Digital Divide: How to find up to date and dynamic information for homeless people in Amsterdam

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ABSTRACT

This research paper proposes an web application that offers homeless people in Amsterdam information on where to find food, shelter, medical aid, education, useful goods and WiFi. After ascertaining the particular needs of the target group a NLP approach was chosen to find all the required information. The focal point of this master project is on the algorithmic retrieval and processing of the necessary data. In conjunction with another master project a user-friendly, sustainable and effective service was realised.

KEYWORDS

Digital Divide, Homeless People, Natural Language Processing, Sustainability

Contents

1 INTRODUCTION AND BACKGROUND

Homelessness in the Netherlands is dangerously rising. While in 2009 18,000 people were without a permanent stay, 31,000 people were considered homeless in 2015 constituting an increase of 74% over 6 years[1]. Interestingly, especially among young people (18-30 years) homelessness has increased about 55% from 8,000 to 12,400. These numbers illustrate the significance of homelessness even in first world.

In order to further examine this issue one should first try to find a definition of the term homelessness, which naturally varies from country to country or even city to city. A generally accepted definition of homelessness, which essentially also applies to the Netherlands, was made as part of the Stewart B. McKinney Homeless Assistance Act in 1987 aiming for inclusion of people, who lack a fixed, regular, and adequate nighttime residence, and people with a primary nighttime residence that is (a) a supervised publicly or privately operated shelter designed to provide temporary living accommodations; (b) an institution that provides temporary residence for individuals intending to be institutionalised; or (c) a public or private place not designed for or ordinarily used as a regular sleeping accommodation [4].

A huge problem that these people face is finding affordable or ideally free food, adequate sleeping places or medical aid. Paradoxically, especially in bigger cities such as Amsterdam there are plenty of institutions and charities providing all kinds of help. The arrival of the technological era in the early 2000s brought us web enabled phones which allow us to be reachable at any given moment and to retrieve information of any kind. As a consequence one would assume that this issue is a thing of the past. Indeed smart phones became more and more popular until they seem indispensable in the world of today. Yet, the correct use of smartphones still highly depends on one's acquaintance with technology itself and its design. On the one hand, this includes knowing where and how to look for information online (e.g. Google or homepage of the municipality of Amsterdam) and on the other hand properly evaluating the acquired information. In addition, not everyone in this group owns a smartphone, let alone, has permanent access to the internet which has to be considered, too. Altogether, finding useful information can present an almost insurmountable obstacle for some people in our world. In the worst case this could lead to a two-tier society. Since the correct use of (mobile) technology often correlates with one's social status, especially marginal groups are affected.

However, even for people adept at using the internet it may be difficult at times to find the desired information online. This is due to growing complexity of the software and and also to the abundance of data to chose from[2]. Thus, a software is proposed that is capable of providing homeless people with information on places that were determined by an algorithmically improved Google search which will then be displayed in an application. This research both intends to delineate the content-related requirements homeless people have regarding digital information and also to design a software that locates places in Amsterdam . Together with Marc Hegeman and his master thesis project *"Mobile apps for homeless people: Co-creation of Information Solutions for Digital Inclusion"*, which mostly addresses design and usability, this endeavour resulted in this application. Henceforth *we* stands for Marc Hegeman and Carlbandro Edoga as we worked closely together in the course of this project.

The implications for homeless people using this application could be huge such as mitigating their social exclusion, familiarising them with (mobile) technology and empowering them to independently acquiring information; all of which could potentially enhance their (re-)socialisation.

The group of homeless people in Amsterdam was selected because we were initially liaised with a charity institution in Amsterdam, *Huis Sant'Egidio*, that focuses on aiding homeless people and served as one of our main contact points. Most certainly after some adaptation the findings of this project just as the application itself can be used for other (constrained) groups such as low-literate or elderly people too.

In order to satisfyingly implement this plan the following underlying search questions were identified.

- ***RQ1: Which is the most crucial information for homeless people?***
- ***RQ2: Where can this data be automatically retrieved?***
  - ***SRQ1: How can entirety and accuracy of the information be technically realised?***
  - ***SRQ2: How can this process be repeatedly improved to make it more accurate and more sustainable?***

2 RELATED WORK

The overall significance of this project and the demand for our application is supported by a systematic research that was done in the US. It suggests that there is a potential to fundamentally improve the lives of homeless people by the use of ICT. Though they discerned the mobile phone as the most essential factor serving as a platform to contact friends or family members for example to ask for support and also as a figurative link to our modern society, they failed to show an independent use of the smart phone by the target group [9].

Like the Research Questions the literature review has to be subdivided into two parts, namely the needs and expectations of homeless people for digital information in a fast-developing technological society and the technical methods that allow to specifically albeit completely detect this data in the sheer limitless information online.

2.1 Target Group

In a study conducted with 301 homeless people in New York, United States, needs like safety, education, transportation, medical/dental treatment, and job training/placement were identified as at least as necessary as affordable housing. In addition, these needs were also described as difficult to satisfy by the participants. On the contrary, needs such as formal mental health and substance abuse appeared to be less relevant [1].

Furthermore, Roberson and Nardi distinguished two types of use

[1] CBS: Central Bureau of Statistics

[2] Roughly 10^9 GB are produced every day (see domo report)

of technology, *technology for survival* and *technology for social inclusion*. The latter hypothesis was confirmed in the study, but is not decisive for this project. Technology for survival though was characterised by "study participants [who] developed ways to use digital technologies to find food and shelter, to secure their safety, and to make money". Seemingly also less technologically inclined people can both adopt technological skills and also invent new strategies to use technology in a way that suits them surprisingly fast (length of study: 14 weeks) [14].
Likewise, showed Miller et al. that men who lived in a homeless shelter and had no or strictly limited access to the internet gained self-efficacy by the use of web enabled computers. Within eight weeks the participants managed to acquire new technological skills and deemed the computer a new component in their lives that could help them re-socialise [12].
Hersberger raised the blatant question *"Are the Economically Poor Information Poor?"* respectively *"Does the Digital Divide affect the Homeless and Access to Information?"*. He concluded that the precarious financial situation of homeless people reduces their ability to find the information needed online. Interestingly, she also ascertained that the people saw themselves socially disadvantaged due to limited access to the internet. She identified transportation difficulties, technological inabilities and privacy concerns as reasons why the existing service for example free WiFi in public libraries is not exploited sufficiently by homeless people [7].
A very important insight for our research was gained when it was shown that almost half of the homeless youth indeed owns a smart phone. However, it was also described that these homeless adolescents tend to use social networks merely to communicate, whereas sheltered college students spend recreational time on social platforms and use them as source of information [6].
This outcome is also supported by another descriptive study from the US where 421 homeless people participated. The scientists even found that more than half of the sample group owned a smartphone and accessed the internet daily. Also noteworthy is that most of them (85%) use Android as their operating system. On the other hand, an alarming one-third stated to have not have used the internet in the past 3 months whatsoever [13].

2.2 NLP

Natural Language Processing is engaged with the interaction between computers and the human language. It mainly deals with deciphering speech, text mining and the generation of natural language. Its application is virtually limitless and ranges from improvement of voice-assisted systems like Alexa[3] over the systematic analysis of large text documents to the automatic creation of taxonomic word trees.
For decades many companies and research institutions have been looking for a way to automatically finding synonyms. As per today one has to state that a universal solution to this problem has not been found but every problem has to be tackled individually. One reason for that is the complexity of the human language. If a machine reads the word *right* without any further information, it does not understand if the direction (right/left) or the judgement is meant (right/wrong). Likewise, words can and in most cases do have different meanings depending on their context. Homonyms and ambiguous meaning among others contribute to the sophistication of our language which makes it hard to automatically process and understand it.
Nevertheless, research and software emerging from it have improved substantially. In the following the most significant methods will be presented.
One remarkable breakthrough was achieved by Tomas Mikolov. First he proposed *word vectors* [10] and later introduced the corresponding *Word2Vec* model [11]. This is a Neural Network with two layers[4] which uses a large text corpus, mostly Wikipedia, to produce a multidimensional vector space in which every word is assigned a unique real-valued vector. This whole vector space is called *Word Embedding*. This word embedding can now be used to trace back the linguistic context of single words, analyse them automatically and eventually get insight into the semantic similarities between words. This method takes a distributional approach meaning that the surrounding words of target word w_1 and w_2 are examined. The so-called *distributional hypothesis* then states that two words with a similar meaning have a similar distribution, hence occur in similar contexts [15].

3 METHODOLOGY

Again, we need to regard the first and the second part of this master thesis project separately. In order to answer *RQ1* a exploratory case study in form of a questionnaire and informal 1-on-1 interviews were chosen. *RQ2* then will be examined by means of an experiment. As per ICT[5] 3.0 framework which was developed at the *Vrije Universiteit Amsterdam* [2] there are mainly five steps one should consider from the initial idea until the finalisation of the project. However, this procedure should rather serve as a rough guideline than a rigid instruction; the phases are tightly interconnected and frequently overlap each other. In a chronological order the elements of the framework are *Context Analysis, Needs Assessment, Requirement Engineering, Engineering and Sustainability Analysis* (see Figure 1). This master project also orientates itself towards this framework. RQ1 encompasses the phases context analysis, needs assessment and requirement engineering whereas the engineering and sustainability aspect will be realised technically when answering RQ2. The engineering phase and the sustainability evaluation constitute the focal part of this work and will be examined more thoroughly, whereas the remaining phases of the ICT4D framework are also partially covered by Marc Hegeman in his master thesis.

3.1 Context Analysis

The Context Analysis tries to find all factors that potentially affect the realisation of the project and/or have an interest in its deployment. It is often described as an elevator pitch, a 30 second brief explanation of the project to a person that is unfamiliar with the topic.
The main goal of this thesis is to create a mobile application that

[3] *Amazon's* intelligent speech-controlled personal Assistant

[4] layer here describes layers of artificial neurons that are implemented between input and output data; they are responsible for the calculations being made. The number of layer determines the complexity of the neural network

[5] Information and Communication Technology

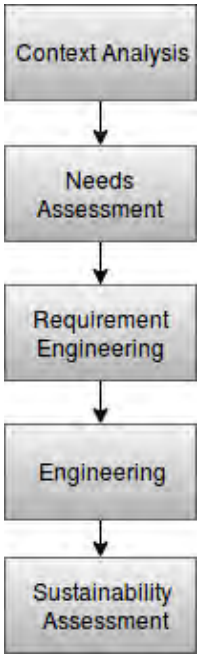

Figure 1: The ICT4D Framework of Development

supplies homeless people with up-to-date information on where to find useful places such as food banks, shelter for the night or hospitals. In the following the factors involved will be delineated and their contribution to the success of the project scrutinised.

3.1.1 Target Group. Certainly the most important stakeholder of this project are the end-users, namely the homeless people in Amsterdam, more precisely, the homeless people in Amsterdam that own a web-enabled phone. Finding these people turned out to be a formidable challenge. Thankfully, we were supported by several organisations along our way, which not only gave valuable insight into the current situation but what is more they liaised us with our target group.

3.1.2 Social. The social factors of the project are evident. As mentioned in section 1 the product of this master project can play a part in contributing to bridge the digital gap homeless people face. This, in turn, may lead to a better integration of these people into the rest of society. Ideally, our product is generic enough to also use it in other countries where the situation for homeless people may even be more delicate. Altogether, the main purpose of this project is to level the digital disparity between homeless people and the rest of society.

3.1.3 Political. The municipality of Amsterdam is an important stakeholder of this entire project. If the situation of homeless people regarding information acquisition wants to be changed fundamentally, awareness should be raised in politics. This would require an all encompassing assessment of the status quo and draft proposals on how to approach problems. Maybe this project can release the required pulse for a subsequent larger project. In any case, the insights we gained will be valuable and the product immediately usable.

3.1.4 Technology and Methods. State-of-the-art technology plays an important role in this project. The expectations people across all social classes have towards technology are increasing. Ab initio we were aware that our software has to include cutting-edge technology to satisfy the target group's needs. Only by doing that it can be avoided to widen the existing digital gap between homeless people and other members of society.
The same is true for our approach to the topic. Since we abided by the ICT4D 3.0 framework we could be certain at any given moment that our project is well-structured and has a firm goal.

3.1.5 Economic. Although we deployed state of the art technology and methodology, one still has to consider the economic constraints of an academic project like this one. Except for travel expenses for interviews no money was spent. Clearly this had effects on the development of our software. For instance, we knew that we would need to find a free web host which we managed to do. Fortunately, Marc had access to server and database due to his part-time job. We also created a Google Platform account which grants access to the Google API but is limited in the number of requests. Also, the scripts to retrieve the data from Google are currently run locally on our machine which can cause performance problems at some point. To summarise the project is viable for its geographic scope but would certainly need to be supported financially in case of an expansion.

3.1.6 Competing software. Based on the conversations we had with all stakeholders there is currently no software in the Netherlands serving the same purpose as ours. Although many plans especially by research institutions and the municipality of Amsterdam were devised, as per today, no ready product is available. On a global scale the application *OurCalling* from the US just like our application lists services such as addiction recovery, food resources and shelter. *Strappd* and *HelpFinderNYC* operate similarly. For all of them is true though that they only work in a very limited area and that the services are added manually hence undynamically.

3.1.7 Ethics. As mentioned in section 1 homeless people are a very sensitive group of people in our society. Any contact with them has to be well-considered to not make a wrong impression on them. Particularly members of less represented groups often get the feeling that scientists only want to instrumentalise them for their research. A sincere interest in their situation is indispensable. Considering this we always approached a person with a mediator who acquainted us with him/her. Let alone, we never approached someone without his/her consent. Additionally, all the answers we received from people (see subsection 3.2) regardless of their content were candidly taken into account and included in our assessment.

3.1.8 Organisations. Very kindly the *Huis van Sant'Egidio* which is located in the centre of Amsterdam agreed on helping us with our project. Sant'Egidio is a Christian community that is concerned with charity work all over the world. On Tuesdays and Fridays they hand out food in the city centre of Amsterdam to people in need. In total we attended three meetings during which we assisted the volunteers in distributing the food and got in contact with the

homeless people.
A further stakeholder of the project Digital Divide is the Municipality of Amsterdam. The municipality was one of the hosts of the Digi Challenge, a kick-off event about the digital divide in Amsterdam in December 2018. We arranged one meeting with a representative of the department for homeless people who provided us with information on the current situation within the municipality. By its very nature municipalities design projects on a much larger scale and have to satisfy many other stakeholders. Therefore, the allocation of appropriate staff and the mobilisation of necessary funds can be arduous and slow. This assumption was reconfirmed by the representative of the municipality in Amsterdam when he stated that there indeed was a project to address digital needs of homeless people in Amsterdam but it had to be discontinued due to the aforementioned reasons.
Considering other topics at the Virje Universiteit Amsterdam in the department of Computer Science the ICT4D research group under the supervision of Anna Bon clearly stands out through social projects in countries worldwide. This may have caused the internal newspaper of the Vrije Universiteit Amsterdam, *AdValvas*, to become aware of our project. As a consequence one of their journalists invited us to give a short speech about the project. The corresponding article can be found here.

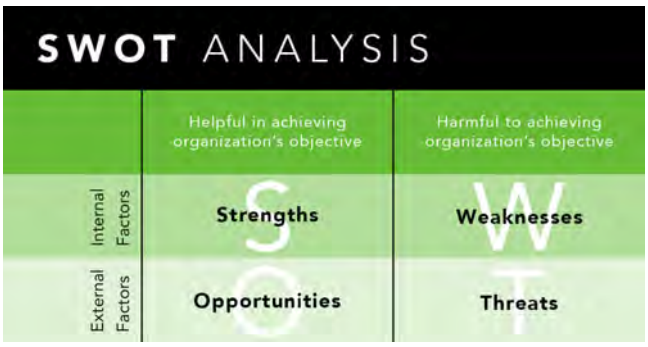

Figure 2: Overview SWOT Analysis

A SWOT analysis was conducted to get further insight into how the factors emerged from the Context Analysis are intertwined and how they affect the project. This is a strategic technique to identify **s**trengths, **w**eaknesses, **o**pportunities and **t**hreats, normally of a business. Long since, though, this strategy has found its way into academic projects too. It is deemed as a gold standard that helps to not disregard negative influences (weaknesses and threats) and equally to fully exhaust positive ones (strengths and opportunities). The former have an internal character meaning they arise from the project itself whereas the latter spring from external parties (see Figure 2). The results of this SWOT analysis are captured in Figure 3.

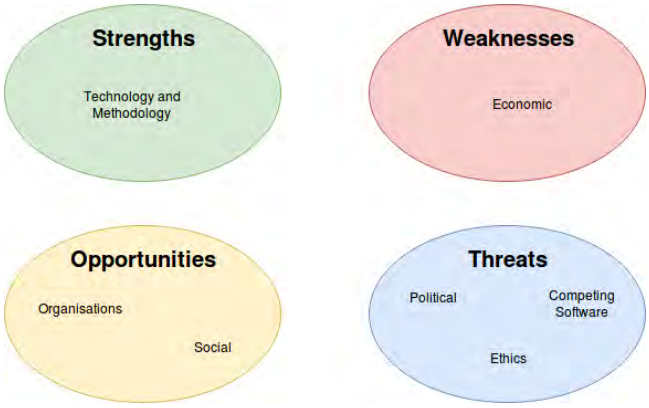

Figure 3: Results of SWOT analysis on factors of the Context Analysis

3.2 Needs assessment

During this phase the customer's needs for the application, in this case the homeless people, are determined. In order to do so, this vulnerable target group required a considered and cautious approach. Hence, it was desisted from conducting structured interviews. We rather tried to informally elicit their needs and expectations which is in line with subsubsection 3.1.7. On that account four questions were elaborated which were either asked in informal 1-on-1 interviews or handed out via a questionnaire (see subsection 9.2). Naturally, depending on the interviewee the questions sometimes had to be slightly modified in order to get more extensive or more precise answers; this especially holds for the open questions 3 and 4. Because some people were sometimes only willing to answer questions partially, we here refrain from giving an exact number of participants. We roughly interviewed 30 participants in this first test session which constitutes an approximate one third of the total number of people who on overage visit Sant'Egidio.

(1) **Do you own a smart phone?** (*Yes / No*)

(2) **How often do you use your smart phone per day?** (*<1h / 1h / 2h / 3-5h / >5h*)

(3) **Which applications are installed on your smart phone and which of them would you consider the most useful?** (*open question*)

(4) **What is the most crucial information you get in your everyday life?** (*open question*)

The reasoning behind this selection is as follows.
Question 1 aims at getting an overview over how many people actually could use the application. [6, 13] have shown that an approximate 50% of homeless people own a smart phone. Due to political, technological and socioeconomic similarities between the United States and the Netherlands we presumed a similar number.
Question 2 gives insight into how the person currently uses his/her smart phone. We expect people who spend more time on and with

their phone to have a better understanding of where to find useful information than people who barely use it.
Question 3 rather focuses on the scope of the information. Is the information we supply something that the target group is really interested in? Also, are we right in assuming that this group of people wants to use their smart phone as a source of information or do they rather use it for example for leisure pursuit or communication? For instance, our application heavily relies on the use of *Google* and its various services. Users who are already familiar with Google and its usability and functionality will understand and be able to use our application without any problems.
Through Question 4 the globe is expanded from mere digital information to information in general. We strived to ascertain which type of information the target group deems relevant.

A selection of answers:

"Except for this place [Sant'Egidio] I don't know where to get free food."

"I ask my friends and they show me where to find clothes."

"WiFi is really important for me."

After evaluating the answers and speaking to all stakeholders involved six categories were identified as most vital. Those are:

- Food
- Shelter
- Medical Aid
- Education
- Useful good (such as clothes, chargers and bags)
- WiFi

3.3 Requirement Engineering

In systems and software engineering this step is characterised by finding an appropriate way to descriptively explain the requirements that the needs assessment yielded. Thus, this phase serves as a connection between the requirements found and their technical implementation. It comprises the steps *Requirement Analysis*, where the needs are identified and *Requirement Design*, that aims at conceptualising a coherent software system that meets all the needs.
A distinction is made between *functional* and *non-functional* requirements. The former are defined as "functions of a system or its component, where a function is described as a specification of behaviour between outputs and inputs" [5]. This comprises any functionality that is necessary to satisfy the needs from subsection 3.2. Non-Functional requirements on the other hand are "requirements that specify criteria that can be used to judge the operation of a system, rather than specific behaviours" [3]. These are requirements such as reliability and accuracy supporting the functional requirements. As mentioned before this thesis focuses on the efficient and sustainable procurement and processing of the data. Thus, topics such as usability and design are only covered peripherally. Marc Hegeman's master project gives further insight. To get a feeling of the application though Figure 4 shows the home screen with the six categories, derived from the needs assessment.
The second test session was in contrast to the first one not only conducted with the target group but also with other stakeholders like the organisation team of Sant'Egidio and officials from the municipality of Amsterdam. By that we ensured that every party (see subsection 3.1) is actively involved in our purposes.

These functional requirements were elaborated in the course of the requirement engineering with all stakeholders:

- Name of locality
- Address
- Telephone number
- Opening hours
- Homepage

We included two more requirements that were not mentioned by stakeholders:

- Photo
- Rating

The photo provides the page of a certain place with familiarity and kindness. The rating is used to give the end-user a feeling about the quality of the place.

Figure 4: Home screen of our application

We identified several non-functional requirements that will help serving high quality data:

Accuracy
The places that our system returns have to be existing places

in Amsterdam. Also, they have to be categorised correctly (e.g. food bank to the category *food*).

Precision
The results have to be repeatable, meaning one end user should be offered the same places when he uses the services in short time intervals. They also have to reproducible which requires that different end users with different devices should get the same information when selecting one of the categories.

Maintainability
From the beginning it was clear that the web host should be connectable to a database which shows the current data for each category in a comprehensible way. It should also be possible anytime for us as developers to intervene and modify data if needed.

Legal
In times of legal threats regarding licensing every use of a third part service has to be in accordance with applicable law. Many services at least require to appear somewhere on the application or to be named in the licensing section.

Usability
Ideally our software should be usable by a person who has never touched a smart phone before. Thus, also the data has to be as clear as possible. Here the data we retrieve should be understandable without further explanation.

Performance
These days we are used to immediate handling of our requests. Despite our limited technical capacities we aspired after a highly performant service.

Integrity
The data should be consistent over the whole life-cycle. This also includes data retention, which is the ability to restore data from the database.

Reliability
Reliability is one of the pillars of high-quality systems engineering. From our perspective it would be a worst-case scenario if a person in need was unable to reach our service because the server is down or similar. Some problems are unforeseeable but it is wise to always have a backup just in case.

In addition to functional and non-functional requirements, we added *basic requirements* for each category that concern general aspects about existing law, regulations and ethics. This can also concern requirements that were not explicitly mentioned by interviewees but are in our opinion crucial and self-evident. We also included *specific requirements* which were mentioned during the second test session. These requirements will have to be implemented independently. However, not all of them could be incorporated into our system (see Figure 5).

	Basic requirements	Specific requirements
Food	Food banks or very affordable restaurants. Naturally only official organisations were considered that comply with the regulations of the Dutch Health authority and periodically undergo a health examination.	A surprisingly high number of the interviewees indicated that they are vegetarian or even vegan. Food banks also represent a social meeting point for many homeless people. Hence, a building that allows them to sit down and talk to each other is preferred. This will be even more important in the cold winter time.
Shelter	This category mainly includes homeless shelters that are fully roofed and heated. Beds with mattresses and a blanket or a bedroll constitute a minimum requirement.	Some interviewees liked to know in advance how many were already in the shelter, respectively how many people were expected to come.
Medical Aid	A practice or a hospital that treats in case of need without asking for identification or Dutch health insurance. The practising doctors should be specialised in health issues that prevail among homeless people.	Ideally, the health workers speak multiple languages to overcome possible language barriers. Many people reported to feel stigmatisation when seeking medical help, which can deter them from doing so. Health workers should be considerate of that.
Education	Places where the target group can find free books or attend training courses on various topics.	If personnel is available they could assist in finding what they are looking for or in giving some advice on a certain topic.
Useful Goods	Cleanness and proper functioning are necessities.	Clothes and electronic devices were frequently mentioned as most important goods.
WiFi	The WiFi has to be completely free of charge and nothing has to be purchased in order to use it.	Some people expressed concerns on data privacy. They should not be urged to enter personal information such as name or email address to use the WiFi.

Figure 5: Basic and specific requirements for the six categories

Overview

Time-wise the actual engineering part overlapped with the requirement engineering part. This was necessary because of the limited time frame of the project. Since we were a team of two people,though, we managed to smoothly merge the phases.
Figure 6 shows a UML use case diagram of the software which we devised after the Requirement Engineering.
In a typical use case scenario the end user clicks on one of the six icons to know where he can find places providing that service. There are two ways how the database is filled with information. On the one hand we manually created a list containing the in our estimation most adequate places for each category in Amsterdam. On the other hand there an algorithm (subsubsection 6.0.5) is being run periodically that fills the database with additional information. Together this information is displayed on our application and can be viewed by the end user.

4 ENGINEERING

4.1 Idea

When we searched the web for suitable places in Amsterdam that should be included into our predefined list (see Figure 6), we quickly noticed that we needed many search queries to find them - yet still we assumed that we did not manage to find all of them. We came up with the idea to use two or three words that unambiguously describe what we wanted to find. We then wanted to use similar words to enrich the search query and combine all of the search results to our final outcome. This was realised with a NLP approach.

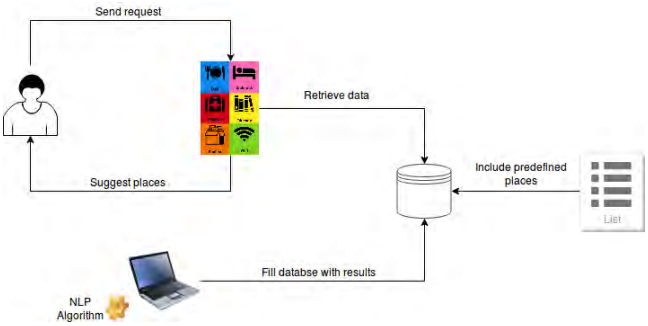

Figure 6: Use case scenario of our application

4.2 Essentials

4.2.1 Google. Since the application requires dynamic and live data, an adequate data source had to be found. Soon Google emerged as the best candidate due to its large amount of data and its completeness of content. The *PageRank* algorithm that was invented by Larry Page and Sergey Brin in 1997 laid the ground stone for the later success of Google. Google offers an API[6] for developers so they can have access to its services such as *Google Maps*. This API corresponds with the results you get when you search for a venue. Integrated in Google Maps there is a service called *Google Places* which provides information such as opening hours, rating or telephone number of a certain place. As Figure 7 shows, Google Places offers all the information we defined as necessary for our application (see subsection 3.3). At the moment the free license we acquired from Google grants 150,000 request per month which is definitely enough for the current scope of the project.
Although Google is undoubtedly the most used search engine (77% of all search request are made on Google), search results depend on the quality and validity of the words entered. As a consequence many potentially correct results are either omitted by Google's optimisation algorithm or do not even appear in the list of results.

4.2.2 Word Embedding. After word embeddings (see subsection 2.2) haven been overly successful in almost any NLP task in the last few years, their number has increased alike. As of this writing the algorithm had to be run on a local machine[7] which excluded the use of huge word embeddings. This may, but not necessarily does, have an effect on the result. After some testing the Word Embedding *GloVe.6B.300d* was selected. This word embedding is based on the Wikipedia 2014 and the Gigaword corpus, which was created by the Linguistic Data Consortium (LDC). The *6B* stands for 6 billion tokens, how single words are called in this context. The *300* describes the number of dimensions. On Figure 8 one can see that - in compliance with the distributional hypothesis - words that usually appear in the same context like *bottle* and *alcohol* or *laundry* and *dryer* are semantically similar and thus relatively close together in the word embedding.

4.2.3 Cosine Similarity. If one now would want to quantify how similar two words actually are, a mathematical metric is needed.

[6] Application Programming Interface: Set of clearly defined methods of communication among various component
[7] Latitude-E6320, 4GB RAM, IntelÂő CoreâĎć i5-2520M CPU @ 2.50GHz × 4

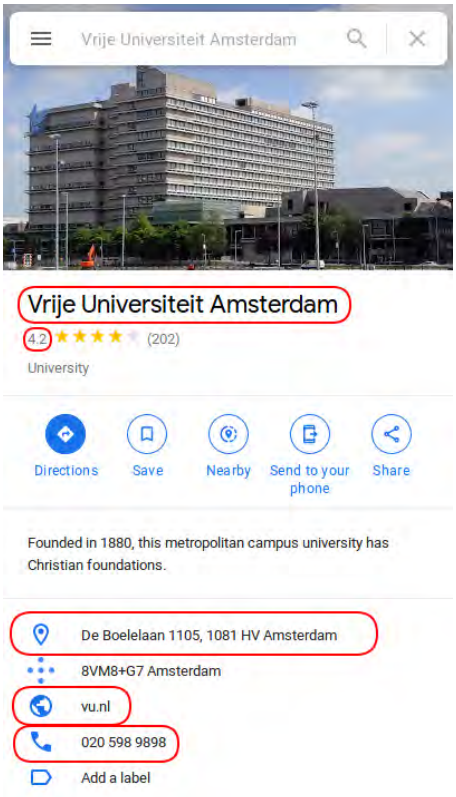

Figure 7: Google Places information about the Vrije Universiteit Amsterdam

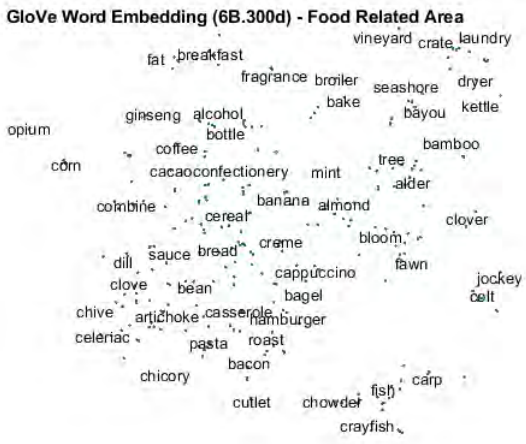

Figure 8: Selection of food related words in the word embedding GloVe.6B.300d (link)

The cosine similarity has been proved to be successful in many NLP tasks where word embeddings were deployed.
For two word embedding vectors v_1 and v_2 of two words w_1 and

w_2 their cosine similarity is defined as:

$$\text{similarity}(w_1, w_2) = cos(\theta) = \frac{v_1 \cdot v_2}{|v_1| \cdot |v_2|} \qquad \theta : \sphericalangle v_1, v_2$$

The value of similarity has the interval [-1,1]. The closer it is to 1, the closer both words in the word embedding and the more similar they are. Two identical words have a similarity of 1 (see Figure 9).

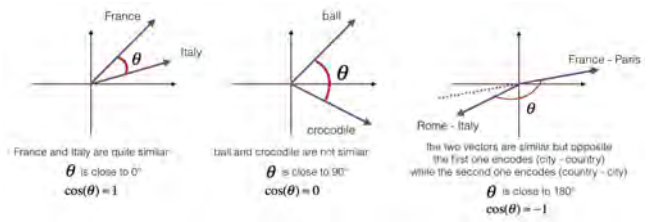

Figure 9: Illustration of different cosine values between two words (link)

4.2.4 Python. Everything was solely and exclusively programmed in the programming language *Python 3.7.3*. This was a clear choice since Python has a very active community and offers a wide range of libraries, especially in the realm of NLP. For the calculation of the cosine similarity this was the excellent NLP library *gensim*. To smoothly connect with WordPress the library *python-wordpress-xmlrpc* was used. XML-RPC is a remote procedure call protocol which uses XML to encode its calls and HTTP as a transport mechanism, whereby it allowed us to automatically sign in to our Wordpress website. Still a lot of data formatting had to be made until the data retrieved from Google was suitable for the internal WordPress structure.

4.2.5 WordPress. WordPress is a free content-management system and used on roughly 30% of all web pages[8] by now. It captivates due to its straightforward usability and its adoptability of other services. So technically we did not create an application but a website-application-hybrid, which is a website that you can save on your desktop. By that the services can be used just like an application without internet connection once its is fully loaded.

4.3 Algorithm

The expanded Google query is composed of three words per category. The first word w is the name of the category e.g. *food*. The second word is always the word *homeless*. This has two reasons. First, the word *homeless* is a concise and meaningful words in many regards. Semantically it includes the fact that the offered service should preferably be for free since homeless people are probably unable to spend a lot of money. Secondly, the Google algorithm identifies certain places as suitable for this target group. The third word signifies the city respectively the location where to search. Currently this is set to *Amsterdam* but can be changed dynamically to the user's location. The location tells Google that a place is wanted as opposed to a website.
Now by the means of the cosine similarity the word embedding is searched for the most similar words to w, here *food*. Based on that the 30 most similar words of w were chosen. On a first sight 30 may seem fairly high, considering the postprocessing, though, which eliminated many places the number was reasonable. Since the Google algorithm also regards the order of the words, as a last step the first and the second word were turned around; the third word for the location, here Amsterdam, seemed to have no effect on the outcome when placed somewhere else. Figure 10 shows the procedure using the examplaric category *food*. On our application the places are displayed in decreasing order from most to least relevant. The relevance here is determined by the value of the similarity.

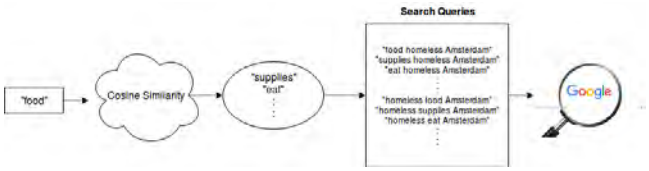

Figure 10: Schematic illustration of the algorithm

4.4 Preprocessing

One disadvantage word embeddings clearly have is that they only consider tokens i.e. single words. Hence, the algorithm is unable to intake the word *food bank* but would perceive it as a composition of the two independent words *food* and *bank* which evidently does not reflect the meaning of the word. Consequently, the terms *medical aid* and *useful goods* were shortened to *hospital* and *goods* respectively.

4.5 Postprocessing

Some postprocessing was necessary to get accurate results. Conveniently, the Google API also stores *tags* about places.
Since we were looking for places that were (almost) free of charge, we dismissed all results that contained the tag *restaurant*, *cafe* or *store*. Also, some places have a *pricetag* ranging from € to ~~€€€€~~ insinuating that one will be charged. These places were also omitted.

4.6 Results

As a baseline serve all the places we were able to find by just using the category word (e.g *"food homeless Amsterdam"*).

Category	Query word	# Found places (basic)	# Found places (+ NLP)
Food	"food"	4	18
Shelter	"shelter"	1	9
Medical Aid	"hospital"	8	36
Education	"education"	-	39
Useful Goods	"goods"	4	14
WiFi	"wifi"	-	7

[8] https://trends.builtwith.com/cms

Our algorithm managed to expand the list of places for each category, in some cases magnificently. The exact list with results can be found in subsection 9.3.

4.7 Evaluation

In order to asses the algorithm and the results it yields, we take a look back on the (non-)functional requirements (see subsection 3.3). Unfortunately it was impossible to derive the basic and specific requirements from the Google results. Some of the information in these requirements is not even manually retrievable, let alone with a Google query. Also, a metric would have to be conceived to evaluate some of the requirements.
The functional requirements could be met satisfyingly with the help of the information on Google.
The non-functional requirements that only concern the algorithm itself as opposed to the whole application and that are objectively examinable are:

Precision
The algorithm does not depend on the operating system, the end user or other external factors. One click on the category suffices to get the results which will only change when new places are traceable on Google (a recently started business, place with better SEO[9], ...) or old ones are not detected anymore (closed, different name,...)

Data integrity
We only have one database where information is stored, which is a *MySQL* database used in combination with *phpadmin*[10] to connect to WordPress. Therefore, modification of data (inserting, altering, deleting) will always affect the whole system.

4.8 Testing

We used the third session as a test session to ascertain if the target group was satisfied with our application and what in their view still has to implemented or adapted. The critique was positive in every aspect. Some of them even asked us if they could use the application right away.
To this point the front end of the application was in English and Dutch. The interviews elicited that there is a considerable number of people who speak neither of those languages sufficiently to properly use our service. Languages that were mentioned the most were Arabic, Polish, Spanish and Russian. We used a plugin in Wordpress to translate the data.
A forth session is planned to conclusively verify the application.

4.9 Further improvements

After the requirements engineering repeatedly new ideas how we could improve design and/or functionality of the application came to our minds. We always meticulously minded that we did not change the fundamental concept of the software.

4.9.1 Bilateral Rating system. Alongside the current Google rating of a place (see subsection 3.3) which already contributes to quality assurance we also established an internal bilateral rating system. Although this rating system was not a requirement that initially was derived from the needs assessment, it is supposed to enhance the sustainability of the data. On each place we included a *thumbs up* and a *thumbs down* together with the question "*Does this place offer what you expected*". This gives us first hand information on the quality of our Google results. In addition to that we wrote a script that composes an email saying that we are two master students writing their theses who would like to know if this place indeed is a food bank, shelter, etc and then send it to the owner/operator of the locality. Currently this script is not yet activated because we decided to first wait for the evaluation made by the users. We also had to adhere to the *GDPR*[11] which was enacted in the European Union in 2018.

4.9.2 Comment. To gain a more meaningful insight into the acceptance of our service, we also included a comment section under each place. In contrast to the rating system these entries have to be evaluated manually to understand what exactly user wanted to convey. The comment section could also expand the basic and specific requirements which were defined in subsection 3.3. Possibly our sample group disregarded aspects that other people in a similar position would deem mandatory.

5 SUSTAINABILITY ANALYSIS

Sustainability is becoming more and more a factor in system engineering, which is why it is dedicated a separate section. Anna Bon and her research group also direct their particular attention on the question how to build effective software systems that are resource saving at the same time. What makes sustainability so hard to grasp and to implement is one side the fact that everyone has a different idea of its meaning. On the other side people often associate sustainability with sacrifice or abstinence which makes it an unpopular issue in political discussions. We decided to scrutinise our entire application regarding its sustainability based on the framework devised by Lago et al. [8]. They proposed that sustainability as a software quality should be perceived in four dimensions: *social, economic, environmental and technical*. Especially the dimensions social and environmental should be regarded more highly in the future compared to economic and technical if one really aspires to create a sustainable software product. Naturally the dimensions affect each other and a trade off has to be made for the final software solution.

Social
By advertising places such as food banks or shelters our project can further communities within the group of the homeless people. In this group a person can benefit from mutual activities or can rely on someone else's advice or help. Another aspect of social sustainability is the quality of life

[9]Search engine optimisation: process of increasing the quality and quantity of website traffic by increasing visibility of a website or a web page to users of a web search engine
[10]free software tool written in PHP, intended to handle the administration of MySQL over the Web
[11]Regulation in EU law on data protection and privacy for all individual citizens of the European Union (EU) and the European Economic Area (EEA)

which covers an appropriate supply of health, housing, education, employment and safety. Three out of these categories are directly approached by our service. This will eventually warrant that future generations ending up in such a situation can already build upon an existing stable structure.

Economic
At this stage the entire project is drastically inexpensive and depending on future plans at least has the potential to stay like that. Throughout it was our highest concern to create a software for every person that owns a web enabled device or knows such a person in his/her surrounding and has momentary access to the internet, regardless of his/her financial situation.

Environmental
This dimension is hard to asses based on the information we have. Just recently after a long period of silence Google gave insight into their energy consumption. Among others they reported that one average Google query equals 0.0003 kWh or 0.2 of carbon dioxide. This should be considered when automatically firing Google requests. Apart from that our project seems too minuscule (no big servers, no facilities) to have an perceptible environmental impact.

Technical
One pillar of technical sustainability is long range planning. This certainly is the case for our project; we conceptualised a software that should deliver valid results even in many years from now. In this fast changing era, where countless new software is launched every day, technical sustainability is an invaluable asset.

One should bear in mind, however, that these assertions refer to the current scope, the city of Amsterdam. Extrapolating the software to other cities or even countries will surely require more resources, especially financial wise.

6 LIMITATIONS AND FUTURE WORK

6.0.1 Google. Our software heavily relies on the information provided by Google. Over the past years Google has managed to build a vast data empire. Nevertheless, the information is not always flawless. For the future use a critical accuracy examination of the places should be conducted. Presumably though, this has to be done manually. We for our part included additional features (see subsection 4.9) to contain the impact of Google on our results. Still at the moment we do not see a different source of information which gets somewhere close to Google's abundance and quality of data.

6.0.2 Language. To this stage the algorithm solely focuses on word of the English language. We promised ourselves a higher quality of results when sending requests in English. Also, word embeddings for other languages for the greater part are less extensive and tested. This is why we decided to initially find the places by using English words and then afterwards to translate our findings to the desired language.

6.0.3 Word Embedding. For the future multiple Word Embeddings should be tested although *GloVe* constitutes a much-cited data basis. The problem of disregarded composite words like *food banks* was already covered in subsection 4.4.

6.0.4 Predefined List. Our predefined list of places for each category served as a baseline which we could compare our results to. This list too is not proven to be accurate though. Based on information on the respective homepage, reviews and conversation with responsibles we drew the conclusion that the places on the list are adequate for our purpose. This part of our solution slightly taints dynamic and sustainability as someone will have to update it at some point.

6.0.5 Algorithm. The algorithm has many parameters that decisively determine the result, such as which word is defined in the beginning to concisely and accurately describe the category or how many similar words are chosen. Again, in order to entirely evaluate the algorithm, qualitative information are necessary (*Does the place indeed belong to the category indicated?* or *Is this place suited for homeless people?*.

6.0.6 Social effects. The social repercussions of our application which were partially covered in section 1 cannot be assessed in such a short time. This will require a whole new research approach. However, we are confident that the software will lead to immediate information empowerment among homeless people in Amsterdam.

7 CONCLUSION

This paper aims at explaining how an application has to be conceptualised and then later developed to provide homeless people in Amsterdam with information on food, shelter, medical aid, education, useful goods and WiFi. Altogether, Marc and I managed to create an application that answers all expectations we had delineated before. Our thorough needs assessment not only answered *RQ1*, namely which information is crucial for homeless people (see section 1), but also set the ground stone for the whole purpose of our endeavour. The consistently positive feedback we received from homeless people in Sant'Egidio but also from people who were otherwise involved in the project was both motivating and assuring.
The core part of our application is the algorithm based on a Natural Language Processing approach that was presented in this paper; it confers the application dynamic and persistence. By that also *RQ2* with its two sub-research questions could be answered. In case of questions and remarks of all sorts, Marc and I will be on hand with help and advice.

8 ACKNOWLEDGEMENTS

First of all, I would like to express my most sincere gratitude to Anna Bon and her research team who enabled us to work on such an interesting topic at the interface between society and technology. Further on I would like to thank all parties that were directly or indirectly engaged with the project. This includes the municipality

of Amsterdam who has made the project Digital Divide in Amsterdam possible in the first place. A special thanks is due to the Huis Sant'Egidio at Waterlooplein in Amsterdam. Although we connected many institutions for homeless people in Amsterdam they were the only ones that were willing to assist us and that were open during the summer months. Throughout the project they supported us wherever they could. As this is a highly collaborative work, I would also like to thank Marc Hegeman; without his contribution the application would not exist in the current form. Working together with him was always constructive and inspiring.

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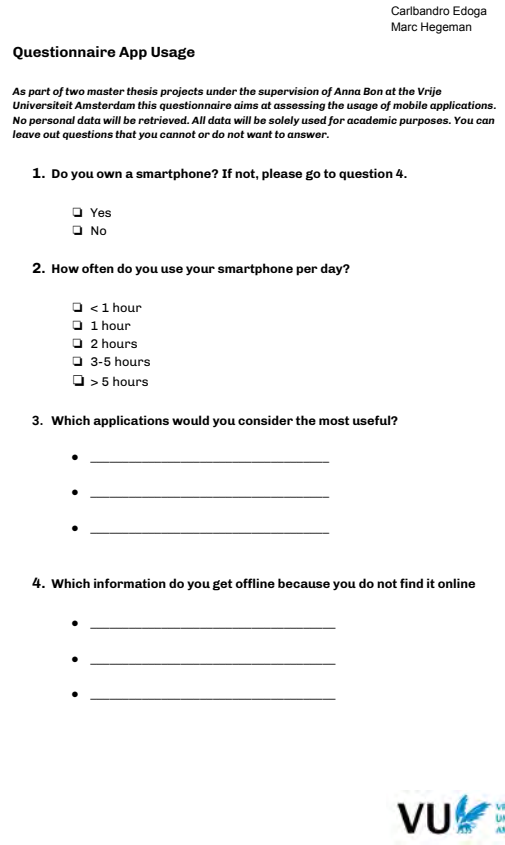
9 APPENDIX

9.1 Appendix A

List of Figures

9.2 Appendix B



Carlbandro Edoga
Marc Hegeman

Questionnaire App Usage

As part of two master thesis projects under the supervision of Anna Bon at the Vrije Universiteit Amsterdam this questionnaire aims at assessing the usage of mobile applications. No personal data will be retrieved. All data will be solely used for academic purposes. You can leave out questions that you cannot or do not want to answer.

1. **Do you own a smartphone? If not, please go to question 4.**

   - ❑ Yes
   - ❑ No

2. **How often do you use your smartphone per day?**

   - ❑ < 1 hour
   - ❑ 1 hour
   - ❑ 2 hours
   - ❑ 3-5 hours
   - ❑ > 5 hours

3. **Which applications would you consider the most useful?**

   - _____
   - _____
   - _____

4. **Which information do you get offline because you do not find it online**

   - _____
   - _____
   - _____

VU VRIJE UNIVERSITEIT AMSTERDAM

Figure 11: Questionnaire for Needs Assessment

9.3 Appendix C

Category	30 most similar words with cosine similarity	Results with basic search	Results with algorithm
Food	[('foods', 0.669407069683075), ('supplies', 0.6068812608718872), ('eat', 0.5903003215789795), ('meat', 0.5677604675292969), ('eating', 0.5674232244491577), ('meals', 0.5671917796134949), ('products', 0.5494305491447449), ('meal', 0.5464716553688049), ('vegetables', 0.544741153717041), ('nutrition', 0.5385702848434448), ('foodstuffs', 0.5342221260070801), ('supply', 0.5310319662094116), ('goods', 0.5256985425949097), ('cooking', 0.5212074518203735), ('feed', 0.5201836228370667), ('aid', 0.5129438638687134), ('bread', 0.5100951194763184), ('rations', 0.5082888603210449), ('drinks', 0.508281946182251), ('medicines', 0.5072884559631348), ('shortages', 0.5024582147598267), ('items', 0.49599534273147583), ('clothing', 0.49313241243362427), ('restaurants', 0.4853544235229492), ('grain', 0.48232826590538025), ('seafood', 0.481238454580307), ('water', 0.48117268085479736), ('ingredients', 0.48040270805358887), ('staple', 0.4801837205886841), ('health', 0.4780890643596649)]	Stichting Stoelenproject Foundation Food Bank Amsterdam De Regenboog Groep Nieuwmarkt	Inloophuis De Princehof Stichting Stoelenproject Foundation Food Bank Amsterdam Inloophuis Makom Inloophuis De Kloof Inloophuis Blaka Watra Inloophuis Oud-West De Regenboog Groep Passantenhotel Sanna Sumner Nutrition Anna's Nutrition Italiaanse kookschool Stichting HVO-Querido Eating Amsterdam Food Tours Domus 3 Leger des Heils Inloophuis De Spreekbuis Majoor Bosshardtburgh Amsterdammers Helpen Amsterdammers

Shelter	[('foods', 0.669407069683075), ('supplies', 0.6068812608718872), ('eat', 0.5903003215789795), ('meat', 0.5677604675292969), ('eating', 0.5674232244491577), ('meals', 0.5671917796134949), ('products', 0.5494305491447449), ('meal', 0.5464716553688049), ('vegetables', 0.544741153717041), ('nutrition', 0.5385702848434448), ('foodstuffs', 0.5342221260070801), ('supply', 0.5310319662094116), ('goods', 0.5256985425949097), ('cooking', 0.5212074518203735), ('feed', 0.5201836228370667), ('aid', 0.5129438638687134), ('bread', 0.5100951194763184), ('rations', 0.5082888603210449), ('drinks', 0.508281946182251), ('medicines', 0.5072884559631348), ('shortages', 0.5024582147598267), ('items', 0.49599534273147583), ('clothing', 0.49313241243362427), ('restaurants', 0.4853544235229492), ('grain', 0.48232826590538025), ('seafood', 0.481238454580307), ('water', 0.48117268085479736), ('ingredients', 0.48040270805358887), ('staple', 0.4801837205886841), ('health', 0.4780890643596649)]	Foundation Food Bank Amsterdam	Dierenopvang Amsterdam Shelter City Hostel Amsterdam Shelter Jordan Amsterdam Hostel Stichting Stoelenproject Sanna Sumner Nutrition De Poezenboot Arons and Gelauff Salvation Army Welfare and Health
Medical Aid	[('hospitals', 0.7079260349273682),	Amsterdam UMC, locatie VUmc Academic Medical Centre	Amsterdam UMC, locatie VUmc OLVG location East

	('medical', 0.690507173538208), ('clinic', 0.6487334966659546), ('doctors', 0.6249721050262451), ('psychiatric', 0.5711121559143066), ('doctor', 0.568318784236908), ('care', 0.5647674202919006), ('patients', 0.5621917247772217), ('hospitalized', 0.5581384897232056), ('ambulance', 0.5498062372207642), ('patient', 0.5410522222518921), ('nursing', 0.5383747220039368), ('nurse', 0.5382150411605835), ('surgery', 0.5326883792877197), ('treatment', 0.5252301096916199), ('wounded', 0.5250986814498901), ('condition', 0.5221331715583801), ('treated', 0.5177657604217529), ('health', 0.5055230855941772), ('physician', 0.494479775428772), ('died', 0.49033123254776), ('nearby', 0.48802852630615234), ('infirmary', 0.4857127070426941), ('morgue', 0.481844961643219), ('heart', 0.4807090163230896), ('surgeon', 0.47617214918136597), ('nurses', 0.4708079695701599), ('maternity', 0.46984878182411194), ('wounds', 0.4649696946144104), ('outpatient', 0.4638965427875519)]	OLVG, location West OLVG location East Amsterdam Tourist Doctors Passantenhotel De Regenboog Groep Ambulant Team Noord	OLVG, location West BovenIJ ziekenhuis Doctor Service Amsterdam, Expat Medical Center Passantenhotel Amsterdam Tourist Doctors Tourist Doctor Amsterdam A'dam Doctors Central Doctors Stichting Stoelenproject De Regenboog Groep Stichting Doctors for Homeless Found. Stichting HVO-Querido Inloophuis De Princehof - De Regenboog Groep Inloophuis Makom, De Regenboog Groep Inloophuis De Kloof - De Regenboog Groep Inloophuis Blaka Watra - De Regenboog Groep Inloophuis Oud-West- De Regenboog Groep Inloophuis De Spreekbuis- De Regenboog Groep Domus 3 Leger des Heils Lommerrijk Wonen Inloophui s Ondro Bong- De Regenboog Groep Majoor Bosshardtburgh Amsterdammers Helpen Amsterdammers Reigerplek Paalbergweg Het Wapen Van Riga Belangenvereniging Druggebruikers MDHG Ambulance Amsterdam Stichting Kuria Bewonerscommissie De Aak AMOC Walk-In Centre Heart of Amsterdam Stichting NL Cares Herstart English Reformed Church, Amsterdam
Education	[('educational', 0.7371156811714172), ('schools', 0.6788167953491211),	No places found	Inloophuis De Princehof - De Regenboog Groep The British School of Amsterdam Amsterdam International Community

	('teaching', 0.6455217003822327), ('health', 0.6404516696929932), ('curriculum', 0.6398585438728333), ('school', 0.6297630667686462), ('programs', 0.6106065511703491), ('students', 0.602547287940979), ('vocational', 0.5982197523117065), ('teachers', 0.5969220995903015), ('academic', 0.5789217948913574), ('teacher', 0.5788564682006836), ('schooling', 0.5754714012145996), ('social', 0.5727742314338684), ('learning', 0.5630523562431335), ('care', 0.5593063235282898), ('science', 0.5584522485733032), ('program', 0.5559808611869812), ('colleges', 0.5549830794334412), ('college', 0.5526309609413147), ('public', 0.5524200201034546), ('welfare', 0.5477100610733032), ('graduate', 0.5363028049468994), ('student', 0.5337462425231934), ('funding', 0.5327966213226318), ('development', 0.5293144583702087), ('courses', 0.5254578590393066), ('reform', 0.5237506628036499), ('arts', 0.5222621560096741), ('literacy', 0.5197247862815857)]		School AICS Satellite Amsterdam School of the Arts Stichting Stoelenproject Inloophuis Makom, De Regenboog Groep Inloophuis De Kloof - De Regenboog Groep Passantenhotel De Regenboog Groep Inloophuis Blaka Watra - De Regenboog Groep Domus 3 Leger des Heils Inloophuis Oud-West- De Regenboog Groep Inloophuis De Spreekbuis- De Regenboog Groep Reigerplek Paalbergweg Lommerrijk Wonen Inloophui s Ondro Bong- De Regenboog Groep Majoor Bosshardtburgh Amsterdammers Helpen Amsterdammers Het Wapen Van Riga Stichting HVO-Querido Belangenvereniging Druggebruikers MDHG NEMO Science Museum Amsterdam University College UvA PPLE Academy of Architecture Cannabis College University of Amsterdam Amsterdam University of Applied Sciences The College Hotel Prince Claus Fund for Culture and Development English Reformed Church, Amsterdam Art Chapel Amsterdam Affordable Art Fair Amsterdam AICS South East Bewonerscommissie De Aak AMOC Walk-In Centre VluchtelingenWerk Nederland Stichting Hvo-querido
Useful Goods	[('products', 0.6454414129257202), ('imports', 0.6368396878242493), ('exports', 0.6308286786079407),	Stichting Stoelenproject Inloophuis De Kloof - De Regenboog Groep De Regenboog Groep Passantenhotel	De Regenboog Groep Stichting Stoelenproject Inloophuis De Princehof - De Regenboog Groep Inloophuis Makom, De Regenboog Groep Inloophuis De Kloof - De Regenboog

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WiFi	[('wi-fi', 0.8057460188865662), ('wi', 0.6679092645645142), ('802.11', 0.6453174352645874), ('bluetooth', 0.6031467318534851),	No places found	Stichting Stoelenproject Passantenhotel De Regenboog Groep gnTel Babbl Telecom Group B.V. Stichting HVO-Querido

	('wireless', 0.5697356462478638), ('connectivity', 0.56831955909729), ('wimax', 0.5635520815849304), ('wlan', 0.5477571487426758), ('router', 0.5382174253463745), ('4g', 0.534935712814331), ('ethernet', 0.5336732268333435), ('voip', 0.5278327465057373), ('gprs', 0.5243924856185913), ('3g', 0.5214462280273438), ('fi', 0.5064341425895691), ('modem', 0.5001892447471619), ('broadband', 0.48768240213394165), ('routers', 0.4858793616294861), ('laptops', 0.4824982285499573), ('adapters', 0.47993090748786926), ('handsets', 0.4756931662559509), ('hotspots', 0.466614305973053), ('dsl', 0.4571734666824341), ('built-in', 0.45615682005882263), ('hsdpa', 0.45483362674713135), ('lte', 0.45060598850250244), ('gsm', 0.4446640610694885), ('adsl', 0.4440551698207855), ('gps', 0.44353151321411133), ('adapter', 0.4424089789390564)]		