Homegate, Immscout	Address, Town or postcode	Related to GIS
Comparis, Homegate, Immoscout	"within radius of"	Related to GIS
Comparis.ch	Tax comparison within Canton	Can be GIS-enabled
ZKB	Commuting time to work with public transportation	Related to GIS
ZKB	Proximity to schools, kindergarten, day care facilities	Related to GIS
ZKB	Proximity to supermarket	Related to GIS
ZKB	Proximity to train & bus station, high way entry	Related to GIS
ZKB	Proximity to forest and waterbodies	Related to GIS
ZKB	Tax comparison from existing and evaluating site	Can be GIS-enabled

The Cantonal Bank of Zurich (ZKB) provides the most filters and functions related to GIS. These filters are relevant when performing a site selection. Further important criteria might be also of interest to users of a site selection chatbot, but are not implemented in any of the above platforms: proximity to industrial site, power plants or other factories. Another criterion might be the presence of natural hazards such as flood. Especially flood is a high risk in this canton of Aare, Reuss and Limmat. Further noise caused by highways and railroads might also be interesting to know to the user.

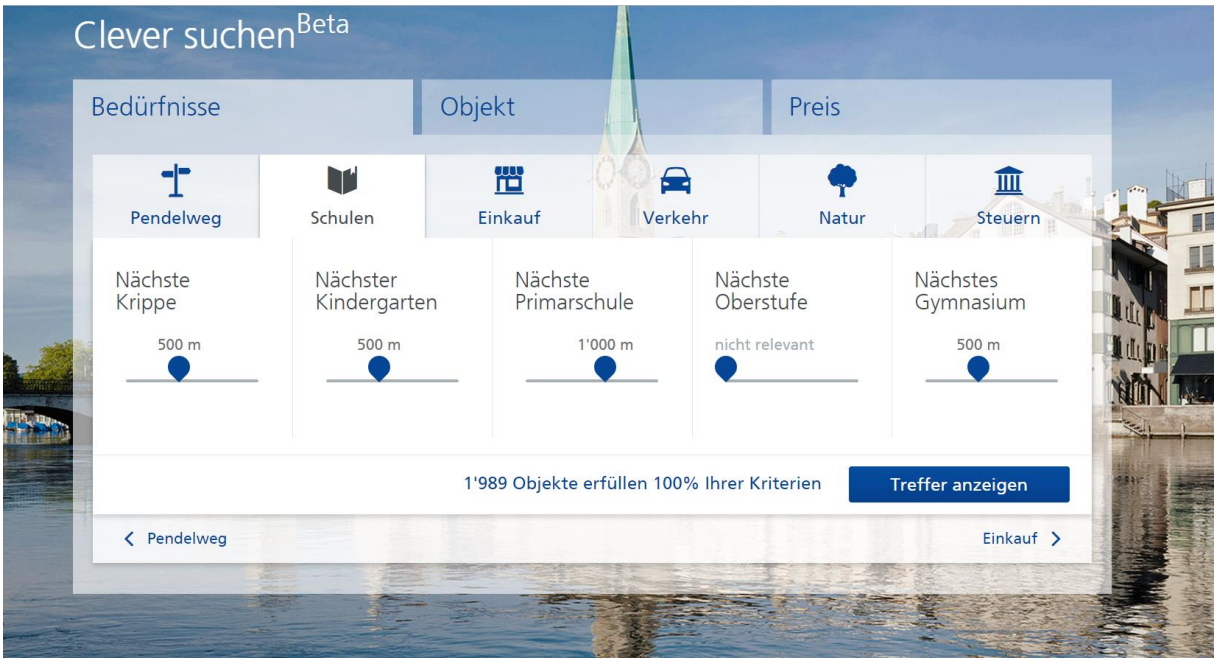


FIGURE 7: ZKB'S CLEVERSUCHEN BETA

For the prototype chatbot MCDM-GIS integration only a handful of criteria will be considered. To prove a meaningful integration there is no need to go into further details about the MCDM criteria data preparation. The chosen data are therefore exemplary and based on the given real estate platforms.

Figure 8 below is illustrating the use case gone through from a user perspective. The chat starts with a small talk, where both the user and the chatbot can introduce themselves. Fairly straight forward the user can type in an address and is able to validate it.

In all the platforms mentioned above the user can search for an address. This user requirement seems to be critical and therefore is also implemented in the chatbot GIS integration.

The user has then a choice of performing one analysis at a time. The first option is a multi-criteria analysis based on a pre-processed criteria analysis. This multi-criteria analysis goes back to the filters and functions in Table 4: Overview of GIS related Filters and Functions. It is therefore related to the proximity filters provided in the ZKB Clever suchen[beta] platform.

The user can also perform a walking time analysis to find out how far it is to walk from the selected site to next bus station for example. The user is asked to type in the number of minutes the user is willing to walk, e.g. 2 minutes. This is not a filter nor a function provided in the platforms mentioned earlier. Nevertheless, it is GIS-related and related to proximity.

The last analysis offered in the chatbot is related to "within radius of" filter. It offers users the possibility to search nearby facilities such as shops, kindergarten etc. Again, the user is asked to define the distance to these facilities.

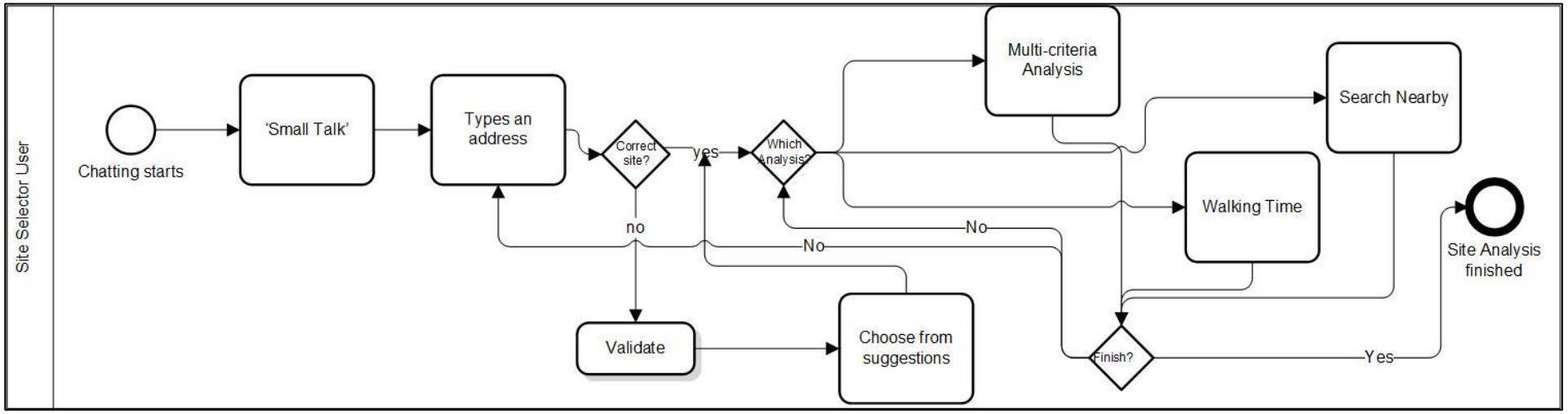


FIGURE 8: SITE SELECTION USE CASE

Functional & Non-functional Requirements

The filters and functions from Table 4: Overview of GIS related Filters and Functions have been translated into requirements.

TABLE 5: RATING OF REQUIREMENTS

Value	Rating	Description
1	Critical	This requirement is critical to the success of the project. The project will not be possible without this requirement.
2	High	This requirement is high priority, but the project can be implemented at a bare minimum without this requirement.
3	Medium	This requirement is somewhat important, as it provides some value but the project can proceed without it.
4	Low	This is a low priority requirement, or a "nice to have" feature, if time and cost allow it.
5	Future	This requirement is out of scope for this project, and has been included here for a possible future release.

TABLE 6: FUNCTIONAL REQUIREMENT – DESCRIBING THE BEHAVIOUR OF THE SYSTEM

Req# (FR)	**Priority**	**Requirement**	**Rationale**	**Field; Tooling**	**Parent**
1	critical	Integrate GIS search component on address.	Like the search function on real estate platforms. A search is performed on the address provided by the user (query). This is related to the 'Address Search' function in Table 4.	GIS; ArcGIS Online or Swisstopo, or Google Places	6
2	High	Integrate a pre-calculated MCDM.	Prepare a multi-criteria analysis based on Bus stops, Kindergarten and industrial sites (GeoProcessing).	GIS; ArcGIS Pro and ArcGIS Online (Raster to Polygone / Fishnet)	1

3	High	Integrate printing of MCDM-map.	Prepare a printing service based on MCDM (GeoProcessing). This is related to the 'Proximity' filters and functions in Table 4.	GIS; ArcGIS Pro and ArcGIS Online	1
4	High	Integrate a dynamically parametrized 'Walking Time analysis' query.	Calculate Walking time to relevant PoIs (query). This is related to the 'Proximity' filters and functions in Table 4.	GIS; ArcGIS Online (Network Analysis / Find closest Facilities) or Google Places	1
5	High	Integrate a dynamically parametrized 'Search Nearby' query.	Calculate relevant PoIs in buffer (query).	GIS; ArcGIS Online or Google Places	1
6	High	Define address for chatbot, so that it can be passed to 'Search' component.	The chatbot can understand the user's input as an address, so that it can pass it on.	Chatbot; RiveScript	
7	High	Opening conversation with users. Asking which site, the user is interested in.	Basic conversational skills of the chatbot.	Chatbot; RiveScript	1
8	Medium	Chatbot displays values for location.	Basic display possibilities of the chatbot.	Chatbot; RiveScript	7
9	High	A logical conversation based on the individual's input.	The chatbot has a certain logical 'brain' based e.g. on pattern matching techniques.	Chatbot; RiveScript	10

10	High	Structuring the conversation to require as little as possible user input to carry on the conversation.	Clear structure for the conversation based on the user's input. User input required to perform Webservice requests.	Chatbot; RiveScript	
11	Medium	A logic that provides feedback and or further information.	The chatbot has a certain logical 'brain' based e.g. on user inputs provided earlier.	Chatbot; RiveScript	10
12	Future	Chatbot has speech recognition.	Impaired people e.g. with poor eye sight can use chatbot conveniently.	Chatbot; RiveScript	

TABLE 7: NON-FUNCTIONAL REQUIREMENT – ELABORATING A PERFORMANCE CHARACTER

Req# (NFR)	**Requirement**	**Source**
1	Reliability of the GIS 'Search' component. The component should deliver the correct address, or at least provide an option of addresses to choose from. An autocompletion integrated into the chat line would be most elegant solution.	FR-1
2	Reliability of multi-criteria analysis and Efficiency in the response time to the user.	FR-2
3	Quality of printing map.	FR-3
4	Reliability of 'Walking time analysis' query and Efficiency in the response time to the user.	FR-4
5	Reliability of 'Summarize nearby' query and Efficiency in the response time to the user.	FR-5
6	Effectiveness of the chatbot's understanding of addresses.	FR-6
7	Quality of conversations with the user with regards to opening up the conversation and asking the right questions.	FR-7

8	Quality of the displayed results such as values from the analysis.	FR-8
9	Quality of the chatbot's 'brain' with regards to logical conversations.	FR-9
10	Efficiency in structuring the conversation, to use as little user input as necessary.	FR-10
11	Quality of the chatbot's 'brain' with regards to user inputs provided earlier.	FR-11

Data & Services

In this chapter I am going into the following subjects:

- The processes and sub-process
- The underlying detailed data flows
- The data selection and data models

Technical Specification

Below I created a Flow Chart including processes, sub-processes, sub-process related data, user decisions, user parameters required, and results.

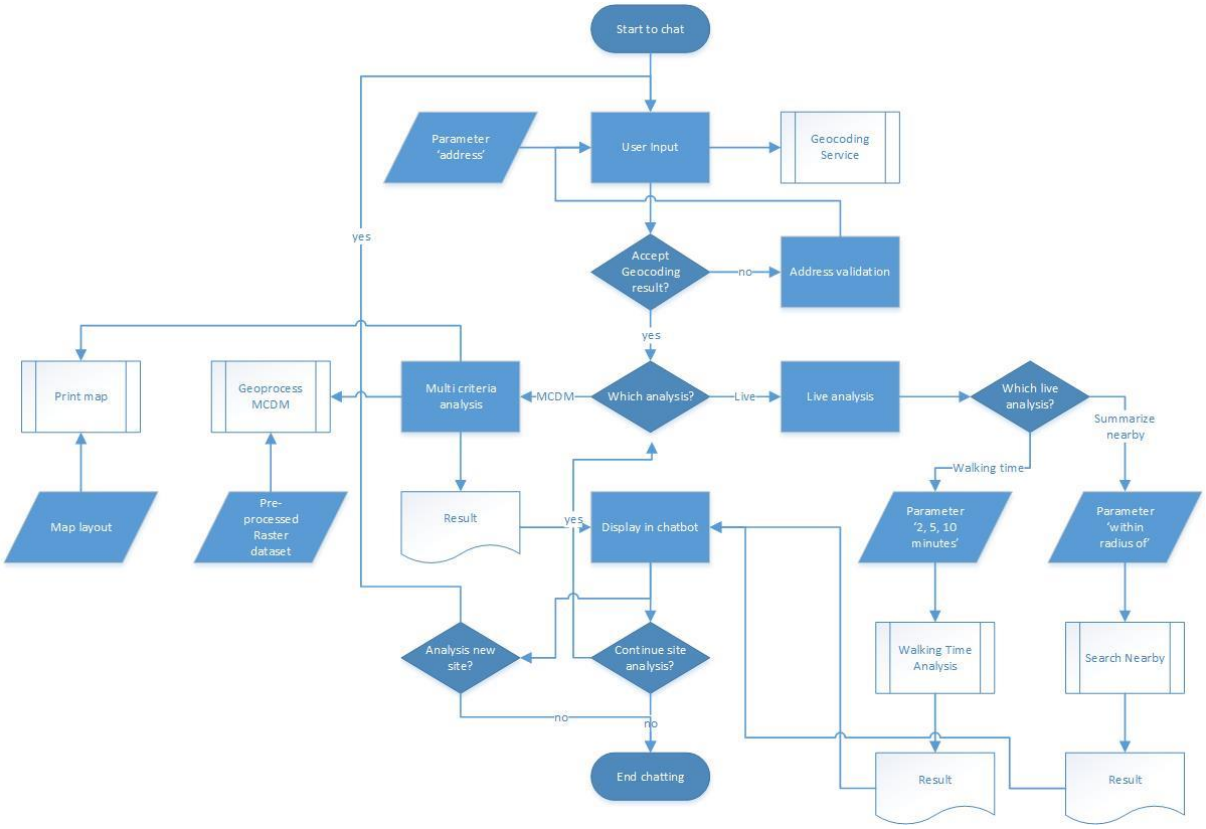


FIGURE 9: FLOW CHART ON TECHNICAL PROCESSES

The process ultimately leads in results, which can be displayed in the chatbot. The user has the option to analyse another site or continue to analysis the existing site.

- Processes are Address validation, Multi-criteria analysis, Live Analysis, Display in Chatbot.
- Sub-processes are Geocoding, Print Map, Geoprocessing MCDM, Walking Time Analysis and Search Nearby.
- Sub-process related data are Map layout and Pre-processed raster dataset.
- User decisions are all diamond formed shapes.
- User parameters are the address to be analysed, parameters in time and distance.
- Results are text and maps.

Detailed Data flow

In this chapter a deep dive into the data flows are provided. Five data flows are examined in detail. The diagrams show when where which data is passed or passed on. The data flows are illustrated from user input and within Site Selector Chatbot including chatbot, GIS system and 3rd party Web Services.

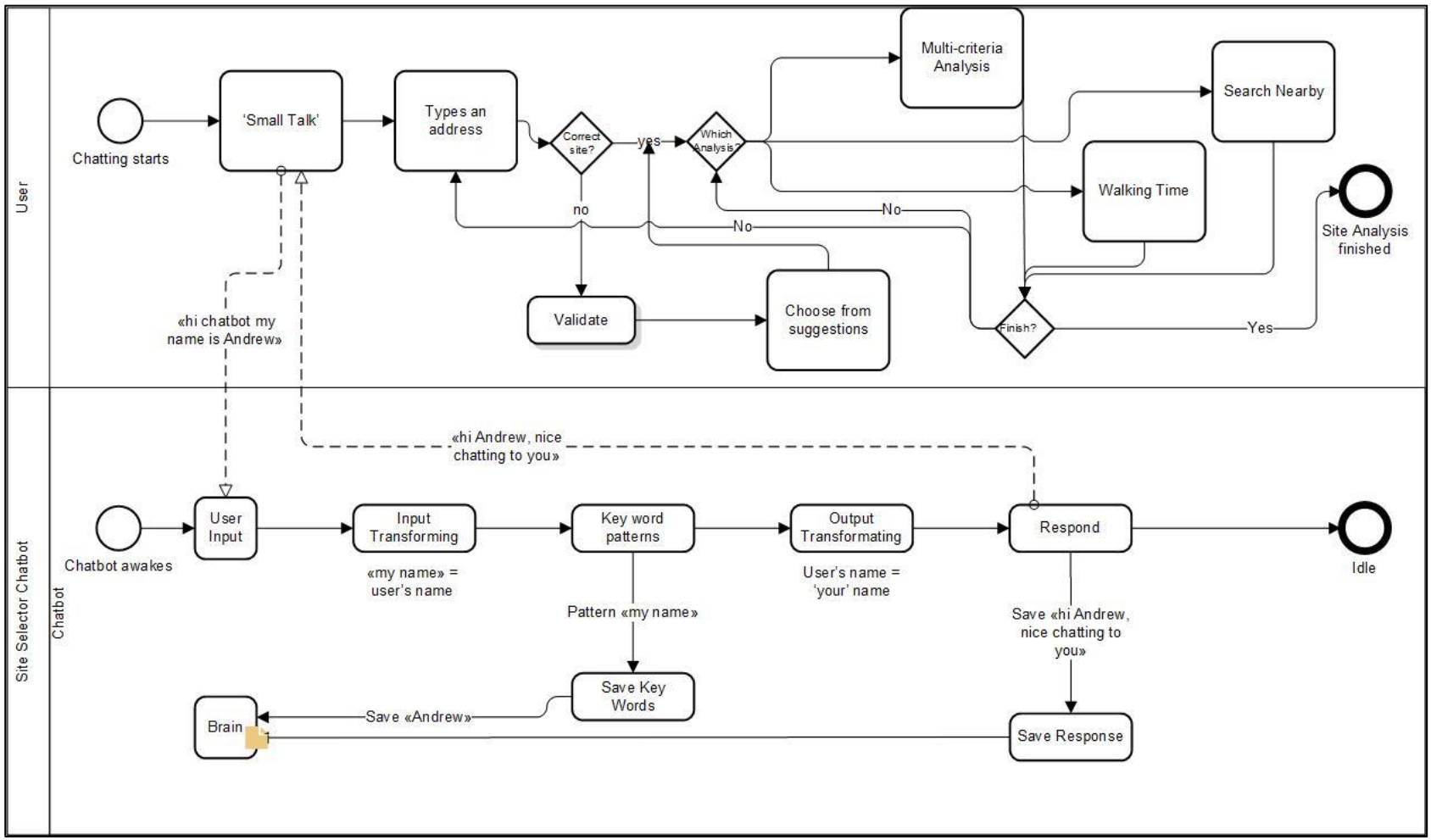


FIGURE 10: 'SMALL TALK' DATA FLOW DIAGRAM

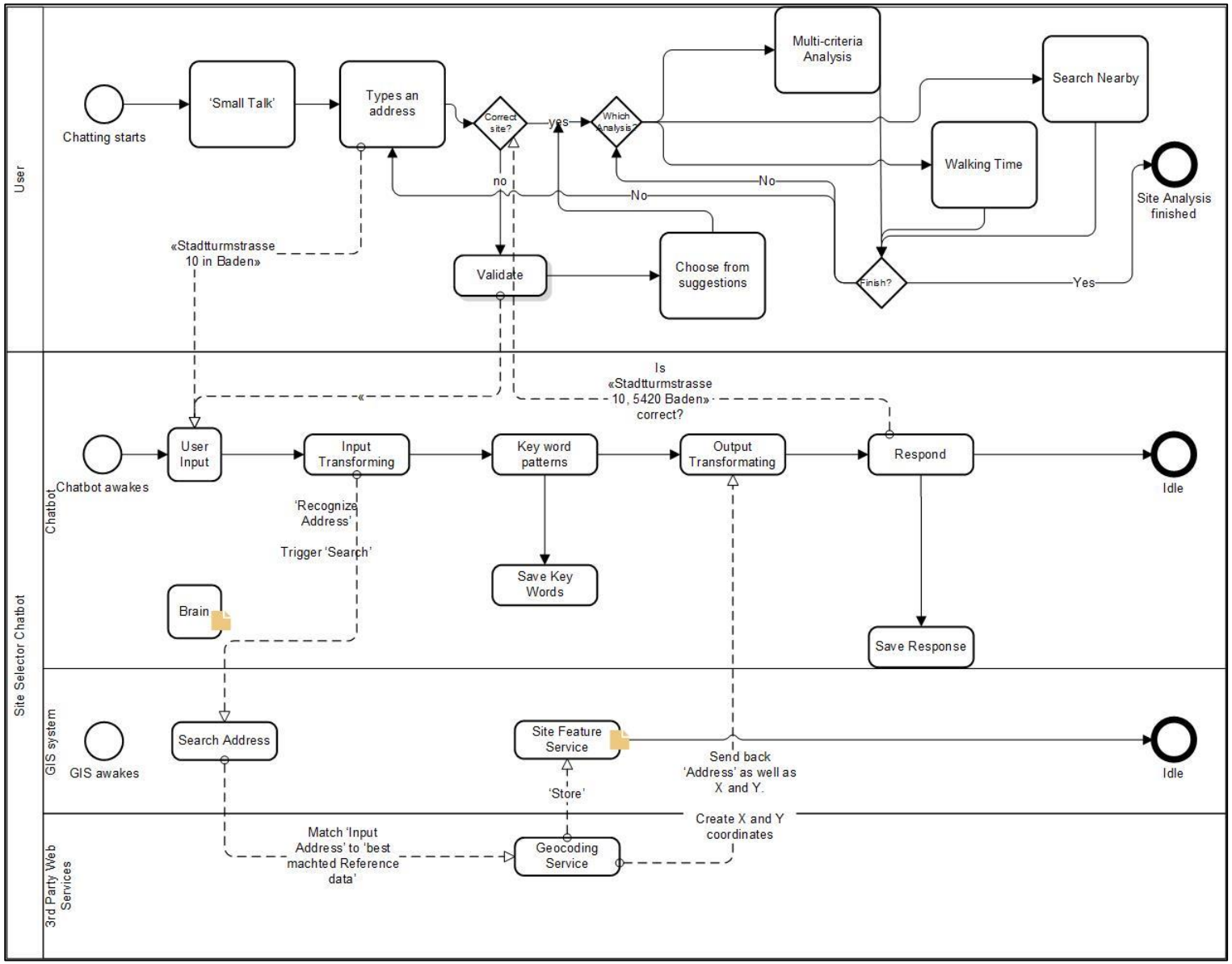


FIGURE 11: 'SEARCH' DATA FLOW DIAGRAM

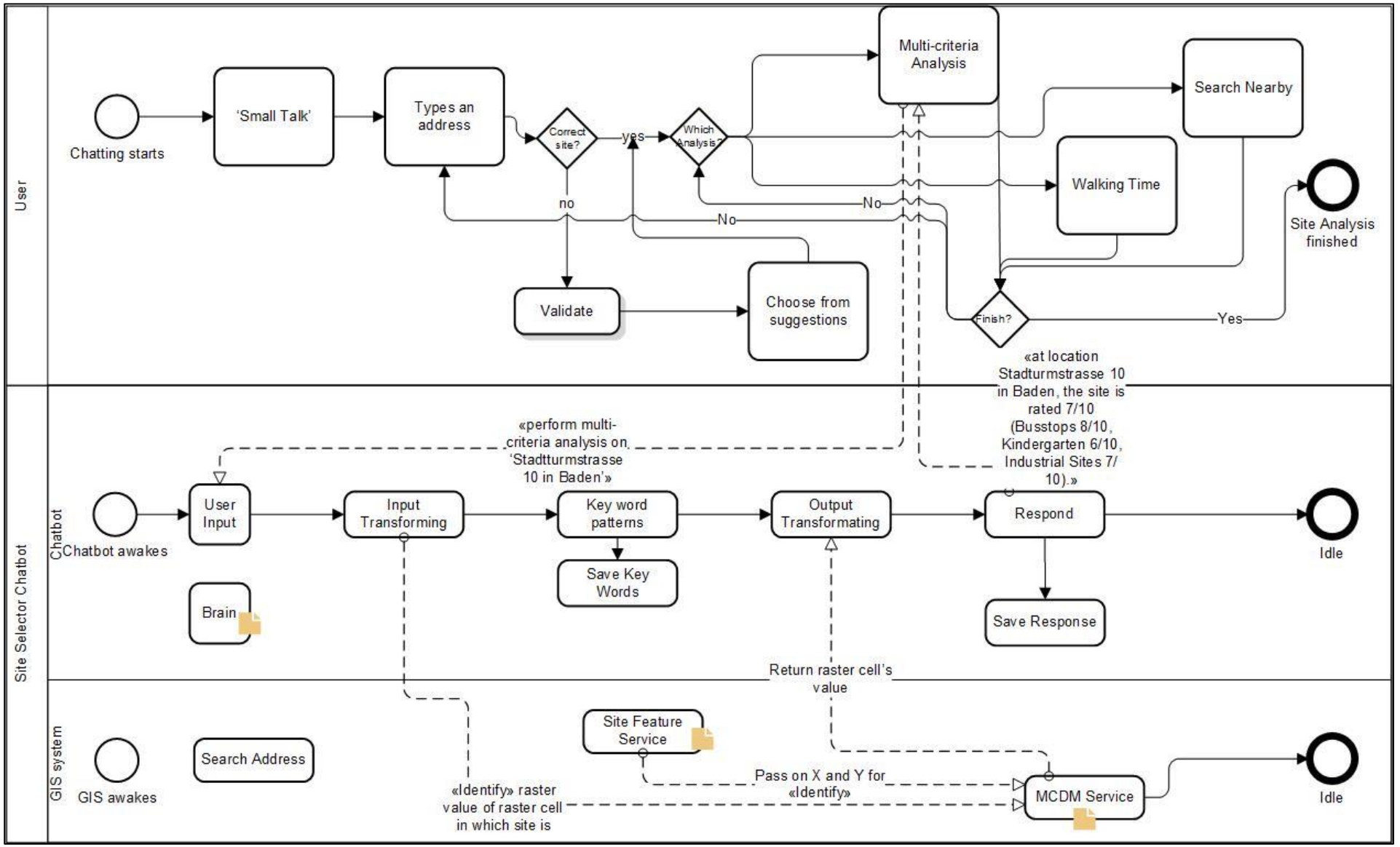


FIGURE 12: 'MULTI-CRITERIA' DATA FLOW DIAGRAM

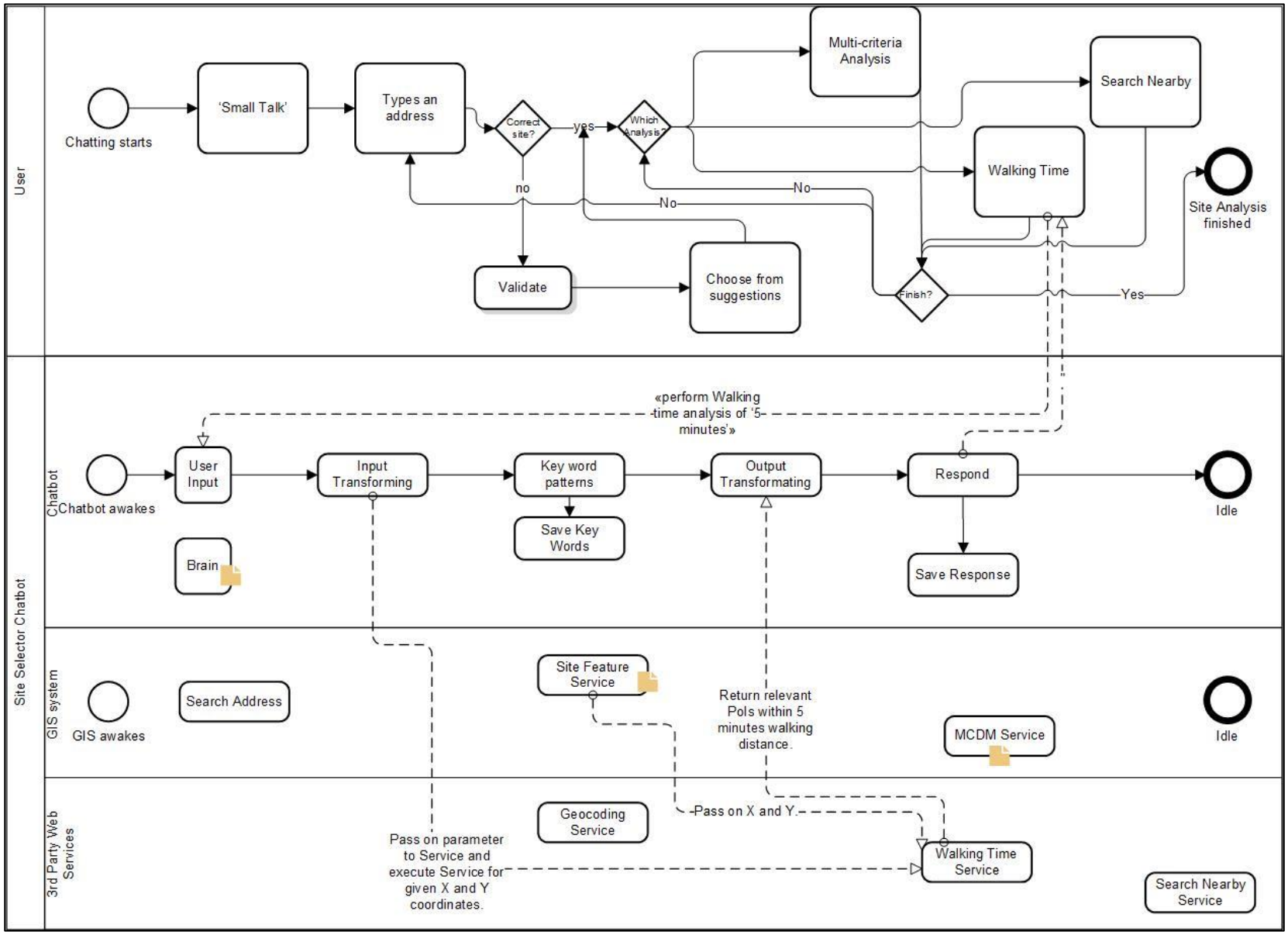


FIGURE 13: 'WALKING TIME' DATA FLOW DIAGRAM

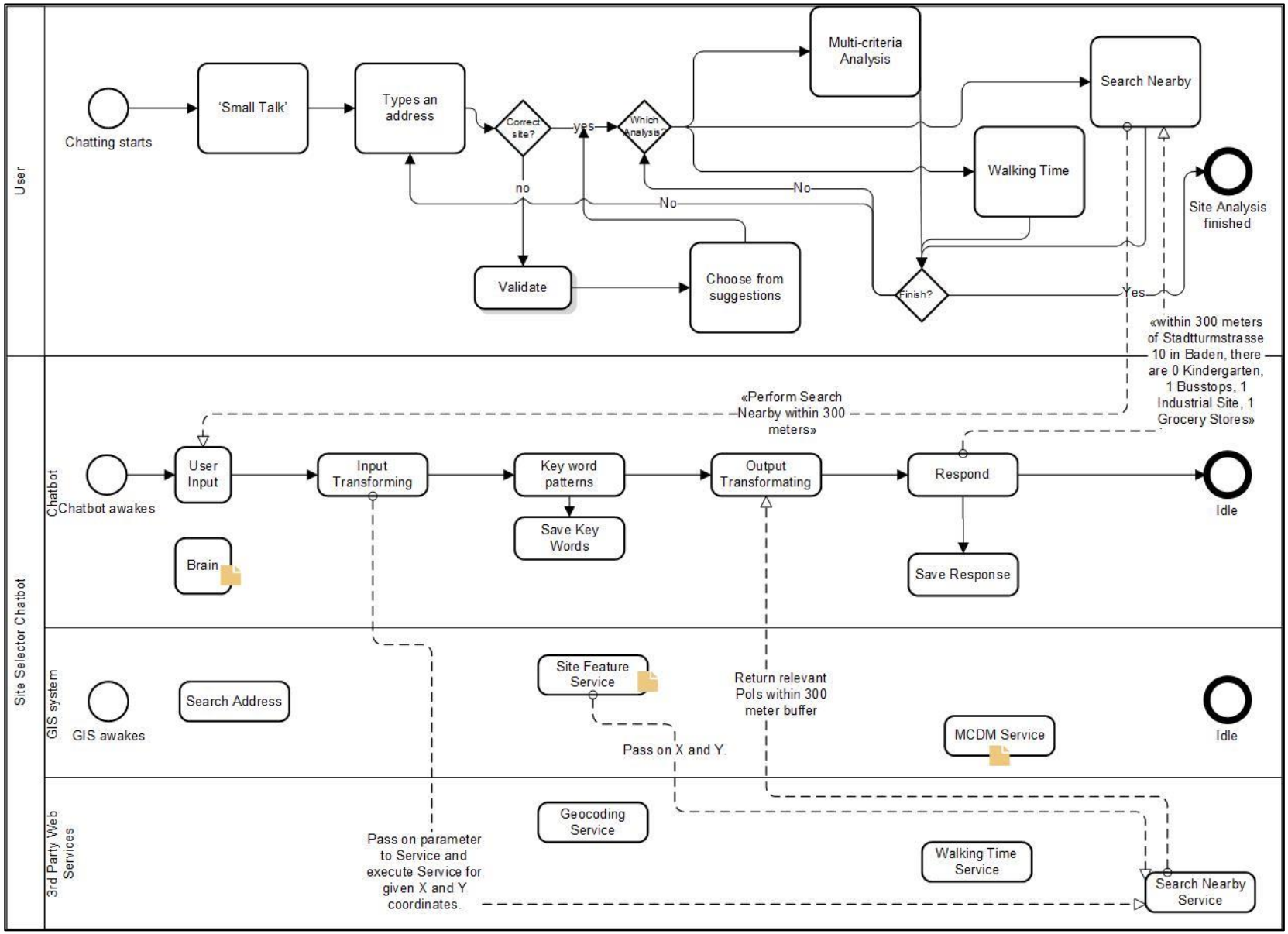


FIGURE 14: 'SEARCH NEARBY' DATA FLOW DIAGRAM

Data Selection

For the five mentioned data flow diagrams in the chapter above Detailed Data flow, some data should be gathered beforehand.

TABLE 8: DATA FLOW AND DATA SELECTION

Data flow	**Data selection**
'Small talk'	Chatbot: create data, especially key words patterns and response templates.
'Search'	Chatbot: create data, especially key words patterns and response templates related to 'Address Search'.
'Multi-criteria'	GIS System: create MCDM raster based on POIs Bus stops and Kindergarten, and based on areas such as Industrial Sites. All these datasets will be downloaded from OpenStreetMap.
'Walking time'	Whenever Google Places API is implemented, then no additional layers of relevant POIs nor areas need to be stored in GIS system. Whenever ArcGIS Online is implemented, then additional layers of relevant POIs and areas need to be stored. In the latter case again OSM data would be chosen as data source.
'Search Nearby'	Whenever Google Places API is implemented, then no additional layers of relevant POIs nor areas need to be stored in GIS system. Whenever ArcGIS Online is implemented, then additional layers of relevant POIs and areas need to be stored. In the latter case again OSM data would be chosen as data source.

Data Models

The data modelling is an essential part with the multi criteria analysis, which has in my case three criteria: Bus Stops and Railways, Schools and Kindergarten, and Commercial and Industrial Sites.

Those datasets can also be used to perform Walking Time and Search Nearby analysis. Again, the datasets will be published as Feature Services so that the Chatbot can interact with them.

TABLE 9: MCDM DATA MODELLING

Overview Site Selection Suitability Model		
Bus Stops and Railway Stations, Source: OSM points Layer transport, fclass = bus_stop, bus_station, railway_station (OpenStreetMap 2018)	Schools and Kindergarten, Source OSM polygons Layer public, fclass = school, kindergarten (OpenStreetMap 2018)	Commercial and Industrial Sites, Source: OSM polygons Layer landuse, fclass = industrial, commercial (OpenStreetMap 2018)
gis.osm_transport_free_1.shp	gis.osm_pois_a_free_1.shp	gis.osm_landuse_a_free_1.shp
GIS analysis See Appendix Figure 46 and Figure 48		
• Generation of Service Areas • Polygon to Raster	• Euclidean Distance Calculation	• Euclidean Distance Calculation
Raster Cell Values See Appendix Figure 50		
Bus stops Service Areas are from 0 to 300 meters and 300 to 600 meters classified.	Euclidean Distance Rings are from 0 to 550 meters, 550 to 1129 meters, 1129 to 1736 meters etc.	Euclidean Distance Rings are from 0 to 547 meters, 547 to 1094 meters, 1094 to 1642 meters etc.
Reclassification of Values See Appendix Figure 51		
Values 0 to 300 meters correspond to 2. Values 300 to 600 meters correspond to 1.	Values 0 to 550 meters correspond to 3. Values 550 to 1129 meters correspond to 2.	Values 0 to 200 meters correspond to NoData. Values above 200 meters correspond to 1.

Values above 600 meters correspond to NoData.	Values 1129 to 1736 meters correspond to 1. Values above 1736 meters correspond to NoData.	
Symbology		
Unique Values 1 and 2	Unique Values 1, 2 and 3	Unique Values 1
Suitability Weighting		
Max 2 Min 0	Max 3 Min 0	Max 1 Min 0
Associated Suitability Values See Appendix Figure 52 [ArcGIS Toolbox Raster Calculation]		
6 = Very suitable (2 + 3 + 1) 5 = Suitable 4 = Moderately suitable 3 - 1 = Low Suitability 0 = Not suitable		
Credits		
OpenStreetMap and Contributors and Geofabrik GmbH (Geofabrik 2017).		

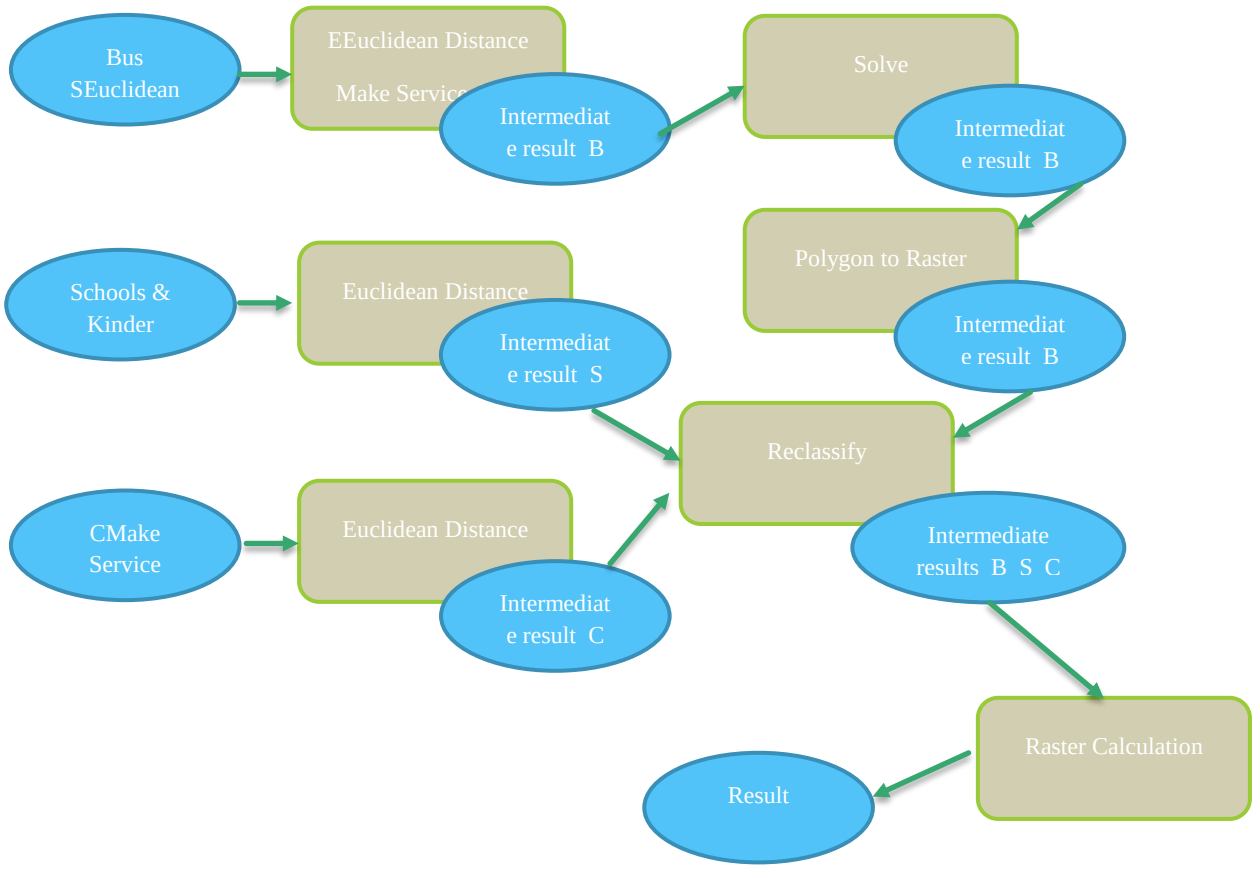


FIGURE 15: PROCESS CHART MULTI CRITERIA RASTER

Since ArcGIS Online cannot hold any raster, the three raster mentioned in the above Table 9: MCDM Data Modelling are converted into polygons using the ArcGIS Toolbox Raster to Polygon.

The Polygons are then published as Feature Services to ArcGIS Online, see Appendix Figure 54.

The final Feature Services can be found in the section Results under By-products of the at page 79.

Systems Architecture and Components

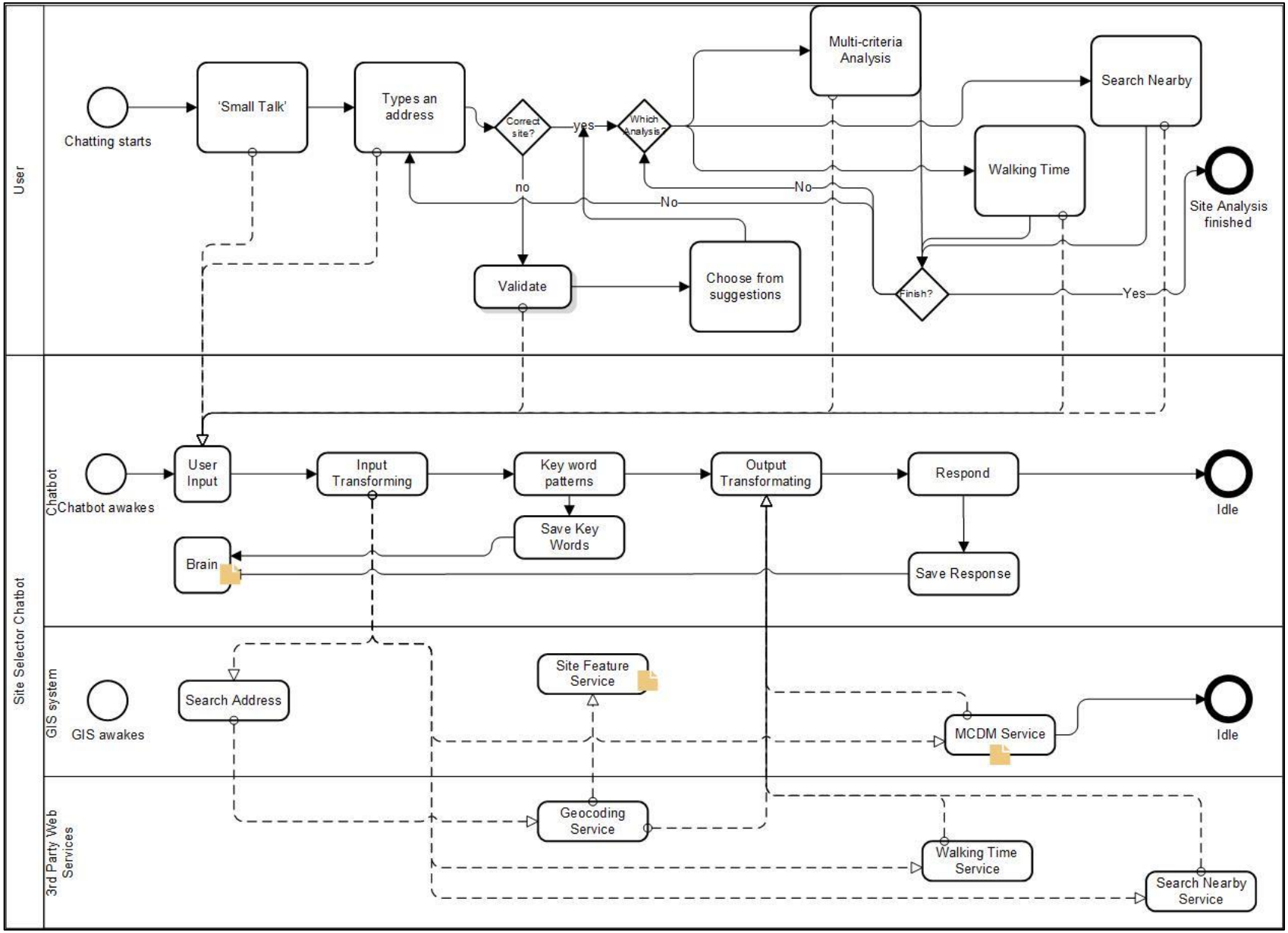


FIGURE 16: SYSTEMS ARCHITECTURE AND COMPONENTS

The systems architecture and its components is separated into three tiers. The 3rd Party Web Services, the GIS system and the chatbot. These three components are forming the Site Selection chatbot. This chatbot is in interaction with the user. The upper part of the figure is identical to the Figure 8.

The chatbot tier has the following components:

- Chatbot brain
- User input unit
- Input transforming unit
- Key word pattern
    - Possibility to save user's key words
- Output transforming unit
- Respond unit
    - Possibility to save chatbot's responses
- Storage of validated address

The GIS system tier comprises of the following components:

- Search address function
- Address validation function
- the MCDM component based on pre-processed analysis
    - The Multi Criteria layer[17] is create in advanced and is not dependent on a 3rd Party Web Service.

The 3rd Party Web Services are the following:

- A Geocoding Web Service (and a Search Web Service)
    - The 3rd Party Web Service in place is ArcGIS Online Search API[18].
    - This service does not require any credits and is therefore suitable for a public facing application.
- A Search Nearby Web Service
    - This is not based on a 3rd Party Web Service. Nevertheless, for systems architectural reasons I separated it from the GIS system.
- A Walking Time Web Service
    - This is service is based on the Network Area Service[19]. This is a token secured 3rd Party Web service[20] and allows developer applications to perform a certain number of requests per day.

---

[17] https://services.arcgis.com/OLiydejKCZTGhvWg/ArcGIS/rest/services/MultiCriteria_Services/FeatureServer/4

[18] https://developers.arcgis.com/rest/geocode/api-reference/overview-world-geocoding-service.htm

[19] https://developers.arcgis.com/rest/geoenrichment/api-reference/network-service-areas.htm

[20] //route.arcgis.com/arcgis/rest/services/World/ServiceAreas/NAServer/ServiceArea_Europe (token secured)

GIS Functionalities of the Chatbot

In this section I want to elaborate on how the chatbot works.

Search Address function

The chatbot asks the user for an address. Afterwards the chatbot checks the address and asks the user whether this is the address he or she is searching for. The chatbot then saves the address as variable in RiveScript.

The chatbot calls the JavaScript function 'startAddressSelection' to proceed with address search. Technically the chatbot sends the verified address or place to the ArcGIS Online Search API. See page 49 for the 3rd Party Web Service URL.

JavaScript subroutine 'Search' executes an HTTP-GET request to the ArcGIS Online Search API (REST API) with the parameter address and receives a geocoded and geosearched with a reference address including X and Y coordinates (JSON Data) back.

Please see below a possible HTTP-GET Request:

https://geocode.arcgis.com/arcgis/rest/services/World/GeocodeServer/findAddressCandidates?singleLine=lindenhofstrasse%2019search%20martinsbergstrasse%201%2C%20baden&f=json&outSR=%7B%22wkid%22%3A102100%7D&countryCode=CHE

Please see below the answer in form of a JSON data file:


```
{"spatialReference":{"wkid":102100,"latestWkid":3857},"candidates":[{"address":"Martinsbergstrasse 1, 5400, Baden, Aargau","location":
{"x":924406.93721469957,"y":6019889.0527105266},"score":95.040000000000006,"attributes":{},"extent":
{"xmin":924286.56695273286,"ymin":6019709.0237382539,"xmax":924509.20593431918,"ymax":6020038.4112544265}}]}
```


Whenever the service is not able to geocode the address, the chatbot is triggered to notify the user that the address is not valid.

Whenever the found address is fine for the user, the chatbot asks the user which analysis he or she would like to perform.

Multi Criteria Analysis subroutine

The Multi Criteria analysis layer is a feature layer holding polygons. With the X and Y coordinates the intersect function of the REST Endpoint is executed to retrieve the feature at this position.

Please see below a possible HTTP-GET Request:

https://services.arcgis.com/OLiydejKCZTGhvWg/arcgis/rest/services/MultiCriteria_Services/FeatureServer/4/query/query?f=json&where=1%3D1&returnGeometry=true&spatialRel=esri

SpatialRelIntersects&geometry=%7B%22x%22%3A924406.9372146996%2C%22y%22%3A6019889.052710527%2C%22spatialReference%22%3A%7B%22wkid%22%3A102100%2C%22latestWkid%22%3A3857%7D%7D&geometryType=esriGeometryPoint&inSR=102100&outFields=*&outSR=102100

Please see below the answer in form of a JSON data file:


```
{"objectIdFieldName":"OBJECTID","globalIdFieldName":"","geometryProperties":
{"shapeAreaFieldName":"Shape__Area","shapeLengthFieldName":"Shape__Length","units":"esriMeters"},"geometryType":"esriGeometryPolygon","spatialReference":
{"wkid":102100,"latestWkid":3857},"fields":[{"name":"OBJECTID","type":"esriFieldTypeOID","alias":"OBJECTID","sqlType":"sqlTypeOther","domain":null,"defaultValue":null},
{"name":"Id","type":"esriFieldTypeInteger","alias":"Id","sqlType":"sqlTypeOther","domain":null,"defaultValue":null},
{"name":"gridcode","type":"esriFieldTypeInteger","alias":"gridcode","sqlType":"sqlTypeOther","domain":null,"defaultValue":null},
{"name":"MC_Value","type":"esriFieldTypeString","alias":"MC_Value","sqlType":"sqlTypeOther","length":50,"domain":null,"defaultValue":null},
{"name":"Shape__Area","type":"esriFieldTypeDouble","alias":"Shape__Area","sqlType":"sqlTypeDouble","domain":null,"defaultValue":null},
{"name":"Shape__Length","type":"esriFieldTypeDouble","alias":"Shape__Length","sqlType":"sqlTypeDouble","domain":null,"defaultValue":null}],"features":[{"attributes":
{"OBJECTID":165,"Id":165,"gridcode":6,"MC_Value":"Very suitable","Shape__Area":3404804.3984375,"Shape__Length":16990.4745392013},"geometry":{"rings":
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[922544.950229682,6018684.76138438],[922578.231479675,6018691.48013438],[922598.231479678,6018691.48013438],[922598.231479678,6018711.48013438],
[922618.231479675,6018711.48013438],[922636.347324405,6018688.00998057],[922687.543918643,6018813.10031261],[922698.231479678,6018851.48013438],
[922698.231479678,6018871.48013438],[922718.231479675,6018871.48013438],[922718.231479675,6018891.48013438],[922737.497379333,6018913.04263438],
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[923538.231479678,6019231.48013438],[923550.129367858,6019216.6221937],[923635.093662295,6019162.58639658],[923658.231479678,6019191.48013438],
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[923738.231479675,6019211.48013438],[923758.231479678,6019211.48013438],[923773.814060241,6019188.91116465],[923903.665439636,6019274.720796],
[923918.231479675,6019331.48013438],[923918.231479675,6019351.48013438],[923938.231479678,6019351.48013438],[923955.656406436,6019328.90506114],
[924014.150669131,6019283.75506724],[924131.589023624,6019251.05258311],[924197.57931903,6019336.54620494],[924110.394260436,6019403.84173716],
[924085.785495792,6019520.45962657],[923946.706211124,6019540.19259776],[923800.791294128,6019497.64788951],[923818.231479675,6019391.48013438],
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[923478.231479678,6019471.48013438],[923478.231479678,6019491.48013438],[923478.231479678,6019511.48013438],[923458.231479675,6019511.48013438],
[923446.631748233,6019528.28067148],[923378.231479675,6019511.48013438],[923358.231479675,6019511.48013438],[923384.193088561,6019539.49984873],
[923454.712802917,6019585.03802623],[923594.145786315,6019629.18261851],[923509.595310245,6019822.93002451],[923498.231479675,6020071.48013438],
[923518.231479682,6020071.48013438],[923526.943943053,6020060.19259777],[923702.390720401,6019989.52792491],[923849.045993835,6020047.18127574],
[923952.145969421,6019984.9905714],[923945.422031436,6020030.49258555],[923918.231479675,6020051.48013438],[923931.512729675,6020078.19888438],
[923938.231479678,6020131.48013438],[923953.143894229,6020136.56756725],[923963.319065124,6020186.39270152],[923993.143894229,6020216.56756724],
[923998.231479678,6020251.48013438],[924098.246128116,6020239.44140757],[924191.824924503,6020267.61584605],[924426.235019717,6020413.92520273],
[924696.082126651,6020494.75024547],[924768.975193057,6020462.22384776],[924778.231479678,6020451.48013438],[924698.065158874,6020427.95512523],
[924665.500766784,6020400.90518321],[924645.415927917,6020203.85623301],[924719.985019714,6020073.65863169],[924760.16904071,6019936.7230543],
[924867.306491885,6019982.40512217],[924898.231479675,6019991.48013438],[924875.253574405,6019807.76950205],[924798.231479675,6019711.48013439],
[924774.273349792,6019792.09963853],[924788.186313659,6019665.84887827],[924798.231479675,6019691.48013438],[924837.5872536,6019791.57992686]
```


In JavaScript the chatbot answer is prepared with the resulting data (attribute of feature) and then showed to the user (postBotReply).

Search Nearby Analysis subroutine

The chatbot asks the user whether he or she would like to perform another analysis. If ever the user is answering with yes and the user would like to execute the Search Nearby analysis, the chatbot asks the user for the distance in meters (buffer).

With the address and the buffer, a parameterized call to the REST endpoints is made, retrieving all the features (Bus Stops[21], Kindergarten & Schools[22], Industrial & Commercial Sites[23]). See page 49 for the 3rd Party Web Service URL. Again, all the features are printed in text form and in a small map.

21 https://services.arcgis.com/OLiydejKCZTGhvWg/ArcGIS/rest/services/MultiCriteria_Services/FeatureServer/0

22 https://services.arcgis.com/OLiydejKCZTGhvWg/ArcGIS/rest/services/MultiCriteria_Services/FeatureServer/5

23 https://services.arcgis.com/OLiydejKCZTGhvWg/ArcGIS/rest/services/MultiCriteria_Services/FeatureServer/6

Please see below a possible HTTP-GET Request:

https://services.arcgis.com/OLiydejKCZTGhvWg/arcgis/rest/services/MultiCriteria_Services/FeatureServer/0/query/query?f=json&where=1%3D1&returnGeometry=true&spatialRel=esriSpatialRelIntersects&geometry=%7B%22x%22%3A924273.2981210263%2C%22y%22%3A6019986.746775726%2C%22spatialReference%22%3A%7B%22wkid%22%3A102100%2C%22latestWkid%22%3A3857%7D%7D&geometryType=esriGeometryPoint&inSR=102100&outFields=*&outSR=102100&distance=500&units=esriSRUnit_Meter

Please see below the answer in form of a JSON data file:


```
{"objectIdFieldName":"OBJECTID_1","globalIdFieldName":"","geometryType":"esriGeometryPoint","spatialReference":{"wkid":102100,"latestWkid":3857},"fields":
[{"name":"OBJECTID_1","type":"esriFieldTypeOID","alias":"OBJECTID_1","sqlType":"sqlTypeOther","domain":null,"defaultValue":null},
{"name":"OBJECTID","type":"esriFieldTypeInteger","alias":"OBJECTID","sqlType":"sqlTypeOther","domain":null,"defaultValue":null},
{"name":"osm_id","type":"esriFieldTypeString","alias":"osm_id","sqlType":"sqlTypeOther","length":10,"domain":null,"defaultValue":null},
{"name":"code","type":"esriFieldTypeInteger","alias":"code","sqlType":"sqlTypeOther","domain":null,"defaultValue":null},
{"name":"fclass","type":"esriFieldTypeString","alias":"fclass","sqlType":"sqlTypeOther","length":20,"domain":null,"defaultValue":null},
{"name":"name","type":"esriFieldTypeString","alias":"name","sqlType":"sqlTypeOther","length":100,"domain":null,"defaultValue":null}],"features":[{"attributes":
{"OBJECTID_1":67,"OBJECTID":17429,"osm_id":"984033903","code":5621,"fclass":"bus_stop","name":"Baden, St. Ursus"},"geometry":{"x":924262.65549999848,"y":6019839.0974000022}},
{"attributes":{"OBJECTID_1":58,"OBJECTID":17360,"osm_id":"984033467","code":5621,"fclass":"bus_stop","name":"Baden, Gartenstrasse"},"geometry":
{"x":924495.25759999827,"y":6020086.9146}},{"attributes":{"OBJECTID_1":14,"OBJECTID":3698,"osm_id":"388204816","code":5621,"fclass":"bus_stop","name":"Rütistrasse"},"geometry":
{"x":924488.97920000181,"y":6019835.3752999976}},{"attributes":
{"OBJECTID_1":16,"OBJECTID":3700,"osm_id":"388204818","code":5621,"fclass":"bus_stop","name":"Lindeli"},"geometry":{"x":924271.26049999893,"y":6019706.059299998}},
{"attributes":{"OBJECTID_1":15,"OBJECTID":3699,"osm_id":"388204817","code":5621,"fclass":"bus_stop","name":"Lindeli"},"geometry":
{"x":924298.31120000035,"y":6019691.7312000021}},{"attributes":
{"OBJECTID_1":13,"OBJECTID":3697,"osm_id":"388204815","code":5621,"fclass":"bus_stop","name":"Rütistrasse"},"geometry":{"x":924536.16750000045,"y":6019822.0022}},{"attributes":
{"OBJECTID_1":31,"OBJECTID":5599,"osm_id":"551234789","code":5621,"fclass":"bus_stop","name":"Belvédère"},"geometry":{"x":923963.64020000026,"y":6019770.0912000015}},
{"attributes":{"OBJECTID_1":30,"OBJECTID":5598,"osm_id":"551234788","code":5621,"fclass":"bus_stop","name":"Belvédère"},"geometry":
{"x":923944.87180000171,"y":6019781.1585000008}},{"attributes":{"OBJECTID_1":53,"OBJECTID":16997,"osm_id":"984028248","code":5621,"fclass":"bus_stop","name":"Baden,
Stein"},"geometry":{"x":924678.73440000042,"y":6019762.6307}},{"attributes":{"OBJECTID_1":35,"OBJECTID":6505,"osm_id":"642136477","code":5621,"fclass":"bus_stop","name":"Baden,
Bahnhof West"},"geometry":{"x":924722.21579999849,"y":6020181.2045999989}},{"attributes":
{"OBJECTID_1":1,"OBJECTID":457,"osm_id":"206245065","code":5622,"fclass":"bus_station","name":"Baden Bahnhof West"},"geometry":{"x":924722.49410000071,"y":6020204.7731999978}},
{"attributes":{"OBJECTID_1":11,"OBJECTID":3695,"osm_id":"388204702","code":5621,"fclass":"bus_stop","name":"Schlossbergplatz"},"geometry":
{"x":924750.40190000087,"y":6019781.8667000011}},{"attributes":{"OBJECTID_1":79,"OBJECTID":30786,"osm_id":"4078322199","code":5641,"fclass":"taxi","name":" "},"geometry":
{"x":924790.87759999931,"y":6020079.8655999973}},{"attributes":{"OBJECTID_1":69,"OBJECTID":17468,"osm_id":"984034225","code":5621,"fclass":"bus_stop","name":"Baden,
Bahnhof"},"geometry":{"x":924792.23570000008,"y":6020086.6675999984}},{"attributes":
{"OBJECTID_1":74,"OBJECTID":24993,"osm_id":"1857809590","code":5621,"fclass":"bus_stop","name":"Baden, Bruggerstrasse"},"geometry":
{"x":924315.74379999936,"y":6020541.9042999968}},{"attributes":{"OBJECTID_1":36,"OBJECTID":6506,"osm_id":"642136482","code":5621,"fclass":"bus_stop","name":"Baden,
Trafo"},"geometry":{"x":924606.77749999985,"y":6020449.6692000031}},{"attributes":
{"OBJECTID_1":78,"OBJECTID":28191,"osm_id":"3080695733","code":5601,"fclass":"railway_station","name":"Baden"},"geometry":{"x":924817.40509999916,"y":6020185.5856000036}},
{"attributes":{"OBJECTID_1":34,"OBJECTID":6277,"osm_id":"619290524","code":5622,"fclass":"bus_station","name":"Baden Bahnhof Ost"},"geometry":
{"x":924857.51350000128,"y":6020216.0715999976}},{"attributes":{"OBJECTID_1":37,"OBJECTID":6507,"osm_id":"642136485","code":5621,"fclass":"bus_stop","name":"Baden,
Bruggerstrasse"},"geometry":{"x":924281.27930000052,"y":6020643.5288000032}},{"attributes":
{"OBJECTID_1":76,"OBJECTID":26768,"osm_id":"2407985038","code":5621,"fclass":"bus_stop","name":" "},"geometry":{"x":924726.79100000113,"y":6020489.675999999}},{"attributes":
{"OBJECTID_1":12,"OBJECTID":3696,"osm_id":"388204730","code":5621,"fclass":"bus_stop","name":"Weite Gasse"},"geometry":{"x":924756.72480000183,"y":6019451.7808}},{"attributes":
{"OBJECTID_1":75,"OBJECTID":25531,"osm_id":"2076953230","code":5641,"fclass":"taxi","name":" "},"geometry":{"x":924410.95540000126,"y":6019278.2861}},{"attributes":
{"OBJECTID_1":9,"OBJECTID":3693,"osm_id":"388204644","code":5621,"fclass":"bus_stop","name":"Lindenplatz"},"geometry":{"x":924523.83329999819,"y":6019308.7854000032}},
{"attributes":{"OBJECTID_1":33,"OBJECTID":6242,"osm_id":"618966755","code":5622,"fclass":"bus_station","name":"Baden, Postautostation"},"geometry":
{"x":924885.71070000157,"y":6020373.7242000028}}]}
```


Regarding the displayed map, the JS API of Esri renders a map with the retrieved features.

Walking Time Analysis subroutine

The chatbot asks the user whether he or she would like to perform another analysis. If ever the user is answering with yes and would like to execute the Walking Time analysis, the chatbot asks the user for the time in number of minutes.

With the address and the time, a parameterized call to the REST endpoint is made, retrieving a service area (see page 49 for the 3rd Party Web Service URL) in form of a polygon according to the specified time. The polygon is now used to intersect with all the features (Bus Stops, Kindergarten & Schools, Industrial & Commercial Sites). The intersect is again a function of the three REST endpoints (Bus Stops, Kindergarten & Schools, Industrial & Commercial Sites). All the features are printed in text form and in a small map.

Please see below a possible HTTP-GET Request (token secured):

https://utility.arcgis.com/usrsvcs/appservices/XsyXlrdMbYtGTUqC/rest/services/World/ServiceAreas/NAServer/ServiceArea_World/solveServiceArea

Please see below the answer in form of a JSON data file:

{"messages":[],"saPolygons":{"fieldAliases":{"ObjectID":"ObjectID","FacilityID":"FacilityID","Name":"Name","FromBreak":"FromBreak","ToBreak":"ToBreak","Shape_Length":"Shape_Length","Shape_Area":"Shape_Area"},"geometryType":"esriGeometryPolygon","spatialReference":{"wkid":102100,"latestWkid":3857},"features":[{"attributes":{"ObjectID":1,"FacilityID":1,"Name":"Location 1 : 0 - 3","FromBreak":0,"ToBreak":3,"Shape_Length":2586.6121696182336,"Shape_Area":10608.88348489407},"geometry":{"rings":[[[924023.24230000004,6020250.3654000014],[924128.55539999902,6020087.6413000003],[924293.31969999894,6020183.7674999982],[924288.2239000015,6020168.6887999997],[924163.37680000067,6020095.1805000007],[924158.28090000153,6020095.1805000007],[924138.32250000164,6020080.1020999998],[924208.38969999924,6020035.4948000014],[924403.30409999937,6020168.6887999997],[924448.31709999964,6020183.7674999982],[924333.23690000176,6020109.6308000013],[924328.1409999989,6020109.6308000013],[924213.48550000042,6020028.5838000029],[924408.39990000054,6019895.3920999989],[924548.53440000117,6019835.7076999992],[924553.20560000092,6019835.7076999992],[924568.49300000072,6019850.7858000025],[924568.49300000072,6019872.7748999968],[924573.16420000046,6019843.246799998],[924563.39719999954,6019828.7969999984],[924583.35570000112,6019813.7189000025],[924583.35570000112,6019799.2691000029],[924558.30139999837,6019828.7969999984],[924483.13839999959,6019821.2577999979],[924528.15129999816,6019835.7076999992],[924403.30409999937,6019887.8528999984],[924293.31969999894,6019961.9878000021],[924293.31969999894,6019968.8985999972],[924128.55539999902,6020072.5627000034],[924023.24230000004,6020242.8259000033],[924023.24230000004,6020250.3654000014]]]}]}}

During the development of the chatbot I had support from Beda Kuster and Julian Kissling, both are Software Developers. They have guided and helped me with the development of the following components:

- Development of Subroutines with JavaScript
- Development of Asynchronous chatbot behaviour with JavaScript
- General JavaScript guidelines and tutorial

Design and User Guidance

The design of the chatbot is like a messaging application such as Facebook Messenger. It is kept simple and tidy. A short introduction of the chatbot and a chat window is provided at the beginning.

The chatbot is based on HTML5 and JavaScript, called ArcGIS API for JavaScript. Further the chatbot's interface is responsive and therefore adjusts to any screen sizes. The common browsers such as Chrome, FireFox, Edge and IE are supported.

Regarding Standard application integration:

- Exposing functional capabilities through standardized (REST/SOAP) and properly documented web services, those GIS services are accessible over standard HTTP.

Regarding customized Web based Frontend

- The access from customized Web based frontend applications like the chatbot is possible by working directly with the interfaces exposed by the ArcGIS REST API.
- Most of the geo-analytics capabilities of ArcGIS are accessible as web services using REST. The ArcGIS REST API is the open web interface to ArcGIS.

In general, the ArcGIS REST API provides a standard way for web clients to communicate with ArcGIS Online.

Token secured services receive a token that is included with requests for secured content on ArcGIS Online for authenticated resources.

Results

The Results section is divided into three parts:

1. The GeoBot prototype
2. Results of the survey GeoBot prototype
3. By-products of the GeoBot prototype

The results are driven by the aim and objective. My aim is to present a chatbot prototype which

- integrates with a GIS-MCDM in a meaningful way and
- provides multi-criteria analysis information on site selection.

The objective is that the chatbot delivers answers to GIS-related questions.

The developed chatbot has reached this objective. The results are demonstrated in my prototype called GeoBot, which is inspired by Vadym Markov's GeoBot see section 'GeoBots – Fiction or Reality?' on page 25.

Here is the link to GeoBot: http://wvps178-77-65-224.dedicated.hosteurope.de/bot/

The proof of the pudding is in the eating. Therefore, I created a survey to structure the answers of the test users and to analyse those answers. In total eleven non-GIS test users were asked to test the GeoBot and then fill-up the survey.

Here is the link to the survey: https://arcg.is/W9OSC

The survey intention and instructions can be found in appendix Figure 55.

Also, I recorded a test user while testing my GeoBot. Of course, the test user accepted the recording.

Here is the link to the recording: https://youtu.be/cBwvdJYJY2g

The GeoBot prototype

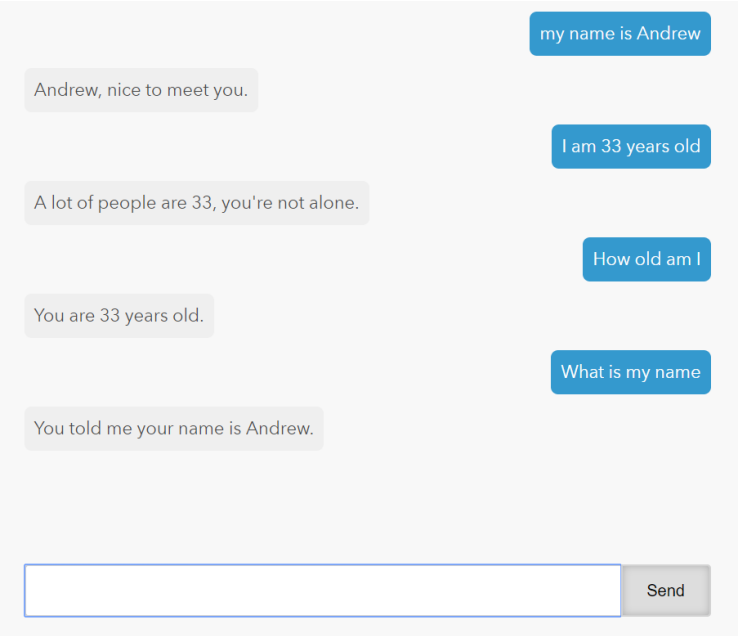


FIGURE 17: SMALL TALK WITH THE GEOBOT

The GeoBot is able to have a small talk with the user. It can remember a user's age, name and even the partner's or spouse's name.

Conversational questions such as 'How are you?', 'What is your name?' and 'What is your purpose?' can be easily answered by the GeoBot. Also, a call for help such as 'Help!' can be catered by it.

Nevertheless, the GeoBot's personality is hardly recognisable. Jemuel, a test user, has stated "*Make it more interactive in such a way it it feels like chatting to a real person or expert.*", see page 78.

Informative questions such as the following ones are no problem for the GeoBot.

- What is a site selection?
- What is GIS?
- What is a Multi Criteria analysis?
- What is a Search Nearby analysis?
- What is a Walking Time analysis?

These answers are all fed directly from the GeoBot's brain. The brain and the Keyword patterns reside in a RiveScript file. The input triggers the key word pattern matching and subsequently defines the output and the GeoBot is ready to respond.

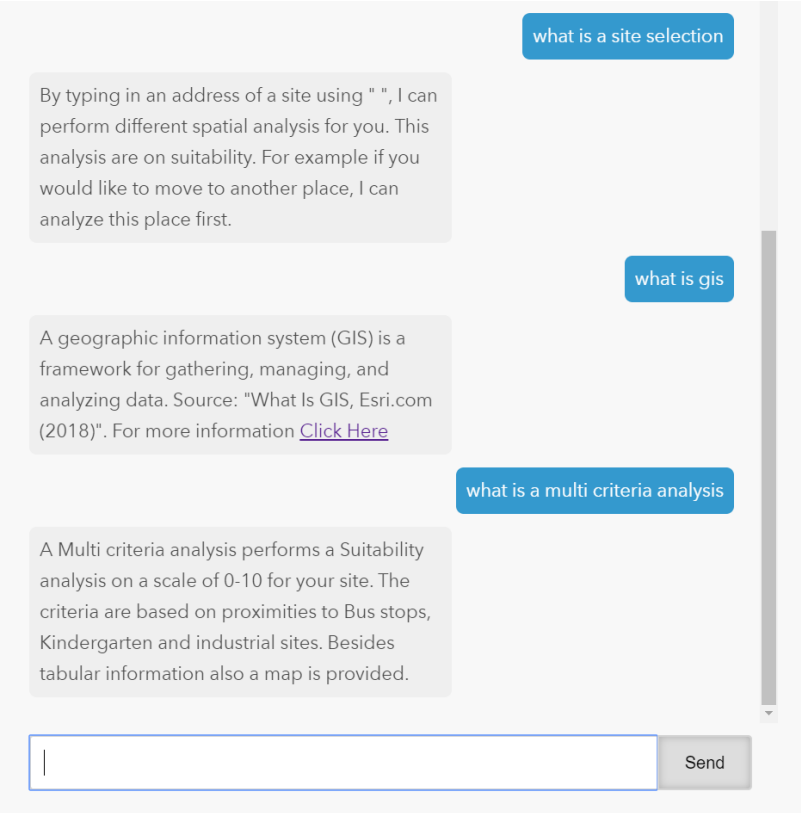


FIGURE 18: ASKING THE GEOBOT FOR INFORMATION

The main purpose of the GeoBot is to perform geographical analysis on specific addresses or spots and places, e. g. Manor in Baden. Whenever a user types in an address, the GeoBot asks the user to verify the address by asking 'Thanks, I found an address, is this the right one? [address search result]'.

In the background the JavaScript calls the ArcGIS Online 'Search'API, which has the capability to search based on the locator service. See also section 'Search Address function' page 51 for technical outline.

The user can then go on and verify the address. After the verification the GeoBot asks the user which analysis it should perform.

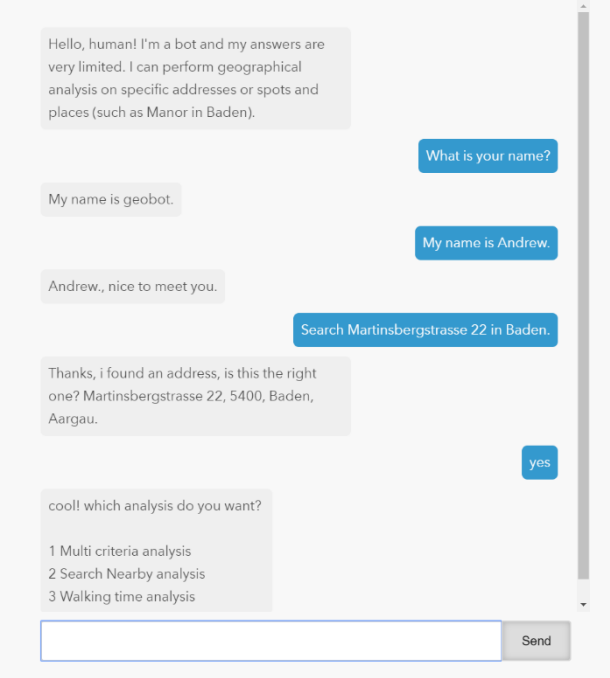


FIGURE 19: SEARCHING FOR 'MARTINSBERGSTRASSE 22 IN BADEN'

The user has then the possibility to choose between the three mentioned analysis options.

In this case the use has asked the GeoBot to perform a Multi Criteria analysis by typing in '1'. For information on the model, please see Table 9: MCDM Data Modelling.

The GeoBot asks the user to hold on for a while.

In this situation asynchronous tasks are performed. The analysis itself is carried out in the JavaScript. This prevents GeoBot's chat window to freeze. Also, the GeoBot remains autonomous of the carried-out performance.

The JavaScript calls the 'query' function of the Multi Criteria Layer[24]. This 'identify' function returns the attribute 'Very suitable'.

See also section 'Multi Criteria Analysis subroutine' on page 51.

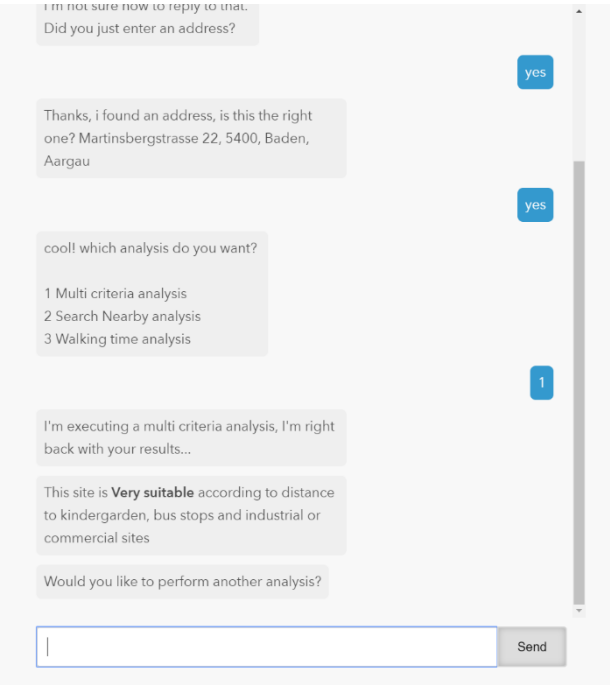


FIGURE 20: MULTI CRITERIA ANALYSIS AT 'MARTINSBERGSTRASSE 22 IN BADEN'

24 https://services.arcgis.com/OLiydejKCZTGhvWg/ArcGIS/rest/services/MultiCriteria_Services/FeatureServer/4

The GeoBot goes on and ask the user whether he or she wants to perform another analysis.

Whenever the user types in ‘yes’, the GeoBot asks the user which of the three analysis he or she wants to carry out.

In this case the user carried out a Search Nearby Analysis. The GeoBot asks ‘Within how many meters should I search?’. The input parameter provided by the user is in this case 455 meters.

The JavaScript calls the intersect function of the REST Endpoint to find features that are within a specified distance of the address provided earlier.

See also section Search Nearby Analysis subroutine on page 52 for technical outline.

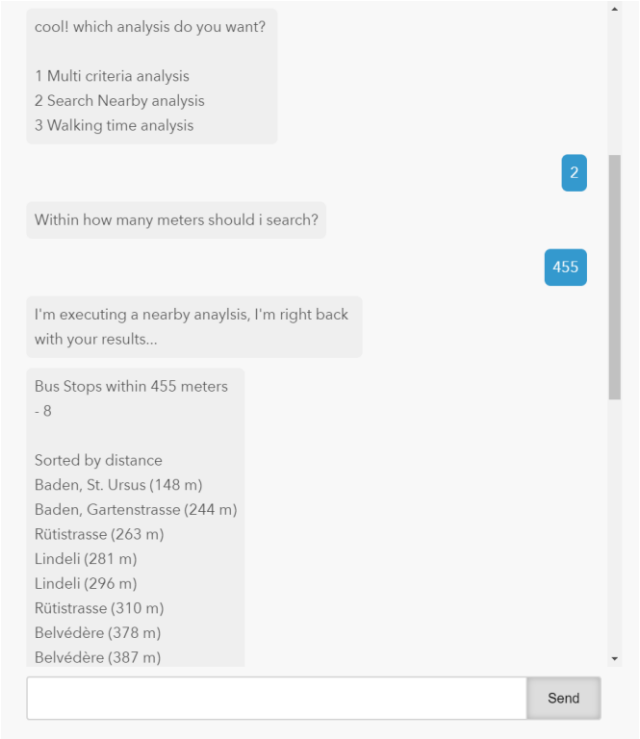


FIGURE 21: PARAMETERIZED CALL FOR NEARBY FEATURES AT MARTINSBERGSTRASSE 22 IN BADEN

This parameterized service call returns

- A list of Bus Stops within 455 meters of Martinsbergstrasse 22 in Baden. In this case 8 Bus Stops in ascending order of distance to the address.
- A list of Schools & Kindergarten within 455 meters. In this case 3 Schools or Kindergarten. Again, ordered in ascending order.
- A list of Commercial & Industrial sites. In this case 0.
- A Map with a red diamond symbolizing Martinsbergstrasse 22, Bus Stops represented as grey circles and the black footprints of Kindergarten & Schools. All found features can be identified.

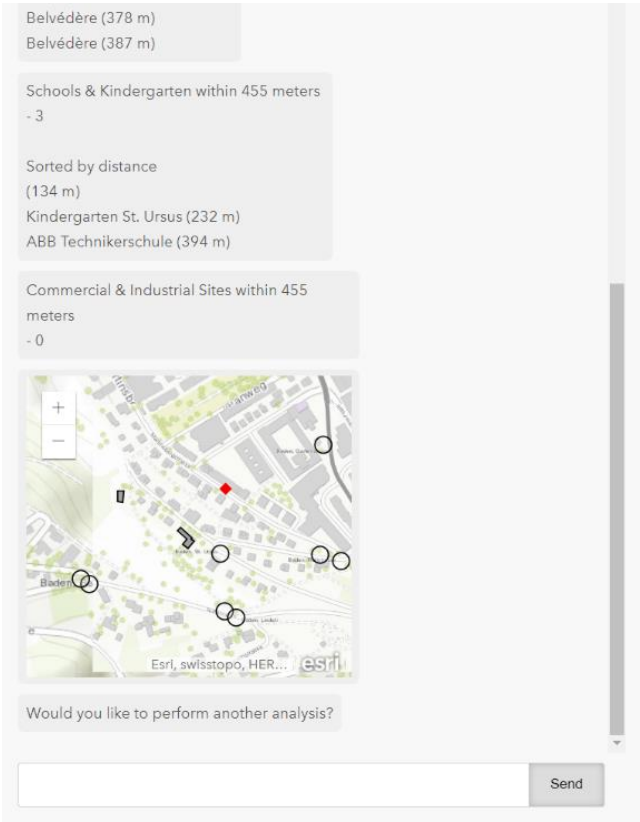


FIGURE 22: RESULTS OF SEARCH NEARBY ANALYSIS AT MARTINSBERGSTRASSE 22 IN BADEN

Again, the user has the possibility to perform the last available analysis.

The Walking Time Analysis is also dependent on the user's parameter. In this case the GeoBot searches within 14 minutes the Bus Stops, Schools & Kindergarten and Industrial & Commercial sites.

A a parameterized call to the REST endpoint is made, retrieving a service area. This REST endpoint can also perform Walking Time Areas.

Within the Walking Time area the mentioned points and areas are queried.

Again, the GeoBot is able to return a list and a map.

Please see section Walking Time Analysis subroutine on page 53 for technical outline.

Please see section 'By-products of the GeoBot' regarding the used Feature Services.

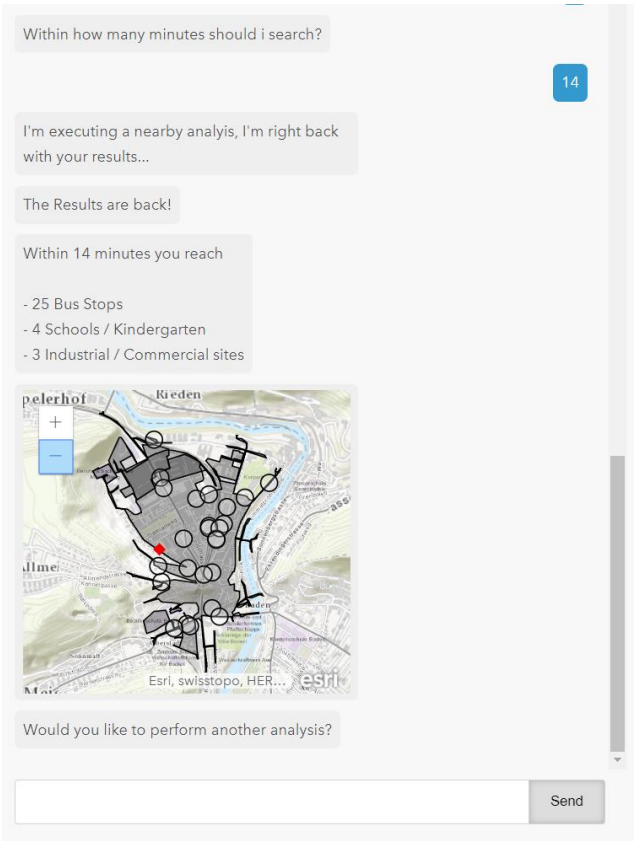


FIGURE 23: WALKING TIME ANALYSIS OF 14 MINUTES AT 'MARTINSBERGSTRASSE 22 IN BADEN'

Results of the survey GeoBot prototype

The survey has the intention to validate the aim and objective, see section Aim & Objectives. So, the questions asked to the test users are related to

- Is the integration of a chatbot and a GIS-MCDM meaningful to the test users?
- Could the chatbot answer geographical-related questions and perform spatial analysis, such as Multi Criteria analysis?

Below you find the survey questions which try to answer those two main questions above. Followed by the survey questions are sometimes information on how to understand the question. The diagrams, bar charts and tables are based on the eleven test-users answers.

Would you recommend this GeoBot for Site Selection?

Imagine you are moving to a new place and you would like to understand how suitable this particular street is.

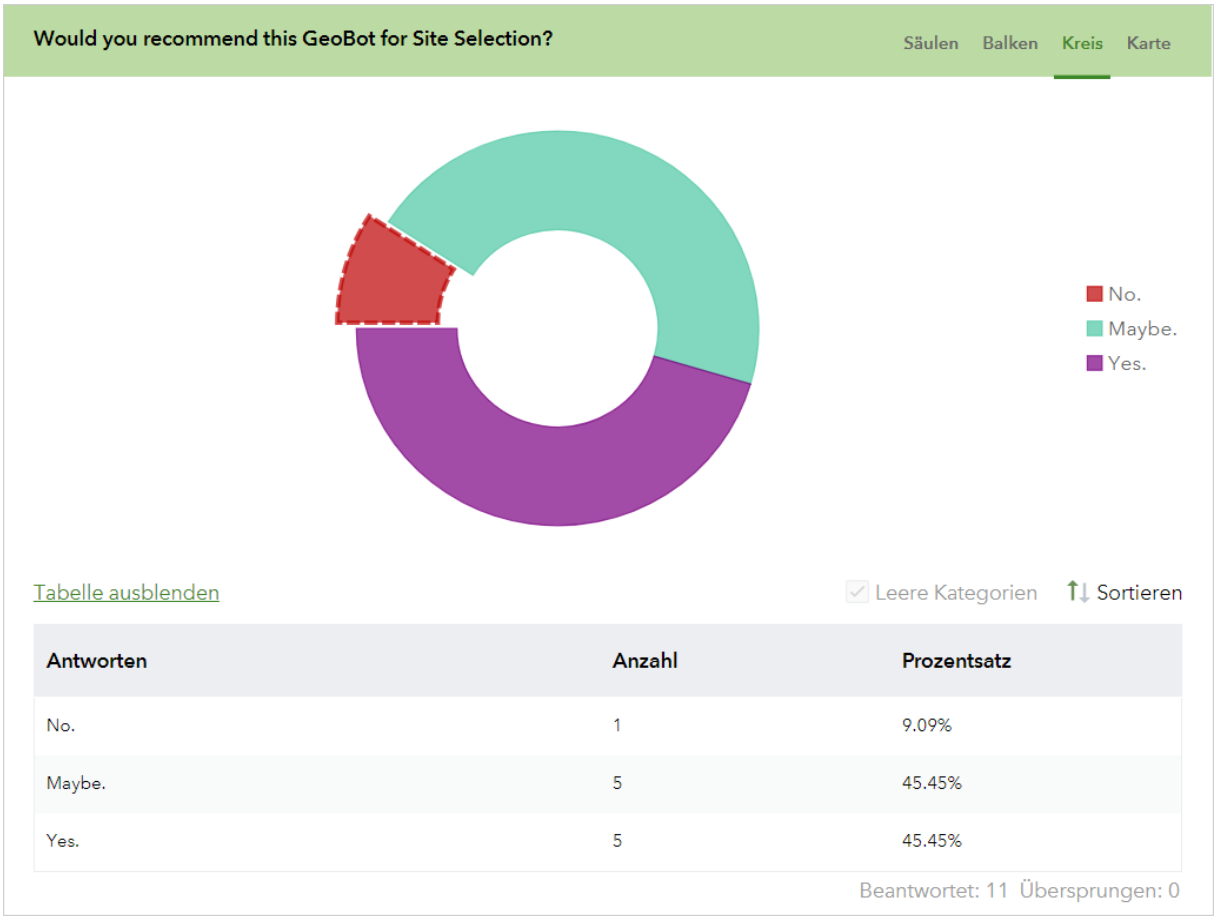


FIGURE 24: CIRCLE DIAGRAM ON RECOMMENDING THE GEOBOT

Almost 50% of the test users would recommend the GeoBot as it is. Five out of eleven are unsure whether to recommend. To bring the GeoBot to production the comments below should be taken into consideration. Especially the compelling advantages over existing Search Engines such as Google / Google Maps should be revised and embedded in a next version of the prototype.

Please specify why are unsure whether to recommend this GeoBot for Site Selection?

- *Because current analysis done can already be available using the web service such as google wherein you dont need to download a new app.*
- *I like the idea of the GeoBot, but the results didn't show up.*
- *i dont really see the advantage of using geobot instead e.g. Google etc.*

Please specify why would recommend this GeoBot for Site Selection?

- *It can be very useful for a young family to get information on a possible new home. Information what is within reach. The map adds additional information to have a geographical view.*
- *Es zeigt mir alles im Umkreis an. (English translation: It shows me everything in a certain radius.)*
- *The walking distance map is good for tourists with limited time in a place.*
- *listing of facilities, no need of searching on maps*
- *Wenn ich mit den ÖV arbeiten gehe, dass ich weiss wo es eine Haltestelle hat. Und welche Läden in der Nähe sind. (English translation: Whenever I go to work with public transportation, it is helpful to know where there are bus stops. And which stores are nearby.)*

Please specify why would not recommend this GeoBot for Site Selection?

- *Other tools such as google maps are much easier to use, hence why should I change?*

Do you find it useful to chat with a GeoBot on Site Selection?

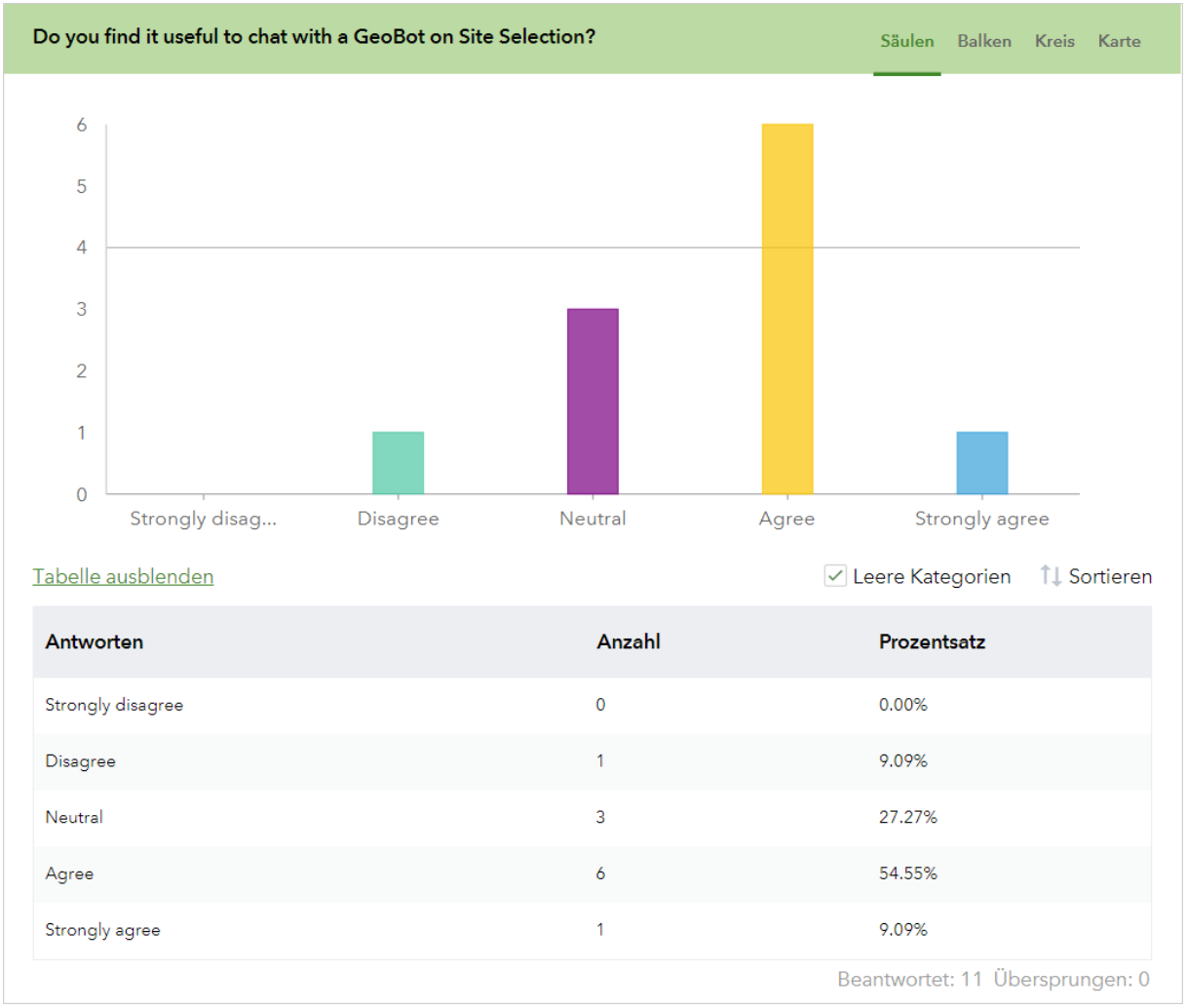


FIGURE 25: BAR CHART ON USEFULNESS OF THE GEOBOT

Almost 64% agree or strongly agree that chatting with a chatbot about Site selection is useful.

Please rate the overall analysis possibilities of the GeoBot

Whenever the GeoBot executed the analysis, the GeoBot should have displayed the results in the conversation.

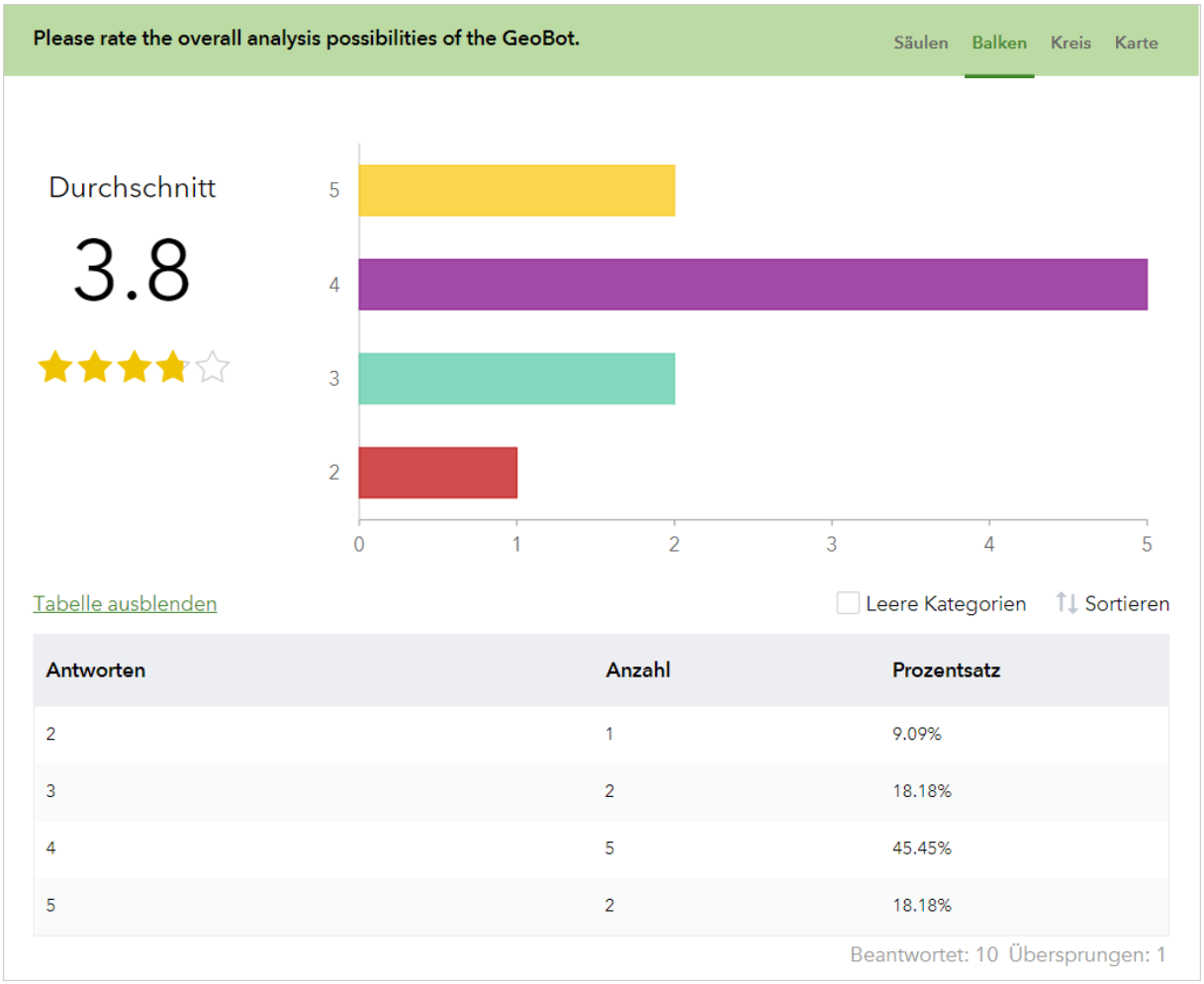


FIGURE 26: BAR CHART ON ANALYSIS POSSIBILITIES OF THE GEOBOT

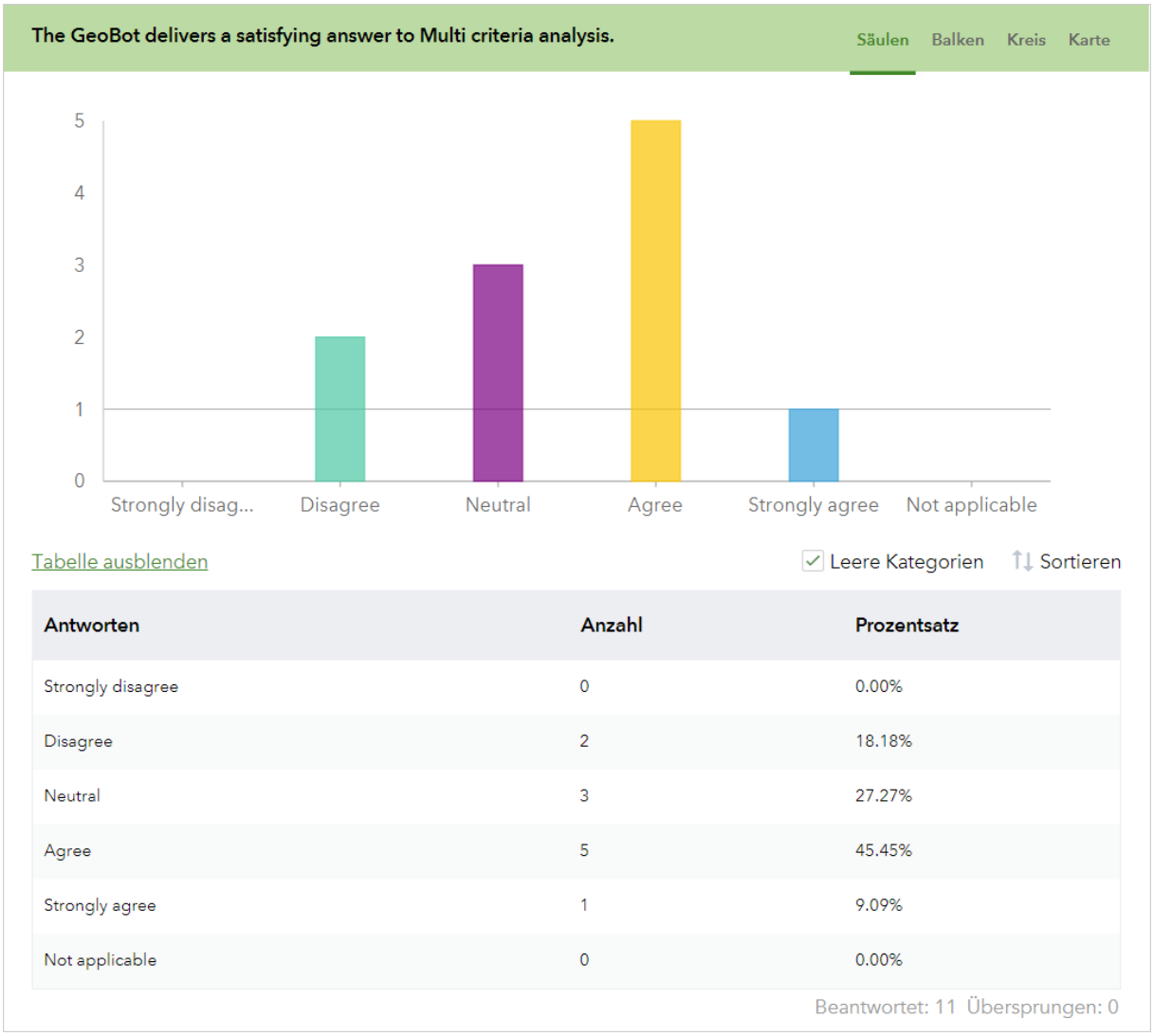
Eleven people rated the existing analysis possibilities of the GeoBot at 3.8 out of 5 possible stars. Seven out of eleven rated it with 4 or more stars.

Add a comment on the analysis possibilities:

- *Address of the found places/sites. The distance from searched place to the found places.*
- *It would be better if it can highlight specific areas of interest such us sports center, available clubs for specific interests, etc..*
- *The results are not that useful*
- *Mehr Informationen für die Umgebung. Karte zu klein! Und nicht farbig! Evtl. Umrisse von Gebäude nicht sichtbar. (English translation: More information about the surrounding, map is too small! And not colourful! Probably footprints of buildings not visible.)*

The GeoBot delivers a satisfying answer to Multi criteria analysis. Agree?

The GeoBot should deliver the correct results for the above analysis.



Antworten	Anzahl	Prozentsatz
Strongly disagree	0	0.00%
Disagree	2	18.18%
Neutral	3	27.27%
Agree	5	45.45%
Strongly agree	1	9.09%
Not applicable	0	0.00%

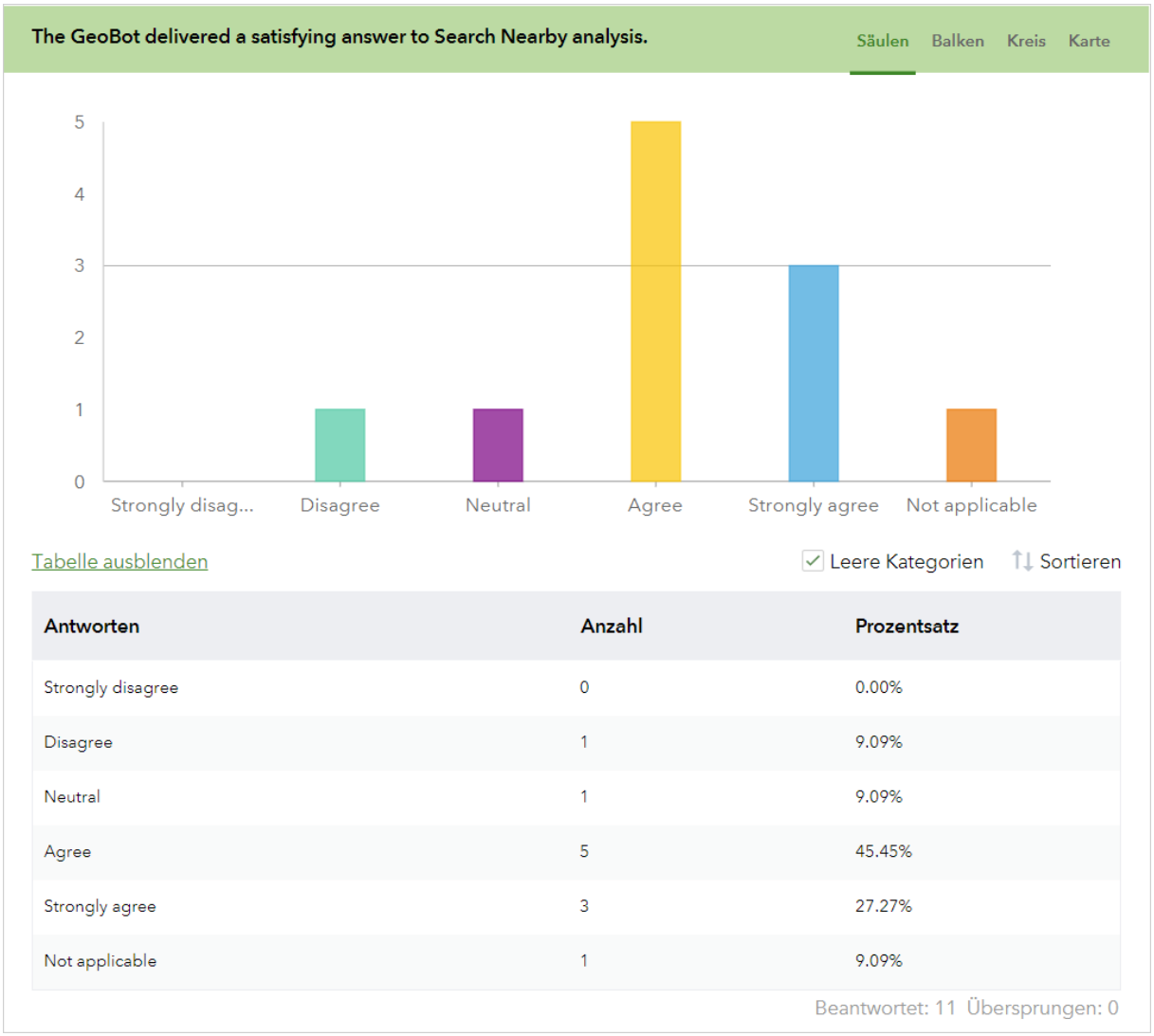
Beantwortet: 11 Übersprungen: 0

FIGURE 27: BAR CHART ON THE ANSWER OF THE MULTI CRITERIA ANALYSIS

Almost 55% agree or strongly agree that the Multi Criteria analysis answers are satisfying. Nevertheless, two people disagree.

The GeoBot delivered a satisfying answer to Search Nearby analysis. Agree?

The GeoBot should deliver the correct results for the above analysis.



Antworten	Anzahl	Prozentsatz
Strongly disagree	0	0.00%
Disagree	1	9.09%
Neutral	1	9.09%
Agree	5	45.45%
Strongly agree	3	27.27%
Not applicable	1	9.09%

Beantwortet: 11 Übersprungen: 0

FIGURE 28: BAR CHART ON THE ANSWER OF THE SEARCH NEARBY ANALYSIS

Almost 73% agree or strongly agree that the Search Nearby analysis answers are satisfying. One person disagrees.

The GeoBot delivered a satisfying answer to Walking time analysis. Agree?

The GeoBot should deliver the correct results for the above analysis.

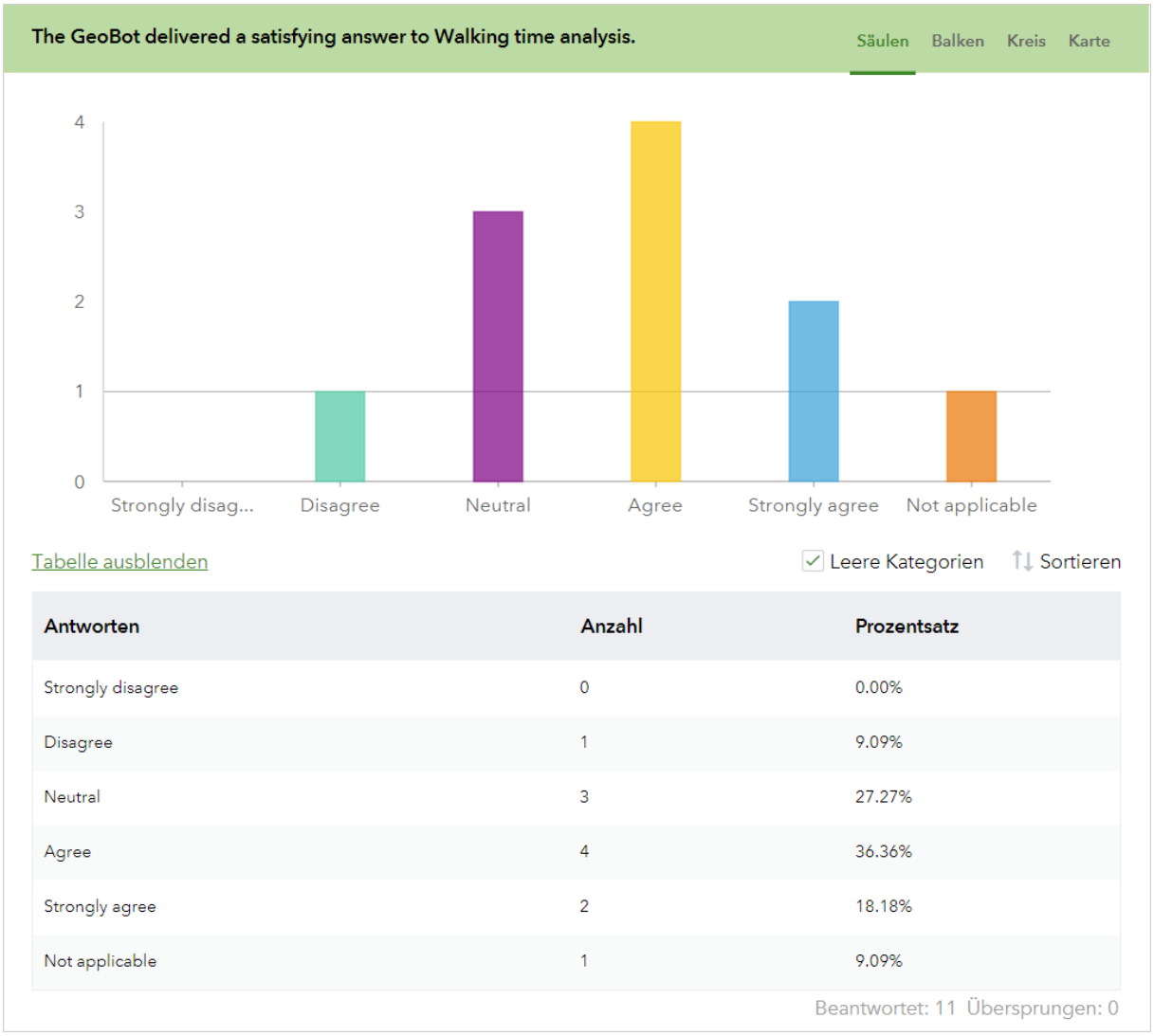


FIGURE 29: BAR CHART ON THE ANSWER OF THE WALKING TIME ANALYSIS

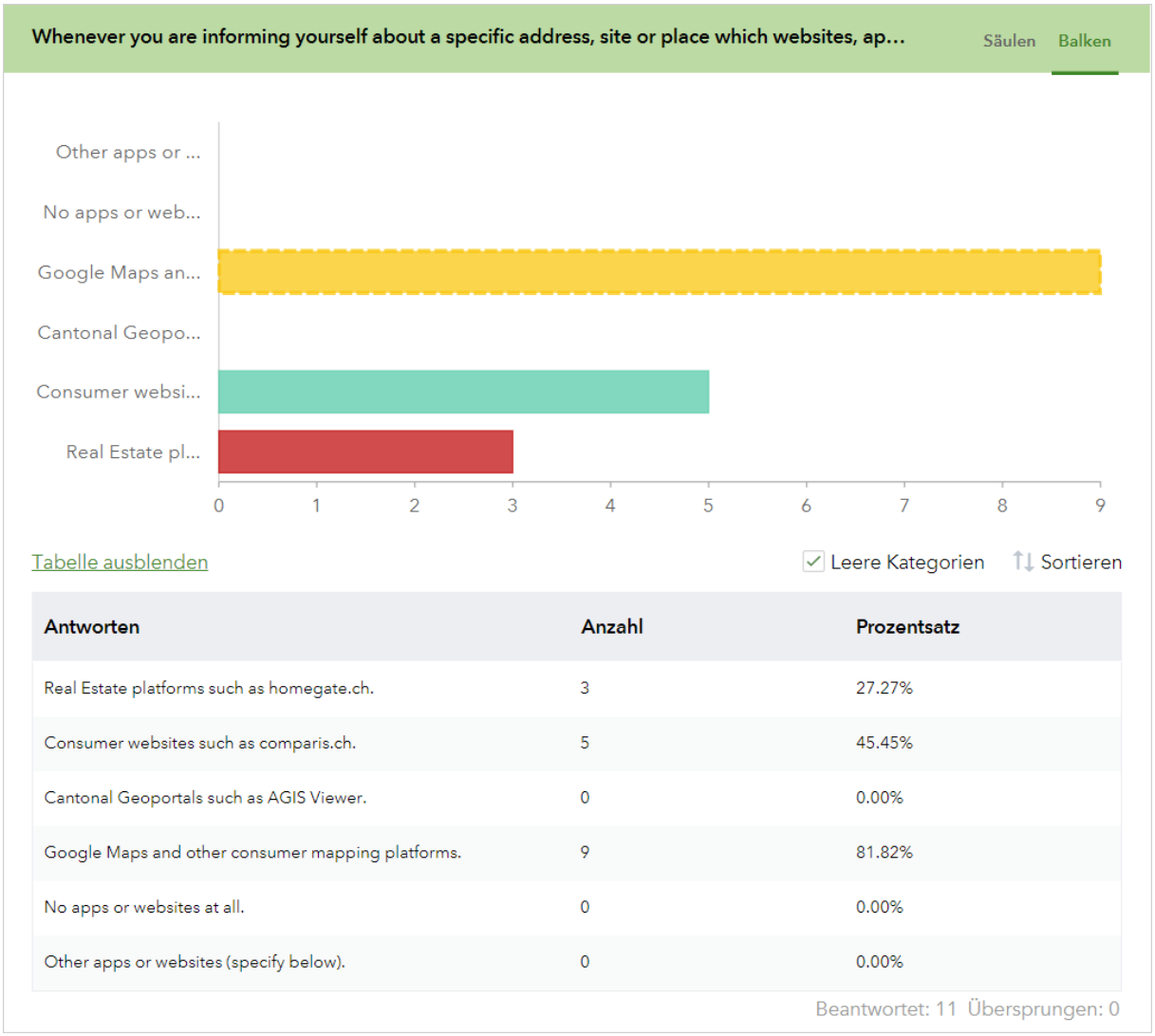
Almost 55% agree or strongly agree that the Walking Time analysis answers are satisfying. One person disagrees.

Further answers to the survey

Whenever you are informing yourself about a specific address, site or place which websites, apps, tools do you use?

Imagine you want to move to another place and you require information.

To gather information, you can use tools to find out for example how far the place is from the next bus stops, railway stations, kindergartens, schools, etc....



Antworten	Anzahl	Prozentsatz
Real Estate platforms such as homegate.ch.	3	27.27%
Consumer websites such as comparis.ch.	5	45.45%
Cantonal Geoportals such as AGIS Viewer.	0	0.00%
Google Maps and other consumer mapping platforms.	9	81.82%
No apps or websites at all.	0	0.00%
Other apps or websites (specify below).	0	0.00%

Beantwortet: 11 Übersprungen: 0

FIGURE 30: BAR CHART ON HOW SURVEYED PERSONS GATHER INFORMATION ON SITE SELECTION

Most of the test users use Google Maps for Site Selection. Almost half of the users also utilize consumer website such as comparis.ch.

*Where you able to search a specific address or a spot / place with the help of the GeoBot?**

A search can be performed on the address provided by the user.

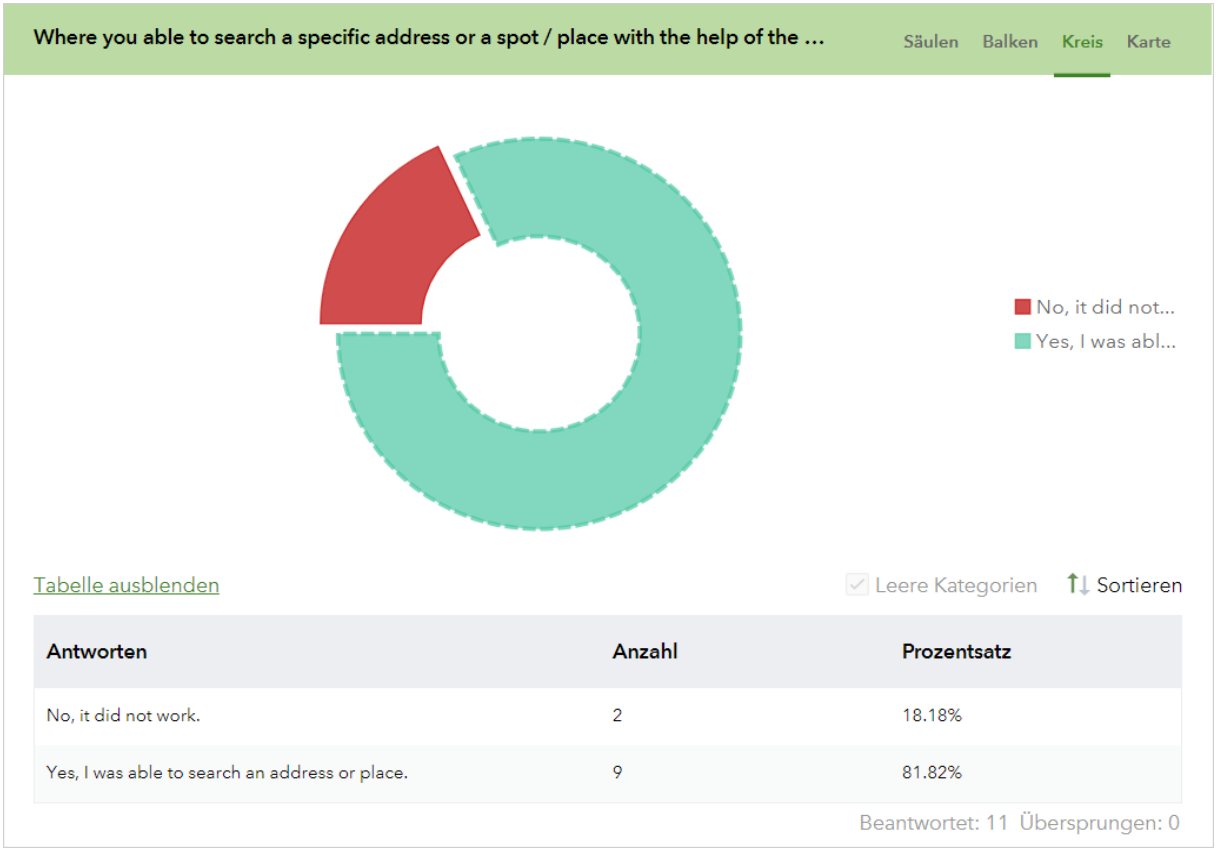


FIGURE 31: CIRCLE DIAGRAM ON SEARCH FUNCTION

Two out of eleven users were not able to search for a specific spot or location. It is vital for further prototypes to work towards 100%, because searching for an address is a prerequisite to perform analysis.

Please rate the reliability of searching an address or place.

The GeoBot should deliver the correct address.

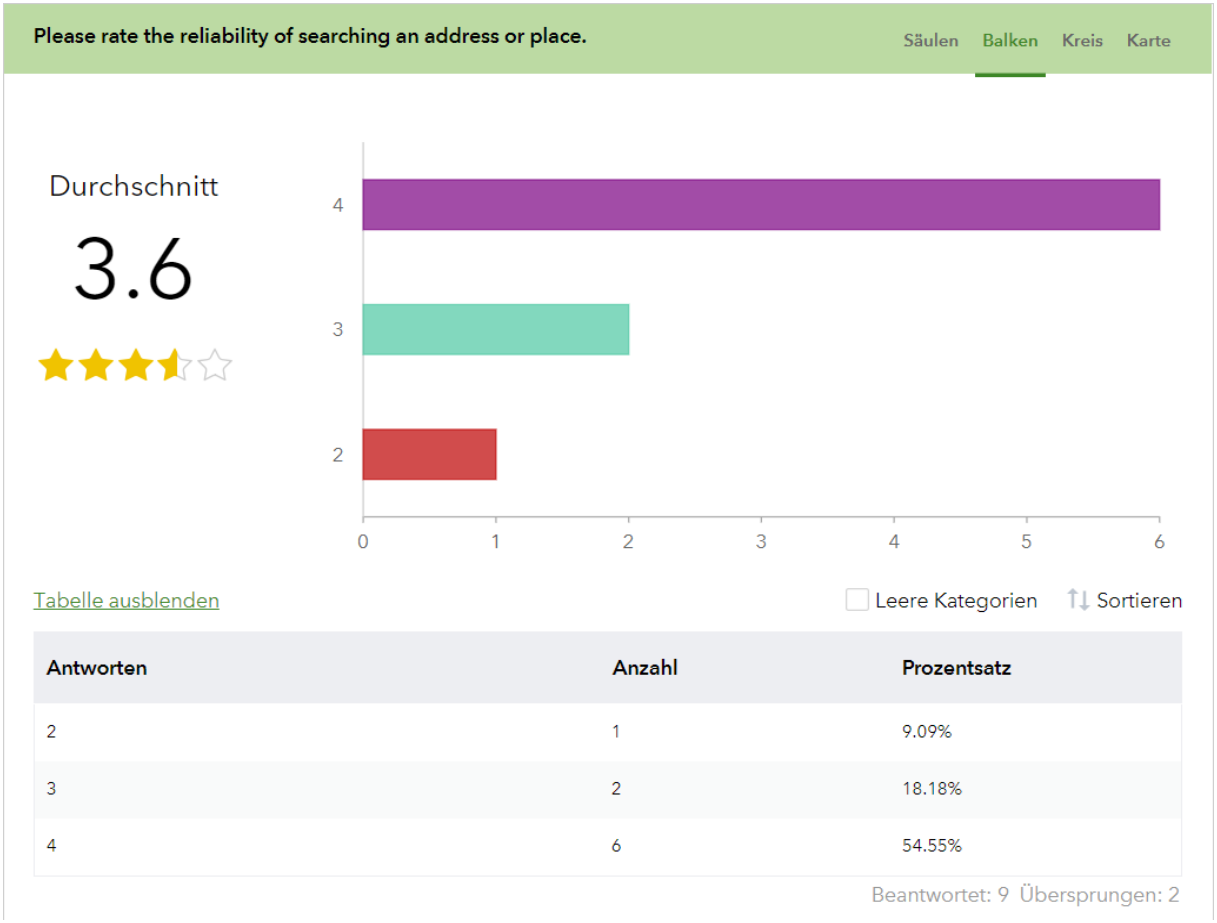


FIGURE 32: BAR CHART ON REALIABILITY OF SEARCH FUNCTION

The reliability of the search function (search engine and GeoBot implementation) was rated 3.6 out of 5 stars.

Why were you not able to search a specific address or a site / place?

- *Was searching for Universität Zurich*
- *Maybe I asked the wrong way?*

Add a comment on searching an address:

- *Give more information on places found such as full address.*
- *Wäre cool, wenn die Adresse direkt erkennt wird, nicht das ich 2x Yes eingeben muss. (English Translation: Would be cool, whenever address is recognized, I nomore need to type in 2x Yes.)*
- *Did not find it: Check here: https://www.dropbox.com/s/m9daapa9dogrulp/Screenshot%202018-06-04%2018.06.06.png?dl=0*

- *If specific address is given it works well, but if a place of interest or just name of place not specific the bot cannot identify correctly in some cases.*
- *Good analysis, address entry is limited (no recognition of ä, ü, ö; address formats)*
- *NOt easy to find*
- *Wenn ich zb Coop suche, habe ich keine Auswahlmöglichkeiten der verscheidenen Coop`s in der Nähe. (English Translation: Whenever I am searching for Coop, I do not have a choice of different Coops nearby.)*

*Where you able to perform an analysis on a specific address or a site / place?**

The GeoBot can perform different analysis.

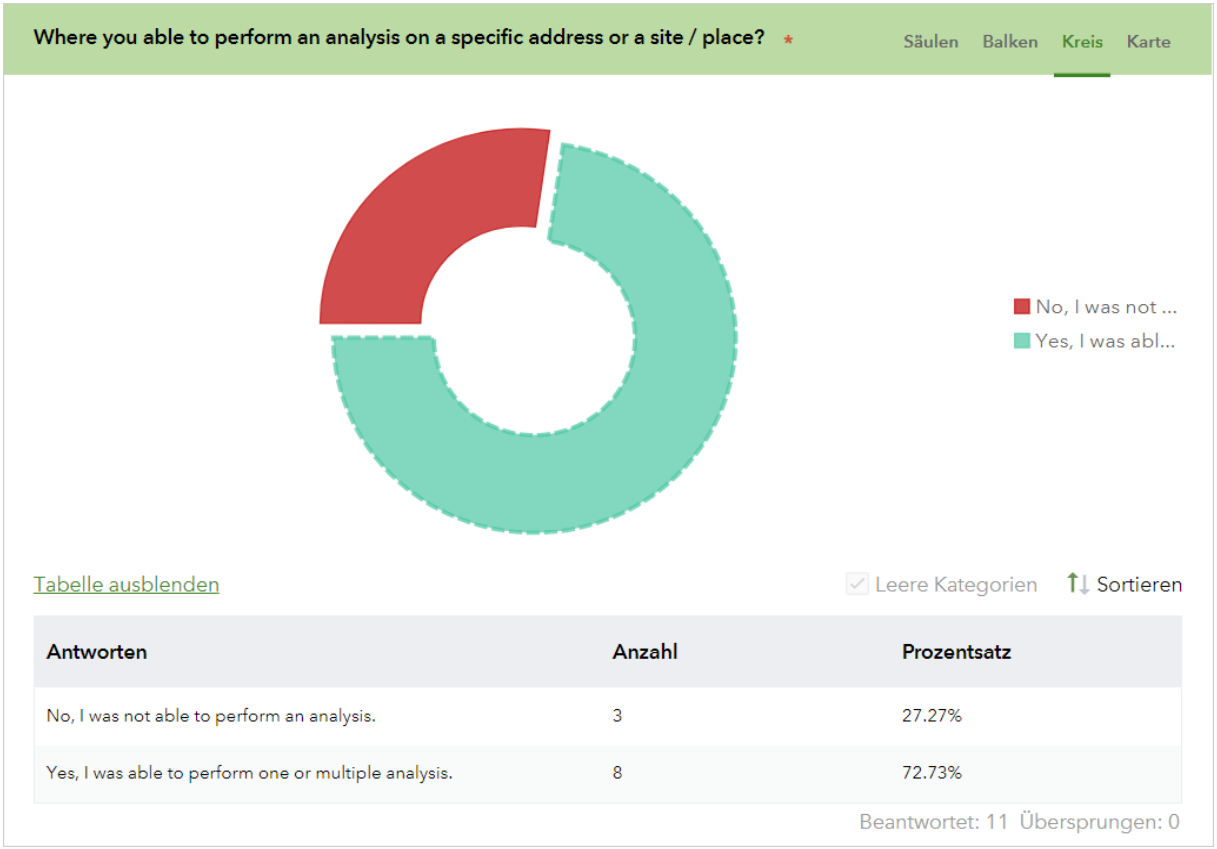
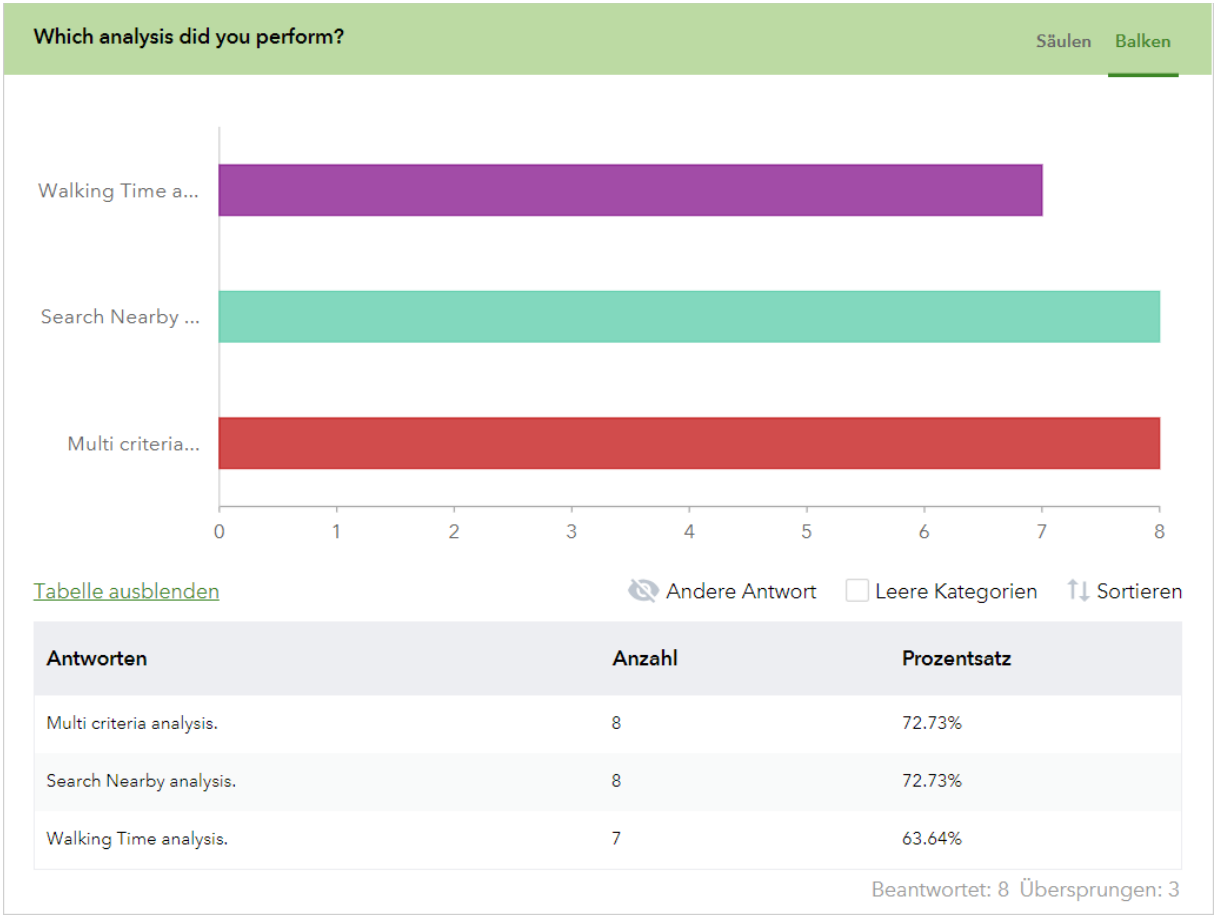


FIGURE 33: CIRCLE DIAGRAM ON ANALYSIS FUNCTIONS

Three out of eight where not able to perform perform analysis.

Which analysis did you perform?



Antworten	Anzahl	Prozentsatz
Multi criteria analysis.	8	72.73%
Search Nearby analysis.	8	72.73%
Walking Time analysis.	7	63.64%

Beantwortet: 8 Übersprungen: 3

FIGURE 34: BAR CHART ON PERFORMED ANALYSIS

Are there any other analysis possibilities which you would have expected by the GeoBot?

For example you would prefer a drive time analysis or a travel time analysis to your work place.

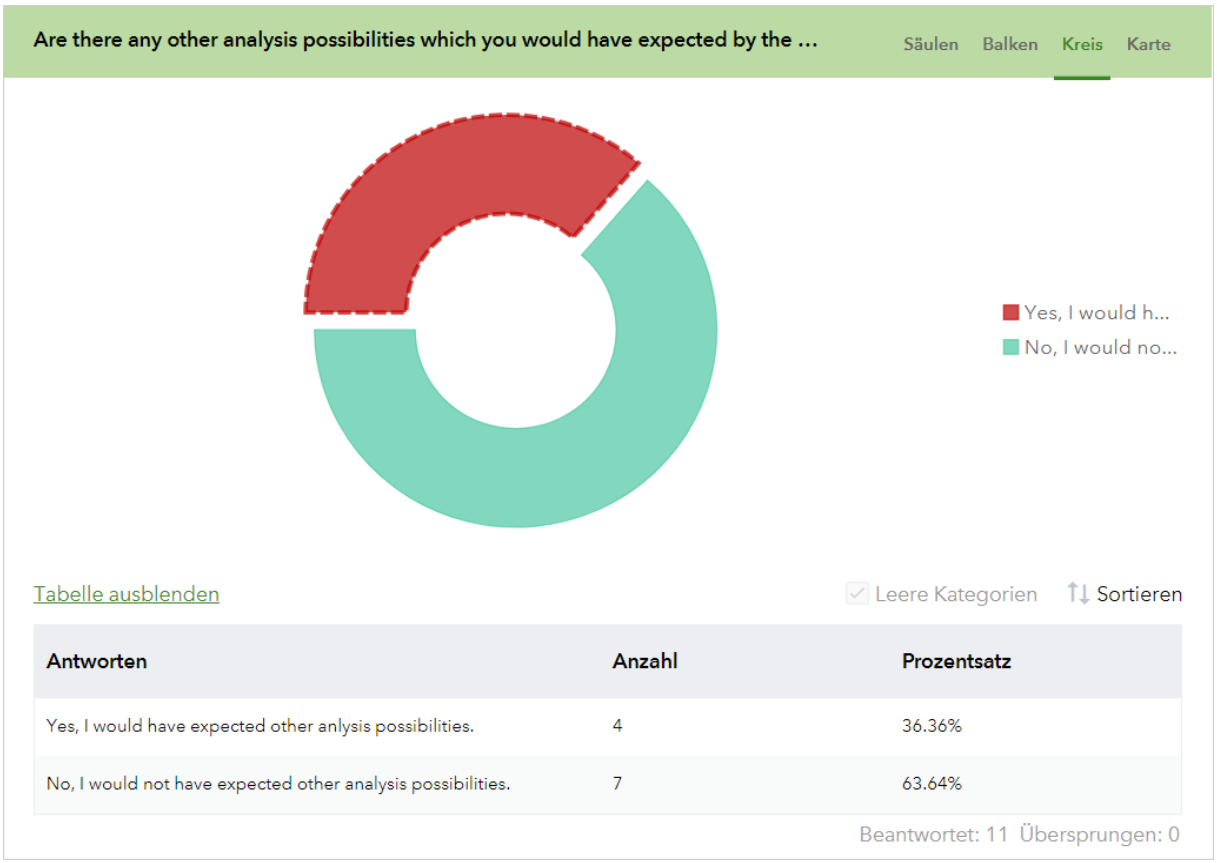


FIGURE 35: CIRCLE DIAGRAM ON EXPECTATIONS REGARDING ANALYSIS POSSIBILITIES

Please specify the other analysis possibilities you would have expected:

- *Wäre cool, wenn man eigeben könnte, nach was man sucht in der betreffender Umgebung. Z.b. Kita innerhlab von 500m in 5400 (English Translation: Would be cool, if I could type in what I am looking for in that particular region, e.g. day nursery within 500m of postalcode 5400.)*
- *major clubs available (sports, cultural, etc.) and diversity of the place in terms of population and others*
- *further infos leisure facilities / food / drinks / hospitals / doctors etc*

Would you expect the GeoBot to deliver more information on a specific site or place?

For example how far are shopping centers or convenient stores the specified site.

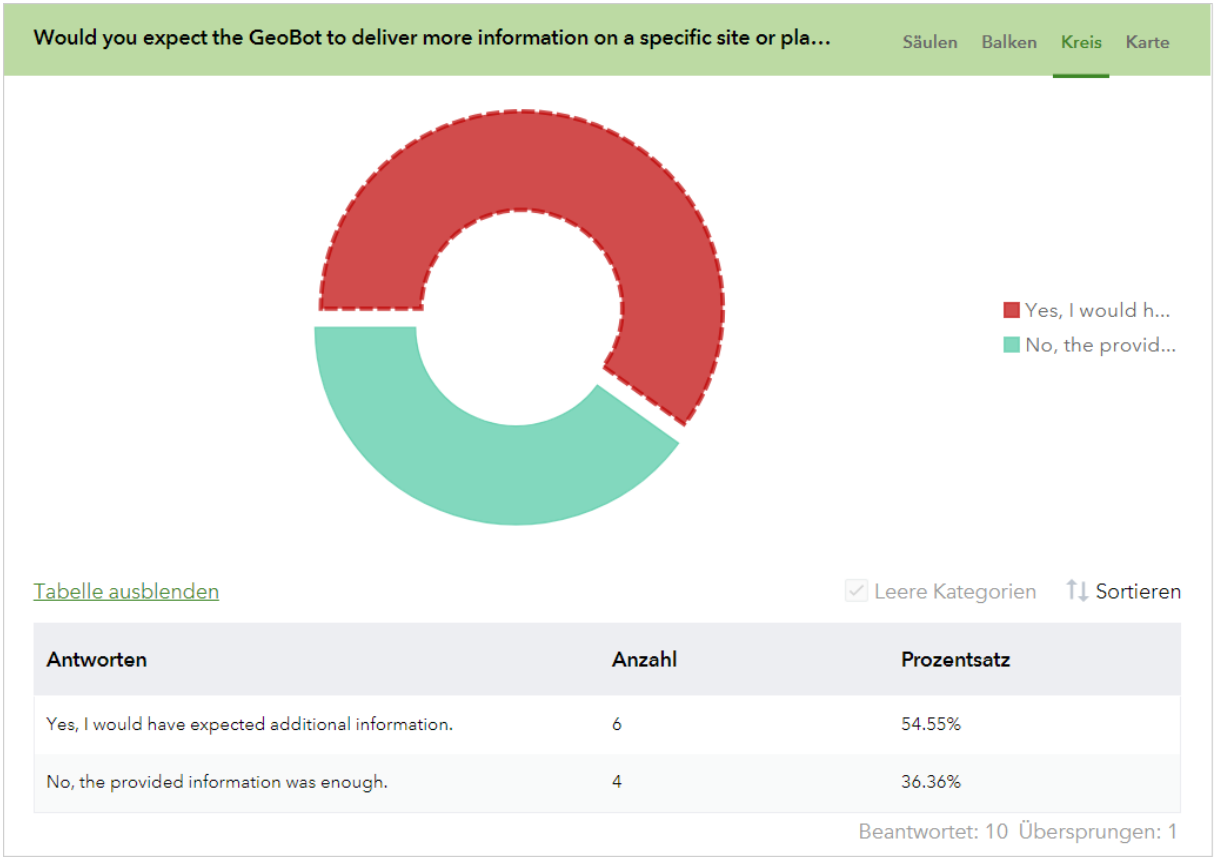


FIGURE 36: CIRCLE DIAGRAM ON EXPECTATIONS REGARDING INFORMATION ON A SITE

Most of the test users would have expected additional information by the GeoBot.

Please list the information you would expect from a GeoBot:

- *See your example. For example how far are shopping centers or convenient stores the specified site.*
- *Shopping, Restaurants etc.*
- *exact address and background information*
- *inter-connectivity in terms of transport, healthcare cost, and communication signals.*
- *More precise information*
- *Generell Retailshops angeben.(English Translation: general retail shops.)*

Please rate the quality of the conversation with the GeoBot.

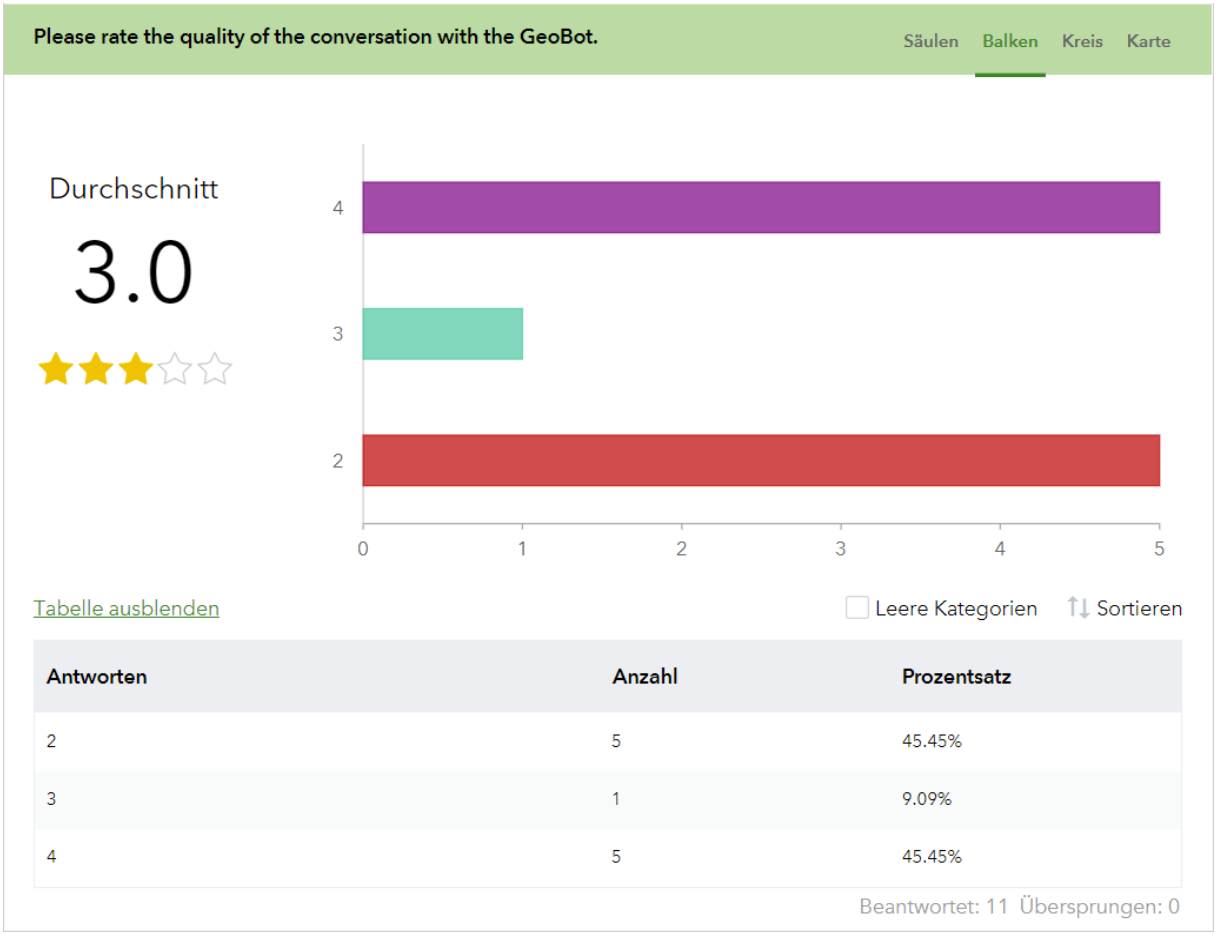


FIGURE 37: BAR CHART ON QUALITY OF CONVERSATION

The quality of the conversation with the GeoBot was rated with 3 out of 5 stars only. Five out of eleven test users only gave 2 out of 5 stars.

Please rate the quality of the displayed results such as the values from the analysis.
Results comprise of lists, maps and texts.

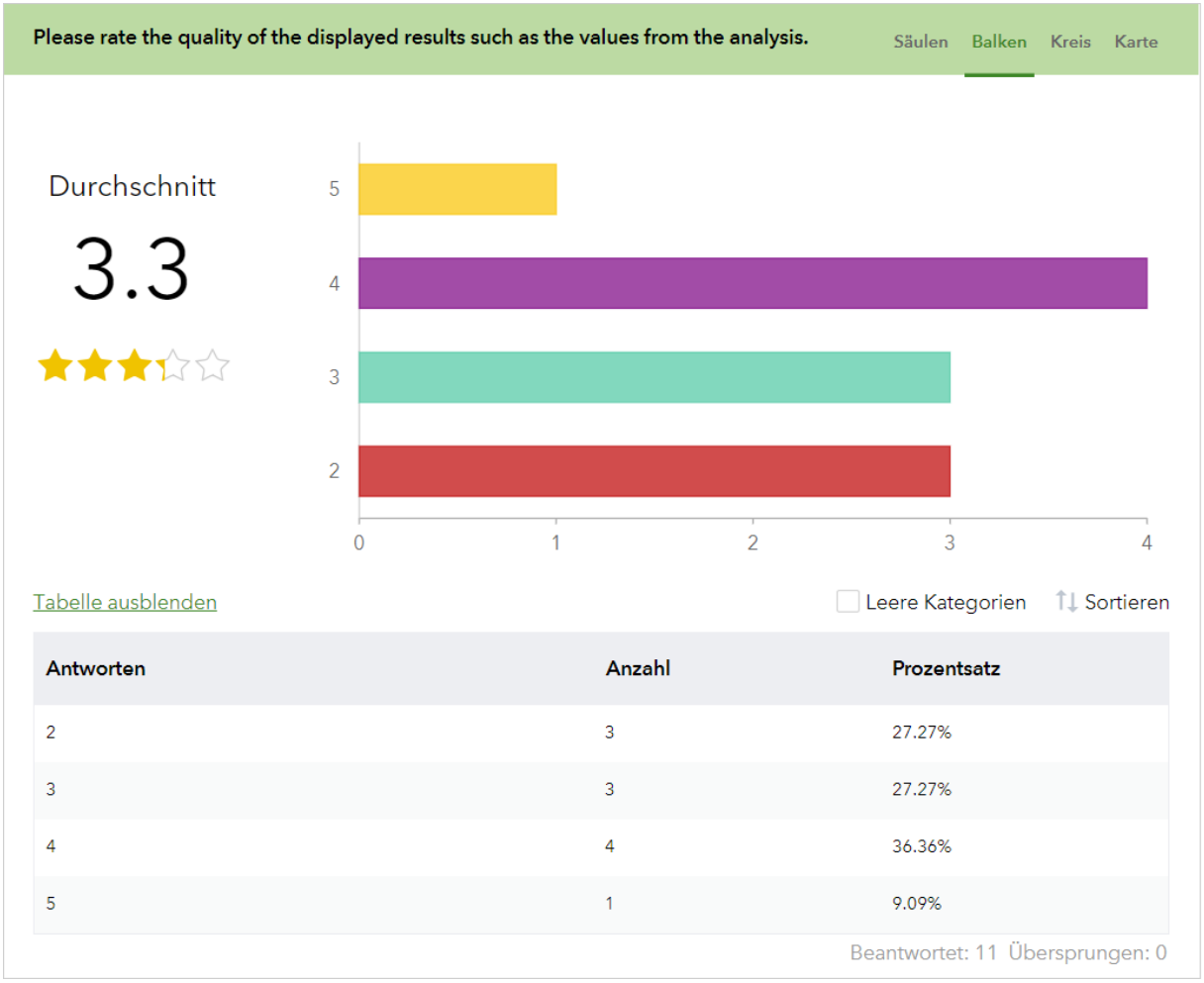


FIGURE 38: BAR CHART ON QUALITY OF DISPLAYED RESULTS

The displayed results by the GeoBot were rated slightly higher than the quality of the conversation.

Please rate the quality of the GeoBot's 'brain'.

How well could the GeoBot remember inputs provided earlier in the conversation.

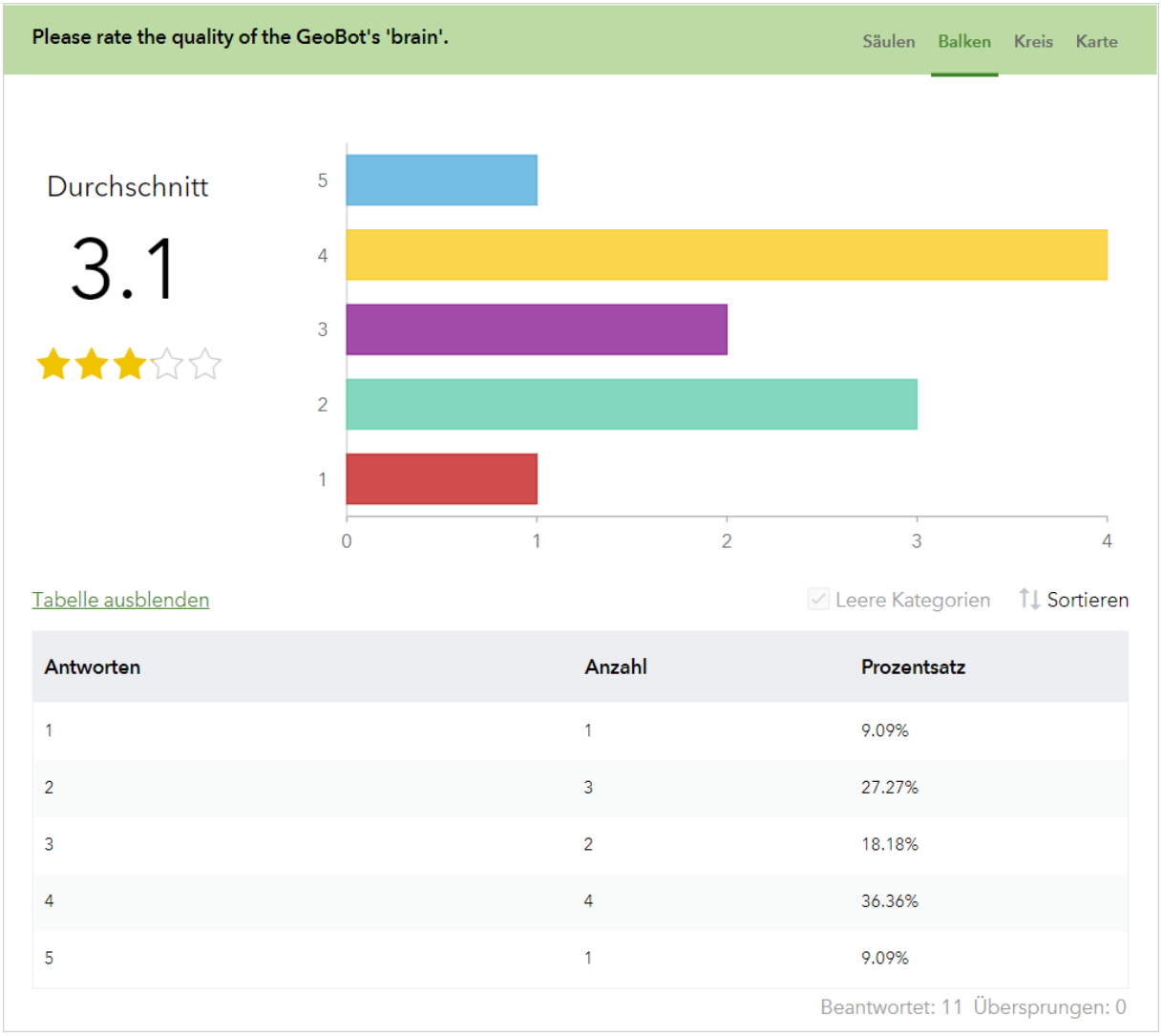


FIGURE 39: BAR CHART ON QUALITY OF THE GEOBOT'S BRAIN

Please add suggestions on how the conversation, the displayed results, or the GeoBot's 'brain' could be improved:

- *More answers on more possible answers from users.*
- *I think this bot can still be improve in terms of interactivity if search function can be interlink to a search engine such as google and inputs be analyzed by an algorithm that then define the correct response using top 10 search results.*
- *Visualisation of data / lists. Connecting Words with Information. Let's say Address + food, address + doctor, etc.*
- *The map on my ipad was too small, answers to unprecise. i have to provide a super precise input in orrder to get a useful answer.*

Please add a comment on the GeoBot:

- *Really great idea and would be very helpful.*
- *Wäre cool, wenn alle Informationen auf der Karte ersichtlich sind. Manchmal war das Feld mit den Infos abgeschnitten. (English Translation: Would be cool if all the information could be visible on the map. The info pop-up was cut off sometimes.)*
- *A good application if develop more to be as interactive as possible.*
- *i compare it to google, hence there is a long way to go*
- *Schnell. Jedoch nicht immer klar wie abzufragen, nichts selbsterklärend. Karte muss grösser sein undfarbig. Bei meinem Ipad hat es mir nur die letzt ca. 10 sätze angezeigt. Konnte nicht mehr zurück scrollen. (English Translation: Fast. But it is not always clear how to query, it is not self-explanatory. Maps must be bigger and colourful. With my iPad only the last ten sentences were displayed. I was not able to scroll back.)*

Do you have any further suggestions on how to improve the GeoBot?

The suggestions can be related to conversational and analytical capabilities.

- *More colors on map.*
- *data for whole Switzerland*
- *Make it more interactive in such a way it it feels like chatting to a real person or expert.*
- *That it accepts other info in search, for example 250 meters*
- *address recognition system iprovements, visualization of data, clearer "storyline"*
- *Chat was basic and not yet that useful*

By-products of the GeoBot prototype

There are by-products to the GeoBot. One by product is a map on Site Selection Suitability, see Figure 40: Site Selection Suitability, City of Baden Switzerland.

Another by-product is the the public WebMap created out of the published Feature Services. The WebMap can be accessed here: https://goo.gl/eQEt4a

Below you find a list of the Feature Services required by the GeoBot:

- Link to all the Feature Services: https://services.arcgis.com/OLiydejKCZTGhvWg/arcgis/rest/services/MultiCriteria_Services/FeatureServer
- Link to the Multi Criteria Feature Service: https://services.arcgis.com/OLiydejKCZTGhvWg/ArcGIS/rest/services/MultiCriteria_Services/FeatureServer/4
- Link to the Bus Stops Feature Service: https://services.arcgis.com/OLiydejKCZTGhvWg/ArcGIS/rest/services/MultiCriteria_Services/FeatureServer/0
- Link to the Kindergarten & Schools Feature Service: https://services.arcgis.com/OLiydejKCZTGhvWg/ArcGIS/rest/services/MultiCriteria_Services/FeatureServer/5
- Link to the Industrial & Commercial Sites Feature Service: https://services.arcgis.com/OLiydejKCZTGhvWg/ArcGIS/rest/services/MultiCriteria_Services/FeatureServer/6

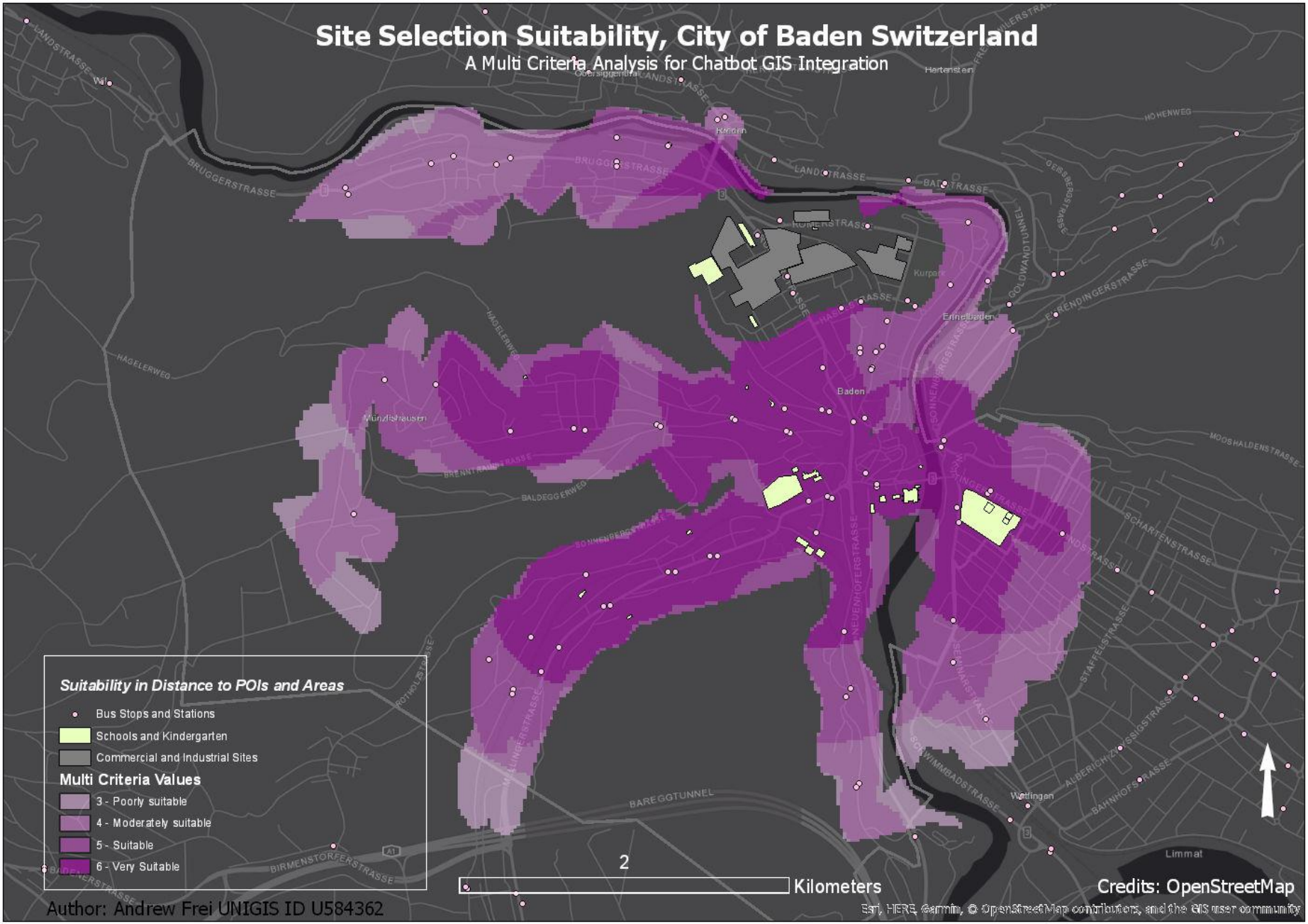


FIGURE 40: SITE SELECTION SUITABILITY, CITY OF BADEN SWITZERLAND

Discussion

From the answers it can be interpreted that the GeoBot and GIS integration is meaningful and useful. The questions are:

- *Would you recommend this GeoBot for Site Selection?* on page 61 and
- *Do you find it useful to chat with a GeoBot on Site Selection?* on page 63.

Test users' comments were encouraging and recommending young families in search of a new home, tourists or commuters using public transportation as possible users.

Almost 64% agree or strongly agree that chatting with a chatbot about Site selection is useful. One test user even said: "*Really great idea and would be very helpful."*

Nevertheless, the test users expect more from a productive version. They expect clear advantages over Google / Google Maps, more information, better map visualization, better search results, interactivity and personality of the GeoBot, user guidance and user design.

So, the expectations towards a consumer facing GeoBot are extremely high. One test user said, "*Whenever I am searching for Coop, I do not have a choice of different Coops nearby."* This is surely something which can and should be fixed in a next version. But there are other comments, which are related to and dependent on the 3rd party Web Services in place.

One test user said: *"If specific address is given it works well, but if a place of interest or just name of place not specific the bot cannot identify correctly in some cases."* So, this is totally dependent on the Geosearch or Geocoding Web Service in place. Nevertheless, the different Geocoding Web Services could be benchmarked prior to the productive version.

Regarding the analysis possibilities one test user mentioned "*More information about the surrounding, map is too small! And not colourful! Probably footprints of buildings not visible."* All these insights are very helpful and justified. Nevertheless, there are also test user comments which are not as supportive *"The results are not that useful"*.

The test users would have also expected much more information by the GeoBot, such as

- *"major clubs available (sports, cultural, etc.) and diversity of the place in terms of population and others"*
- *"further infos leisure facilities / food / drinks / hospitals / doctors etc"*
- *"Shopping, Restaurants etc."*
- *"inter-connectivity in terms of transport, healthcare cost, and communication signals."*

There are interesting suggestions on how the GeoBot could be improved. One test user suggested that the GeoBot should be able to provide more answers on possible answers by the users. Another test user suggested that the interactivity and the personality of the GeoBot should

be improved. The test user goes on and argues that "*if search function can be interlink to a search engine such as google and inputs be analyzed by an algorithm that then define the correct response using top 10 search results."*

Regarding the personality of the GeoBot, a test user commented: "*Make it more interactive in such a way it it feels like chatting to a real person or expert."*

The GeoBot - as it is today - has its major limitations. This test user also realized some limitations of the GeoBot: "*Fast. But it is not always clear how to query, it is not self-explanatory. Maps must be bigger and colourful. With my iPad only the last ten sentences were displayed. I was not able to scroll back."*

The limitations can be narrowed down to all the relevant parts of the GeoBot, which are summarized in Figure 5: Simplified Chatbot-GIS Process and Figure 6: Simplified Integrational Structure:

- Chatbot
    - Chatbot's brain: the ability to store and reuse information provided earlier by the user. The repository is not large enough and therefore has sometimes difficulties with logical conversations. This can be observed with test user statements mentioned earlier: "*But it is not always clear how to query, it is not self-explanatory."*
    - Keyword patterns: the possibilities on understanding the user's inputs are limited to the Keyword patterns. It has been argued by a test user that the GeoBot should be able to react on more answers provided by the user. Perhaps this is also where a composite versus simple pattern method should be investigated further. See Table 1: Comparison Table Alice vs Elizabeth on page 15.
    - Personality: as mentioned by Britz (2016) one of the common challenges is typically a coherent personality of the chatbot.

Britz (2016) also mentioned also other challenges such as

- Incorporating context into the conversation
- Evaluation of models with regards to building a chatbot
- Intention and diversity of the chatbot

I also faced problems with incorporating context into the conversation. According to the test users' comments and feedbacks some of them did not understand what spatial analysis means. Instead of asking the chatbot questions such as 'What is a site selection? What is GIS? What is a Multi Criteria analysis?', the test users expected the GeoBot to explain them what spatial analysis means.

Therefore, some test users were also not able to understand the introduction given by the GeoBot at the beginning of every conversation "*Hello, human! I'm a bot and my answers are very limited. I can perform geographical analysis on specific addresses or spots and places (such as Manor in Baden)."*

Britz (2016) calls it intention and diversity of the chatbot. In my mind the intention was very clear what the GeoBot has to offer to the users, but it was not always understood by the test users. Therefore, this is really a challenge on programming a chatbot which serves a specific domain such as spatial analysis. Probably, unconsciously I expected a certain domain knowledge in geography and geographical analysis. The 'perception of spatial cognition' has been also discussed in section Usability Engineering for GIS on page 21 and the 'The spatial citizen' in section Interacting with geospatial technology on page 23. Human Computer Interaction especially when interacting with GIS, is a very important topic and should be more heavily considered when developing other GeoBots or chatbot-GIS integrations.

There are also limitations on the GIS side. For one the simplification of the Multi Criteria analysis, which I stated in the section Aim & Objectives on page 10. Multi Criteria analysis is based on Bus Stops, Kindergarten & Schools as well as Industrial & Commercial sites only.

Another limitation is that the spatial data is only for the city of Baden in the Canton Argovia in Switzerland. This is the perimeter I decided for the Site Selection.

As mentioned in the introduction of my literature review Chatbots - An Overview on page 12, a chatbot is

- a Tool of Entertainment
- a Tool to Learn and Practice a Language
- an Information Retrieval Tool
- Assistants in E-Commerce, Business, and other Domains (Shawar and Atwell 2007).

In a wider and more generic context the journey of GeoBots have just begun. Christian Hürzeler, GIS Specialist at Urban Development of the City of Zurich, is thinking about testing chatbots in combination with the city's own geoportal[25]. The argument he puts forward is that example given a citizen wants to find the zone which he or she is living in, the geoportal can answer the question. But it takes the citizen several clicks from googling the information, the website of the City, the correct geoportal of the City and then the citizen should toggle in the exact layer and put in his or her address in the address search line. He argues that a chatbot could answer this and similar questions with just one query.

When adding speech recognition to the chatbot or GeoBot, it has the potential to be very helpful for any citizen by increasing location intelligence, hence supporting the idea of an empowered spatial citizen.

[25] https://www.stadt-zuerich.ch/ted/de/index/geoz/geoportal.html

Conclusion and Outlook

My conclusion is that a chatbot can be integrated with a GIS- in a meaningful way. Furthermore, a chatbot can provide multi-criteria analysis information on site selection to users. Users are also able to perform parameterized queries dynamically including time or distance.

Below I summarise the most important findings as follows

1. Combining GIS with a user-centric communication paradigm such as a chatbot is very powerful and has huge potential in terms of providing GIS analysis capabilities and its results in a meaningful and user-friendly way.
2. It is important to test the prototype with test users which have preferably no background in cartography, GIS, ICT. This helped me to gather valuable information on HCI, usability and GIS-integration.
3. Understanding that interactivity and personality of a chatbot is key, but very difficult to implement. The user expects a highly interactive chatbot which can understand all user comments and is able to interact upon it in a humanly way. The chatbot should almost pass the Turing Test so that it gives the impression of a conversation with a subject matter expert.

Since Facebook has asked developers to embrace Messenger-bots, the number of bots have increased to more than 150'000 active chatbots. The trend is so clear that Gartner projects that 85 percent of all customer interactions will be handled by chatbots (Grötz 2018).

Online customer services have the highest potential for chatbots. Chatbots will handle a big chunk of requests to call centre agents. Only complex questions which are too complicated for the chatbot to handle, will be handled by humans (Grötz 2018).

So, what does this mean for GIS and its applications? As Stephan Heuel of EBP puts it "Bots are the new Apps" (2016).

It is vital for the GIS community and its reach and impact to move closer to the user. This means understanding technological trends such as chatbots, speech recognition, Artificial Intelligence etc. This will lead to a combination of new and exciting ventures such as GeoBot, GeoAI and the like.

"The forth industrial revolution" as Klaus Schwab (2016), Founder and Executive Chairman World Economic Forum Geneva expressed it, "is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres."

The fusion of technologies and sciences is therefore irresistible. I am encouraging the GIS community and to fuse with other communities such as HCI, marketing, social media communities and I am encouraging other communities to engage with GIS.

Chatfuel, a chatbot platform, integrates also analytics. Besides the basic metrics such as number of users, time of chat etc. new metrics are developing to understand in depth the conversation with the user. How happy is the user? Which user questions are asked at which time? The answers to these questions help to improve the chatbot's behaviour, also with Machine

Learning. Continues improvement and analysis on the usage are key. Facebook Analytics also analysis its Messenger-bots. Aggregated and anonymous user demographics such as age, sex, education, interests, origin, language are available as reports (Grötz 2018).

I am looking forward to more use cases combining GIS and chatbots. It is the right time and place fusing technologies and sciences and testing their impact on spatially unaware users, which have a desire for spatial information.

Appendices

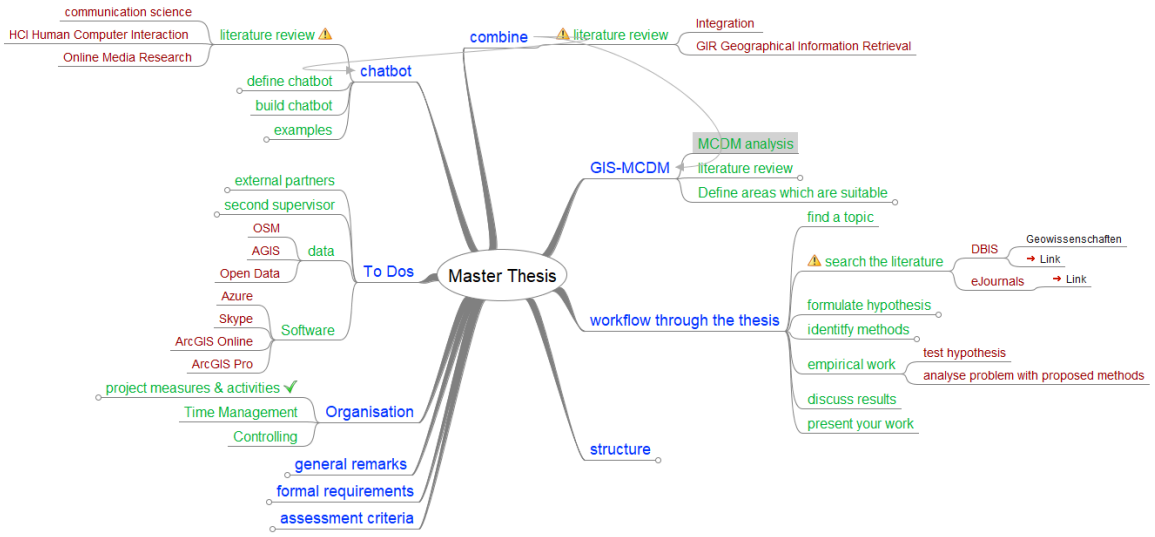


FIGURE 42: MASTER THESIS MIND MAP

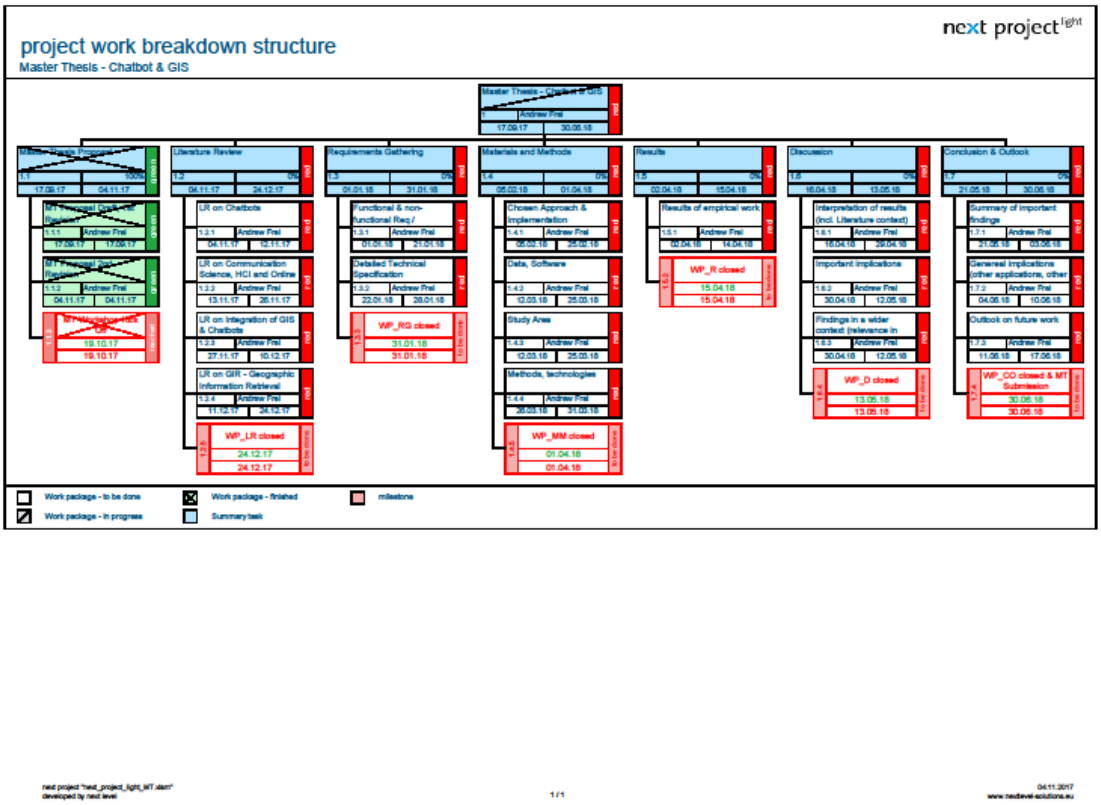


FIGURE 43: MASTER THESIS PROJECT WORK BREAKDOWN STRUCTURE

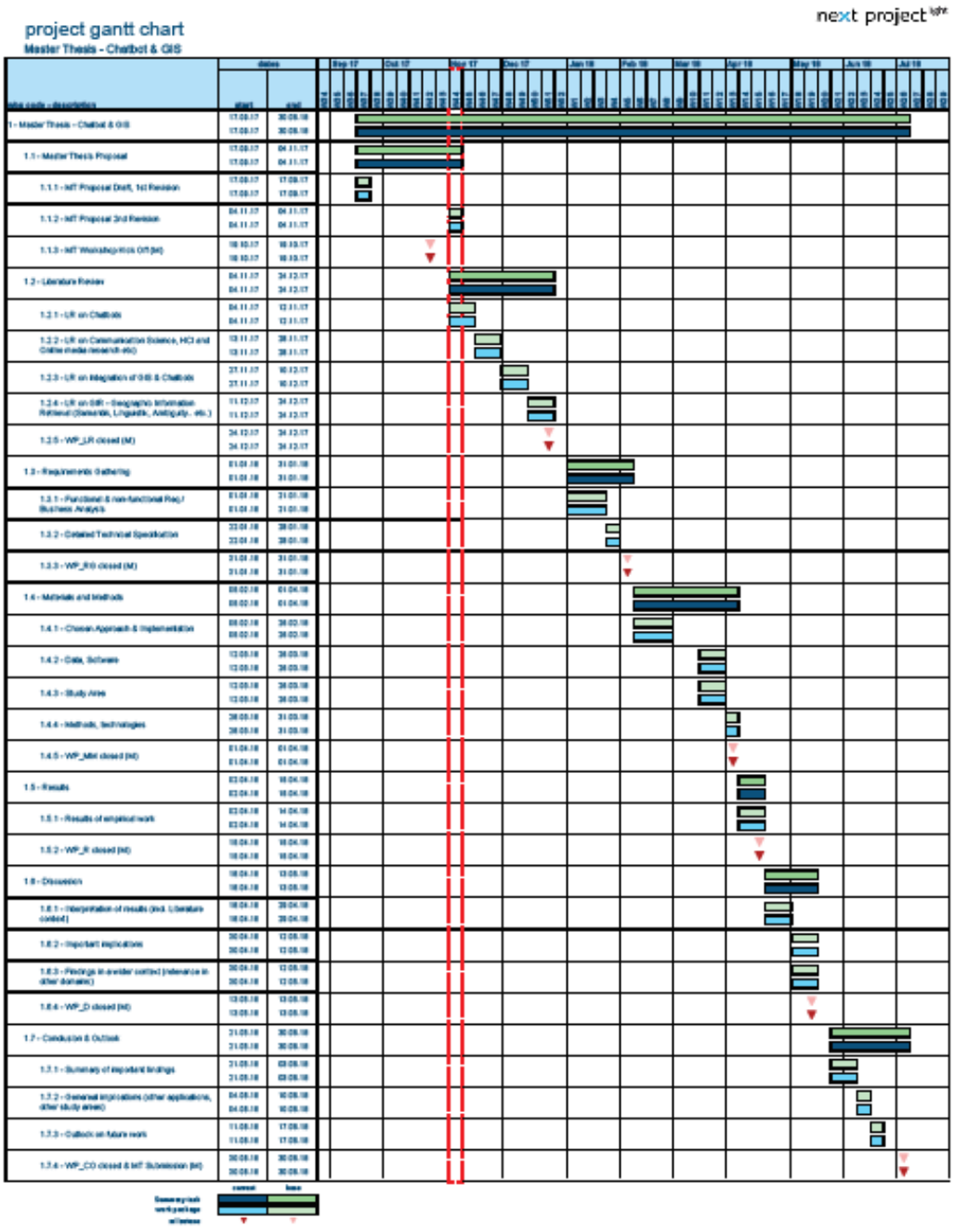


FIGURE 44: MASTER THESIS PROJECT GANTT CHART

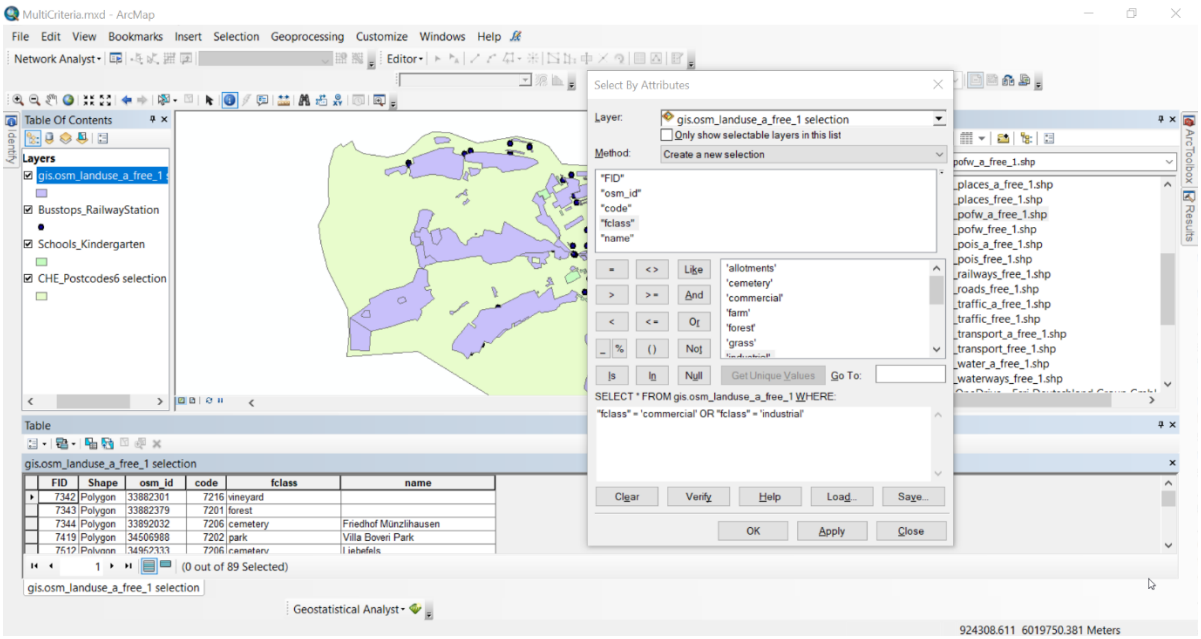


FIGURE 45: EXTRACTING COMMERCIAL AND INDUSTRIAL SITES OUT OF THE OSM DATASET

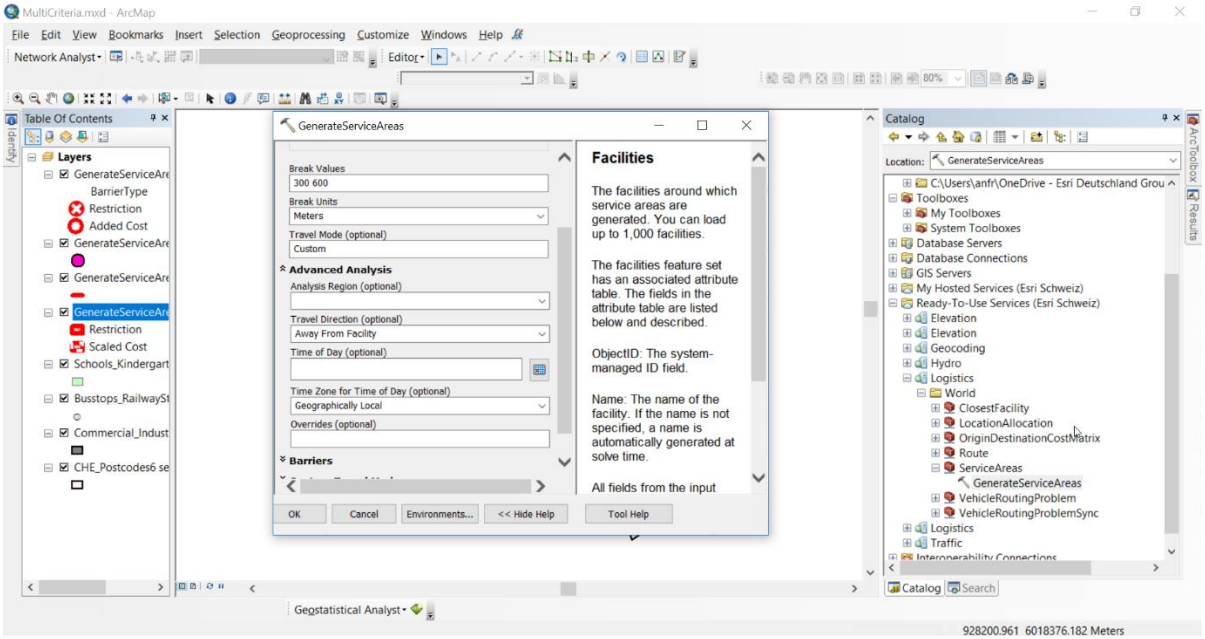


FIGURE 46: GENERATING BUS STOP SERVICES AREAS WITH 300 AND 600 BREAK VALUES

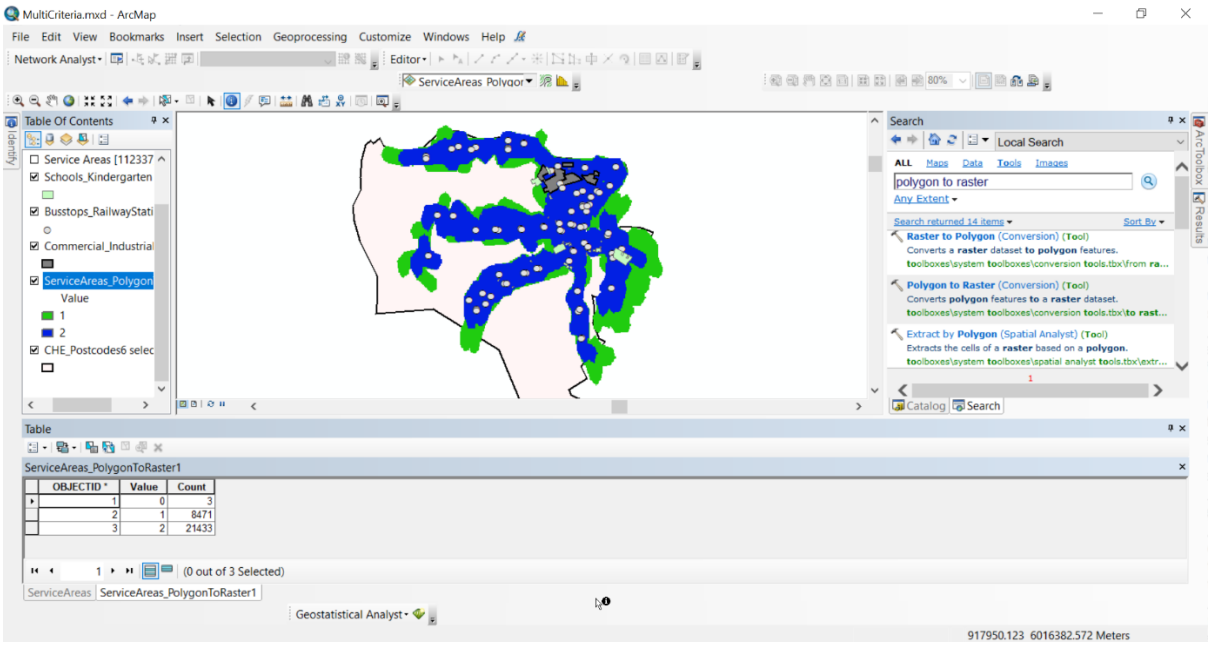


FIGURE 47: SERVICE AREAS WITH 300 AND 600 METERS FOR ALL THE BUS STOPS

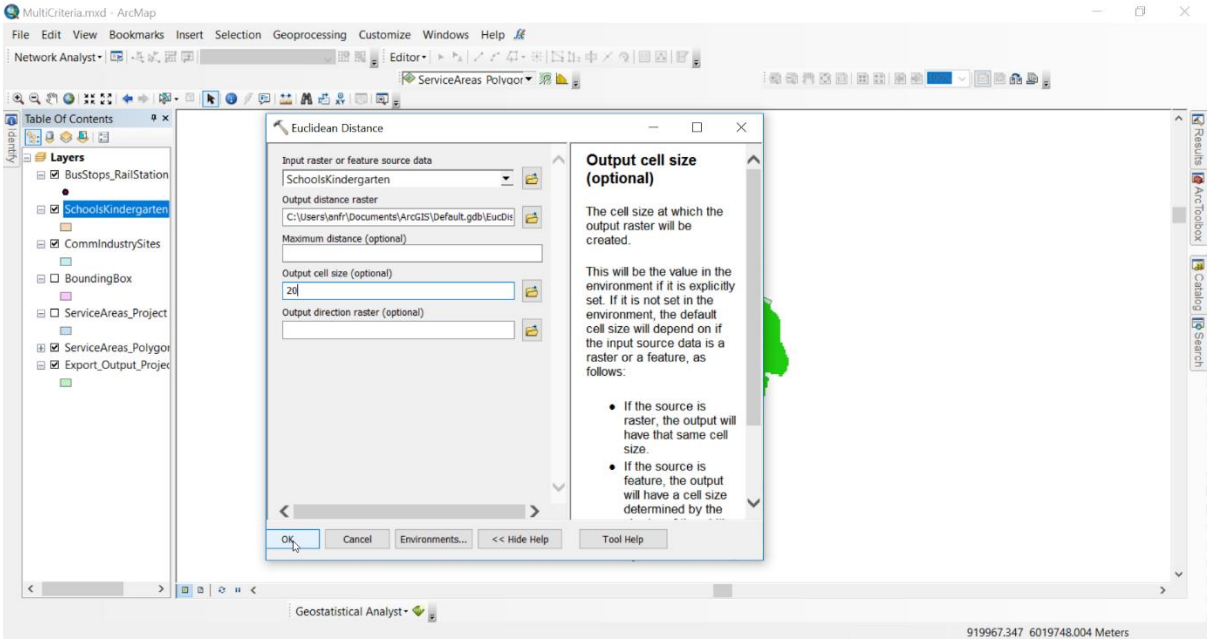


FIGURE 48: PERFORMING EUCLIDEAN DISTANCE ANALYSIS TO KINDERGARTEN AND SCHOOLS

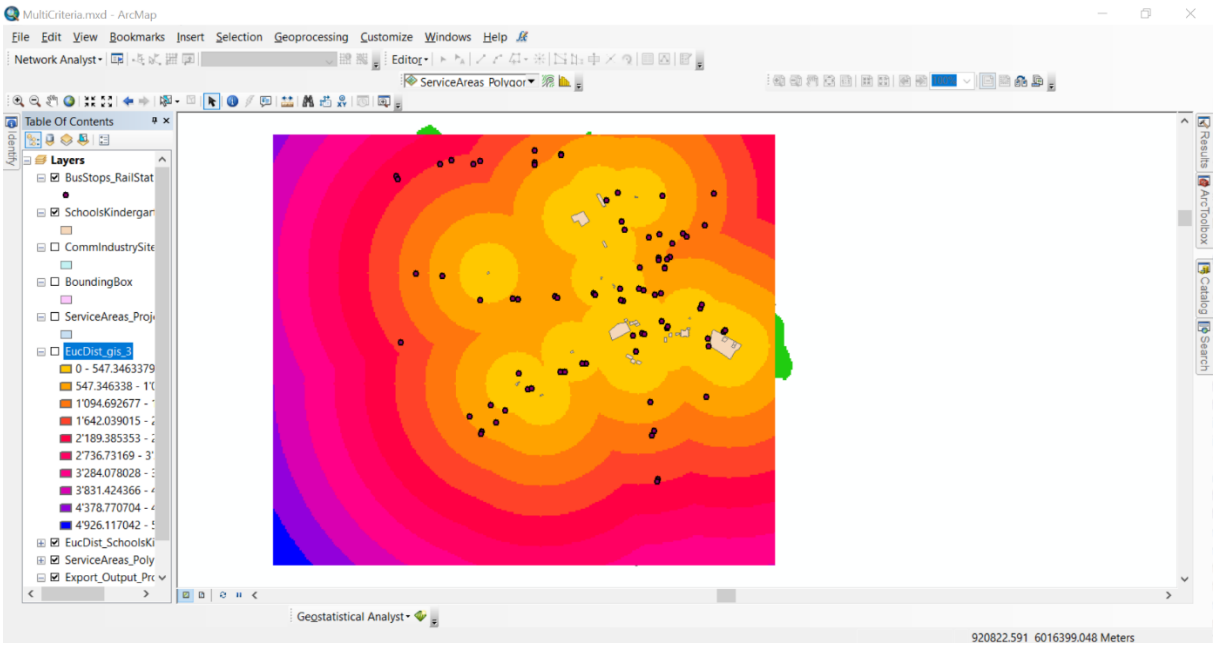


FIGURE 49: EUCLIDEAN DISTANCE ANALYSIS RESULT

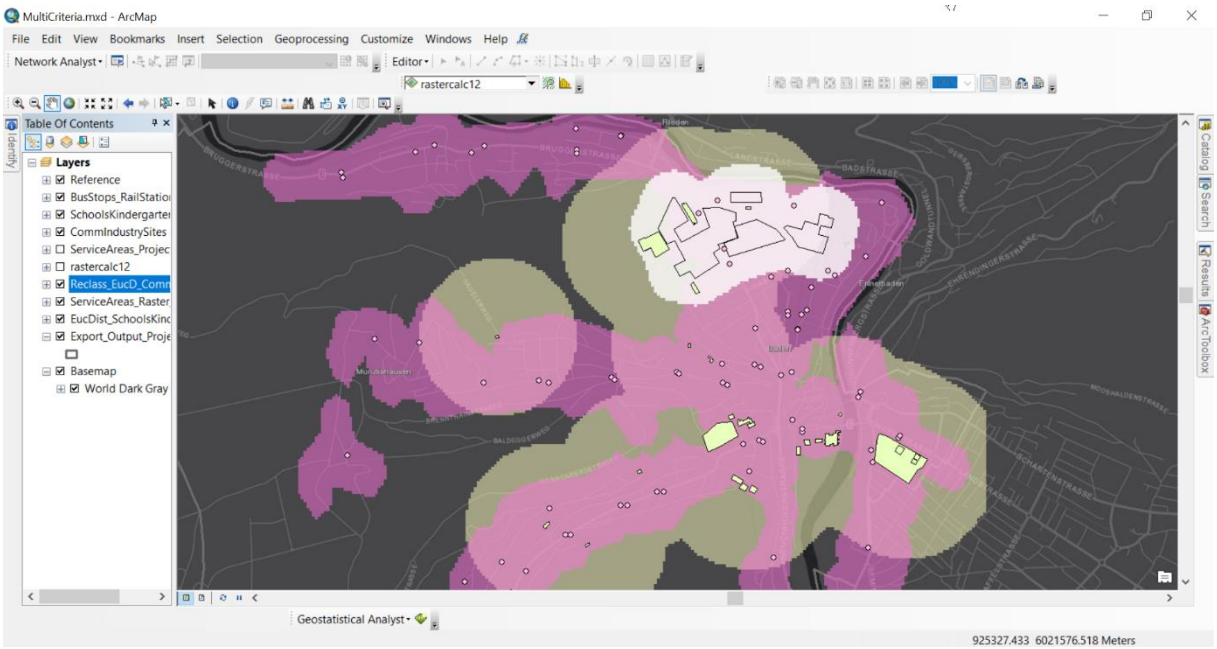


FIGURE 50: SERVICES AREAS FOR BUS STOPS, EUCLIDEAN DISTANCE ANALYSIS FOR INDUSTRIAL & COMMERCIAL SITES AND KINDERGARTEN & SCHOOLS

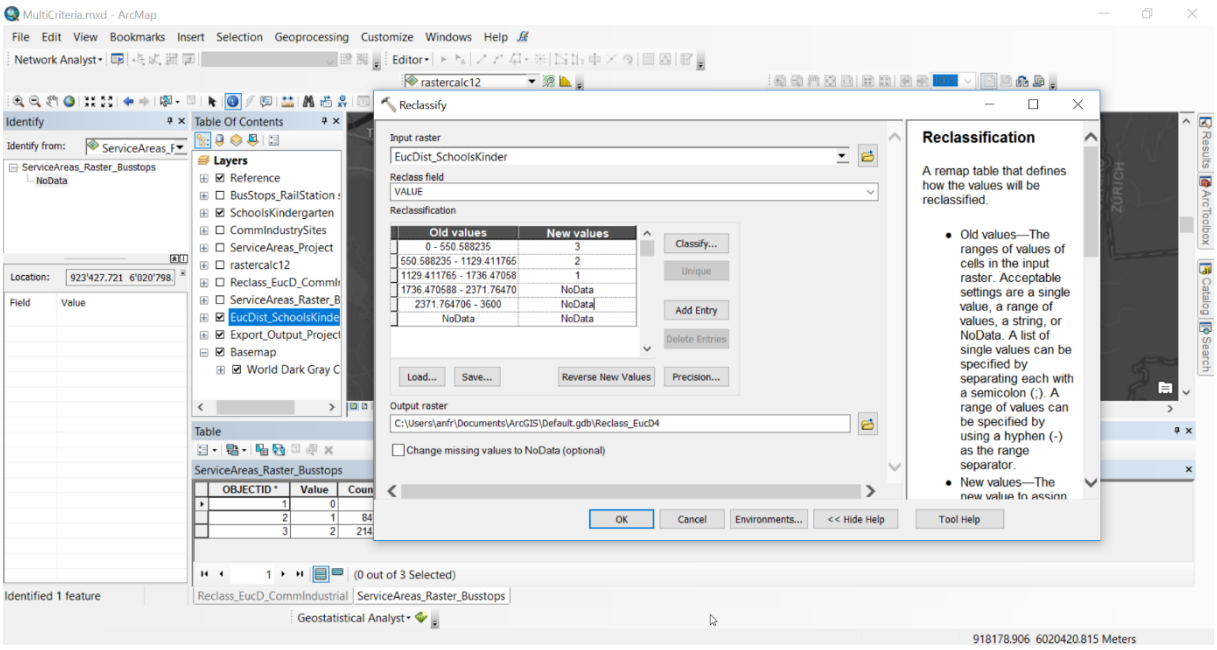


FIGURE 51: RECLASSIFYING KINDERGARTEN & SCHOOLS RASTER

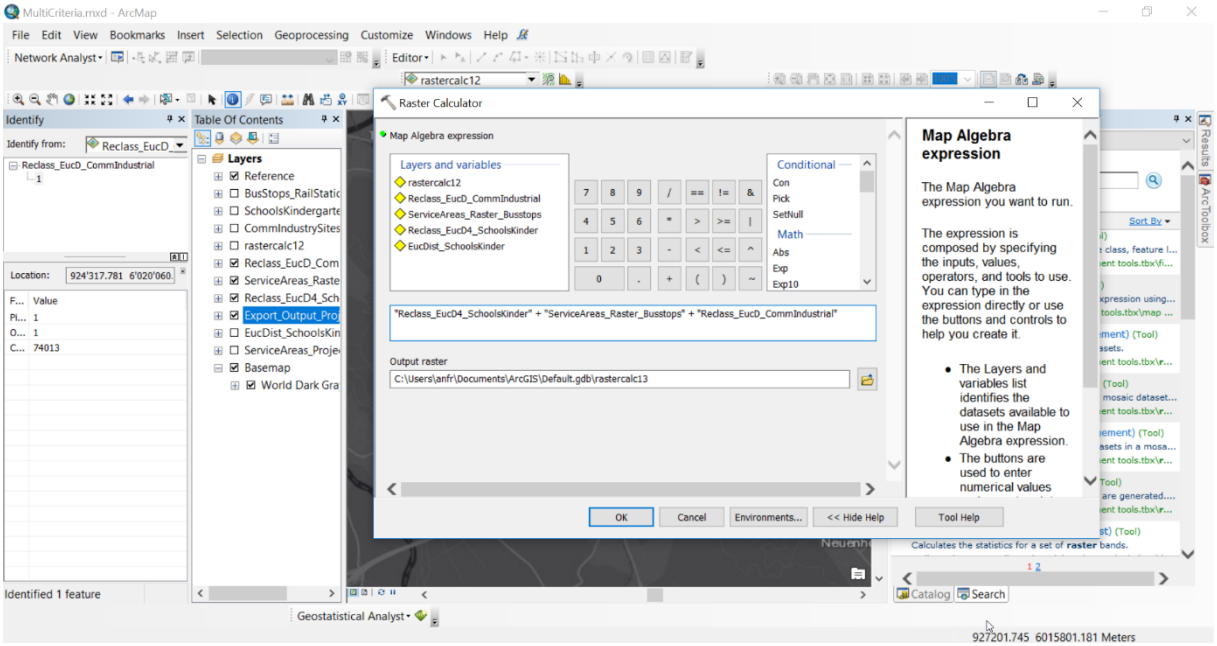


FIGURE 52: RASTER CALCULATION TO GENERATE MULTI CRITERIA ANALYSIS RASTER

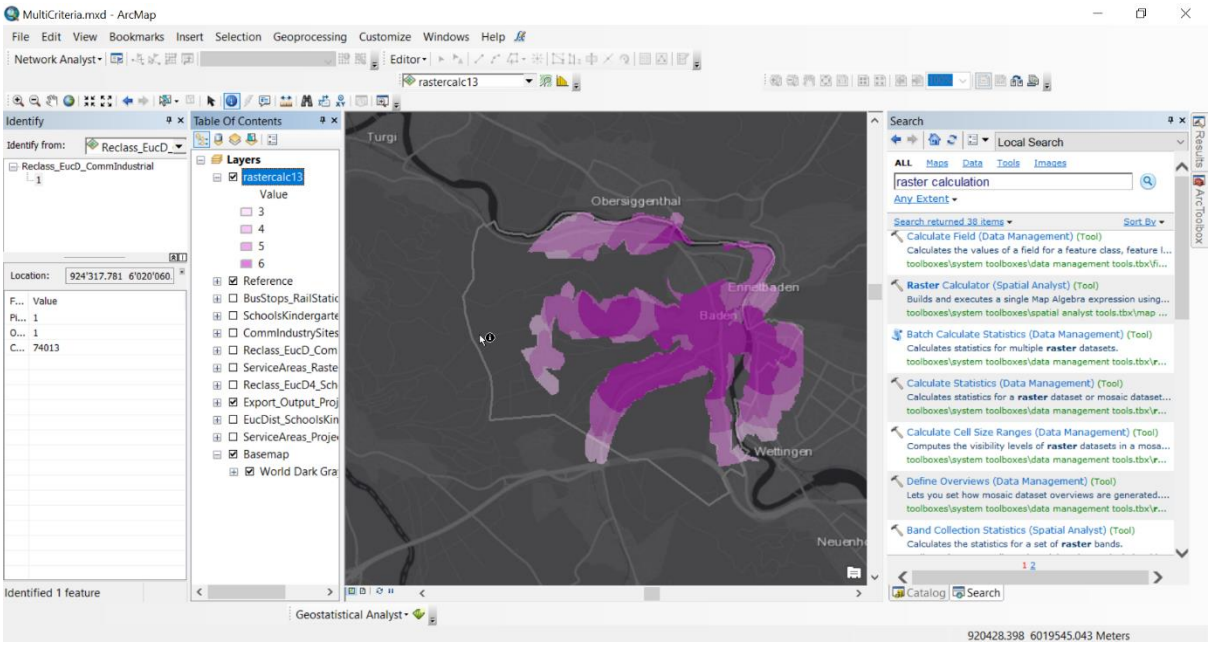


FIGURE 53: FINAL MULTI CRITERIA RASTER

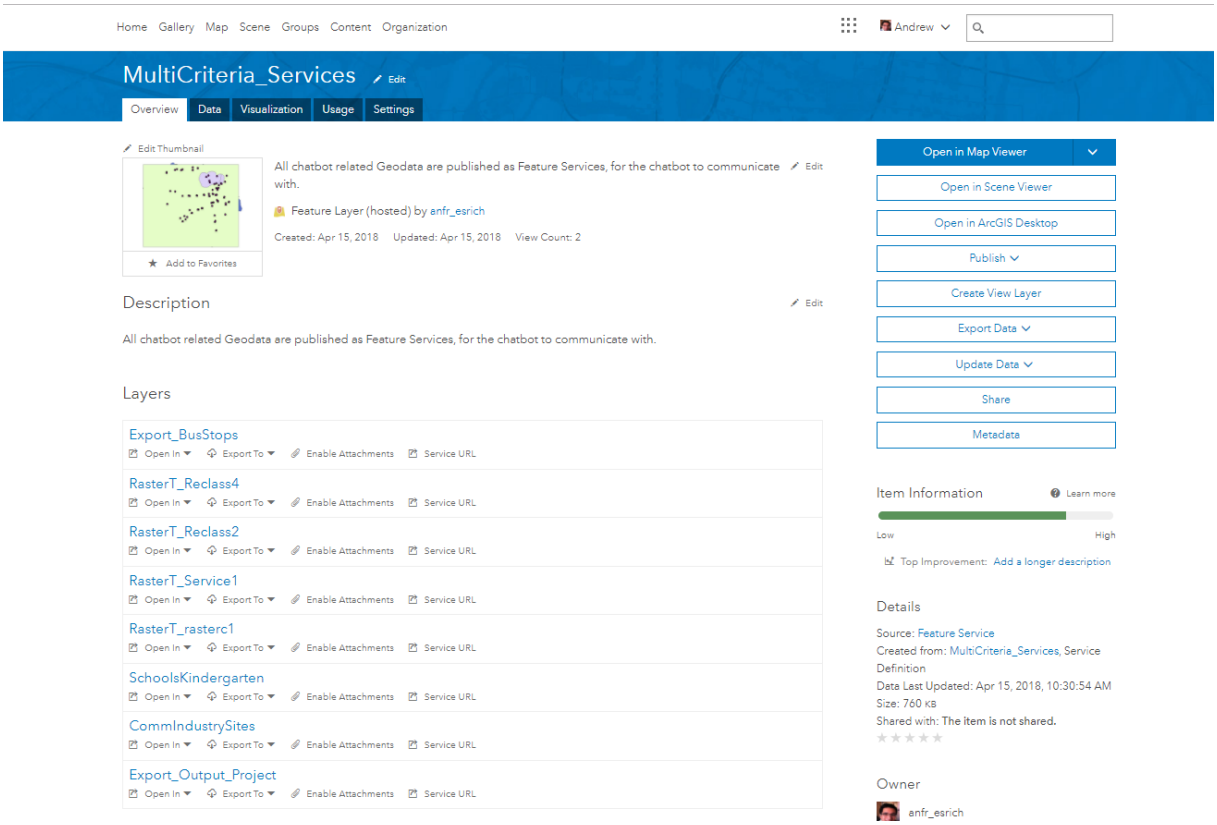


FIGURE 54: PUBLISHED FEATURE SERVICES ON ARCGIS ONLINE

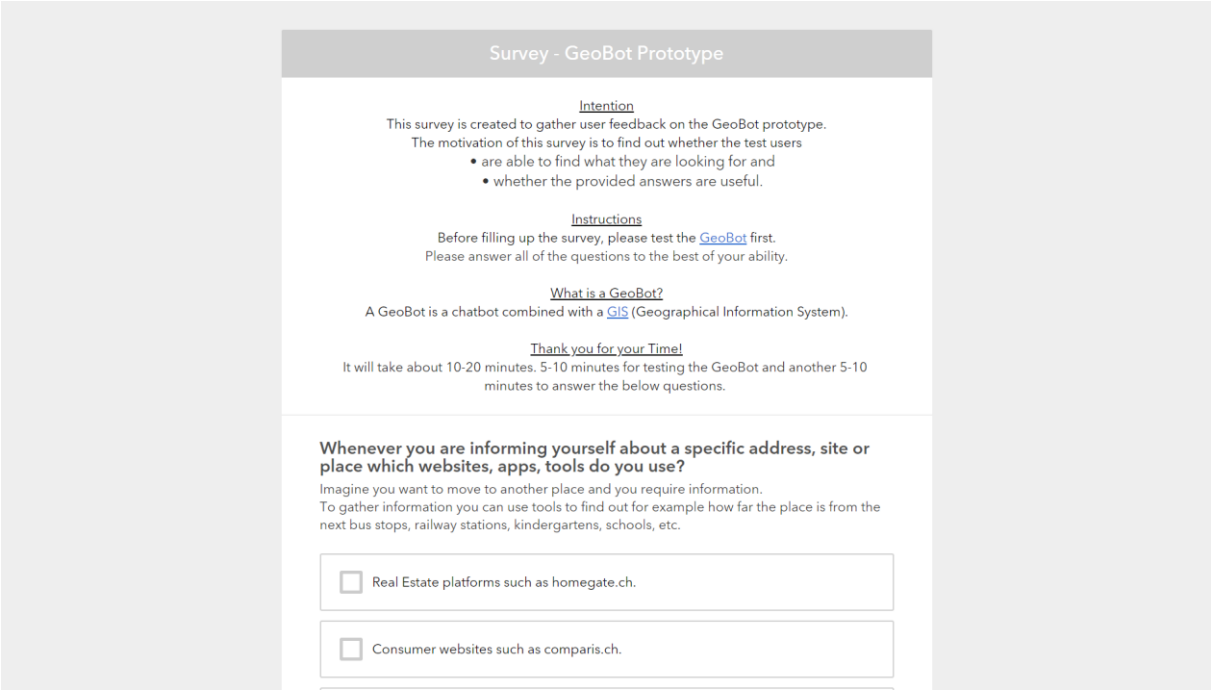


FIGURE 55: SURVEY TO GATHER FEEDBACK FROM THE TEST USERS

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