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The Spatial Pattern of the Fear of Crime in Lund City among Lund University Students

Mapping with a Web-Based Support System

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Abstract

The fear of crime is a negative emotional reaction of people to possible crimes, and there is sometimes a disparity between the actual crime rate and the fear of crime of people. Geographical researchers often combine the sketch map with the fear of crime to analyze the spatial pattern of the fear. The approaches of neogeography can possibly make the surveys with sketch map more effective and allow the people to participate in the research process. A support system for analyzing the fear of crime based on the sketch maps will be developed, the functions, techniques and the components will be concluded from the existing literatures. Then, this system will be used to analyze the spatial pattern of the fear of crime in Lund among Lund University students and the factors of fear. The spatial disparity of the fear and the actual violent crime spots will also be explored. According to the literatures, the support system should include an online questionnaire with an interactive map, and a GIS analysis process which ensures the data transferability, and several coding and web-mapping techniques were used to fulfill these functions. This study discovered that the most fearful places in Lund to the Lund University students locates in the city center, and some margins of the city are also considered fearful. The reasons include poor lighting, being alone, disorder, media, social network and general fear at night. The spatial distribution of the fear does not correspond to the actual violent crime spots. Further research can be done in the base map readability of the sketch map questionnaires, the effect of the accessibilities or popularities of places on the fear, as well as the regularities behind the fear of crime.

Key words: fear of crime, sketch map, neogeography, Lund, crowdsourcing

1 Introduction

1.1 Background

As the geographical mobility of people become easier, some places are undergoing increasing crime rates (Hartnagel 1997). Such situation is caused by the weakened binding between moving people and the local society, subsequently, people show less commitment to the local social norm (Tittle and Paternoster 1988). Obviously, people tend to avoid being victimized by crimes. In some neighborhoods with high crime rate, especially violent and property crimes, people move out which leads to the instability of the neighborhoods (Boggess and Hipp 2010). Researchers and policy makers have been seeking to reduce the crime for a long time, to make the cities or neighborhoods safer to live (Weisburd et al. 2017; Alonso et al. 2019).

However, there is sometimes a disparity between the actual crime rate and people's fear of crime. People probably feel more secure in some cities or neighborhoods with actually high victimization rate (Curiel and Bishop 2016). Some existing studies have proved that the fear of crime can cause some mental and physical problem. It causes stress and physical inactivity which influence overall well-being (Macassa et al. 2017). While the statistic of actual crime or victimization rate is always substantial, the observation of the fear of crime is not neglectable. In some cases, the fear of crime can be an important consideration in neighborhood planning (Dennis 2006).

As the fear of crime is an important research topic in criminology, researchers have been looking for the factors of it since late 1970s (Shotland et al. 1979; Garofalo 1979). The fear of crime can be generated by several factors, such as the crime victimization, people who suffered from crimes in the past tend to be more fearful to crimes (Pryce, Wilson, and Fuller 2018; Curiel and Bishop 2017). Some demographic factors also affect the fear of crime, including gender and age (Pleggenkuhle and Schafer 2018; Tulloch 2000). In addition, some local conditions are also important factors, such the racial composition of a neighborhood (Pain 2001) and the behavior of the surrounding people (Taylor and Covington 1993).

Besides criminology research, the fear of crime is also investigated in geographical research. Researchers are more interested in the space pattern of the fear, and the sketch map is a common method applied by geography researchers. The web mapping 2.0 technique is becoming popular and makes the online crowdsourcing possible, and this is the base of neogeography (Goodchild 2007). As the sketch map has been a method for investigating people's perception of a place for a long time, and the respondents contribute their own feeling towards a place, it can be considered as an early outline of crowdsourced geographical information. It then becomes reasonable to apply the web mapping 2.0 technique in the sketch map surveys to develop a web-based support system of collecting and analyzing sketch maps of the fear of crime.

Lund is a city of Skåne county in south Sweden. Until October 2018, the population of Lund is around 122,000. According to the statistics of previous years, the population raises every year, and is foreseen to raise continuously (Lunds Kommunkontor 2018; Lunds Kommun 2018). In the common knowledge of people, Lund is considered as a safe city, however, a robbery spike occurred in Lund around the end of 2018 and the beginning of 2019, and generated the fear of crime among people (Expressen 2018). In this case study, I am going to analyze the fear of crime in Lund among Lund University students from the sketch maps collected with the online questionnaire and compare them with the actual violent criminal spots.

1.2 Research aim

The aim of the research is to develop a support system based on sketch maps to explore the spatial pattern of the fear of crime and analyze factors behind the fear of crime in Lund among Lund University students with the system. The support system includes an online questionnaire to collect sketch maps and a GIS analysis process. The analysis of factors behind fear of crime is supported by existing studies.

1.3 Research questions/objectives

This thesis has three research questions.

(1) How can a support system based on sketch maps for analyzing fear of crime studies be developed?

One of the research aims is establishing a support system to analyze the fear of crime based on the sketch map. In this study, this question will be divided into three sub-questions: 1) what are the functions of the system? 2) What kind of technique should be employed? and 3) what are the elements of the system?

(2) What is the spatial pattern of the fear of crime in Lund among Lund University students? And what are the factors behind the fear of crime?

This question is the core of this thesis. In this research, the spatial pattern of the fear of crime will be explored and the factors of the fear will be explained, and the system developed based on the first research question will be used to answer this question.

(3) How is the fear of crime among Lund University students different to the actual crime spots in Lund? If possible, what are the reasons for this?

As I have stated in the background, researchers have noticed a disparity between the actual crime rate and people's fear of crime, in this thesis, I am going to explore the disparity in terms of the spatial pattern.

1.4 Research area

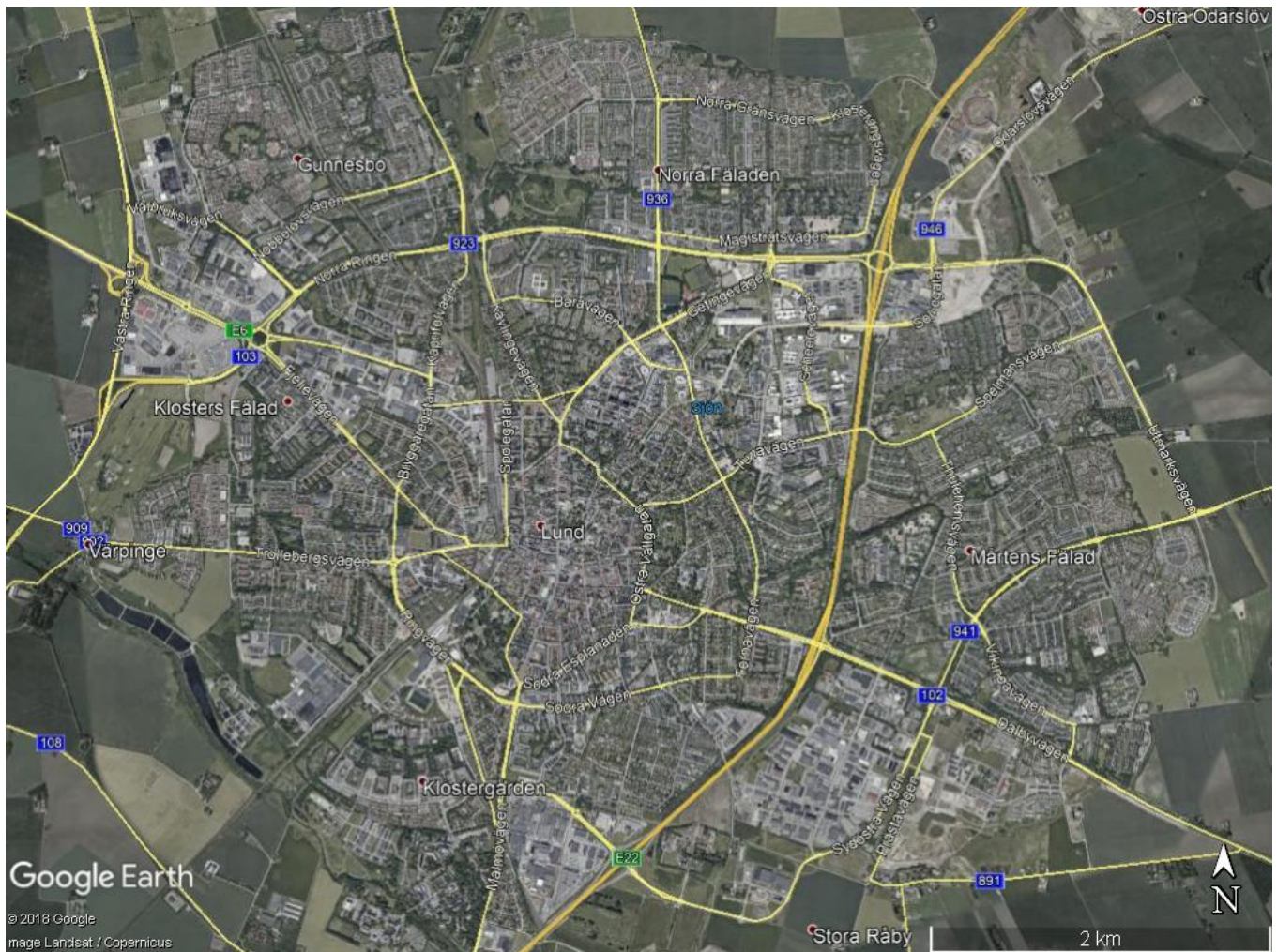


Figure 1. Research area (source: Google Earth Pro)

The research area is Lund city, excluding the towns or villages outside the city area, as shown in figure 2. The south limit of the research area is the intersection of road 108 and highway E22, the north limit is the Lund Nöbbelövs kyrkoväg, the west limit is Värpinge village and the east limit is the intersection of Utmarksvägen and Sandbyvägen. The border of the bounding box of the interactive map in the online questionnaire was also decided by these four limits.

1.5 Thesis outline

This thesis contains several different parts. After this introduction, there will be a brief literature review in chapter 2 about the fear of crime, the sketch map and the neogeography. In chapter 3 the methodology will be described, I will introduce the design of this research, and the method of collecting data. Then, in chapter 4, the result shows how I attempted to answer the three research questions, the development of the support system will be introduced, and the spatial pattern of the

fear of crime in Lund among Lund University students as well as the factors behind the fear will be explored. the spatial disparity of fear and violent crime spots will also be explored. Chapter 5 will be the discussion of this thesis, in this chapter, I am going to write about some reflections on the methodologies of this research, the connections between the findings of this study and other existing studies, and the limitation and some possible further research directions as well. The last chapter will be the conclusion of this study.

2 Literature review and thesis framework

2.1 Definitions of the fear of crime

Because fear of crime is a concept that can be easily interpreted in daily life, earlier research, especially those before 1980s, rarely gave it an explicit definition (Doran and Burgess 2012). Even in some recent research, the definition of the fear of crime is not clarified (J. W. Curtis et al. 2014; Pleggenkuhle and Schafer 2018). Because clarifying the concept of the fear of crime has been neglected, there are not too many definitions of it. The fear of crime was defined as “*a negative emotional reaction to crime or the symbols associated with crime*” (Ferraro and Grange 1987, 72). However, based on the consensus that the fear of crime is a perception, researchers have noticed the difference among perceptions. The perceptions, according to the literature, can be sorted into cognition and emotion, and there are distinctions among them. The emotion is people’s feeling, and the cognition is how people think. Researchers have indicated that the fear of crime should be emotional instead of cognitive (Ferraro and Grange 1987; Doran and Burgess 2012). In other words, the fear of crime should be the feel of threat or negative emotion of being victimized in crimes. On the other hand, the cognitive perception of crime is the self-assessment to the crime risk, it is more related to the actual crime rate but not the personal feeling (Doran and Burgess 2012).

2.2 The spatial pattern of the fear of crime and the actual crime

There have been several studies focusing on the spatial pattern of the fear of crime, however, very few of them explain solely the spatial pattern of the fear, instead, most of the research connects the fear of crime with one or several factors of local conditions. For example, the social network of a person can affect the fear of crime. People feel safer in their own neighborhood when the actual crime rate increases in the neighborhoods of other people who have connection with them, which is a result of the comparison, people compare their own neighborhood with other neighborhoods, when safety of the other neighborhoods gets worse, people tend to feel better in their own neighborhood, even if the actual crime rate in their own place has no significant change (Boessen et al. 2017). In this case, people feel safer when the actual crime rate in their own neighborhood does not change, so it is also an example of the disparity of the fear of crime and the actual crime rate. The disparity was also confirmed in a research of Viçosa, Brazil. The researchers observed the disparity of the fear of crime and actual crime occurrence with the regression model (Alkimim, Clarke, and Oliveira 2013). In this study, the researchers tried to find some sole spatial patterns of the fear of crime instead of connecting them with any local conditions, however, their analysis showed that the areas that people feel unsafe was distributed randomly rather than appearing clustered (Alkimim, Clarke, and Oliveira 2013). Nevertheless, Kohm (2009) found that the high crime rate actually increases the fear of crime in a neighborhood in Winnipeg, Manitoba. Although the effect was not as strong as the exposure of the residents to the disordered society, illegal markets and gang activities (Kohm 2009). It can be concluded from the literatures mentioned above that the spatial pattern of the fear of crime varies a lot among different cities or neighborhoods, there is currently no general discipline of the spatial distribution of the fear discovered by the researcher, instead, it can be affected by several factors such as the social network and people’s exposure to the social disorder, but there is no general factor which works everywhere, either. Each place can have its own spatial pattern and the factors of the fear of crime, which needs to be explored separately.

The spatial pattern of actual crime, as I explained in the previous paragraph, can sometimes be different from the fear of crime, and there have been a lot of works which investigated on this. Weisburd, Groff and Yang (2012) had some insights about the spatial pattern of crime spots. They stressed that the crime is usually significantly clustered at some specific places, regardless of the unit of analysis. Meanwhile, the crime spots tend to concentrate on some specific street segments, which means that very few crime hotspots account for a very high percentage of the total crime, and they also found that the crime hotspots are stable. Figure 2 shows the spatial distribution of the change of crime numbers, the picture shows that most of the street segments are crime free or with low crime rate, but only a few segments suffers from high crime rates. Therefore, Weisburd, Groff and Yang (2012) argue that the spatial pattern of crime is only meaningful on the micro level, but not too much on the macro level. Regarding the generation of crime hotspots, they believed that the opportunity was the most important predictor, they explained that a street with more employees working there or residents living there are more likely to have a crime hotspot, because that more employees means more potential targets of criminal activities. Some segments of arterial streets are also more likely to be crime hotspots, because arterial can be more easily accessed by both offenders and potential targets, which means a higher opportunity of the occurrence of criminal activities (Weisburd, Groff, and Yang 2012). Therefore, the spatial pattern of crime shows a major difference from the spatial pattern of the fear, according to the existing research, the crime hotspots constantly cluster at some specific places at a very small scale, such as the street segments, and the hotspots are largely predictable, and the opportunities of criminal activities can be a main predictor. While the spatial pattern of the fear of crime are sometimes randomly distributed, and the factors vary at different places.

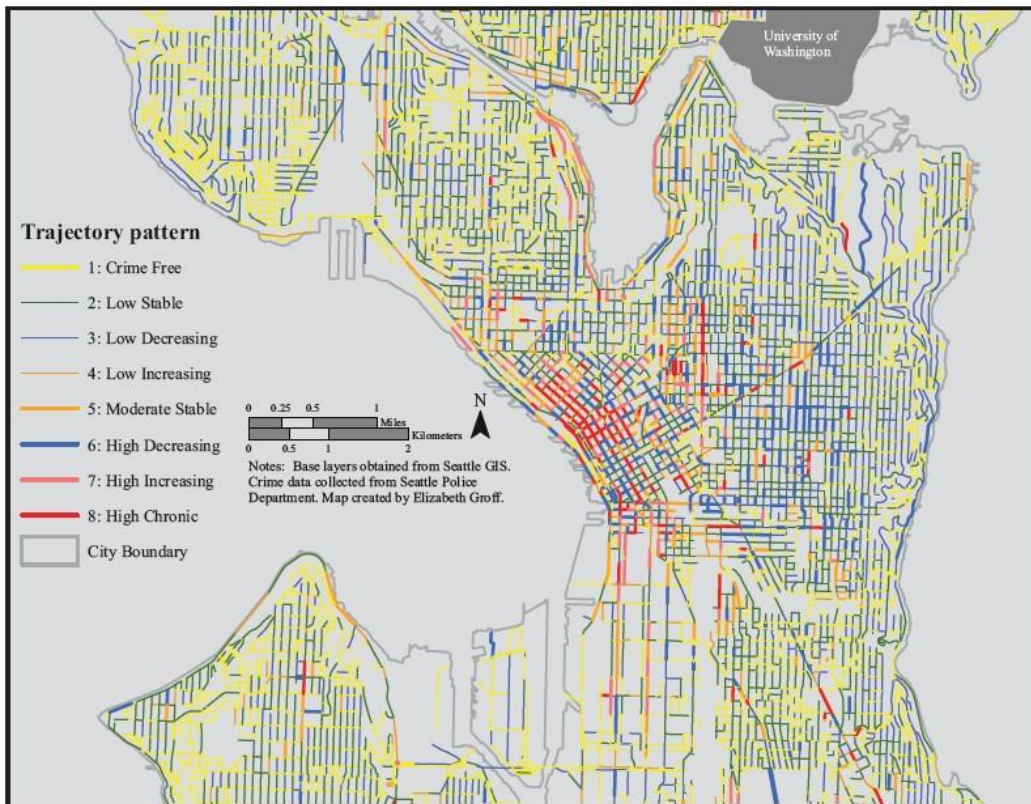


Figure 2. Spatial distribution of crime number change in Seattle center (source: Weisburd, Groff, and Yang 2012, 74)

2.3 Sketch mapping and GIS in fear of crime

Sketch mapping is also called “cognitive mapping” and “mental mapping”. Basically, in a sketch mapping survey, the respondents are asked to draw a map, mark on a base map or draw some other spatial representations of a specific environment (Sloan et al. 2016). Sketch mapping is a common method to assess people’s perceptions towards a place or environment (J. W. Curtis et al. 2014). Contrast to ordinary mapping which is based on the actual geographical objects, sketch mapping reflects the experience of people on a on one or several specific places (Boschmann and Cubbon 2014). Sketch mapping is usually performed by a series of hand-drawn maps from the interview respondents, and the sketch maps will be analyzed by researchers. During interviews, drawing sketch map calm down the participants and let them more eager to answer (Boschmann and Cubbon 2014).

There are several kinds of sketch map which can be employed to investigate the fear of crime. The interview respondents are required to either draw a completed map based on their cognition or mark on the given base maps (J. W. Curtis et al. 2014). The survey of Dennis (Dennis 2006) was an example of requiring the respondents to draw completed maps. He surveyed a group of youth about the feeling and experience of their neighborhood, and in that survey, the youth were asked to depict their neighborhood with drawings and text marks, which included a map of the neighborhood. A survey on male youth in three Los Angeles neighborhoods can be an example of marking on given base maps. In this survey, the respondents were asked to mark the areas which they were afraid to go on base maps, and the base map contained only major geographical objects, streets and streets name in order not to influence the answers (J. W. Curtis et al. 2014). Marking the areas which are dangerous based on the experiences and feelings of the respondents is commonly used in surveys, Boschmann and Cubbon (Boschmann and Cubbon 2014) and Natalie Lopez and Chris Lukinbeal (2010) also employed the same sketch mapping method in the surveys.

However, there are some debates on the base map of the sketch mapping. Some researchers concerned that the respondents would be interfered by the features of base maps, such as base map size and scale (O’Neill et al. 2015). On the contrary, it has been proved that the base map style and size don’t have significant difference on the result (Sloan et al. 2016).

As a tool for storing, managing, analyzing and presenting geographical data, GIS has a lot of advantages on the analysis of sketch maps. Regarding the studies of the fear of crime, the sketch maps from the surveys are sometimes digitized with GIS software, which means that the sketch maps from surveys should be cartographically accurate instead of free hand-drawn maps (Boschmann and Cubbon 2014). Although geodatabase is included in GIS, GIS is never a pure quantitative tool, instead, it can be used qualitatively in many ways (Dennis 2006). There have been several models for analyzing the fear of crime from sketch maps. Three major methods are used by researchers, which are overlay, descriptive analysis and aggregation (J. W. Curtis 2012). Overlay is a straightforward way of processing multiple sketch maps and presenting the survey result in one map, which requires simply to digitize all the marked areas drawn on the sketch maps, and then add them together. Ceccato and Snickars (2000) used overlay method for assessing the perceived border of Jordbro neighborhood and the areas which people tend to avoid because the fear of crime. In his survey, respondents were asked to draw the perceived border of Jordbro as well as mark the areas they tried to avoid, then, both perceived border and risky areas were digitized as line feature and displayed separately on two maps. Overlay is a simple way of analyzing sketch maps, by displaying all the marks under the same topic on one map, however, to make better use of GIS, it is reasonable to use some spatial analysis tools, which give clearer results and more efficient maps.

Descriptive analysis is also a common way of assessing sketch maps, but this method does not always involve GIS analysis. Dennis (Dennis 2006) investigated the feeling of youths towards a neighborhood, and in the survey, he asked the recipients to draw sketch maps of the neighborhood totally by hand without any base maps and mark the bad areas. In Dennis's analysis, he linked the narration of the youths about the neighborhood safety with the photos and sketch maps of the neighborhood, which means the sketch maps in his research acted as the support to the narrations. Descriptive analysis is a good way to convey an in-depth view towards a specific area, however, GIS is sometimes not necessary in relevant research. Aggregation is a relatively statistical method, which usually applies statistical analysis in GIS. Natalie Lopez and Chris Lukinbeal (2010) researched on the residents' and police's perception on crime in a neighborhood, they surveyed the feeling of the residents and the police and collected the sketch maps from respondents, then aggregated the data into land parcels, specifically, only when more than 50% of the area of a land parcel was marked as unsafe, the whole land parcel would be recognized as an unsafe area. Some researchers even divided their research areas into arbitrary zoning system, for example, Matei, Ball-Rokeach, and Qiu (Matei, Ball-Rokeach, and Qiu 2001) surveyed on the fear and misperception of crime in several communities in Los Angeles, and in their research, the research area was divided by zip code.

2.4 The factors of the fear of crime

The fear of crime can be generated or influenced by several factors. To model the fear of crime, it is essential to figure out some factors, or variables, of it. There has been a lot of studies explaining the reasons of the fear, which can be sorted into several types.

First, demographic conditions are a group of factors which can influence the fear of crime. The researchers have been trying to figure out the demographic factors of the fear of crime since 1970s (Lebowitz 1975). Regarding the gender difference, female is more afraid of crime (Pleggenkuhle and Schafer 2018), because the fear of sexual assault probably dominates and increases the fear of all kinds of crime (Ferraro 1996). The age can also be a demographic factor that affects the fear of crime. Some earlier literatures indicated that older people had higher perceptions of crime risk, and it was mainly the young people that made them feel unsafe (Tulloch 2000). However, such conclusion was controversial, Lagrange and Ferraro (1989) denied the relationship between age and the fear of crime, he claimed that the fear of crime among the older people was overestimated by the interview questions which were stereotyped and lack of relevance to everyday life. The fear of crime can also be influenced by an individual's class position. It has been proved that poor and underclass people are more afraid to crimes than nonpoor people, as poor and underclass people are more likely to be exposed to and even victimized in the crime (Will and McGrath 1995).

Then, the local conditions can also be the factors of the fear of crime. In contrast to the demographic factor, this group of factors is more concerned on the external circumstance of the people, especially the environment around them. Racial structure is recognized as a major predictor of the fear of crime of a neighborhood because of the powerful stereotypes. People of some minor racial groups are often seen as prone to crime. In contrast, the minorities showed even higher fear of crime, which is mainly generated by the fear of racial discrimination (Pain 2001). People are also afraid of unsupervised teens, often in gatherings or gangs, and the neighborhoods where people have uncivilized behavior. However, these two factors were seen as overlapped by some researchers, who argued that unsupervised teens had indirect effect to the fear of crime instead of the direct

effect, it was actually the uneducated behavior of those teens that caused the fear of crime (Taylor and Covington 1993). The facility of a neighborhood is also a predictor of the fear of crime, for instance, Castro-Toledo et al. (2017) observed that people walking in poor lighted public spaces had a higher heart rate than those walking in better luminosity, which indicated the poor lighting could increase the fear.

Moreover, the crime victimization is a decisive factor of the fear of crime. Several researchers have found the strong link between crime victimization and the fear of crime, people who suffered from crimes in the past tend to be more fearful to crimes (Pryce, Wilson, and Fuller 2018; Curiel and Bishop 2017).

2.5 Demographic conditions in the fear of crime studies with sketch map

As I stated in the previous section, the demographic conditions are a group of important factors of the fear of crime, especially the gender, the age and the social class position of an individual. However, sketch mapping mainly reveals the spatial pattern of the fear of crime. It can be interesting to see how researchers dealt with the demographic conditions of respondents in the fear of crime studies with sketch mapping method. For the need of research design, I will analyze some of the existing research about the handling of the demographic conditions, specifically, how the demographic conditions were used in the research. Table 1 shows how researchers dealt with the demographic conditions in some of the relevant studies.

Table 1. Demographic conditions in mapping the fear of crime studies

Source	Research object	How demographic conditions were used in the research
J. W. Curtis et al. 2014	Mapping the youth fear in some of the Los Angeles gang neighborhoods	Sampling, the researchers surveyed male youth from 14 to 21 years old
Ceccato and Snickars 2000	Perception of security in Jordbro neighborhood	Sampling, the sample was 1000 inhabitants in Jordbro between 18 and 75 years old
Dennis 2006	The youth fear of crime in South Allison Hill	Sampling, the sample was neighborhood youth
Kohm 2009	The residents' fear of crime in Spence neighborhood	The author employed the simple random sampling method, and the demographic conditions were used to test if the sample could represent the whole population in the neighborhood. Sex, age, aboriginal identity, education, marital status, household income, composition of income, dwelling tenure were involved in the questionnaire and then compared with the demographic compositions of Spence neighborhood and Winnipeg City, to show the demographic conditions of the sample correspond to the whole research area

Natalie Lopez and Chris Lukinbeal 2010	Compared the perceptions of crime between the police and the residents	Sampling, the research sought a mix of participants of different ages, gender, and housing renters and owners, as well as a balanced distribution of living places of the participants
Matei, Ball-Rokeach, and Qiu 2001	The residents' fear of crime in seven ethnically marked communities of Los Angeles	Several factors are involved, including Income, education, age, gender, years in the neighborhood, years in Los Angeles, first-generation immigrants, and if the participant own a home, to show the demographic conditions of the sample corresponded to the whole research area, so the sample group could represent the whole population in the neighborhood

Six research articles are listed in table 1. It is shown from the table that some of the researchers considered a mix of the participants with some different demographical conditions in the sampling of the surveys or the interviews, however, not all the researchers considered the mix of different demographical conditions, especially when they did not conducting the random sampling method. Even if the demographic conditions were involved in the questionnaire or the interview guide, these researchers did not include them in their analysis, which means that the demographic conditions were not one part of the variables in their studies, in other words, they did not attempted to discover the connections between the fear of crime and the demographic condition of people.

The purposes of the listed research were generally mapping the fear of crime. Four of them merely mapped the fear and analyzed the fear with some spatial analyst methods in GIS, and probably used the result for further explorations (Natalie Lopez and Chris Lukinbeal 2010; Ceccato and Snickars 2000; J. W. Curtis et al. 2014; Dennis 2006), for example, Natalie (Natalie Lopez and Chris Lukinbeal 2010) mapped the fear of crime among the residents and the police in a neighborhood, and then compared the spatial difference of the fear between the residents and the police. Two of them explored the causes of the fear, and both concerned only on the local conditions, such as the appearance of some ethnic groups, the media and the disorder of the neighborhood, instead of the demographic conditions of the respondents, like age and gender (Matei, Ball-Rokeach, and Qiu 2001; Kohm 2009).

2.6 Neogeography (Volunteered geography) and crowdsourcing

With the emergence of web mapping 2.0 and the availability of crowdsourced geographical information, the concept of neogeography was established. The most significant difference of the research within neogeography structure is that the source or the creation of geographical information. The neogeography encourages the private citizens to contribute geographical information to the research, so the information is also called volunteered geographical information, and the neogeography is also called volunteered geography (Goodchild 2007).

Neogeography breaks down the tradition of the geographical information creating, and it is considered as an improvement of public participation in planning or researching process. Originally, the private individuals could only know and view the geographical information, planning decision and the research outcome, but in the neogeography context, the private individuals are also accepted as the participants of planning or researching process, which was once dominated by the public agency (Goodchild 2007; Rinner 2003). Such development in public participation also shows a

reversal to the traditional top-down approach of creating and publishing geographic information (Goodchild 2007). According to some critiques on the neogeography, the geographic information from the citizens can have a limited accuracy and reliability, especially those contributed by the untrained public (Connors, Lei, and Kelly 2012). However, on the user's side, it has been proved that the inclusion of volunteered geographical information in the web mapping process enhances the user experience, and produce no negative impacts to the user perception (Parker 2014, 117). In addition, the public participation in creating geographical information in the research process helps reducing the gaps between policy makers, researchers and the public (Connors, Lei, and Kelly 2012).

Sketch maps can be considered as a type of crowdsourced geographical information, as they are mostly collected from private individuals. Sketch maps are the cognition on the surrounding environment of the individuals, although most of the sketch maps are collected with paper questionnaires and has no connection to the technique of web mapping 2.0, we can still consider them as crowdsourcing. However, there is still some difference between the traditional survey method and web-based crowdsourcing. In the traditional paper-based survey only a limited amount of people chosen by the researchers can share their opinions and make their voice hearable. In contrast, web-based crowdsourcing means that everybody has the opportunity to contribute his/her own opinion to the research, and the contribution is not obliged. Therefore, collecting crowdsourced sketch map online can be a considered as a method of volunteered geography or neogeography, and it can be a possible development of the fear of crime studies. As stated by Goodchild (2007), the volunteered geographical information can be valuable and interesting in the research about the life of local level, which are neglected by the local media. Definitely, the fear of crime should be sorted into this area, as the fear occurs at the places of individuals' daily activities. And the fear of crime is intrinsic and unnoticeable, for the media sometimes neglects the underlying difference between the actual crime incidents and the fear of crime. Until now, there is hardly any research on the sketch mapping of the fear of crime employed the technique of web mapping 2.0, therefore, it is reasonable to bring the web mapping 2.0 into the fear of crime research.

An application of neogeography approach is the web-based spatial decision support system (WebSDSS), which is an application that supports the user to solve complex spatial decision problems (Rinner 2003). An example of earlier WebSDSS is the *Virtual Slaithwaite*, an urban planning support system. In this system, after the user enters the website, a map of Slaithwaite village will be displayed in the browser. The user can click on the feature objects, such as buildings and roads, then a web form will be showed, in which the user can write some comments or suggestions about the feature object (s)he clicked on. The user inputs will be sent to the server after it has been submitted, and those inputs can support and shape the planning decisions of the village. (Kingston et al. 2000)

The latest form of WebSDSS is fulfilled by crowdsourced geographical information. Crowdsourcing means that collecting knowledges and information from a large number of individual. It has been proved that in some cases, the information researchers gained from crowdsourcing can be very difficult to observe in other ways (Haklay, Singleton, and Parker 2008). According to this definition, a crowdsourced map is the map with not only geographical objects, but also the cognition of the place collected from a number of individual. The example of Slaithwaite village which was described in the last paragraph can be considered as crowdsourcing. The planners collected comments and suggestions from the villagers with a village map. The geographical information crowdsourcing is also used in the website such as *London Profiler*, which

collect some personal data from the citizens, and then probably be taken into account in the planning process (Haklay, Singleton, and Parker 2008).

2.7 Online questionnaire and web mapping

Regarding the method of collecting sketch maps, the most common way for the researchers is currently letting the respondents draw on papers (A. Curtis et al. 2018; J. W. Curtis et al. 2014). Undoubtedly, this can be the easiest method of collecting sketch maps. However, before analyzing the sketch maps with GIS software, it is necessary for the researchers to digitize the hand-drawn objects on the map. Digitizing is a simple but repetitive work which can take a large amount of time (Haunold and Kuhn 1994). Using online survey tools which allows the users to draw sketch maps saves a lot time because the researcher can get digitized map directly from the survey result. Conducting survey with online questionnaire also saves money (Bryman 2016). There have been a few websites which support online form with embedded map, including Survey123 from ESRI and Maptionnaire. However, none of them are free to use, the users have to pay for the subscription of the survey tool. Then, it becomes reasonable to develop an online questionnaire to collect sketch maps.

The process of designing, generating and delivering maps online is called web mapping (Neumann 2008). There are several web mapping techniques which can embed a map to a web form, including static map publishing, static web mapping and interactive web map. Static map publishing only distributes the map on a webpage as images, but it has no interaction with the user. This technique relies on early web technologies, but it is still applied nowadays, such as the downloadable map of tourist attractions in PDF format. Static web mapping technique allows the user to request a map from the server, and the map will be displayed as an image or a set of vectors. However, complicated user interaction with the web map is still not available in this technique. Interactive mapping technique allow relatively complicated interactions between user and the map, such as navigation, zooming, panning, drawing and searching. Interactive mapping greatly improves the interactivity of the user, as this technique enables drawing on the map, it can be used in web forms of collecting sketch maps. (Peng and Tsou 2003; Neumann 2008)

However, interactive mapping technique is still a single-directional web mapping technique, which means that the map producer or the server only sends out the geographical information, while the user or the client only receives the information. The era of web mapping 2.0 was introduced around 2008, and the core revolution of web mapping 2.0 is that the web mapping process became two-directional. The server does not only give out geographical information to the user, but also collects the geographic information generated by the user (Haklay, Singleton, and Parker 2008).

In the web mapping process, the web mapping 2.0 technique requires the communication between the server side and the client side. The definitions of client and server in the client-server structure is usually not stated in the research, as they are literally understandable, and are considered as a common knowledge (Janicki et al. 2016; Pan et al. 2014; Auer et al. 2011). In the relevant research, the client is usually understood as the element that interacts with the user and sends requests from the user, while the server is the element that process the request from the client and provide service to the client (Li, Dragicevic, and Veenendaal 2011). It has been proved that too frequent communication between the client and server will result in the delay of the mapping process (Haklay, Singleton, and Parker 2008), so the logics of web map are fulfilled at the client-side, with

client-side scripting. Then, in interactive web mapping technique, the task of client-side is mainly map rendering and mapping logics, while the server-side plays a role of storing the data.

2.8 Thesis framework

All the research mentioned in the literature review formed the theoretical influences on this study, and this section provides a summary of the framework of this study, which includes a methodological framework and a theoretical framework. The methodological framework justifies the first research question, which is about the development of the support system, while the theoretical framework justifies the second and third research questions, which are about the spatial pattern of the fear of crime and its relationship with the actual crime spots.

2.8.1 Methodological framework

Sketch mapping is commonly used to people's perceptions towards a place instead of actual geographical objects (J. W. Curtis et al. 2014). There are mainly two kinds of sketch map involved in the relevant research, classified by the use of the base map. The respondents were asked to draw either a complete sketch map without base map or some marks on the base map (Dennis 2006; J. W. Curtis et al. 2014). Although there are some debates that the respondents may be affected by the base map, using a base map in the survey allows the GIS analysis because it regulates the sketch map drawn by the respondents (O'Neill et al. 2015; Sloan et al. 2016; Boschmann and Cubbon 2014).

GIS has a lot of advantages on processing the sketch maps, for its ability of storing, managing and analyzing data (Boschmann and Cubbon 2014). GIS was used both qualitatively and quantitatively in existing studies about the sketch map, and three common ways of processing the sketch maps in the fear of crime studies were overlay, descriptive analysis and aggregation.

Regarding the collection of the sketch maps, the most common way is conducting paper-based survey, however, comparing to the paper-based survey, online survey saves both time and funding (J. W. Curtis 2012; J. W. Curtis et al. 2014; Haunold and Kuhn 1994; Bryman 2016). Currently, there is no free online application that allows collecting sketch maps in a questionnaire, so it is important to develop one in this study. Web mapping 2.0 is the first double-directional interactive web-mapping technique that allows double-sided data transmission between the client and the web server.

The neogeography or volunteered geography approach emphasizes the contribution of geographical information to planning or research process from the public, and the neogeography was led by the invention of web mapping 2.0 technique. It is reasonable to consider the collection of sketch map as a part of the neogeography approach. There are already some examples of neogeography approach applied in the planning process, such as the *Virtual Slaithwaite* and *London Profiler* mentioned in the literature review.

2.8.2 Theoretical framework

The fear of crime is not defined in most of the relevant studies, because this concept can be easily interpreted in the daily life (Doran and Burgess 2012). However, several researchers mentioned the distinction of fear between the cognition and emotion, in other words, how people assess the safety of a place and how people feel of the threat, and it is commonly acknowledged that the fear of crime should only refer to the emotion, which is the feel of threat at a place (Doran and Burgess 2012; Ferraro and Grange 1987). In this research, since the fear of crime is going to be mentioned in the questionnaire, to avoid confusing the respondents, the fear of crime will not be defined as the most of the existing studies did, so, this concept can be understood from the common sense.

The spatial pattern of the fear of crime tends to be random, and the randomness can be explained on at least two different levels. First, the spatial distribution of the fear is highly random, rather than being clustered (Alkimim, Clarke, and Oliveira 2013); second, although spatial pattern of the fear of crime is usually connected with some external factors such as disorder and actual crime rates, the factors that generate the fear is largely different among places (Boessen et al. 2017; Kohm 2009). There are hardly any general factors or spatial patterns of the fear has been discovered. This is totally different from the spatial distribution of the actual crime, which is largely predictable. The actual crime spots are usually clustered at only a few places on a small scale, such as street sections or corners, and these crime hotspots are stable, moreover, the most important factor of the actual crime is the opportunity of crime (Weisburd, Groff, and Yang 2012). There are sometimes a disparity between the fear of crime and the actual crime hotspots, people may feel safer at the places with high crime rates (Curiel and Bishop 2016).

A lot of factors of the fear of crime have been discovered, including demographic conditions, such as the gender or the age of people; the local conditions, such as lighting, racial structure and the behaviors of local residents and; the crime victimization (Pleggenkuhle and Schafer 2018; Tulloch 2000; Pain 2001; Taylor and Covington 1993; Castro-Toledo et al. 2017; Pryce, Wilson, and Fuller 2018; Curiel and Bishop 2017).

However, researchers in different study areas tend to concern on different kinds of factors. In the studies which sought to explain the spatial pattern of the fear of crime, researchers hardly connected any demographic conditions with the fear of crime, in other words, they did not explain the fear with personal characters. They either merely mapped the fear of crime and probably conducted some spatial analyst quantitatively, or discovered some factors of local conditions, such as the disorder. (J. W. Curtis et al. 2014; Ceccato and Snickars 2000; Dennis 2006; Kohm 2009; Matei, Ball-Rokeach, and Qiu 2001; Natalie Lopez and Chris Lukinbeal 2010)

3 Methodology

3.1 Developing the support system for analyzing the sketch maps in the fear of crime studies

The first research question is about the support system for analyzing the sketch maps in the fear of crime studies. There is a few guidance for developing a web application but most of them are developing commercial web applications instead of a web application for researching. Skipping the business and commercial part, this kind of guidance can still be taken as the reference of this study. The requirements or functions of the support system should be considered in the developing process (Standing 2002). In this research, the functions are going to be concluded from literatures, as well as the technique and composition of the system.

3.2 The design of the questionnaire

An online questionnaire is going to be used in this research. The online questionnaire is basically similar with the paper questionnaire, but it still has some advantages and defects comparing to the traditional paper questionnaire. The advantages of online questionnaire includes 1) low cost, because no printing, transportation or postal is need with an online questionnaire, in my case, the whole survey process should be free of charge; 2) faster response, it will be much faster to get the replies with online questionnaire and 3) better data accuracy, manual data entry is not needed with online questionnaire, so it saves time and largely reduces the error (Bryman 2016). These advantages are the reason for me to choose online questionnaire in this study. Bryman (2016) also mentioned some more advantages of the online questionnaire, for instance, the participants tend to give a better response to open questions. However, the online questionnaire has also some defects comparing to the traditional questionnaire, in which the most noticeable one should be the biased sampling, which means the participants are restricted to the online populations that tend to be better educated, younger and wealthier (Bryman 2016). The other defects include the low response rate, confidentiality and anonymity issues and multiple replies given by the same person (Bryman 2016). As a solution to the confidentiality and anonymity issues, as I will describe later, the questionnaire will not include any questions about the personal information of the participants, then the confidentiality and anonymity are not going to be an unacceptable problem of the system. The solution to the other defects will be explained in the following parts of the thesis.

Besides a self-completion questionnaire, the online questionnaire can also be considered as a structured interview, which is used by some of the researchers who collected the sketch maps from their participants (Dennis 2006). A structured interview is standardized and the data collected is well framed and easy to be processed (Bryman 2016).

In this questionnaire, as I mentioned in the theoretical framework, the fear of crime is not defined in this research, so no definition of this concept will be stated in the questionnaire, then the respondents are expected to understand the fear of crime from their daily life. I used the most simple questions in this questionnaire, as several researchers did (Kohm 2009; Natalie Lopez and Chris Lukinbeal 2010). The questionnaire starts with an opening paragraph, including the introduction of the thesis topic, which is the fear of crime in Lund, the guidance on how to fill in the web form, and some privacy statement, this opening paragraph introduces the way of using the online questionnaire, so it avoids some issues caused by the multiple submission from the same person.

The first question is letting the respondents mark the areas which they feel unsafe with polygons. The question was *“Are there any particular places in Lund that you are afraid to go? You can mark them with polygon in the map below”*. Then, the respondents were asked to describe the reason for feeling unsafe in these areas, I asked *“Could you explain why those places are fearful to you?”*. As the respondents may not be familiar with the whole Lund city, it is also important to know the respondents’ area of daily activity, in other words, the places they are familiar with and frequently involved in. In some neighborhood level research, the respondents were asked to draw the border of their own neighborhood based on their cognition (Ceccato and Snickars 2000). Asking the respondents to draw about their daily routine or where their daily activities happen is a straightforward way, but this kind of question is very easily turn out to be unclear, especially on an online questionnaire, where the investigator has very limited communication with the respondents. So, I chose an alternative way, which was asking the living place of the respondents. Concerning the privacy of the respondents, they were not required to write down their full address, instead, I asked about a rough position, such as a street name or a neighborhood name. The question was *“Where do you live? This involves a little privacy, so you don't need to point it out in the map or give your full address. You can just write down the street name or the neighborhood name, for example, Spelmansvägen or Östra Torn”*. It can also be checked from the answers of this question that if the living places of the participants are evenly distributed in the research area. Finally, I also asked for some suggestions to improve my questionnaire, as an optional question *“Do you have any suggestions to this online questionnaire?”*. Easy to be modified is another advantage of the online questionnaire, when the researcher receives some useful suggestions from the respondents, the researcher is able to improve the questionnaire easily and immediately. However, to keep the consistency of the questionnaire in this research, I did not give any major changes on the questions after the questionnaire was released, but only improved the way that the questions were expressed, in order to avoid guiding or unclear questions.

3.3 Selection of participants

In this research, the purposive sampling strategy will be employed (Bryman 2016). As a solution to the defect of biased sampling of online questionnaire, which means the sample only includes the people who use the internet, I choose to conduct this research among Lund University students. Since it is almost necessary for a university student to use the internet because of the need to get access to the research articles, it is reasonable to avoid the biased sampling problem by conducting this survey only among the university students. The students of Lund University are most likely to be familiar with Lund, so I choose the participants as Lund University students.

3.4 Considerations of not involving demographic conditions of the participants in the questionnaire

Based on the suggestions I received from my supervisors and the respondents, it can be necessary to explain about my considerations that if the demographic conditions should be involved in the questionnaire. I would like to explain why I do not group the respondents by their demographic patterns from both theoretical and practical dimension in the thesis. In this section, I am going to connect the existing research to my study, which is the theoretical dimension, then in the discussion part, I will explain about this question again from my research findings. What I want to argue in

this section is, putting the demographic patterns of the participants into consider is not helpful or necessary.

Although The demographic conditions of the participants are a group of important factors of the fear of crime, they are still not an essential part in all the fear of crime studies. I listed six studies on mapping the fear of crime, only some of them included the questions about the demographic conditions of the respondents in the survey or interview, while the others did not ask any relevant questions. Especially when the researchers are employing the purposive sampling method in the survey or interview, they are not seeking the participants on a random basis but focusing only on a specific group of people which is decided by their research objects. In such case, the participants are mostly selected according to their socio-demographic conditions, then the researchers tend not to group these participants into some smaller classes (Ceccato and Snickars 2000; J. W. Curtis 2012; Dennis 2006). Even if the demographic conditions of the participants are involved in the questionnaire or interview, this data was only used as testing if the demographic conditions of sample group can represent the demographic conditions of the whole population of the research area, to show that the sample is valid (Natalie Lopez and Chris Lukinbeal 2010; Kohm 2009; Matei, Ball-Rokeach, and Qiu 2001). In all the six articles I listed in the literature review, researchers did not explore the connections between the demographic conditions and the fear of crime, then it can be obvious that the demographic factors such as gender, age and income are not always necessary in the studies about mapping the fear of crime with sketch maps.

However, in criminology research which does not involve the mapping of the fear of crime, there have been abundant studies regarding the demographic factors that influence the fear. As I mentioned in the literature review, researchers have been looking for the factors of the fear of crime since 1970s, and till now, there are already a large set of demographic factors which affects the fear of crime among people. The demographic factors of the fear of crime is no longer a new or creative topic, which worth the concern. As I am conducting a research on mapping the fear of crime, it is not necessary to look for the demographic factors by repeating some of the existing research in Lund.

Adding the questions about the demographic conditions of the participants in the questionnaire is not only unhelpful and unnecessary but may also produce some ethical problem to the research. Demographic conditions including gender and age involve the personal information of the participants. Bryman listed four main areas of ethical issues that a social research can involve, and one of them is the *"invasion of privacy"* (Bryman 2016, 135), participants are less likely to answer the questions about their privacy in the interviews, including the income. As suggested by Bryman (2016), the researchers should achieve the "minimal risk" of ethical issues based on their research object. The questions of demographic conditions in the questionnaire are not necessary at all, so, to achieve the minimal risk of privacy issues, the demographic conditions will not be included in my research.

In conclusion to this section, I consider that the demographic factors are not necessary to be included in the questionnaire. There are some studies that did not consider the demographic conditions as a part of the variables, for the core interest of the research is mapping the fear of crime. One more reason is that there has already been abundant existing criminology research about the factors of the fear of crime, so the factors are not necessary anymore in mapping the fear of crime study. Not asking about the personal information in the survey reduces the ethical issue of the study as well. For all the reasons above, the demographic information of the participants is

neither necessary nor helpful in this study, so I decide not to include any questions about this in the questionnaire.

3.5 Research design: qualitative research

The cross-sectional research design method will be used in this study. The cross-sectional design means that the data are collected by questionnaire or structured interview from more than one case roughly simultaneously, to collect a set of data in connection with two or more variables, and then find the patterns of association (Bryman 2016). This study focuses on mapping the fear of crime in Lund and faces to the Lund University students. The data collection will be done by online questionnaire which can be considered as a structured interview, while the variables will be the spatial patterns of the fearful places and the reasons of the fear. After the data collection, the data will be processed and analyzed, then some patterns are expected to be found based on the research questions.

GIS is more advanced on processing digital maps, including digitized sketch map, because it contains not only the location of an object but also the attributes, enabling more complex analysis and statistics. GIS software is also powerful to display the maps, for the layers, symbology, colors and other map elements can be easily adjusted (Doran and Burgess 2012).

The studies of mapping the fear of crime can be done either quantitatively (Matei, Ball-Rokeach, and Qiu 2001; Alkimim, Clarke, and Oliveira 2013) or qualitatively (Dennis 2006). This study is intended to be a qualitative research. Referring to the main steps of qualitative research described by Bryman (2016), the general process of this research will be 1) clarifying the research questions, which were stated at the beginning of this thesis; 2) selection of relevant subjects, which was described in the theoretical framework; 3) collection of relevant data. The data will be collected with the online questionnaire, the participants are expected to draw a sketch map of the fearful places and then answer some questions about the reason and their living place, as I described in the previous section. 4) interpretation of data. The sketch map will be processed with GIS and then imported to Google Earth for presentation, while the reasons will be coded and analyzed. This step will be further described in the following sections. 5) conceptual work. After the data process, I will analyze on the difference of the fearful areas and actual crime spots, and why the areas are marked as fearful. As I described in the literature review, the reasons for people to be afraid of some specific places can also be the reason of the disparity or correspondence of fearful areas and actual crime spot, so the reasons of the disparity or correspondence are expected to be concluded in this step. 6) write the findings. This will be the discussion and conclusion part of the thesis.

3.6 Data source

In this study, I used several kinds of data, including the sketch maps, living places of the respondents, the reason that the marked areas were fearful, the crime spots and the base map. As what I have mentioned, the sketch maps, living places, and the reasons were the survey data collected from the questionnaire answers, while the base map was taken directly from Google Earth Pro. The base map used unsaturated colors to keep the mapping topics clear and viewable. An example of sketch map collected from one respondent is shown below in figure 3. The violent crime spots came from the events published on the official website of the police. No existing research

investigated how long the fear of crime among people lasts after the victimization of others, but it has been indicated that the crime victims can remain afraid at least two months after the incidence (Smith 1987), so, I took only the crime events of recent three months, which is from February 25, 2019 to May 25, 2019. In addition, according to the report of Brottsförebyggande rådet, the violent crime includes assaulting (*misshandel*), robbery (*personrån*), sexual crime (*sexualbrott*), threat (*hot*) and harassment (*trakasserier*) (Brottsförebyggande rådet 2017). Then, these types of violent crime were taken from the police events. Both the crime spots and the living places of the respondents are probably not an accurate location, in this case, if the given place name is a name of an area or a street, then the center of the area or street would be marked as the living place of the respondents or the crime spot.



Figure 3. The sketch map collected from a respondent (two polygons in purple are marked areas) (source: base map - Google Earth Pro; sketch map – survey data)

3.7 Data processing and analysis

Since the target of this case study was to test the analysis support system of the fear of crime, this study used the whole support system developed in this research.

First, a survey was conducted within Lund University students about the fear of crime in Lund, with the online questionnaire introduced in the previous section. The link of the online questionnaire was posted in the Facebook group of Lund University students, so it is publicly accessible for most of the students. In order to ensure that I could receive enough answers for completing this research, I also sent it through some of my personal connections, who were more likely to answer the questionnaires.

Then, in the GIS analysis part, I counted the times that each place was included in the sketch maps, and then visualized the result in Google Earth Pro. As I also asked about the approximate living places of the respondents, I marked them on the Google Earth Pro with placemarks, so this

information could be considered in the analysis. Regarding the criminal spots, I searched for the police report of Lund, and marked all the violent crime sites on Google Earth Pro, then the spots were converted to KML format and converted to ESRI Shapefile with ArcGIS. I intended to analyze the hot spot of violent crimes in Lund, however, hot spot analysis was not possible because there were not enough points in the shapefile.

After analyzing the sketch maps, the respondents will be numbered by the order of their submission time, for example, the first one that submitted the answer will be numbered as respondent 1, the answers from the respondents will be coded as well. According to the method provided by Bryman (2016), coding is a way of managing a large amount of data, by turning the long materials such as interview transcript and questionnaire answers into smaller fragments based on the content of the material. In this thesis, the reasons for the places being marked as fearful area will be coded and analyzed. A few answers are in Chinese, so these answers will be translated to English before coding.

4 Result

The result of this study will be divided into two different sections, the first section focuses on developing the analysis support system, and as stated in the first research question, in this section, the functions that the system should fulfill, the techniques which can be employed in the system development as well as the composition of the system will be explored. The second section focuses on the analysis of fear of crime in Lund. In this second section, the spatial pattern of the fear of crime in Lund among Lund University students will be explored, and the answers from the respondents will be coded to find the factors of the fear of crime, then, the difference between the fear and the actual crime spots will be displayed.

4.1 Developing the analysis support system for the sketch maps in the fear of crime studies

4.1.1 Functions

As the analysis support system is targeted to help the research process, it should be able to conduct the online survey and collect, save and transfer the survey data, process the data, do some basic data analysis and then present the data and result.

As it has been stated in the literature review and the methodology, currently, asking for hand-drawn maps from the respondents is the most common method of collecting sketch maps. However, it has been pointed out that this method requires the digitalization of hand-drawn maps (Haunold and Kuhn 1994), which is a time consuming and repetitive work, and the doing survey with printed questionnaire needs both time and funding (Bryman 2016). Then, a tool which can collect digitalized map directly is a possible solution. So, the questionnaire should include an interactive map which is able to collect and save the user input. The questionnaire should also include some open questions, to which the answers from the participants are collected and stored as well.

The sketch map should be transferrable to GIS software, so that the data can be processed and analyzed, then maps should also be transferrable to Google Earth for the presentation. In this step, the analysis is largely customized, because most of the researchers used different methods of analyzing the sketch map, and there is currently no general way for the analysis (J. W. Curtis 2012).

Therefore, the functions of the system should include collecting data with an online questionnaire with an embedded interactive map which can collect and store the user input, processing data and transferring data among different GIS software.

4.1.2 Compositions and techniques

There are some examples of analysis support system, which was developed by other researchers, such as the *Virtual Slaithwaite* and *London Profiler* I mentioned in the literature review. This system collects the suggestions from citizens in the village Slaithwaite, and then present the suggestions to the policy maker and planner (Kingston et al. 2000). Although *Virtual Slaithwaite* is not a support system with web mapping 2.0 technology, it is still a good example of online crowdsourcing and public participation in the research or planning process. Crowdsourcing is one of the focuses in neogeography studies. Both the *Virtual Slaithwaite* and *London Profiler* consist

of an online questionnaire and the decision making or researching process afterwards. Similarly, this system can have two parts as the examples, an online questionnaire and a GIS analysis process afterwards. The techniques will be introduced in the following sub-sections.

4.1.2.1 Online questionnaire

The first part of the system is an online questionnaire, and the first question of the questionnaire requires the user to draw polygons on a map, so an interactive map is needed in the form. The interactive map should allow the client-side navigation such as zoom or pan, as well as the polygon drawing tools. Since there are very few web forms with embedded interactive maps which is free to use, it is necessary to develop a new online form.

the technology of web mapping 2.0 will be needed to fulfill this function, which is a double-sided information transmitting (Haklay, M. Singleton and Parker 2008), so the system presents the map of research area to the participants, as well as collecting the data of fearful areas drawn by them. This online questionnaire uses the simplest client-server structure, which is a direct connection between each client and the server (Haklay, Singleton, and Parker 2008). A free online server, 000freewebhost, is used as the server of the online questionnaire of this research. The questions, the forms and the map are rendered on the client side. There are several online maps which can be embedded in the questionnaire, including Google Maps, Here Maps, OpenStreetMap, Bing map and etc., however, almost all the interactive maps need API key to be embedded in the online form except OpenStreetMap. Concerning the time limit, OpenStreetMap is used in this research. Together with the interactive map, the zoom buttons, the drawing tools are also fulfilled. The center of Lund city will be showed when the respondents open the questionnaire, and a bounding box and the maximum zoom limitation are also set to ensure that the respondents do not mark the fearful places outside the research area. To enable the data transfer among different applications and save the storage space of the server, the polygons drawn by the respondents are then encoded to GeoJSON format, which is a format to store and deliver the geographic information in vector form. The answers of the other three questions are then extracted and sent to the server with the polygons. On the server side, the answers and the polygons from the respondents are formatted and saved. After the whole process, the server will send a response back to the client, showing all the answers given by that respondent, and the acknowledgement.

Regarding the programming language, on the client side, in order to fulfill the interactive web map, html and JavaScript are used in the client-side script, html code renders the elements on the web questionnaire, such as the text, blanks and the buttons, while the JavaScript code enables the map interactions and the user events such as clicking as well as the encoding of the polygons drawn by the respondents. This online questionnaire uses the Openlayers as an external library, to make the map controlling and polygon encoding easier to perform. AJAX technique is used when the user inputs are sent to the server from the client (Haklay, Singleton, and Parker 2008). On the server side, PHP is used to format and store the answers from the respondents and send the response to the server. The code of both server and client side are in the appendix of this thesis.

As a part of the answer to the first research question, the online questionnaire can be accessed at <https://lijianxiong.000webhostapp.com/>.

4.1.2.2 GIS analysis process

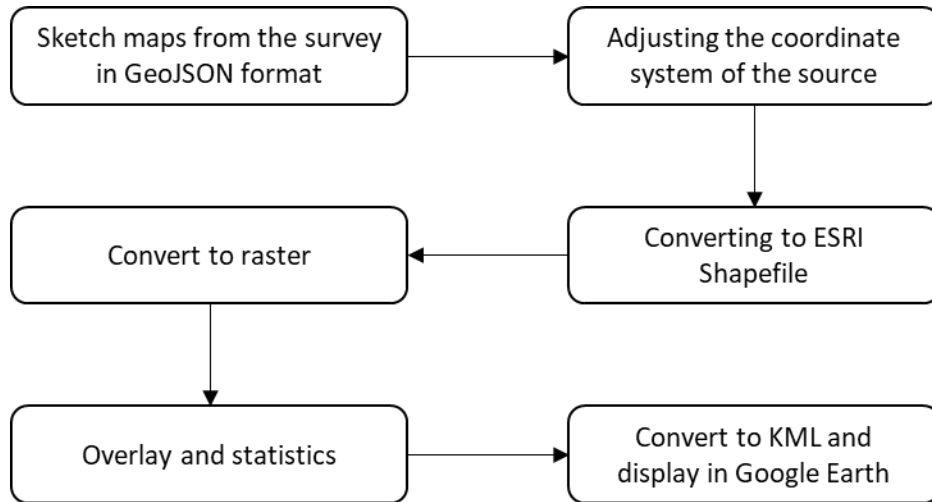


Figure 4. Flow chart of GIS analysis process

The second part of the system is an GIS analysis process. The GIS analysis is basically an overlay and statistics of the sketch maps, in other words, the count of the times that each place is included in the sketch maps (Matei, Ball-Rokeach, and Qiu 2001; Ceccato and Snickars 2000; Curiel and Bishop 2016). A place which is more frequently included is more likely to be fearful to people. The main process of GIS analysis is based on ArcGIS 10.5, however, QGIS 3 is also used as a supplement. As shown in figure 4, after getting the survey data from the online questionnaire, the sketch maps and answers will be downloaded from the server. The sketch maps have been stored in GeoJSON format, so it need to be parsed to polygons. However, the GeoJSON format encoded by Openlayers library cannot be recognized by ArcGIS, so the parsing of the sketch maps needs to be done in QGIS. The sketch maps are opened in QGIS, and the source coordinate system are set as *WGS 84 Web Mercator Auxiliary Sphere*, which is the default coordinate system of OpenStreetMap, so the polygons will be displayed at the right position on the map and have correct sizes. The polygons are then converted to ESRI Shapefile and opened in ArcGIS. because there is no difference between the attributes of the polygons, all the polygons are converted to raster, and the value of each pixel are set as 1. And a new raster will be generated with mosaic tool. The value of each pixel in the new raster is the summary of values of the raster mentioned in the previous step. The value of the raster generated in this step is the count of the times that the corresponding place is included in the sketch maps, which is the result of the GIS analysis. Due to the lack of a base map of Lund in vector or raster format, the result will then be converted to KML format and displayed in Google Earth Pro to have a completed map, so the images of Google Earth are used as the base map directly. However, as the analysis part is customized, the GIS part of the system cannot form a whole program, which means it is not possible for coding. The flow chart in figure 1 can be another part of the answer to the first research question.

In conclusion, the analysis support system consists of two parts, an online questionnaire and GIS analysis. The online questionnaire can be accessed at <https://lijianxiong.000webhostapp.com/>, the screenshot of the webpage is in appendix 1, and the code is in appendix 2 and 3. The GIS part is not a completed application, but it figures out the format for transferring the sketch map. GeoJSON format is used when transferring the map from the server to the GIS software, and KML format is

used for transferring geographic data from GIS software to Google Earth. Figure 1 shows a flow chart of the process.

4.2 The spatial pattern of the fear of crime in Lund city among Lund University students

4.2.1 Spatial pattern of the fear

Twenty valid answers were received during the survey. However, ten of the respondents did not specify any places that are fearful to them, which occupied 50% of the total, and most of these ten respondents felt the whole Lund is safe for them. This corresponds to the common knowledge that Lund is basically a safe city. The other ten respondents marked some areas that they were afraid to go, and their sketch maps were analyzed by the method stated above.

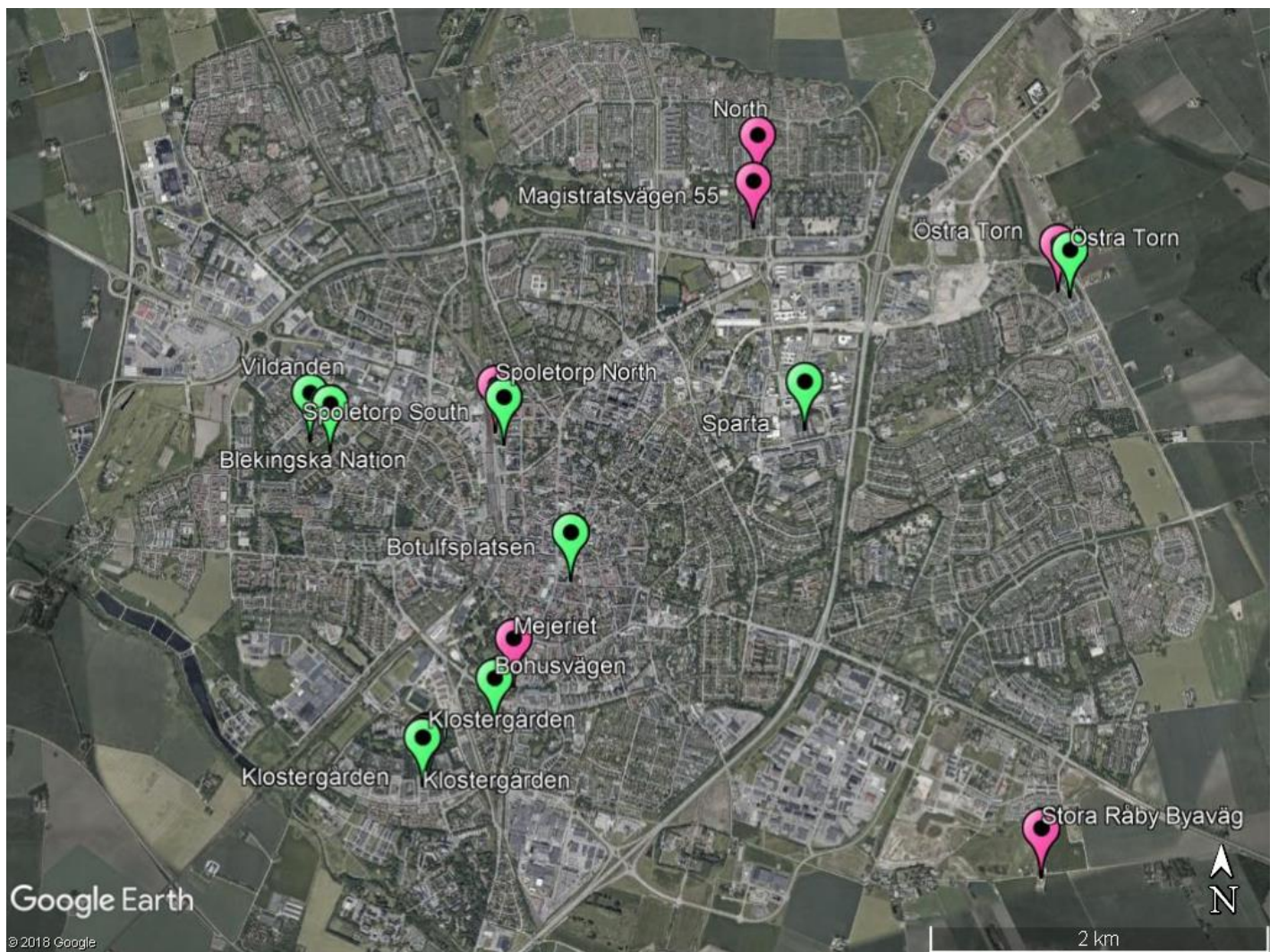


Figure 5. Living places of respondents
(source: base map – Google Earth Pro; placemarks – survey data)

Regarding the living places of the respondents, as shown in figure 5, the green placemarks are the living places of respondents who did not specify any fearful areas in the survey, and the red placemarks are those who marked at least one fearful area. Eighteen of twenty respondents live in Lund. It can be seen from the picture that the living places of the respondents can be considered as evenly distributed, though not too many respondents live in the east of Lund.

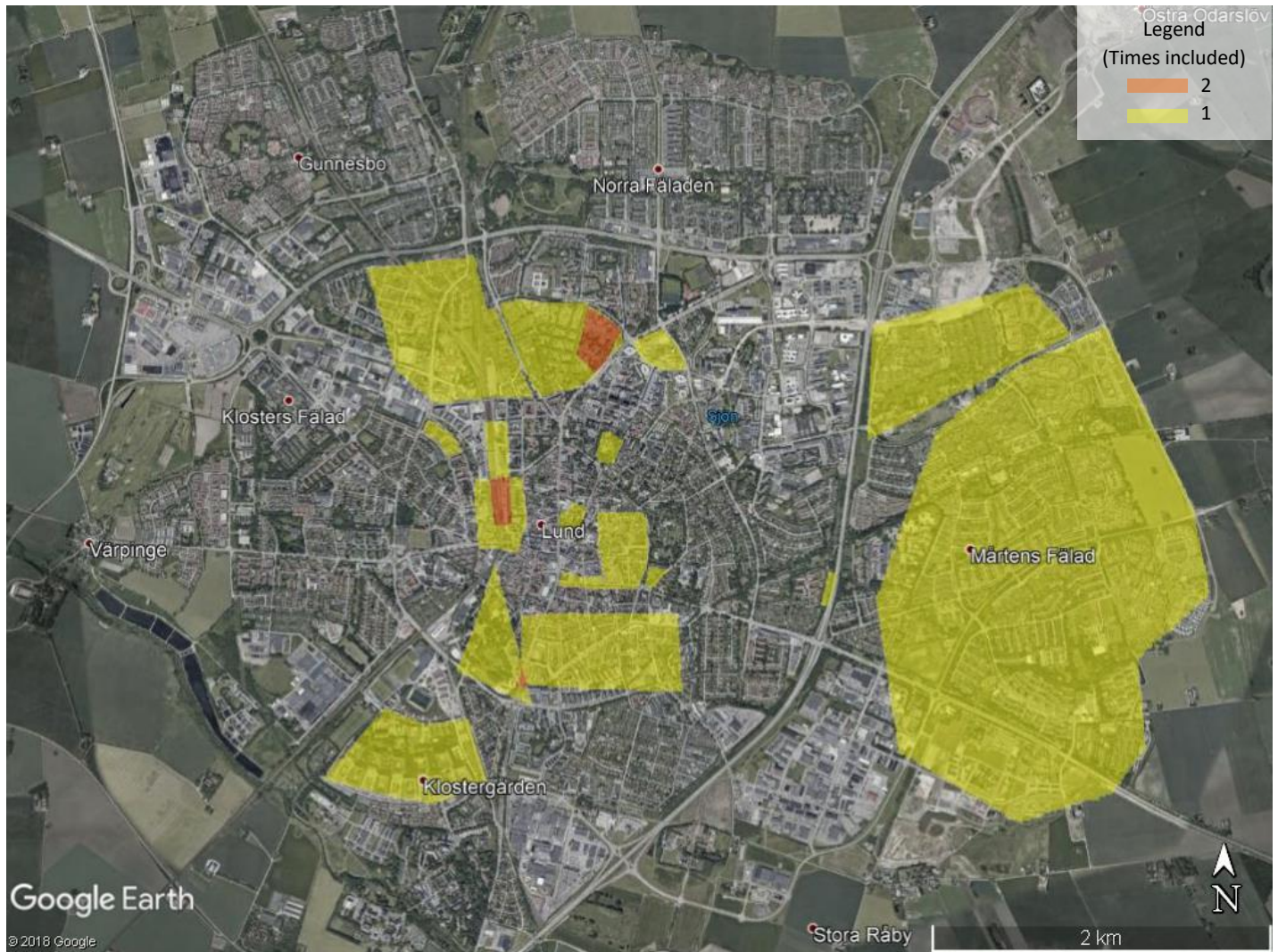


Figure 6. Times that the places were included in the sketch map
(source: base map – Google Earth Pro; sketch maps – survey data)

Figure 6 shows result of overlay in the GIS analysis, which is the count of times that each place was included in the sketch map. The yellow areas were included in the sketch maps once, while the orange areas were included twice, which is 10% of the answers. The places that are not colored were not considered as fearful by the respondents. No places were included more than two times. From this map, it can be concluded that the area around the central station, Norra kyrkogården cemetery and a small area close to Stadsparken were relatively more fearful to the respondents, as they were marked twice in the survey. All those three areas are located in the center of Lund. Then,

it can be inferred that the most fearful areas are more likely to locate in the city center, where is busier than the margins. Some places in the city center, as well as the Klostergården, Östra Torn and Östra Linero were marked once in the survey. Although there is not a huge amount of the participants took part in the survey, it can still be inferred that the city center and some margins of Lund can be fearful. Meanwhile, the areas that marked by the respondents as fearful are big in size, and this is contrast to the spatial pattern of crime, which is clustered to a few street segments.

4.2.2 Difference between the spatial pattern of the fear of crime and actual crime spots

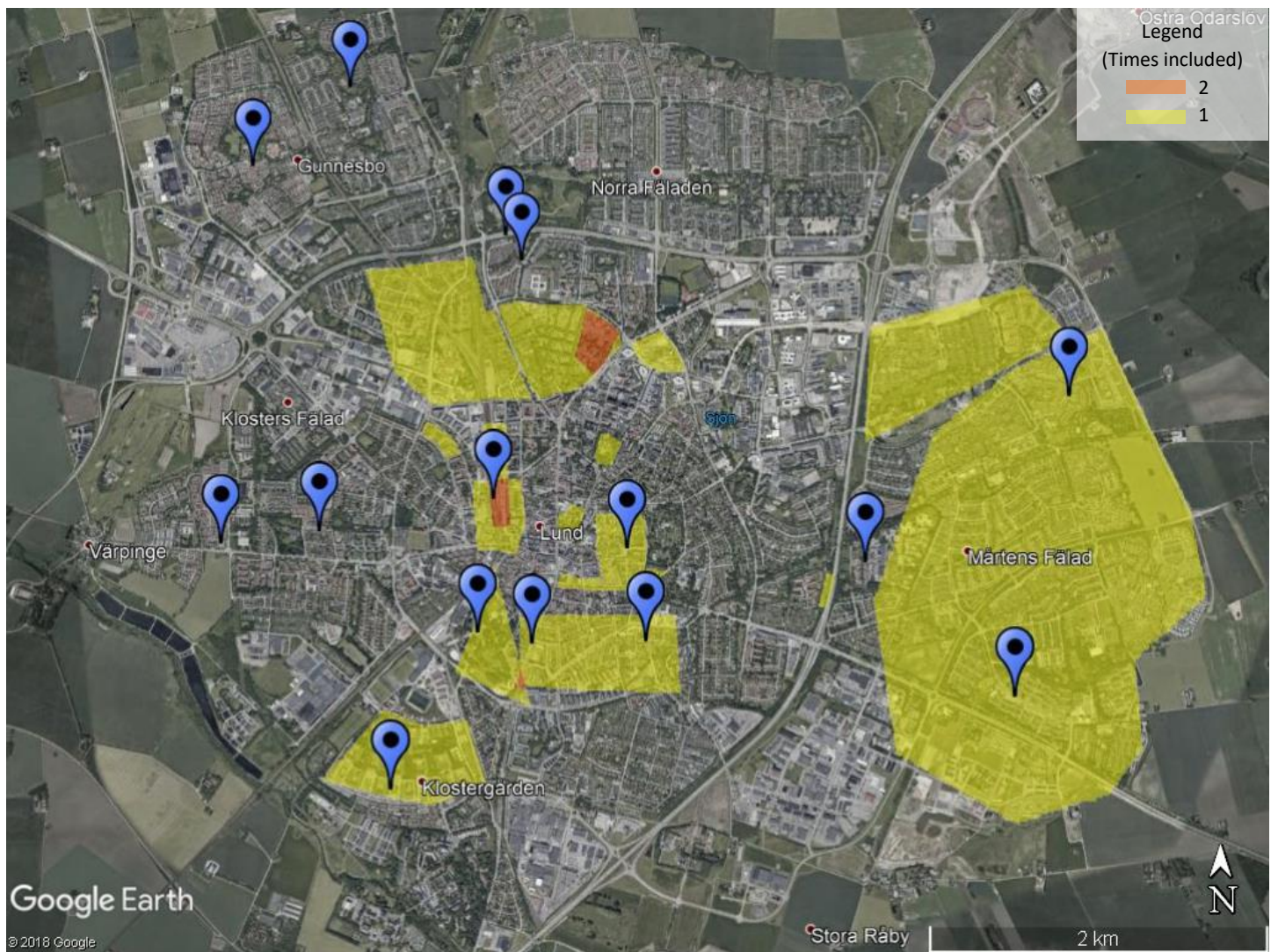


Figure 7. The violent crime spots and the fearful areas of Lund
 (source: base map – Google Earth Pro; sketch maps – survey data; placemarks – <https://polisens.se/aktuellt/polisens-nyheter/?lpfm.loc=Lund>)

Figure 7 shows the spots of violent crimes which occurred in recent three month in Lund, together with the fearful areas which was showed in figure 6. From this map, we can see that violent crimes happened almost all over Lund from February to May in Lund. In addition, eight of fifteen violent crimes occurred in the areas that were marked by the respondents, which means that those fearful areas do not tightly correspond to the violent crime spots in Lund. This is different from some

existing research, which proved that people may feel safer in the areas with high crime rates (Matei, Ball-Rokeach, and Qiu 2001; Curiel and Bishop 2016).

Matei, Ball-Rokeach, and Qiu's research (2001) illustrated the misperception of crime or victimization rate. That research figured out that in its research area, the fear of crime was largely generated by the presence of some specific ethnicities, the population instability, the social media and the personal communication. However, when people have a frequent connection with the areas with high crime rates, they may gradually become comfort with the area, and the perception of unsecure decreases. And this caused the result that people feel more secure in areas with high crime rates.

However, there are no places in Lund suffering from high crime rates. I coded the reasons for the respondents to consider the marked areas as fearful, then investigated on the reasons that the respondents feel afraid to go to some specific places. Table 2 shows the coding result. From the coding result, there are several reasons for the respondents to feel unsafe in some specific places, I sorted them into three categories and six sub-categories.

The first category of factors is the local conditions, according to the answers from the respondents, this category has three sub-categories, including poor lighting alongside the roads in some neighborhoods, some respondents feel afraid or unsure about the safety of the environment when they walk outside. Being alone is another sub-category of local conditions, it is sorted as a local condition because it means that the respondents are outside without the presence of anyone else, and this sub-category refers to the quietness of the environment. Disorder is another sub-category of local conditions, in this study, the disorder was described by the respondents as the police chased a criminal, the gathering of youth or the bad behaviors of people. The second category of factors is the personal experiences, and the two sub-categories that belongs to personal experiences are media and social network. Some of the respondents acquired the information of the criminal events from the news or their friends. The last category is the general fear, and the only sub-category is the nighttime fear. Some respondents were sometimes afraid to walk out at nights, but they did not describe any reason of it.

Table 2. coding result

Respondent number	Categories of factors					
	Local conditions			Personal experience		General fear
	Poor lighting	Being alone	Disorder	Media	Social network	Fear at night
1				"I heard from the news that there were some robberies with knife in the south of Lund"		"I am afraid of being followed when going home at night from the train station"
2		"And for the southeastern part, there are fewer people on the street even at the day time"	"I saw a police chasing a criminal near Lund Nation last year"	"I have heard news about theft, robberies near Lund C and Västenkyrkan"		
3						"As cemeteries always serve as backdrops for terrifying scenes in the movies, these places become more eerie in the evening"

Table 2. coding result (continued)

Respondent number	Categories of factors					
	Local conditions			Personal experience		General fear
	Poor lighting	Being alone	Disorder	Media	Social network	Fear at night
4			"In the evening, there will always be some people who are making noise by shouting. They seem like drunkards or some drug addicts which make me fearful to pass from that path during the night time"			
5			"I have selected the Botulfsplatsen area as it tends to be a gathering place for youth after dark, so getting the bus in the evening can feel a little unsafe at times"			
6			"An inappropriate person lives there"			
7	"Lack of light"					

Table 2. coding result (continued)

Respondent number	Categories of factors					
	Local conditions			Personal experience		General fear
	Poor lighting	Being alone	Disorder	Media	Social network	Fear at night
8	"maybe these places are fearful to me at night because at parks you can not see if it's someone there for mugging"					
9	"low public lighting and I am afraid to walk there"					
10					"I have heard several stories that people have been attacked or mugged at Stadsparken"	

5 Discussion

5.1 Reflections on the methodology

In this research, the sketch map is a clear and direct way of observing and displaying the spatial pattern of the fear of crime. The system developed in this research successfully collected and stored the sketch maps drawn by the respondents and transferred the maps among different GIS software.

The methodologies can be evaluated by the reliability and validity of this research (Bryman 2016). According to Bryman (2016), the reliability includes the external reliability and the internal reliability.

The external reliability refers to the extent that this study can be duplicated (Bryman 2016), however, as pointed by Lecompte and Goetz (1982), the reliability is a natural limitation of the ethnographic or qualitative studies, because the social settings are largely impossible to be replicated. Alternatively, the external reliability can be evaluated from the *status position of the researcher, informant choices, social situations and conditions, analytic constructs and premises and methods of data collection and analysis* (Lecompte and Goetz 1982, 37). As one of the Lund University students myself, and a resident in Lund, I can be one of the research members, which means that my social role is totally in the site of this research, and the conclusion can be qualified and comparable. Regarding choice of informant, as I described in the methodology chapter, the online questionnaire has some limitations on the sampling, because the respondents must be internet users, however, as this research explores the fear of crime only among the students, who are usually likely to have access to the internet, so the choice of informant should not be biased. The social situations and conditions when the data was gathered could not be controlled because this research used an online questionnaire instead of a field survey, however, as I mentioned in the literature review, the sketch map calms down the respondents, so using a sketch map may help to improve the external reliability. Regarding the analytic constructs and premises, the fear of crime, which was the core of this research, was not defined, but as I stated, it is a simple concept that can be interpreted from the daily life, as the most of the relevant research also interpreted the fear of crime from the daily life (Doran and Burgess 2012), I think it is not necessary to define the fear of crime, instead, I clarified the fear should be emotional but not cognitive, this can guarantee that the analytic premises is similar with most of the existing studies. Methods of data collection and analysis were clearly described in the methodology, and the support system for analyzing sketch maps can be used directly in further research after editing the contents of the questionnaire.

Regarding the internal reliability which refers to the members of the research team agrees with the observations (Bryman 2016), this research was conducted by only one person without any colleagues, so the internal reliability is not able to be evaluated.

Internal validity means that the correspondence between the observations and the theories developed in the research (Bryman 2016). As a research on a phenomenon but not a process or a change, the internal validity can be challenged from some aspects, including the observer effects, the selection and the spurious conclusions (Lecompte and Goetz 1982). As the survey was fully conducted online, and the survey questions were neutral but not guiding, the observer effects, in other words, the influences of the researcher on the respondents, can be minimized. Regarding the selection, A simple random sampling method was used so no intend selection of respondents was

conducted other than the sampling criteria I stated in the methodology. However, one possible limitation of this research can be that the number of respondents may not be sufficient, I received twenty answers but only ten of them reported some places that they were afraid to go. In this research, all the conclusions were generated from the survey data and existing research, so the spurious conclusions could be avoided. Therefore, the internal validity of this research may be slightly influenced by the insufficient respondents, but it still can be guaranteed generally.

The external validity concerns the extent that the research can be generalized across social settings (Bryman 2016). This research was specific to Lund University students, although students are one of the main resident groups in Lund, the view of the students can not represent the whole population in the research area, while the techniques, which was mainly sketch mapping, has already been widely used by the researchers. Therefore, the research can be generalized from the aspect of the method I employed to observe the fear of crime, but not from the aspect of sampling. However, as the spatial pattern of the fear of crime is proved to be largely random (Alkimim, Clarke, and Oliveira 2013), the generalization may not be the concern of relevant studies.

5.2 The fear of crime in Lund and its factors

Similar with the existing literatures, the local conditions are a set of factors that generate the fear of crime. Local conditions are the characteristics of the place itself. In Lund, there are three main local conditions making some places fearful, poor lighting, being alone and the disorder. Poor lighting has been figured out by many researchers as a factor that generates the fear. Researchers has observed that the lack of luminosity affects people's behavior, decreasing people's comfort during their movement (Ramsay and Newton 1991). The natural observation becomes more difficult due to the darkness, and people may associate it with the better opportunity of carrying out criminal activities (Castro-Toledo et al. 2017). The answer from a respondent also confirmed this point of view,

"maybe these places are fearful to me at night because at parks you cannot see if it's someone there for mugging" (Respondent 8, 2019-May-23)

In this case, the limited observation in the darkness was associated to the unknown possibility of criminal activities.

Being alone refers to the quietness of the place, when people are walking at a place without the presence of anyone else, they may feel unsafe at that place. Castro-Toledo et al. (2017) mentioned that it is probably caused by the lack of "eyes" in the surrounding environment, and people may also connect it with the better opportunity of criminal activities. However, there is an interesting point that being alone can either increase or decrease the fear of crime, different people can have different preference (Maruthaveeran and Van den Bosh 2015). It need to be mentioned that in this case, not being alone means the presence of strangers, conversely, people tend to feel safer when they are walking with their friends or acquaintances (Maruthaveeran and Van den Bosh 2015).

The disorder of the neighborhood or city is also an important factor which was pointed out by the researchers. The disorder includes a wide range of appearances of things, people or events. Some researchers listed the symbols of disorder, the physical disorder includes such as the presence of narrow streets, forest areas, vacant lots and litter, while the social disorder includes gang activities, drug dealing and etc. (Alkimim, Clarke, and Oliveira 2013; Kohm 2009), these signs of disorder

bring down the assessment of the residents to the area, which leads to the fear of crime. In the answers I got from the respondents, the symbols of disorder in Lund includes the inappropriate behavior of drunk or drug-addicted people, the gathering of youth and the police chasing the criminal. As the disorder is also one of the predictors of the crime hotspot, a disordered place is more likely to have clustered criminal activities. The respondents mentioned Botulfsplatsen and Lunds Nation as the disordered places. They are in the city center of Lund, where several of the criminal activities occurred. Therefore, this should be a reason of the spatial correspondence of the fear and the actual crime.

The personal experience is another category of factors that generates the fear of crime. Personal experience means that the information people get from all kinds of sources. This category of factors is not the characteristics of the place, so the places themselves are not fearful, but the external information generated the fear. This category has two sub-categories, the media and the social network. There is a large amount of research about the effects of media on the fear of crime. Media has been considered as an important factor of the fear of crime for decades, as most of the crime information of people comes from the news media (Roberts and Doob 1990). It is also indicated that people who are never victimized in criminal activities are more likely to be affected by the media, they are more fearful after watching serious crimes (Marczak 2008). The news media was even accused of cultivating the fear by increasingly focusing on the violent crimes. (Marczak 2008). However, in the most recent studies, the effect of the media on the fear of crime is proved to be weak, if there is any (Chadee, Smith, and Ferguson 2019). Therefore, the effect of the media on the fear of crime remains unsure, the existing evidence supports both strong and weak impact. In the survey of this study, two respondents wrote that they were afraid to go to some places because they heard the robberies or theft from the news. The robberies are violent, however, it is difficult to prove that the media is reporting the negative news and avoiding the positive ones.

The social network is also a factor that has been observed by researchers. It is also indicated that the communication with neighbors or friends about the information of criminal activities weakens the effect of news media, people who frequently talk with their neighbors and friends about the criminal information are not easily be scared by the news, however, people tend to trust their friends rather than neighbors about the information of criminal activities (Yamamoto, Ran, and Luo 2019). In this study, only one of the respondents mentioned the affect from his/her own network, it is also worth to note that this respondent wrote that he/she heard several stories about the crime activities, which means that this respondent heard the same information more than once. It has not been proved, but it can still be inferred that the recurrence of the information is more likely to be trusted.

The last category is the general fear, which means that the respondent did not provide any specific reasons of being afraid, but only expressed the general fear during nighttime, which is the only sub-category of factor that belongs to this category. In fact, this is not the spatial pattern of the fear, instead, it represents the time pattern. However, as suggested by some researchers, the fear of crime at night can be relieved by improving the luminosity (Ramsay and Newton 1991), the reason of nighttime fear is probably similar as the poor lighting, which is the limit of observation.

5.3 Limitations and expectations

This research has some possibilities to be improved. Regarding the online questionnaire, I received several suggestions from the respondents. Two of them suggested some improvements on the cartography or functionalities of the interactive map.

The cartography of the interactive map should be taken into consider, as suggested by some respondents. The OpenStreetMap has some defects on this aspect. For example, the names of some important landmarks are missing. Several of other interactive mapping APIs can solve this labeling problem, such as Google Maps or Here Maps. However, I did not use these interactive maps because their API keys were needed to be embedded in the online questionnaire, and it took time to apply for the API keys from those companies. Using a better interactive mapping API is the first possible improvement of the support system developed in this research. In addition, it is also possible to go deeper in this direction and investigate on how to optimize the map elements of the base map for sketch map surveys, for example, the labels or the styles of streets and buildings.

Regarding the reliability of the survey data, the length of the answer to question 2 and question 3 are checked after clicking submit button, if one or the both of the blanks are empty, the questionnaire cannot be handed in. This prevents the users from sending in empty questionnaires and increases the possibility of getting valid answers. However, the survey of this research faced to the Lund University students, in order to make the questionnaire publicly accessible, which is the basis of crowdsourcing, the questionnaire was posted in the Facebook group of the students with an instruction, which said that the students were welcome to answer. However, the questionnaire does not block the visit of non-students, so, it cannot be guaranteed that all the answers were given by the students. I read all the answers to check if any of them is not reasonable from the common knowledge, but it is not a perfect way. A better reliability check should also be considered in the future study.

As I mentioned in the case study, I selected Lund as my research place due to the time limit. Most of the Lund University students are familiar with Lund, so if I investigate the fear of crime in Lund, I am more likely to get enough answers in a short time. One of the respondents also mentioned that I could include Malmö as the research area, and this is a suggestion that I can take for the future study. I did not include Malmö because I did not have access to any open platforms to make my questionnaire visible to the people in Malmö, and if I only share it in my personal connection, that could not be crowdsourcing. Since I intended to acquire volunteered geography information, making my questionnaire publicly visible is essential. It can be inferred that the research result of Malmö can be more interesting, since there are more crimes in Malmö than in Lund, and people are probably fear more about the crime. And more crime spots may enable the hot spot analysis in GIS, so the spatial patterns of violent crimes will be more clearly displayed.

It is necessary to mention that most of the students in Lund are likely to be familiar with the city center, which means the center may be more likely to be marked, however, there are two violent crimes occurred in the northwest part of Lund, but since no respondents live there, that part of the city may not be familiar to any of the respondents. Therefore, the effect of accessibility or the popularity of the places on the fear of crime can be further explored.

Moreover, till now the spatial pattern of the fear of the crime is still considered as random. So, it is also a direction of further research to explore some regularities behind the spatial pattern of the fear.

6 Conclusion

In this research, a support system of analyzing sketch maps in the fear of crime studies has been developed, and spatial pattern of the fear of crime in Lund was explored. As the answer of the first research question about the support system of analyzing sketch maps, the system consists of two parts, an online questionnaire and a GIS analysis process. The functions of questionnaire of this system include collecting data with an online questionnaire with an embedded interactive map which can collect and store the user input, processing data and transferring data among different GIS software. Several techniques were used to fulfill the functions of the system. Client-side coding enables the questionnaire to render in the web browsers of the user, and the server-side coding stores the inputs from the respondents, both client- and server-side coding enables the online questionnaire works smoothly, so it can be used to conduct surveys online. The web mapping 2.0 technique were used to render an interactive base map in the questionnaire and collect the sketch maps drawn by respondents. As the technique which allows the transmission of the sketch maps among different applications, the maps were encoded to GeoJSON format which is supported by most of the GIS softwares. The screenshot and the codes of the online questionnaire is in the appendix, and the questionnaire is also accessible at <https://lijianxiong.000webhostapp.com/>.

The second research question concerned the spatial pattern of the fear of crime and the factors behind the fear. It has been proved that an area around the central station, a small area close to Stadsparken and Norra kyrkogården cemetery were relatively more fearful to the respondents, while the center and some margins of Lund can also be fearful. People tend to mark the fearful areas with large polygons instead of smaller. There are three categories or six sub-categories of factors for the respondents to feel unsafe in the marked areas. The first category identified is the local conditions, which is the factors of the place itself, including the poor lighting, being alone and disorder, and in Lund, the sign of disorder is the drunk or drug-addicted people with inappropriate behavior, or the police chasing the criminal. Personal experience is another category of factors, which includes media and social network. The third category is the general fear at night, without any reason provided by the respondents. I consider this as a temporal pattern of the fear instead of the spatial pattern, however, as suggested by some researchers, the general fear at nights is partly due to the poor lighting.

The third research question concerned about difference of spatial distribution of the fear and the recent violent crime spots. The spatial distribution of fear does not correspond to the violent crime spots.

There are still several possible improvements in the future studies, for example, the choice of interactive map APIs and the optimization of map elements of the survey base maps. The effect accessibility or the popularity of a place on the fear of crime can be further explored, as well as some regularities behind the spatial pattern of the fear, which is currently considered as random.

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Appendix 1: the screenshot of the online questionnaire

Fear of Crime Survey

Hello! I am Li Jianxiang, a student of Lund university. I am now doing my master thesis about the fear of crime in Lund. This is a questionnaire about your own feeling on the safety of Lund, which includes 3 questions and takes 10 minutes. Your answers will be very valuable to my research. You are welcome to answer in English, Chinese or Swedish.

This web form does not take excellent security measures, so please do NOT include any of your personal information.

Be a nice respondent, I kindly ask you not to hack this website, especially inject any code in the blanks. If you are very interested in hacking websites, you may do it after I finish my thesis, let me know before you do. Thanks a lot!

Q1: Are there any particular places in Lund that you are afraid to go? You can mark them with polygon in the map below. If you want to delete a polygon you have drawn, click the "select" button first, then click on the polygon you want to delete, and then click "delete". You can delete only one polygon each time.



Q2: Could you explain why those places are fearful to you?

Q3: Where do you live? This involves a little privacy, so you don't need to point it out in the map or give your full address. You can just write down the street name or the neighborhood name, for example, Spelmansvägen or Östra Torn.

Q4: Do you have any suggestions to this online questionnaire? (Optional)

Submit

Appendix 2: client-side script

```
<!DOCTYPE html>
<html lang='en'>
  <head>
    <meta charset="UTF-8">
    <title>Fear of Crime Survey</title>
    <link rel="stylesheet" href="libs/ol.css" type="text/css">
    <style>
      #header{
        text-align:center;
        color:black
      }
      .map{
        height:400px;
        width:60%;
        margin:auto;
      }
      .question{
        margin:auto;
        width:60%;
      }
      .answer{
        display:block;
        margin:auto;
        width:60%;
        height:100px;
      }
      #submit{
        display:block;
        margin:auto;
      }
      #draw{
        margin-left:43%;
      }
      .instruction{
        width:60%;
        margin:auto;
      }
      #notice{
        color:red;
        width:60%;
        margin:auto;
      }
    </style>
    <script src="libs/ol.js"></script>
    <script src="
https://cdn.polyfill.io/v2/polyfill.min.js?features=requestAnimationFrame,Element.prototype.classList,URL "></script>
  </head>
  <body>
    <div id="container">
      <div>
        <h2 id="header">Fear of Crime Survey</h2>
```



```

var selectedFeatures;

var raster = new ol.layer.Tile({
  source: new ol.source.OSM()
});

var source = new ol.source.Vector({wrapX: false});

var vector = new ol.layer.Vector({
  source: source
});

var draw = new ol.interaction.Draw({
  source: source,
  type: 'Polygon'
});

draw.on('drawend', function (event) {
  featureID = featureID + 1;
  event.feature.setProperties({
    'id': featureID
  });
});

var snap = new ol.interaction.Snap({
  source: source,
});

var modify = new ol.interaction.Modify({
  source: source,
});

var view = new ol.View({
  center:
ol.proj.transform([13.1935,55.7040], 'EPSG:4326', 'EPSG:3857'),
  zoom: 14,
  extent:
ol.proj.transformExtent(extent, 'EPSG:4326', 'EPSG:3857'),
  minZoom: 12,
});

var map = new ol.Map({
  layers: [raster, vector],
  target: 'map',
  view: view,
});

function drawPolygon(){
  map.addInteraction(draw);
  map.addInteraction(snap);
  map.addInteraction(modify);
  map.removeInteraction(singleClick);
};

function selectPolygon(){
  map.removeInteraction(draw);
  map.removeInteraction(snap);
};

```

```

    map.removeInteraction(modify);
    singleClick = new ol.interaction.Select({
        toggleCondition: ol.events.condition.never
    });
    map.addInteraction(singleClick);
    singleClick.getFeatures().on('add', function (event) {
        var properties = event.element.getProperties();
        selectedFeatureID = properties.id;
    });
};

function deletePolygon(){
    map.removeInteraction(draw);
    map.removeInteraction(snap);
    map.removeInteraction(modify);
    map.removeInteraction(singleClick);
    var features = source.getFeatures();
    if (features != null && features.length > 0){
        for (x in features){
            var properties = features[x].getProperties();
            console.log(properties);
            var id = properties.id;
            if (id == selectedFeatureID) {
                source.removeFeature(features[x]);
            }
        }
    }
};

function submit(){
    //save polygons in geojson format
    var writer = new ol.format.GeoJSON();
    var ans1 = writer.writeFeatures(source.getFeatures());

    //get Q2 answer
    var ans2 = document.getElementById("ans2").value;

    //get Q3 answer
    var ans3 = document.getElementById("ans3").value;

    //get Q4 answer
    var ans4 = document.getElementById("ans4").value;

    if (ans1.length > 0 && ans2.length > 0 && ans3.length >
0){
        //pass the values to the server
        var xmlhttp = new XMLHttpRequest();
        xmlhttp.onreadystatechange = function(){
            if (this.readyState == 4 && this.status == 200)
{
                document.getElementById("container").innerHTML = this.responseText;
            }
        };
        UrlToSend = "save.php?ans1=" + ans1 + "&ans2=" +
ans2 + "&ans3=" + ans3 + "&ans4=" + ans4;
        xmlhttp.open("POST", UrlToSend, true);
    }
}

```



```
        xmlhttp.send();
    }else{
        document.getElementById("notice").innerHTML =
        "Please answer Question 1-3!";
    }
}
</script>
</body>
</html>
```

Appendix 3: server-side script

```
<?php
    $ans1 = $_REQUEST["ans1"];
    $ans2 = $_REQUEST["ans2"];
    $ans3 = $_REQUEST["ans3"];
    $ans4 = $_REQUEST["ans4"];

    $retmsg = "Thank you for your participation, here is your
answer:<br><br><b>Q1 (in GeoJSON format):</b> " . $ans1 .
"<br><br><b>Q2:</b> " . $ans2 . "<br><br><b>Q3:</b> " . $ans3 .
"<br><br><b>Q4:</b> " . $ans4 . "<br><br>Have a nice day!";

    #Question 1
    date_default_timezone_set("Europe/Stockholm");
    $t = date("YmdHis");
    $filename = $t . ".json";
    $saveAns1 = fopen($filename,"w");
    fwrite($saveAns1,$ans1);

    #Question 2
    $ans2 = $t . "\r\n" . $ans2;
    $ans2 = $ans2 . "\r\n\r\n";
    $saveAns2 = fopen("Answers2.txt","a");
    fwrite($saveAns2,$ans2);

    #Question 3
    $ans3 = $t . "\r\n" . $ans3;
    $ans3 = $ans3 . "\r\n\r\n";
    $saveAns3 = fopen("Answers3.txt","a");
    fwrite($saveAns3,$ans3);

    #Question 4
    $ans4 = $t . "\r\n" . $ans4;
    $ans4 = $ans4 . "\r\n\r\n";
    $saveAns4 = fopen("Answers4.txt","a");
    fwrite($saveAns4,$ans4);

    echo $retmsg;
?>
```